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The Impact of Climate Change on Rural Livelihoods: An Empirical Study of Coconut Sugar Farmers (*Penderes*) in Banyumas Regency

Dampak Perubahan Iklim terhadap Penghidupan Pedesaan: Studi Empiris pada Petani Gula Kelapa (Penderes) di Kabupaten Banyumas

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Abstrak

This study examines climate injustice and its impact on rural livelihoods, focusing on the case of coconut sugar farmers (locally known as *penderes*) in Pageraji Village, Cilongok Subdistrict, Banyumas Regency. Drawing from political ecology, climate justice theory, and the sustainable livelihood framework, this research seeks to understand how global and national socioeconomic inequalities contribute to climate change and disproportionately affect vulnerable rural communities. Employing a qualitative case study approach, data were collected through in-depth interviews, field observations, and literature review. The findings reveal that *penderes* face multiple layers of vulnerability, including declining productivity due to extreme weather events, limited access to adaptive technologies, and weak social protection mechanisms. Structural inequalities in the production and distribution of climate change impacts exacerbate their livelihood insecurity across natural, human, social, physical, and financial capital dimensions. The study argues that *penderes* are not only ecological victims but also subjects of structural and historically rooted development injustices. Accordingly, this research calls for a reorientation of climate policy towards a more just and context-sensitive approach that centers the needs and rights of vulnerable local communities.

Keywords: climate justice, political ecology, rural community, sustainable livelihood, structural inequality

Abstract

This study examines climate injustice and its impact on rural livelihoods, focusing on the case of coconut sugar farmers (locally known as *penderes*) in Pageraji Village, Cilongok Subdistrict, Banyumas Regency. Drawing from political ecology, climate justice theory, and the sustainable livelihood framework, this research seeks to understand how global and national

socioeconomic inequalities contribute to climate change and disproportionately affect vulnerable rural communities. Employing a qualitative case study approach, data were collected through in-depth interviews, field observations, and literature review. The findings reveal that *penderes* face multiple layers of vulnerability, including declining productivity due to extreme weather events, limited access to adaptive technologies, and weak social protection mechanisms. Structural inequalities in the production and distribution of climate change impacts exacerbate their livelihood insecurity across natural, human, social, physical, and financial capital dimensions. The study argues that *penderes* are not only ecological victims but also subjects of structural and historically rooted development injustices. Accordingly, this research calls for a reorientation of climate policy towards a more just and context-sensitive approach that centers the needs and rights of vulnerable local communities.

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Introduction

Climate change has become one of the most far-reaching global transformations caused by human activity. Defined as long-term shifts in climatic patterns resulting directly or indirectly from anthropogenic emissions (United Nations, 1992), its impact has accelerated rapidly over the past century. The Intergovernmental Panel on Climate Change (IPCC, 2023) estimates that human activities have contributed 0.8 – 1.3°C of global surface warming between 1850 and 2019, a trajectory that places nearly all regions at heightened risk of climatic hazards in the coming decades. These hazards include sea-level rise, coastal inundation, groundwater salinization, and intensification of storm events (Fankhauser, 1995; Nicholls et al., 1999). In the agricultural sector, climate change is projected to reduce global productivity, increase pest and disease outbreaks, and elevate the risk of large-scale crop failures (Parry et al., 2005; Fischer et al., 2002). Hydrological disruptions further threaten freshwater availability (Hagemann et al., 2013), while cascading effects on global health are observed in rising malnutrition, unsafe water supplies, and exposure to household air pollution (St. Louis & Hess, 2008).

Indonesia is among the world's most climate-vulnerable countries. USAID (2017) warns that sea-level rise could submerge up to 2,000 small islands and expose nearly 6 million people to annual coastal flooding by 2100. Critical sectors – including agriculture – face escalating risks: heat stress lowers yields, pests and diseases spread more rapidly, inundation damages croplands, and prolonged droughts heighten crop failure. Yet these national-level risks manifest unevenly across communities, including coconut sugar production, despite contributing USD 38.24 billion in export value in 2020 (Ditjenbun Kementan, 2021) and showing an 18.2% rise in coconut-sugar export volume in 2021 (BPS, 2021), the livelihoods underpinning this industry remain precarious. Banyumas Regency, one of Indonesia's major production centres with over 5,200 hectares of tapping coconut plantations and an annual output exceeding 56,000 tons in 2021 (indepth interview, Banyumas Agricultural Office, 6 November 2024),

signalling the sensitivity of tappers (*penderes*) to climatic anomalies, disrupted sap flow, and ecosystem instability.

These localized impacts reflect a broader structural problem. Fairtrade NAP (2023) highlights that climate change amplifies structural inequalities: groups contributing least to emissions – smallholders, rural workers, indigenous communities – bear disproportionate burdens. Reduced income, heightened occupational hazard, and limited access to adaptive technologies deepen their vulnerability. Similar dynamics were evident in the 2009 drought and prolonged rains in Kulon Progo, Yogyakarta, which drastically reduced coconut sap production, triggered landslides and flooding, and escalated work-related accidents (Aid Environment, 2023). These cases underscore a systemic form of climate injustice, where marginalized rural communities face not only economic losses but also exclusion from climate-policy decision-making at both national and local levels.

This study departs from the premise that climate change is inextricably linked to historical and contemporary socioeconomic inequalities. At the global scale, unequal wealth and power structures shape differential contributions to greenhouse-gas emissions, and unequal exposure to climate change is not merely an environmental phenomenon but also a product of political and developmental choices – often driven by growth-oriented "political will" that sidelines ecological sustainability. This research positions itself as a critique of how global and domestic power structures perpetuate climate vulnerability among rural populations.

Literature Review

A substantial literature treats climate change as structural injustice rooted in global inequality. Moss (2015) frames it ethically, holding industrialized nations responsible for accumulated emissions, while Green & Healy (2022) show how their dominance entrenches imbalances that expand carbon-intensive production and stall climate policy. Harvey (2022) ties historical wealth divergence to warming, amplified by inequality within societies, and Maslin (2021) reads global negotiation as a hegemonic order verging on green colonialism, with India and China resisting cuts seen as threats to development. Less-developed countries bear the harshest costs of exploitative growth (Mikulewicz, 2018; Thomas & Twyman, 2005). The injustice also operates within states. Chakravarty et al (2008) apply common but differentiated responsibility to individuals, separating affluent high-emitters from the low-emitting poor who suffer most, and (Islam & Winkel, 2017) recast it as multi-dimensional, working between and within nations.

Against these asymmetries, Indonesia is acutely exposed, ranking 48th of 191 on the 2023 INFORM Risk index amid recurrent floods, droughts, and heat (Inter-Agency Standing Committee and the European Commission, 2023). Sea-level rise and

flooding threaten coastal communities and food production (Neumann et al., 2015), while El Niño heat adds risk (Matthews et al., 2017; Mora et al., 2017); in 2015, low rainfall in Kalimantan and Sumatra intensified fires (Field et al., 2016). Because rice is sensitive to seasonal shifts, such disruptions deepen food insecurity in provinces like Nusa Tenggara and make shortages likelier (The World Bank Group and Asian Development Bank, 2021; USAID, 2017), with rural and coastal communities most at risk (Rudiarto et al., 2018). Their vulnerability reflects agricultural dependence and lower climate awareness along the urban-rural divide (Diamond et al., 2020). Morton (2007) attributes smallholder exposure as much to non-climatic pressures like poverty and weak social protection as to tropical geography, across biological, ecological, and socio-economic levels. An integrative lens is therefore needed, joining climate justice, which treats vulnerability as structurally produced, with the Sustainable Livelihood Framework's view that natural, social, physical, human, and financial assets shape adaptive capacity.

Recent empirical studies apply these frameworks yet leave gaps. Adelakun et al (2021) apply the SLF and participatory methods to forest-dependent communities in Nigeria, finding that shifting seasons erode livelihoods and the rural poor bear disproportionate burdens despite minimal contribution, yet say little about how impacts fall by gender or age, rights and participation, or durable outcomes. Anser et al (2023) embed environmental justice in a model of rural poverty in Pakistan, using robust least squares on 1990-2022 data to show that climate stress worsens poverty while justice-oriented intervention and mechanization ease it, yet privilege distributive over procedural justice and skip a full livelihood-asset analysis. Closest to this case, Zulhilda & Gravitiani (2018) link climatic extremes to falling coconut-sap and sugar output in Kebumen, but treat climate change as a purely natural phenomenon, ignore global and rural inequality, and never cast coconut sugar farmers as vulnerable. Their variable-driven design also lacks depth on how climate injustice threatens the sustainability of these farmers' natural, social, physical, financial, and human capital, the gap this study addresses.

Theoretical Framework

Climate justice is an extension of environmental justice, whose intersectional frame connects ecology to inequalities of poverty, race, indigenous dispossession, and agrarian conflict (Schlosberg & Collins, 2014). Its roots lie in Rawls (1999) theory of distributive justice, which seeks to widen opportunity while reducing inequality in the distribution of resources. Brown Weiss (1989) was the first to name climate justice, framing it as a matter of intergenerational justice that gives policy its moral foundation; the concept was later broadened to include historical responsibility, per capita equity, and the right to development (Brown Weiss, 1989; Schlosberg & Collins, 2014).

For Bou-Habib (2019), the absence of historical responsibility allows global institutions to let developed countries avoid contributing their share, and obligations should therefore be tied to historically accumulated wealth. Tokar (2020) emphasizes the disproportionate burden carried by vulnerable populations and the limits of conventional politics, while Giacomini (2022) argues that the commodification of the atmosphere and the capitalist, industrialized treatment of nature erode the rights of indigenous and vulnerable groups. Justice itself remains contested. Understood as the distribution of resources and opportunities (Hayward & Swanstrom, 2011), it is criticized by Young (2011) and Fraser (1998), who argue that justice must begin from questions of power, domination, and oppression and requires the recognition and participation of those who are oppressed. Sen (1993) adds the dimension of capability, understood as access to resources, freedom, and the institutions needed for a dignified life, and Shue (1993) brings distribution, recognition, participation, and capability together into a single account.

When this framework is transposed to the global South, however, it tends to lose sight of the link between poverty and injustice (Lawhon, 2013) and risks epistemic violence, since Southern knowledge remains marginal within it (Vermeylen, 2019). From a decolonial perspective, Wilkens & Datchoua-Tirvaudey (2022) identify three pressing concerns: a dominant Westphalian, ideal-theory view that ignores affected communities; the need for alternative forms of knowledge production drawn from the diverse knowledge of those communities; and normative change in governance. Giacomini (2022) adds that such an approach helps dismantle the relations that cast indigenous identities as inferior while colonial capitalism is sustained through emissions and extraction. Because joint knowledge production can itself be elitist, it calls for self-reflection and attention to positionality (Wilkens & Datchoua-Tirvaudey, 2022). In a similar vein, Escobar & Mignolo (2013) read history as the working of imperial power rather than as a linear Western narrative, which makes development inseparable from environmental oppression and racism. A decolonial frame therefore asks how colonial capital accumulation produces climate vulnerability in rural communities.

At the micro scale, this vulnerability can be read through the lens of sustainable livelihoods. Chambers & Conway (2014) define livelihoods as comprising capabilities, assets, and activities, and consider them sustainable when they can recover from stress, maintain their assets, and do so without undermining the livelihoods of others. Carney (1998) emphasizes the importance of not depleting the natural resource base, while Morse & McNamara (2013) treat assets as forms of capital but argue that access matters as much as ownership, and caution that diversification does not necessarily improve sustainability. DFID's Sustainable Livelihood Approach (SLA) identifies five assets, namely natural, social, human, physical, and economic capital, as variables shaped by a vulnerability context of shocks, trends, seasonality, and climate change, and

distinguishes tangible capital (physical and natural) from intangible capital (networks, knowledge, and health).

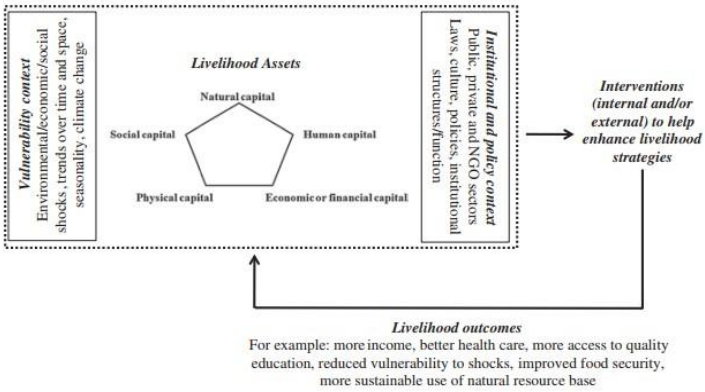

Figure 1: Sustainable Rural Livelihoods Framework by the Department for International Development (DFID) United Kingdom. Source: www.nssd.net/references/SustLivel

Natural capital consists of land, water, and plants that provide partly irreplaceable services (Ekins et al., 2003; Norberg, 1999) and ecosystem functions (de Groot et al., 2002). Social capital refers to the norms and networks that enable collective action and mutual support under conditions of rural uncertainty (de Souza Briggs, 1998; Holzmann & Jorgensen, 1999; Woolcock & Narayan, 2000). Economic capital covers money, cash flow, and credit-type claims or invested stocks (Azad & Pritchard, 2022; Goodwin, 2003). Physical capital is the infrastructure that supports a livelihood (Lax & Krug, 2013), and human capital is the skills and health of individuals, measured through age, education, gender, and leadership (Bezemer & Lerman, 2003; Scoones, 2009).

The framework of this research links the two traditions through two main references. Green & Healy (2022b) connect inequality to climate change through five variables: consumption patterns, production decisions, elite barriers to mitigation, household economic insecurity together with the social effects of mitigation, and the erosion of the social bonds that sustain collective action. In doing so, they reverse the usual logic and argue that inequality drives climate change rather than the other way around. Harvey (2022) reinforces this argument through the sociogenesis of climate change, tracing economic development since the eighteenth century, when disparities both between and within countries became its principal driver, on the premise that the injustice of climate impacts is distributed unevenly (Paglialunga et al., 2022).

Agriculture is the central variable linking climate change, poverty, and income inequality (Hallegatte & Rozenberg, 2017). Heat, low rainfall, and heatwaves reduce yields and farmer incomes in rural areas of developing (Dell et al., 2014; Laubier-longuet Marx et al., n.d.); workers bear greater risk as outdoor productivity falls (Graff Zivin & Neidell, 2014); the rural poor, who have weaker access to land and markets (Barbier & Hochard, 2018; Castañeda et al., 2018), face higher disaster risk because of their dependence on natural resources and their low adaptive capacity (Angelsen &

Dokken, 2018; Narloch & Bangalore, 2018; Yamamura, 2015); and rising food prices compress wages and consumption in proportion to the share of income spent on food and the degree of reliance on markets (Bandara & Cai, 2014; Janssens et al., 2020).

The present study is therefore grounded in materialist political ecology and framed by climate justice, which reads climate impacts as unjust because the heaviest burdens fall on poor developing countries and their vulnerable groups. Green and Healy's (2022) variables of consumption, production, and elite barriers, set against the chronology of capitalism since the eighteenth century, serve as tools for examining how inequality triggers climate change and how Indonesia's social and economic structure deepens that injustice. This is read through sustainable livelihood theory and livelihood resilience in order to assess how far the livelihoods of coconut sugar farmers can withstand climate shocks and the injustices that accompany them, with agency and human rights at the center of the analysis.

Methods

This study employs a qualitative methodology to understand the meaning of a social or individual problem through an inductive lens centered on participant perspectives (Creswell, 2009). The choice rests on the five features of qualitative inquiry identified by Yin (2016): it examines the meaning of people's lives under real-world conditions and favors naturalness over imposed procedures such as questionnaires; it treats participant perspectives as the primary source for interpreting reality; it stresses contextuality because social, institutional, and environmental contexts shape human behavior; it enriches existing concepts through a dialectical process; and it integrates evidence from diverse sources to account for the complexity of reality. The methodology fits this study because the research requires the standpoint of a rural community as a group vulnerable to climate change, together with a natural record of their activities free from researcher intervention.

Two methods operationalize this approach. The first is a single case study, which (Stake, 1995) and Yin (2018) describe as an in-depth analysis of a subject bounded by clear limits of time and activity and supported by multiple techniques; (Yin, 2013) considers a single-case design appropriate when the case is unusual, when it is used to test a hypothesis, or when it represents a classic instance of a phenomenon. The second is participatory research (PR), a research-to-action approach that emphasizes the direct involvement of those affected for the purpose of action and change (Vaughn & Jacquez, 2020). Among PR approaches, the study adopts decolonizing methodologies, which challenge traditional Western methods and position marginalized groups as knowers throughout the research process (Chilisa, 2012), and specifically Transformative Participatory Action Research (Hsia, 2006), which combines participants as co-researchers with a focus on personal and social

transformation, drawing on Freire's (2013) notion of liberatory consciousness. This choice aligns with climate justice theory through a decolonial approach and positions coconut-sugar farmers to co-produce knowledge about the injustice of climate change impacts on their livelihoods.

The case is the community of coconut-sugar farmers (penderes) in Pageraji Village, Cilongok District, Banyumas Regency. Banyumas Regency covers 132,759.56 ha (4.08% of Central Java Province, the fifth largest) and has a population of about 1.8 million spread across 27 districts, 301 villages, and 30 urban wards; Cilongok is the largest district at roughly 105.34 ha, comprising 20 villages and located 12 km west of the regency capital (BPS, 2022). Since the 1980s the social cohesion built on agricultural mutual aid has weakened as capitalism and the modernization of Purwokerto advanced, yet for the penderes the coconut tree remains an ecological-economic foundation that preserves soil fertility and provides income within an intercropping system (Perhimpunan SETARA, Indepth Interview, March 14, 2025). The penderes remain caught in structural poverty driven by inequitable trade in the coconut-sugar supply chain and unequal land ownership, leading the researcher to hypothesize that their marginal position exposes them to the injustice of climate change impacts. In keeping with PR, the researcher acts not only as an observer but also as a facilitator who treats the penderes as research subjects in identifying problems, eliciting experiences, and understanding local perspectives.

Data are collected through three techniques. Qualitative interviews are chosen because they are open-ended, free from a rigid questionnaire, and able to build an intimate discursive relationship (Yin, 2016); informants include farmers of the Abhinaya Karya Mandiri Cooperative (four farmer groups), government agencies (the Banyumas Department of Agriculture and Food Security, the Department of Environment, BAPPEDALITBANG, and the Pageraji Village Government), and Perhimpunan SETARA. Focus group discussions (FGDs) serve as in-depth group interviews in which interaction among participants becomes the unit of analysis and an arena for the dialectic of knowledge (Mishra, 2016), held within each farmer group. A literature review gathers secondary data and reinforces the primary data, focusing on the theorization of climate justice and sustainable livelihoods.

Data validity follows the four criteria of (Lincoln & Guba, 1990): credibility, the extent to which findings are trustworthy and reflect the lived reality of subjects, safeguarded through triangulation, member checking, and sufficient field engagement; transferability, the applicability of findings to similar contexts through descriptive-contextual narrative rather than generalization; dependability, the consistency of the research as documented in an audit trail; and confirmability, the freedom of findings from bias through empirical evidence and the researcher's reflective notes. Analysis uses triangulation, which Flick (2018) define as examining a research problem from at least two different vantage points and which comprises four

forms: triangulation of data, investigator triangulation, triangulation of theories, and methodological triangulation.This study applies triangulation of data by validating interview results against FGD results, and triangulation of theories by reconciling empirical data with the study's perspectives, theory, and hypothesis.

The research runs for approximately seven months, covering concept design and proposal preparation (April to May), three months of fieldwork through FGDs with the penderes and interviews with stakeholders (June to August), and analysis and writing of the discussion (September to October).

Results and Discussion

Socio-Economic Inequality: Climate Change Phenomenon Catalisator

Global socio-economic inequality operates at both between-country and within-country levels, and its historical trajectory clarifies the material conditions underlying climate change. (Milanovic, 2024) identifies three phases of global income inequality from 1820 to 2018. The first (1820 to 1950) climbed from about 50 to 62 Gini points before World War I: the Great Divergence, when industrial economies (Western Europe, North America, and Japan) pulled away from a stagnating China, India, and Africa, alongside European colonial expansion and Japan's occupation of Korea and Taiwan. The second (1950 to the late twentieth century) peaked at 67 to 70 Gini points, splitting the world into first, second, and third blocs under Cold War rivalry, with United States output growing 26% from 1990 to 1998 against 17 % in Europe and 7 % in Japan. The third declined as Asian incomes rose, led by China, whose real GDP grew 9.5% annually through 2018 after Deng Xiaoping's 1979 reforms.

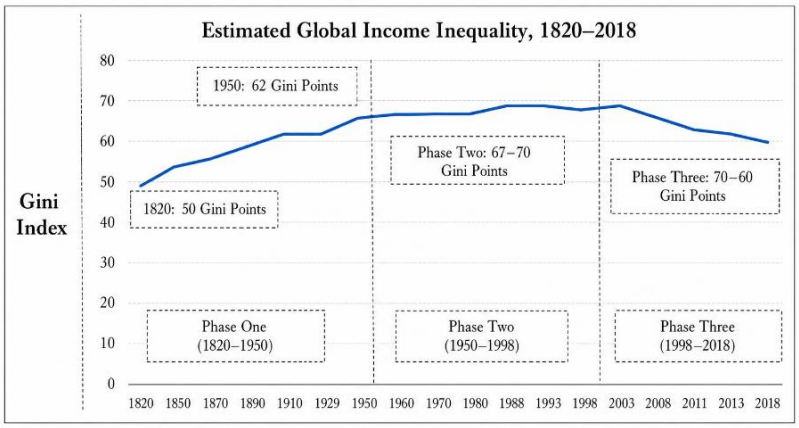

Figure 2. Estimates of Global Income Inequality (1820–2018). Source: Milanovic (2016)

Current figures sharpen the gap: against an average global income of €16,700, Sub-Saharan Africa reaches only 31% of that average and South and Southeast Asia 50 %, while Europe exceeds 215% and North America 315%, making North American incomes six to ten times those of the poorest regions and East Asian incomes half of

Europe's (Chancel et al., 2022). Wealth gaps are wider still, with poorer regions holding 20 to 50% of the global average against North America's 390%.

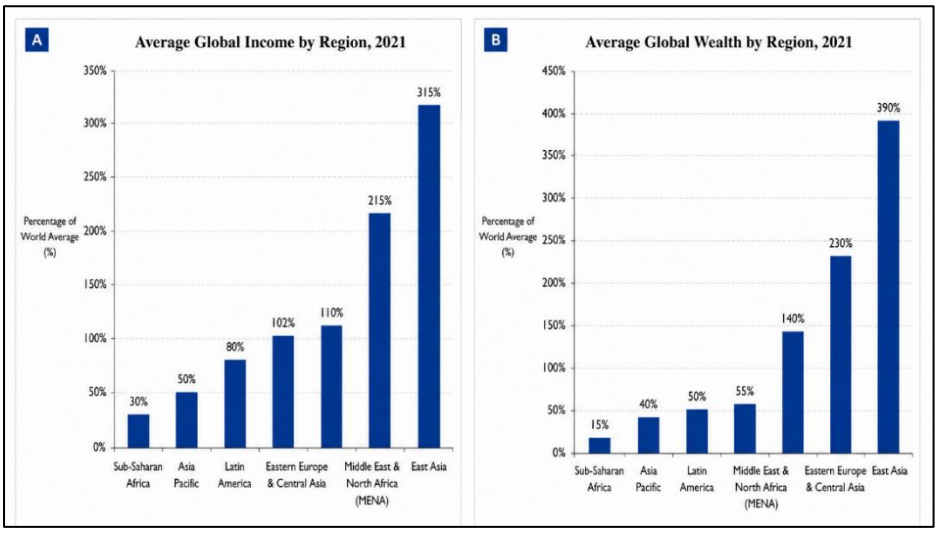

Figure 3 & 4. the average income in North America was 315% of the global average income. Furthermore, in 2021, the average wealth in North America was 390% of the average wealth. Source: **wir2022.wid.world/methodology.**

In Indonesia, long-run Gini data for 1976 to 2018 (Tadjoeddin, 2020) trace a similar dynamic. After the political and economic crisis of the mid-1960s, three decades of stabilization and liberalization under Soeharto produced average growth near 7% per year and cut poverty from 60% in 1966 to about 11% in 1996. Inequality stayed low and stable, the Gini ratio holding between 0.32 and 0.35 (Hill, 2000), though this rested on authoritarian, centralized, and liberal policies emphasizing agriculture, rural development, and basic health and education. The Asian Financial Crisis then drove inequality to a historic low in 1999; (Levinsohn et al., 1999) attribute this to the steep price increases that followed the Thai baht's free float, which raised poor households' living costs disproportionately. Inequality then rose 32% between 2000 and 2011, peaking at 0.41, above the 0.4 danger threshold, before stabilizing and declining after 2015. Wage inequality consistently exceeded expenditure inequality (Tadjoeddin, 2020).

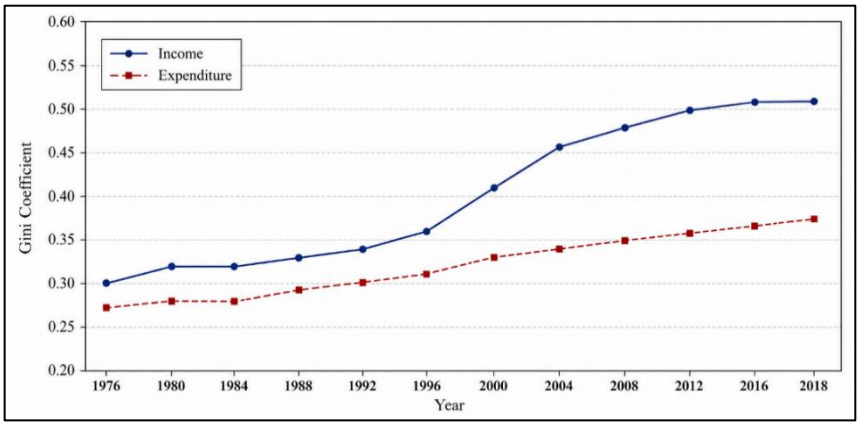

Figure 5. Indonesia's Long-term Gini Coefficient, 1976–2018 (Income and Expenditure), Source: (Tadjoeddin, 2019)

By March 2024, expenditure inequality had fallen to 0.379, down from 0.388 in March 2023 and 0.381 in September 2022, continuing a decline that began in 2017 and was briefly interrupted in 2020 (0.381 and 0.385) (Badan Pusat Statistik, 2024). Spatial disparities persist, however. Of the 25.22 million poor (9.03%) recorded in March 2024, rural areas held 13.58 million (11.79%) against 11.64 million (7.09%) in urban areas, and 65.4% of the chronically poor lived in rural areas with limited access to electricity, fuel, and sanitation (Badan Pusat Statistik, 2024). Miranti et al (2013) show this urban-rural gap to be persistent rather than transient, widest in 2001 at 15%, when 77% of the poor lived in the countryside.

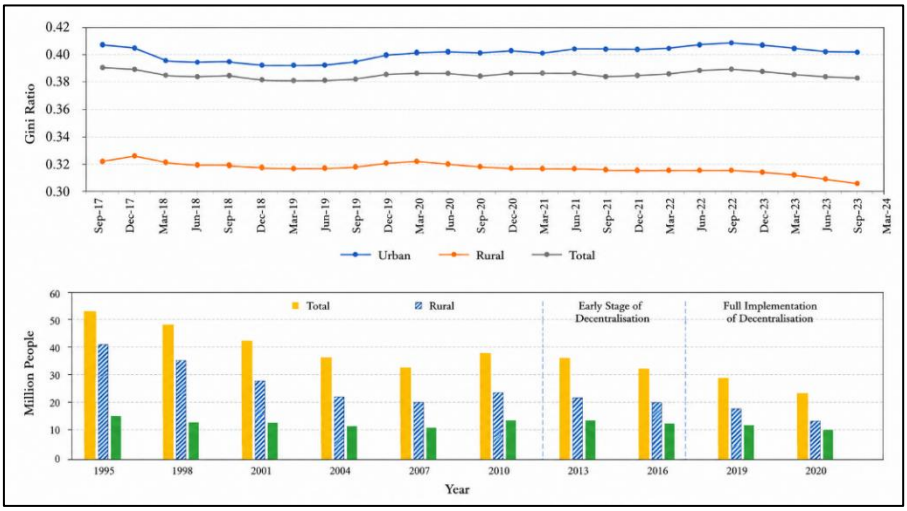

Figure 6 & 7. Trends in Indonesia's Gini Ratio (September 2017–March 2024) and Trends in the number of poor people in Indonesia (1976–2010). Source: Report on Expenditure Inequality Levels Among the Indonesian Population (March 2024), Statistics Indonesia (BPS) & Miranti et al., (2013)

Energy Consumption Inequality and Its Social Implications: The Intersection of Materiality and Socio-Historical Relations

Research linking economic growth and energy consumption expanded after the 1970s. (Mutumba et al., 2021) identified four hypotheses in this literature: growth, conservation, feedback, and neutrality. This study adopts the growth hypothesis, which holds that energy consumption drives economic growth through a unidirectional causal link, so rising energy use becomes a rational means of stimulating output alongside labor and investment, while conservationist policy is argued to harm economic health (Destek & Aslan, 2017; Kahia et al., 2017; Zallé, 2019). Against the gap between developed and developing economies, this connects to (Boyce, 1994) argument that environmental degradation tracks socio-economic inequality, with wider disparities of power and wealth producing more severe damage. (Huber, 2009) adds that fossil fuel is a historical and inherent component of capitalist production, so ecological contradictions such as climate change become difficult to avoid. Energy consumption is therefore treated not as a resource but as a

social and historical relation within global capitalism. The analysis draws on the World Energy Consumption database (1820 to 2020, 2022 revision; (Malanima, 2022)), covering 8 regions and 72 countries.

Across two centuries, total consumption rose more than fortyfold, shifting from premodern sources (food, fuelwood, fodder) to the first fossil transition of coal, oil, and gas, while per-capita use grew five to six times and peaked around 2016 (Figures 9 and 10).

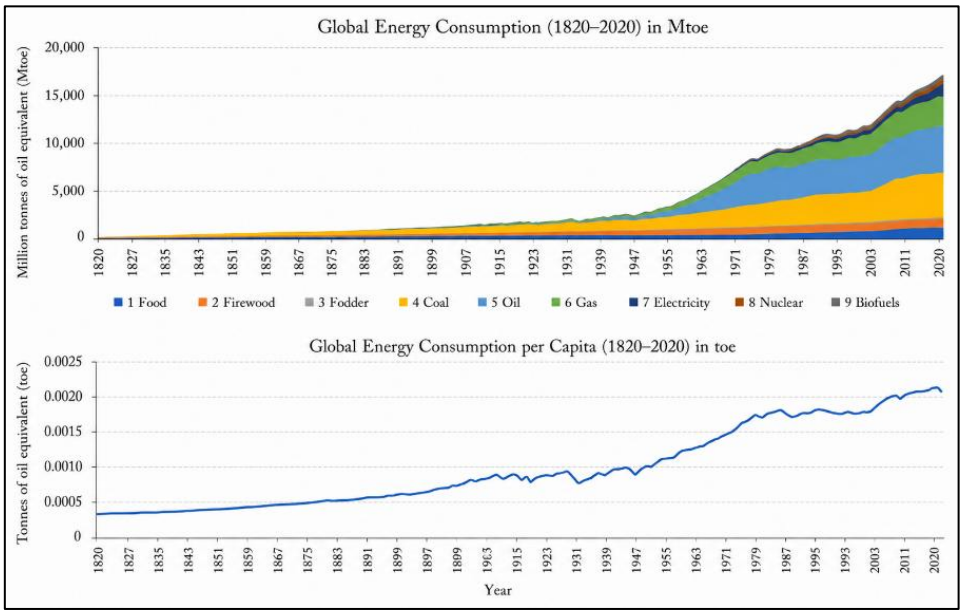

Figure 8 & 9. Global Energy Consumption and Global Per Capital Energy Consumption, 1820 – 2020. Source: World Energy Consumption (WEC): A Database, 1820 – 2020 (Malanima, 2020)

The trend broke twice: between World War I and the end of World War II, and from the 1973 oil crisis to 2000, with a dip during the 2020 pandemic. Malanima (2014) frames this as the modern fossil-organic phase beginning around 1820, when usable energy sources multiplied and efficiency improved in step (Bairoch, 1993; Grubler, 1997; Kander et al., 2014), a precondition for modern growth. During the Industrial Revolution (1820 to 1913), coal use rose exponentially, jumping after 1850 as industry, railways, and electrification spread across the West (Figure 11). Western Europe dominated at 13,007.9 Mtoe, consistent with Britain's role as pioneer of steam-powered industry, while North America surged after the 1880s to 6,611.01 Mtoe, led by the United States. Asia, Latin America, the Middle East, and Africa stayed marginal until 1913, as global inequality climbed from 50 to 62 Gini points by World War I.

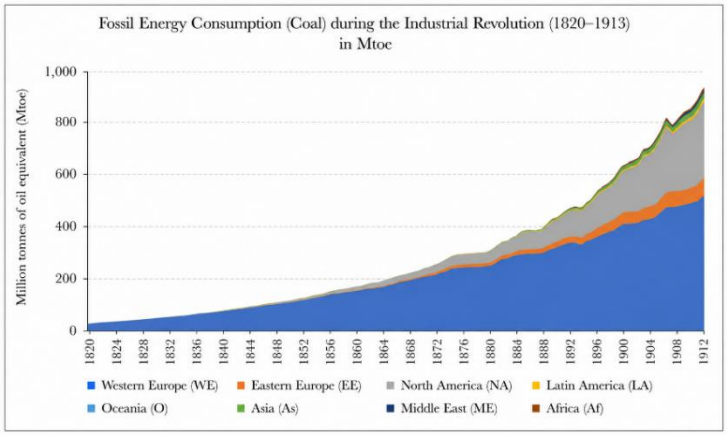

Figure 10. Fossil Energy Consumption (Coal) during the Industrial Revolution (1820 – 1913) in Mtoe. Source: World Energy Consumption (WEC): A Database, 1820 – 2020 (Malanima, 2020)

The twentieth century moved consumption toward oil during what (Perez, 2002) calls the 1908 to 1971 age of petroleum, motor vehicles, and mass production, enabled by falling prices for fuel, electricity, and road transport. Oil use rose 94 percent after 1945 as postwar industry, transport, and military demand intensified, peaking around 1980 after its steepest gains between the 1950s and late 1970s (Figure 11). North America led at 36,563 Mtoe, reflecting United States industrial and military power, while Soviet-led Eastern Europe and parts of Asia, notably Japan, South Korea, and China, emerged as new demand centers from the 1950s and 1960s.

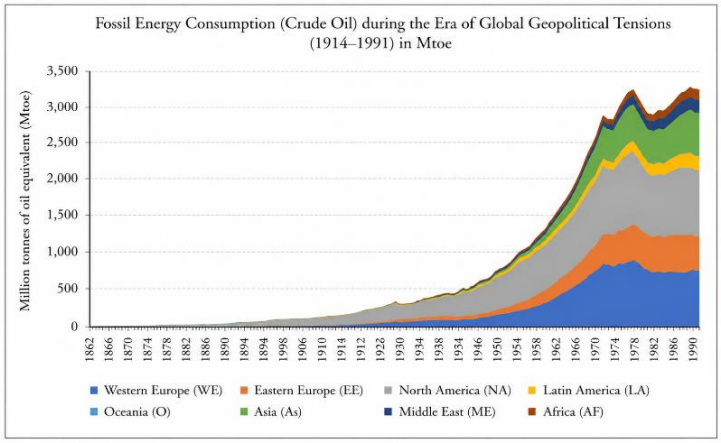

Figure 11. Fossil Energy Consumption (Crude Oil) during the Era of Global Geopolitical Tensions (1914 – 1991) in Mtoe. Source: World Energy Consumption (WEC): A Database, 1820 – 2020 (Malanima, 2020)

After the Soviet collapse in 1991, a fourth phase concentrated growth in East Asia (Figure 13): consumption was moderate in the early 1990s, accelerated after 2000, and became the world's highest from around 2010 through 2020, driven by China, India, Japan, and South Korea. North American demand stayed large but stable, a mature market shaped by efficiency policy and alternative energy. Together these phases trace a shift of the global energy core toward Asia, with consequences for geopolitics and world energy markets.

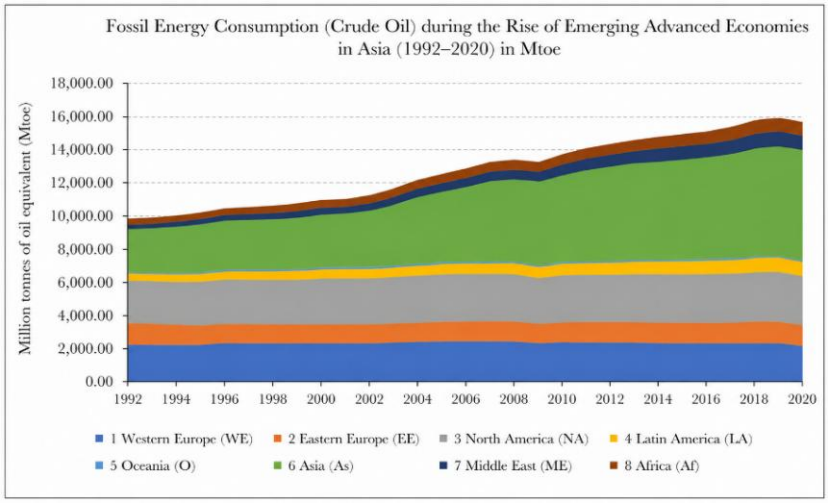

Figure 11. Fossil Energy Consumption (Crude Oil) during the Rise of Emerging Advanced Economies in Asia (1992 – 2020) in Mtoe. Source: World Energy Consumption (WEC): A Database, 1820 – 2020 (Malanima, 2020)

Inequality in Carbon Emission Production: A Residue of Economic Development

Britain became the world's largest producer of CO_2 emissions in the mid-nineteenth century. By 1850, British emissions were almost six times those of the United States, followed by France, Germany, and Belgium. This position stemmed from Britain's role as the pioneer of the First Industrial Revolution between 1750 and 1840. (Mohajan, 2019) describes Britain as the first country to industrialize systematically, shifting from human and animal labor to machines powered by water and steam and transforming iron, textile, and chemical manufacturing. Early industrial modernity later spread worldwide, reshaping textiles, mining, transportation, and infrastructure (Sachs, 2005). Chancel and Piketty (2015) note that the use of coal in industry made Britain responsible for more than 95% of global CO_2 emissions in the early eighteenth century (Chancel & Piketty, 2015).

From 1850 to the mid-twentieth century, global emissions grew at a nearly constant rate, driven by industrialization and population growth in the United States and Europe. The United States recorded its sharpest acceleration in 1887 and held that lead over the following nine decades, ahead of the United Kingdom and Germany. The surge coincided with the second industrial period, the "Age of Synergy" (Smil, 2005), characterized by electricity, the internal combustion engine, and the chemical and metal industries (Mohajan, 2019). Notable figures included Samuel Slater, who opened the first American factory in 1790, Robert Fulton, who built the first steamboat in 1807, and Thomas Edison and Alexander Graham Bell.

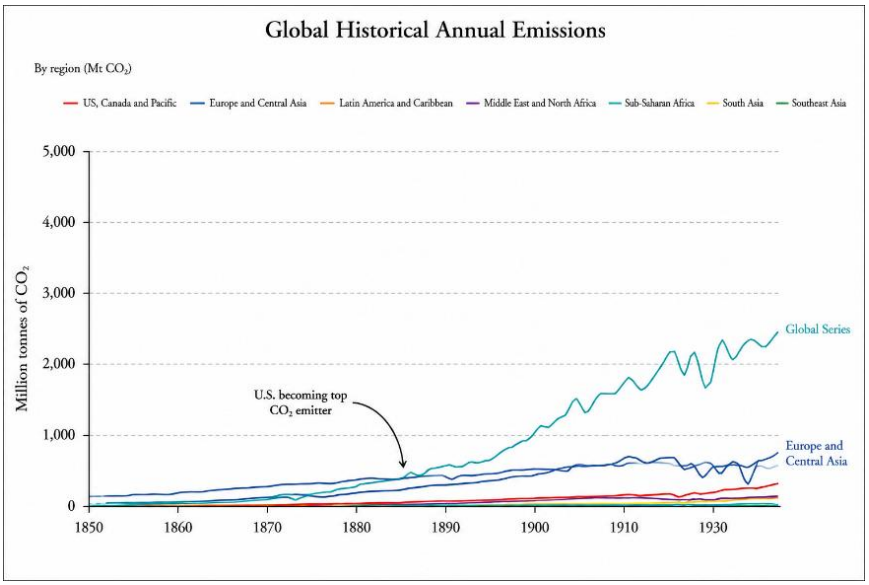

Figure 12. Global Historical Annual Emissions Production Chart (1850 – 1920). Source: https://www.wri.org/insights/history-carbon-dioxide-emissions

Between 1887 and 1920, the United States was the world's largest carbon emitter. Emission trends in North America and Western Europe were interrupted by the Great Depression of the 1930s and the end of World War II in 1945, but the reductions were temporary. The United States emitted 39.93% of global CO_2 in 1932, the year global concentration reached its lowest point before rising again, and this interval was too short for cumulative CO_2 to leave the atmosphere, so the anthropogenic reductions did not lower global temperature (Rolandas Giedraitis et al., 2010). (Herndon & Whiteside, 2019) likewise attributes wartime warming to heat-trapping aerosol particulates rather than CO_2, since ice-core data from 1936 to 1952 show no significant CO_2 rise during the war years of 1939 to 1945 (Bastos et al., 2016), and tropospheric particulates settle within days to weeks (Müller, 1984) whereas CO_2 persists for decades (Stocker, 2014).

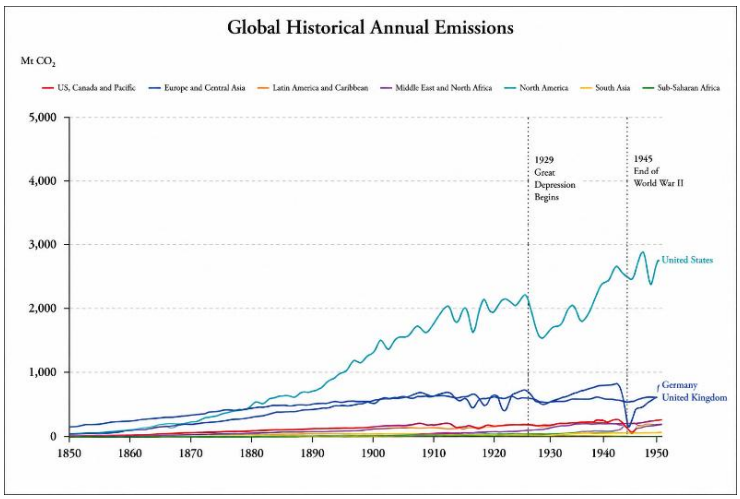

Figure 13. Global Historical Annual Emissions Production Chart (Reduction in U.S. CO2 Emissions Production Caused by the Great Depression and the End of World War II). Source: https://www.wri.org/insights/history-carbon-dioxide-emissions

toward Asia, first in Europe and Japan and later in China, India, and the wider region (McNeil, 2001). Rapid economic growth and rising fossil fuel consumption led China to overtake the United States as the largest CO_2 emitter in 2005.

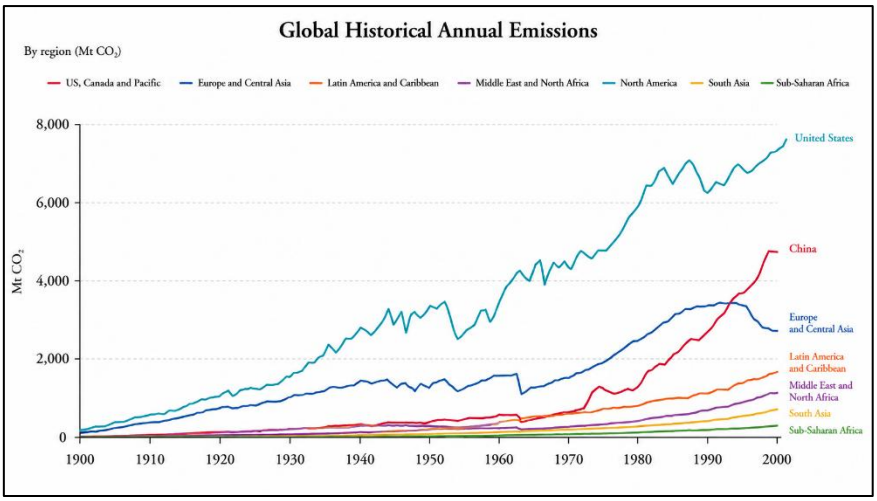

Figure 14. Global Historical Annual Emissions Production Chart (The United State as the Highest *CO_2* Emmisions Producer Throughout the 20th Century and the Rising of *CO_2 Emmisions Production in Asia Led by China*). Source: https://www.wri.org/insights/history-carbon-dioxide-emissions

Examining the period from 1950 to 2015, Kurokawa and Ohara (2020) document marked increases in SO_2, NO_x, and CO_2 across East, Southeast, and South Asia, driven mainly by power generation, industry, and road transport. Chinese emissions rose almost monotonically until about 1995, stabilized in the late 1990s, and climbed steeply from the early 2000s, largely through coal-fired power and iron and steel production. NO_x continued to increase until 2011 before declining, while black carbon grew more slowly because of industrial control equipment, reaching 2.2 times its 2000 level by 2015 (Kurokawa & Ohara, 2020)

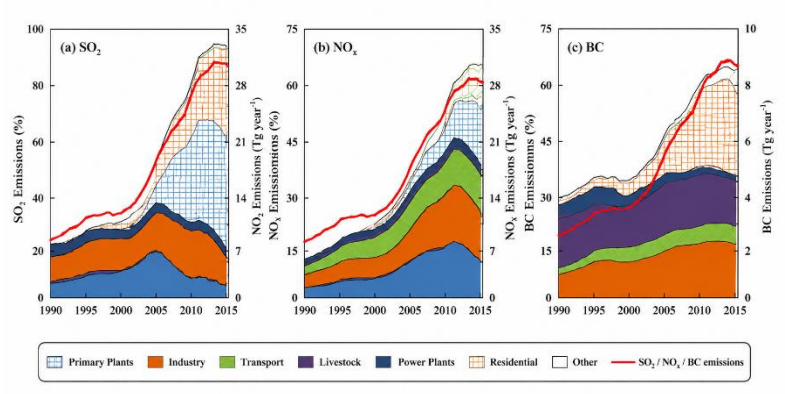

Figure 14. Emissions of (a) *SO_2, (b) NO_x, and (c) BC from each major sector in China during 1990 – 2015. The solid-colored areas represent actual emissions, while the hatched areas (-) indicate emissions reduced due to control measures. The red line in each panel represents total CO_2 emissions (Kurokawa & Ohara, 2020)*

The International Climate Regime and the Barriers of Global Inequality in Negotiation

Climate-policy barriers must be situated within the global structures that preceded and followed the institutionalization of climate justice. This study draws on (Lucia, 2009), who argues that justice narratives often serve as ideological instruments sustaining hegemony in the climate crisis. In international relations, a regime is a set of rules governing interstate interaction, and structuralist accounts hold that hegemonic power shapes and maintains it. It follows dependency theory, which counters modernization theory by explaining the underdevelopment of poorer states as a product of systemic reliance on richer ones in the global economy (Ghosh, 2001). This study therefore treats the climate regime as a form of social disciplining produced by structural inequality, through which industrialized states preserve geopolitical dominance. (World Climate Conference, 1979) show that such inequality weakens international cooperation by entrenching ideological hierarchies, dividing perceptions of justice, and eroding trust and reciprocity. The analysis centers on material and historical conditions.

Global awareness of climate change began with the First World Climate Conference in 1979, which called for international cooperation on climate research, monitoring, and integrating climate information into policy (World Climate Conference, 1979). The Advisory Group on Greenhouse Gases (1985) and the IPCC (1988) followed, and the Second World Climate Conference (1990) urged concrete emission cuts despite scientific uncertainty. In 1992 the UNFCCC, grounded in cosmopolitan justice, sought to share climate responsibility fairly, later reinforced by the Kyoto Protocol and its principle of common but differentiated responsibilities (Eckersley, 2012; Newell et al., 2021). That principle proved difficult to apply given the inequality between developed and developing states (Gupta, 2010; World Climate Conference, 1990).

The United States rejected Kyoto as unfair for binding only developed countries to cuts (Okereke, 2010), and the two groups read the principle differently: developing states stressed the differentiated element rooted in historical burden, developed states the common element grounded in economic and technological capacity. Finance was another flashpoint. (Okereke & Coventry, 2016) document a sharp gap between pledges and disbursements: of roughly 14 billion US dollars promised, the Global Environment Facility and the Green Climate Fund together received no more than 4 billion, with less approved or spent. Developed states also favored market mechanisms such as the Clean Development Mechanism and REDD+, which in practice marginalized local communities and deepened social inequality (Olsen, 2007).

The pattern continued. COP-15 in Copenhagen (2009) collapsed under developed-country dominance, minimal developing-country input, and a clash between cosmopolitan justice and market approaches. COP-19 in Warsaw (2013)

created the Loss and Damage mechanism, yet the same dominance appeared in the legally weak term contribution (Barrios et al., 2013; ENB, 2009). The Paris Agreement at COP-21 (2015) confirmed this through the scientific and economic framing of the 1.5°C target. Developing countries first pushed for that target, but the scenarios for reaching it came largely from Integrated Assessment Models run by European and North American institutions, many relying on unproven negative-emissions technologies such as bioenergy with carbon capture and storage (BECCS). They let developed states keep an ambitious goal without restructuring their economies, while EU funding such as Horizon 2020 reinforced this control. The 1.5°C target thus reflects a codependency between science and policy: an aspiration from developing countries, framed and steered by the scientific and diplomatic infrastructure of developed ones, accommodating justice rhetorically while remaining bound to their political economy (Cointe & Guillemot, 2023).

Indonesia Paradox: Dilemmatic Conditions between National Economic Growth and Climate Change Vulnerabilities in Rural Area

Indonesia's rural-urban disparities have stayed structurally stagnant despite fluctuating national growth since the New Order era. This section tests whether that growth gap produces an unequal contribution to climate change, with rural areas bearing disproportionate harm. Following (Green & Healy, 2022a), the analysis uses three variables: energy consumption inequality, carbon emissions, and national policy barriers.

Table 1. Fossil Fuel Consumption by Country — 2023 (Mtoe).

Country	Oil	Natural Gas	Coal	Total
China	718.6	348.0	2195.9	3325.5
United State	856.4	762.0	195.9	1814.3
India	252.5	53.7	525.0	831.2
Russian Federation	172.2	389.8	91.5	653.5
Japan	158.8	79.5	108.4	346.8
Iran	83.6	211.1	1.9	296.6
Saudi Arabia	177.5	98.2	0.00	275.6
South Korea	128.0	51.6	64.2	243.8
Canada	103.9	103.9	8.8	216.6
Indonesia	74.0	39.2	103.9	216.3
Germany	95.8	65.0	43.7	204.4

Source: Statistical Review of World Energy 2024 by Energy Institute

Indonesia ranked tenth among the world's twelve largest energy consumers in 2023, recording 214.96 Mtoe, roughly 2% of global consumption, led by coal (103.9 Mtoe), oil (74 Mtoe), and natural gas (39.2 Mtoe) (Energy Institute, 2024). By sector, industry consumed 46% of national energy (56.9% coal), transport 37% (99.86% oil), and households 12% (50% electricity, 47.2% LPG) (Ministry of Energy and Mineral Resources, 2023). Consumption rose continuously from 1965 to 2023, peaking in 2022.

Indonesia also ranked sixth among the ten largest emitters in 2023 at 704.4 MtCO2e, about 3% of the global total (IESR, 2023). Industry and transport were the largest direct contributors, projected to reach 86% of emissions by 2030 and 98% by 2060 absent new policy; transport alone accounts for at least 70%, worsened by fuel-import dependence, while households reach 61.5 tCO2e/TJ, driven by LPG at 43% of household energy (IESR, 2023). Emissions climbed sharply from the 1970s and accelerated after 2000 (Muzayanah et al., 2022).

Table 2. Carbon Emission Gas by Country - 2023

Country	Carbon Emission Gas Production (MtCO2e)
China	11218.4
United State	4639.7
India	2595.6
Russia Federation	1614.7
Japan	1012.8
Indonesia	704.4
Iran	683.6
Saudi Arabia	620.4
Germany	571.9
South Korea	571.2

Source: Statistical Review of World Energy 2024 by Energy Institute

On consumption inequality, (Muzayanah et al., 2022) found that a 1% rise in population density raised energy use by 0.36% (0.77% for electricity, 0.25% for fossil fuel), with demand concentrated in urban areas and western Java, a result consistent with (Sarkodie & Adom, 2018) and (Mindali et al., 2004). Energy poverty fell hardest on rural households, which made up 76.87% of the energy-poor against 23.1% in urban areas (Sadath & Acharya, 2017; Utami & Hartono, 2021; Zhang et al., 2019). Emissions inequality runs the other way. Urban households emit more than rural ones, and the gap widened from 4% in 2019 to 13% in 2021 (Alyasa et al., 2024); wealthy urban households emit over five times more than poor urban households and 1.6 times more than wealthy rural ones (Hartono et al., 2023).

On policy, Indonesia has accumulated climate commitments since the 1990s, from hosting COP-13 in 2007 and the 26% voluntary pledge to the Paris Agreement and successive NDCs targeting a 29% cut, or 41% with international support, against a 2030 baseline of 2,869 MtCO2e (Kaneko & Kawanishi, 2016). (Climate Action Tracker, 2024) still rated these policies "critically insufficient," citing continued coal dependence and deforestation. Rural communities remain largely excluded from policy design (Yayasan Madani Berkelanjutan, 2023), and REDD+ implementation reproduced structural inequality rather than redistributing power, marginalizing indigenous and smallholder groups (Gatto & Sadik-Zada, 2024; Moeliono et al., 2020).

Legi Gendhise, Pait Uripe: Sustainability Livelihood Analysis of Coconut Sugar Farmer Community

Findings from focus group discussions (FGDs) with four producer groups and in-depth interviews with relevant agencies in Banyumas Regency indicate that climate change significantly undermines the livelihoods of *penderes* (coconut-sap tappers). The problem is compounded by the tappers' limited knowledge and planning and by the absence of any Banyumas government policy directed specifically at the impact of climate change on this group. Table 1 synthesizes the impacts identified across the five capitals of the sustainable livelihood framework.

Table 4. Climate change impacts on penderes across the five livelihood capitals, synthesized from focus group discussions with four producer groups.

Livelihood Capital	Reported Impacts of Climate Change
Economic	Sharp income decline. In normal weather, about 5 kg of sugar per day earns Rp 90,000–100,000 (molded sugar Rp 18,000/kg; crystal sugar Rp 20,000/kg). In extreme weather, output falls to about 3 kg per day and earnings to Rp 57,000–69,000, even as prices rise (molded sugar to about Rp 19,000/kg; crystal sugar to about Rp 23,000/kg). The Mugi Rahayu group reported income falling by more than 30%.
Natural	Extreme weather degrades both the quality and quantity of coconut sap. Prolonged drought damages or halts inflorescence growth (*ngendat*) and can kill trees, cutting sap yield. Prolonged rain mixes rainwater into the sap, accelerating fermentation and producing soft sugar, and brings pest outbreaks.
Social	Falling income erodes the capacity to meet customary social obligations (*nyumbang*), risking exclusion from the community. Producers borrow from middlemen or relatives, or sell assets, in order to keep participating.
Physical	Producers have no plan for renewing equipment and use tools until they fail. Without external assistance they borrow from middlemen to replace them. Lower income further weakens their capacity to upgrade kitchens and meet export-quality requirements.
Human resources	An aging workforce (average about 50 years) and youth disinterest, driven by low income and high accident risk, worsen regeneration. Rainy-season conditions make trunks slippery and raise the risk of falls.

Across the five livelihood indicators, two interrelated capitals form the root of vulnerability. The two tapper groups dominated by men (Nira Berkah and Mugi Rahayu) located the problem in natural capital, while the two craftsman groups dominated by women (Gendhis Manis and Maju Lancar) located it in economic capital.

In natural capital, extreme weather changes the quality and quantity of coconut sap (*nira*). A prolonged dry season damages or prevents the growth of the inflorescence (*manggar*), the source of the sap, a condition known locally as *ngendat*, and in severe cases kills the trees. One Mugi Rahayu tapper reported that many coconut trees had died during an extended drought (Mugi Rahayu Group, FGD, September 28, 2024). Yield falls accordingly: a normal day produces about 20 litres of sap, enough for 5–6 kg of sugar, but a long dry season leaves only about 12 litres and 3–4 kg (Nira Berkah Group, FGD, September 24, 2024). A prolonged rainy season instead degrades sap quality, because rainwater mixes into the sap and accelerates fermentation, leaving it cloudy and frothy and producing sugar with a soft texture (Gendhis Manis Group, personal communication, September 11, 2024). Wet bark also makes the trunks slippery, and many tappers stop work for safety reasons.

In economic capital, household incomes have fallen sharply. Under normal conditions, producing about 5 kg of sugar a day, tappers earn Rp 90,000–100,000, with collectors paying Rp 18,000/kg for molded sugar and Rp 20,000/kg for crystal sugar. Under extreme conditions, output drops to about 3 kg a day and earnings to Rp 57,000–69,000, even though prices rise as supply falls and demand holds: molded sugar reaches about Rp 19,000/kg and crystal sugar about Rp 23,000/kg (Gendhis Manis Group and Maju Lancar Group, FGD, September 11 and 26, 2024). As one craftsman put it, being a tapper is the hardest job because it depends entirely on the weather, and in a bad season earnings fall to less than half the normal level (Maju Lancar Group, FGD, September 26, 2024).

These two capitals shape the remaining three. In social capital, participation in community events such as weddings, neighborhood gatherings, and religious activities sustains social ties, and non-participation invites exclusion. In Javanese culture these events carry a social cost through the practice of *nyumbang*, a contribution that may be material, such as cash or staple food, or non-material, such as labour and service (Setiawan, 2022). Fitriya (2012) shows that *nyumbang* has shifted from an expression of collective empathy in rural communities into a transaction of interests, carrying meanings of prestige, social control, and social security, and becoming more individualistic and competitive. For tappers, this social cost is among the largest external expenses: in certain months of the Javanese calendar, three to five events a week can require up to Rp 300,000. To meet these expectations, families borrow from middlemen or relatives or sell livestock, so the income loss from climate change directly reduces their capacity to participate. The pressure carries a stigma, since a

tapper who does not contribute is often presumed unskilled or lazy and assumed to make poor sugar (Mugi Rahayu Group, FGD, September 28, 2024).

Social capital also frames the relationship between tappers and collectors (*tengkulak* or *pengepul*), which is visible in the structure of the coconut-sugar trade. A 2009 mapping by a local NGO described this structure as a supply and value chain (Table 2). Within it operates the *ijon* or *iket* system, a patron-client arrangement in which a tapper who needs market access is bound to a collector through credit advanced for daily needs (SETARA Association, indepth interview, October 12, 2024). The debt must be repaid in sugar delivered to that collector, so the tapper has no choice of buyer. Price is set unilaterally by the collector on the basis of market dynamics and competing collectors' prices, leaving tappers without bargaining power, a weakness captured in the local quip that the tapper rides a sap-pole while the collector rides a motorcycle. The relationship is reinforced by *pekewuh*, the social unease that arises because most collectors are kin. Climate change deepens this dependence: as production and income fall, tappers must keep borrowing, and the *ijon* system perpetuates itself.

Table 5. Value-chain structure of coconut sugar in Banyumas Regency, 2009 (SETARA Association).

Node (N = Number of Actors)	Function and Main Costs	Price
Input Suppliers (N = 7)	Supply mangosteen rind, lime, firewood, sawdust, furnaces, and equipment. Mangosteen rind Rp 2,500/kg; lime Rp 2,000/kg; sugar additive Rp 2,500/250 g; firewood Rp 350/colt; sawdust Rp 8,000/sack.	-
Sugar producers (N = 600)	Tap sap and produce sugar. Fuel cost Rp 1,850/kg.	–
Collector 1 (N = 7)	Transport, packaging, and aggregation. Margin Rp 100–200; plastic Rp 70/kg; melting and spoilage 5%; shrinkage from non-uniform product size.	Rp 4,500–Rp 6,400
Collector 2 (N = 2)	Transport, packaging, and aggregation. Margin Rp 200; plastic Rp 35/kg; labour Rp 40/kg; holiday allowance for producers and Collectors 1 and 2.	Rp 4,500– Rp 6,400
Collector 3 (N = 2)	Transport, packaging, and aggregation. Margin Rp 100–500; transport and labour; spoilage risk; one-month payment terms.	Rp 6,600
Soy-sauce factory, Jakarta (N = 1)	Marketing and end buyer.	Rp 6,600– Rp 7,000

In physical capital, tappers must upgrade their equipment to meet export standards for product quality and safety, yet most are rural poor with limited finances and knowledge. External interventions, including organizing tappers into cooperatives and channeling stakeholder assistance, have improved sugar quality by renewing tools such as the cooking furnace (*tungku*). The FGDs nonetheless showed that tappers have no plan for equipment renewal; they use tools until these fail and,

without external help, return to the collectors for credit to replace them (Maju Lancar Group, FGD, September 26, 2024). Poor equipment combined with declining sap quality makes it still harder to produce quality sugar (Mugi Rahayu Group, FGD, September 28, 2024), and the income loss from climate change weakens the capacity to upgrade.

In human capital, the central concern is regeneration. The tapper workforce averages about 50 years of age, and young people show little interest in a profession whose low income does not match its risks (Mugi Rahayu Group, FGD, September 28, 2024). Many of Pageraji's youth migrate to Purwokerto for more predictable work in shops or factories (Abhinaya Karya Mandiri Cooperative, FGD, October 21, 2024). Some tappers actively discourage their children from the trade, a sentiment expressed in the saying *Legi gendhise, pait uripe* (the sugar is sweet, but the life is bitter). Falling income and rising risk under climate change widen this disinterest. One partial response is the planting of dwarf coconut (*kelapa genjah*), which matures faster and stays far shorter than the tall variety (*kelapa dalam*), so that women and youth can also tap, although its adaptation to climate change still requires study (Banyumas Agriculture and Food Security Office, personal communication, November 6, 2024).

The External Intervention Network: Local Government, Cooperative, and Local NGO

Interviews with local government bodies, the cooperative, and a local NGO revealed no concrete effort to address the impact of climate change on *penderes*, a policy void that deepens their vulnerability. In government, three bodies relate directly to tappers in Pageraji: BAPPEDALITBANG of Banyumas, the Agriculture and Food Security Office, and the Pageraji village government. BAPPEDALITBANG confirmed that no policy specifically targets the climate-change impact on tappers. Its climate-related work sits in planning and research, but the Climate Change Impact Fund it allocates remains focused on food crops and horticulture, which it regards as the most affected sectors, rather than on plantations, even though coconut sugar is designated a flagship export product (BAPPEDALITBANG Banyumas, Indepth Interview, October 28, 2024). On work risk, the provision of safety belts has stalled because tappers, accustomed for decades to climbing 25–30 trees a day unaided, find that the belts restrict movement and reduce efficiency, whereas employment insurance (BPJS Ketenagakerjaan) has been adopted by nearly all tappers. The contradiction between treating coconut sugar as a flagship product and excluding plantations from climate funding reflects an institutional hesitancy that has so far prevented a workable policy. If this continues, the 27,872 tapper households in Banyumas will grow more vulnerable, and bottom-up policy schemes that account for tappers' climbing habits are needed.

The Agriculture and Food Security Office confirmed the field findings on natural capital, reporting that sap production fell by up to 40% in 2024 compared with

the previous year, that drought reduces tree fertility and kills trees, and that humid rainy seasons bring pests (Banyumas Agriculture and Food Security Office, Indepth Interview, November 6, 2024). It warned that, without policy, tappers could fall into extreme poverty. Its responses include extension and training on plant care, opening new water sources through pump irrigation (*pompanisasi*) during drought, developing dwarf coconut, and rejuvenating production kitchens for 400 tappers at Rp 5,000,000 each in 2024, alongside efforts to draw in corporate social responsibility funding. These efforts are constrained by a plantation-sector allocation of only about Rp 60,000,000 a year against a large tapper population and a wide service area. The Pageraji village government focused almost entirely on work accidents, which average about 100 cases a year and can result in paralysis or death (Head of Pageraji Village, Indepth Interview, October 19, 2024). It supports the safety-belt and insurance programs but has succeeded only with insurance, and it reads rising prices as a sign of strong demand without recognizing the fall in production, so it has produced no concrete policy.

The Abhinaya Karya Mandiri Cooperative has no initiative aimed directly at climate change, but it offers a strong arena for one. Through an Internal Control System (ICS) team that visits tappers' homes and attends group meetings, it sustains a discursive exchange on quality across natural, economic, social, and physical capitals. In these meetings the ICS reports market prices and future plans, including free dwarf-coconut seedlings for participating members, intercropping with striped beans (*kacang lurik*), and a planned fair-trade certification offering a 15% premium on sales to fund member needs by agreement. Tappers value the cooperative for protecting them from exploitation by collectors and for opening alternative, better-priced market access, which strengthens their bargaining position and income stability (Mugi Rahayu Group, Indepth Interview, September 28, 2024). The cooperative's leaders frame this collectivity not as a formal organization alone but as a basis for mutual support against shocks, including climate change, and as a vehicle for knowledge transfer among tappers (Abhinaya Karya Mandiri Cooperative, FGD, October 21, 2024).

The SETARA Association, a local NGO with a long record of accompaniment, has developed several ideas but has been held back by the complexity of developing coconut sugar as a vehicle for economic empowerment, particularly its supply chain, product quality, market availability, and producer welfare (SETARA Association, Indepth Interview, March 14, 2025). Around 2012 a landscape approach, arranging gardens for plant diversity, planting schedules, water management, and landslide anticipation, was attempted but stayed at small plot scale, as modeled in Purbalingga and Banjarnegara. A 2019 study funded by Australian Aid in Pangandaran and Pacitan found no concrete action against the climate threat and confirmed its significant impact on tappers' lives and productivity; it recommended water-management systems and locally grounded appropriate technology, such as legume ground cover to retain soil moisture. Three barriers limit land management: a history of commodity monopoly

that depressed prices and bred doubt about whether garden care improves welfare; the pragmatic typology of plantation farmers, who see little urgency in intensive care while prices stay low; and inequality in land ownership, since 20–25 of the 30–40 trees a tapper works each day are not their own but belong to village elites under insecure sharecropping (*maro*) or rental contracts that owners can revoke at will, so tappers tend only the trees they own. SETARA stressed that the narrative of laziness is unfounded and rooted in these historical and structural factors (SETARA Association, Indepth Interview, March 14, 2025).

On cooperatives, SETARA holds that their core purpose is to build producer unity and independence so that tappers can withstand shocks, climate change among them, and to serve as a space for collective learning. It cited the Nira Kamukten Cooperative in Banjarnegara, where group meetings revived cultural knowledge for the rainy season, covering the sap container (*pongkor*) with a coconut leaf or a piece of old trunk to prevent rainwater from fermenting the sap. Building such cooperatives at community level is complicated by top-down government narratives, such as a Ministry of Villages campaign, that reduce the cooperative to its technical and administrative form; SETARA urged government at every level to treat the cooperative as a knowledge center that educates members in social and economic life. Finally, SETARA argued that sustainability must be a shared, reciprocal responsibility across the chain. Because product quality depends on garden conditions, the production process, and farmers' technical capacity, buyers and traders downstream should support upstream producers through technical assistance and social investment, and government should facilitate integration and communication among actors. In practice, however, agencies work within their own segments, with agriculture attending only to cultivation, traders to distribution, and industry to processing, which leaves no whole-of-chain perspective and causes a disarticulation between policy and field practice that weakens any comprehensive response to climate change (SETARA Association, Indepth Interview, March 14, 2025).

Conclusion

This study demonstrates that multidimensional socio-economic inequality constitutes a fundamental driver of climate injustice by reproducing unequal contributions to climate change and unequal exposure to its consequences. At both the global and Indonesian levels, persistent disparities in access to economic resources have reinforced unequal patterns of energy consumption, carbon emissions, and political influence over climate governance. These structural imbalances have ultimately shifted the greatest burdens of climate change onto developing countries and marginalized rural communities despite their limited responsibility for global emissions.

The empirical evidence from coconut sugar tappers in Pageraji Village, Cilongok District, Banyumas Regency illustrates this pattern with particular clarity. As a rural low-income community, the tappers experience declining productivity, unstable incomes, and increasing livelihood insecurity as climate variability intensifies, while receiving only limited institutional support from local government, cooperatives, and civil society organizations. Rather than representing isolated local vulnerabilities, these experiences reflect broader structural inequalities that systematically shape the uneven distribution of climate risks and adaptive capacity. Consequently, the study concludes that the vulnerability of coconut sugar tappers is not merely an outcome of environmental change but a manifestation of enduring socio-economic inequalities embedded within broader political and economic systems.

From a theoretical perspective, the findings reinforce the argument that climate change should be understood not solely as an ecological crisis but as a political and economic phenomenon rooted in the historical dynamics of capitalist development. Drawing upon the materialist political ecology approach, the study shows how unequal power relations have enabled industrialized economies to accumulate wealth through carbon-intensive development while disproportionately externalizing environmental costs to developing countries and rural populations.

Integrating climate justice, decolonial perspectives, and the Sustainable Livelihood Framework further demonstrates that justice extends beyond distributive concerns to encompass recognition, meaningful participation, and the enhancement of local capabilities. By positioning rural communities as active producers of knowledge rather than passive recipients of policy interventions, this research challenges epistemic hierarchies that have frequently marginalized local perspectives in climate governance. At the same time, it reveals how climate-induced shocks have simultaneously weakened the natural, social, physical, human, and financial capitals underpinning the livelihoods of coconut sugar tappers, with inadequate external intervention further exacerbating their vulnerability. These findings provide an important foundation for developing more context-sensitive, participatory, and socially just climate policies capable of addressing both the structural roots of inequality and the lived realities of vulnerable rural communities.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process.

During the preparation of this work, the author(s) used ChatGPT and Claude AI in order to redesign all of the figure for aesthetics purpose and words efficiency. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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