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BEYOND SCAPEGOATING: GREENHOUSE EFFECT MECHANISMS AND HYDROMETEOROLOGICAL ANOMALIES AS PRIMARY DRIVERS OF DISASTERS-CHALLENGING THE MISATTRIBUTION TO OIL PALM PLANTATIONS

Loso Judijanto[1]
[1]IPOSS Jakarta, Jl. Jend. Sudirman No. 86, Jakarta Pusat, DKI Jakarta, Indonesia
Email: losojudijantobumn@gmail.com

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Abstract. This study aims to critically examine public attributions that tend to simplify the causes of flash floods and hydrometeorological disasters in Indonesia by linking them solely to oil palm plantations. The study employed a qualitative literature review of scientific articles, research reports, and relevant documents from 2020–2025. Data were analyzed using content analysis and narrative synthesis techniques to identify the relationship between climate change, environmental factors, and social dynamics in flooding events. The study results indicate that flash floods occur widely, including in areas without oil palm plantations, such as Java and coastal urban areas. The main factors influencing flooding include extreme rainfall, urbanization, land subsidence, spatial planning damage, and anthropogenic climate change. The literature also indicates that not all oil palm plantations are the primary cause of deforestation, as some are developed on degraded land. This study emphasizes the importance of a science-based approach and systems thinking in understanding disaster risk, enabling more objective and sustainable public communication and environmental policy development.

Keywords: Climate Change, Greenhouse Effect, Hydrometeorological Disasters, Climate Literacy, Public Education.

Abstrak. Penelitian ini bertujuan untuk mengkaji secara kritis atribusi publik yang cenderung menyederhanakan penyebab banjir bandang dan bencana hidrometeorologi di Indonesia dengan mengaitkannya secara tunggal pada perkebunan kelapa sawit. Penelitian menggunakan metode tinjauan literatur kualitatif terhadap artikel ilmiah, laporan penelitian, dan dokumen relevan periode 2020–2025. Data dianalisis menggunakan teknik analisis isi dan sintesis naratif untuk mengidentifikasi hubungan antara perubahan iklim, faktor lingkungan, dan dinamika sosial dalam kejadian banjir. Hasil kajian menunjukkan bahwa banjir bandang terjadi secara luas, termasuk di wilayah yang tidak memiliki perkebunan kelapa sawit, seperti Pulau Jawa dan kawasan perkotaan pesisir. Faktor utama yang memengaruhi kejadian banjir meliputi curah hujan ekstrem, urbanisasi, penurunan muka tanah, kerusakan tata ruang, dan perubahan iklim antropogenik. Literatur juga menunjukkan bahwa tidak seluruh perkebunan kelapa sawit menjadi penyebab utama deforestasi karena sebagian dikembangkan pada lahan terdegradasi. Penelitian ini menegaskan pentingnya pendekatan berbasis sains dan berpikir sistem dalam memahami risiko bencana, sehingga komunikasi publik dan kebijakan lingkungan dapat disusun secara lebih objektif dan berkelanjutan.

Kata Kunci: Perubahan Iklim, Efek Rumah Kaca, Bencana Hidrometeorologi, Literasi Iklim, Pendidikan Publik.

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INTRODUCTION

Indonesia has experienced a significant increase in hydrometeorological disasters over the past decades. Data from the National Disaster Management Agency (BNPB) indicate that most natural disasters in Indonesia are hydrometeorological in nature, with flood and flash flood events continuing to rise across many regions (BNPB, 2025). This trend reflects the growing environmental vulnerability faced by Indonesia amid changing climatic conditions and rapid land-use transformation.

Several major flood events demonstrate that hydrometeorological disasters are not limited to specific regions. Flash floods in Sumatra, Java, and coastal urban areas such as Jakarta and Semarang have caused extensive social and economic losses (Julian, 2025; Saputra, 2023). Scientific studies show that these disasters are influenced by multiple interacting factors, including extreme rainfall, urbanisation, land subsidence, poor drainage systems, and coastal dynamics. This indicates that flood disasters are complex phenomena that cannot be explained through a single causal factor alone. However, public discourse after major flood events often places oil palm plantations as the primary cause of environmental disasters. This narrative became particularly prominent following floods in Sumatra and Kalimantan, where plantation expansion was frequently associated with deforestation and ecological degradation (Jong, 2021; Primayanti, 2025). Such monocausal attribution has shaped strong public perceptions, although it risks oversimplifying the actual drivers of hydrometeorological disasters.

Empirical evidence suggests that severe flooding also occurs widely in areas without large-scale oil palm plantations, especially on the island of Java (GAPKI, 2025). In addition, climate attribution studies confirm that anthropogenic climate change has significantly increased the intensity and frequency of extreme rainfall events in Indonesia (Jayawerdana, 2025). Several studies further report that part of Indonesia's oil palm development has taken place on degraded land rather than through direct conversion of primary forests (Gingold, 2010; PASPI, 2024). These findings highlight the importance of understanding disasters through a broader environmental and climatic perspective. Despite the availability of scientific evidence, the gap between public understanding and research findings remains substantial. Limited climate literacy often encourages simplified explanations and environmental scapegoating, while broader structural and climatic factors receive less attention (Hartyan & Suripin, 2024; Islam et al., 2025). Therefore, this study aims to synthesise recent scientific literature on the relationship between climate change, extreme rainfall, hydrometeorological disasters, and oil palm plantation narratives in Indonesia, while critically examining the multifactorial causes of flash floods and the social dynamics underlying public perceptions of environmental disasters.

METHOD

This study employs a qualitative literature review approach to synthesise theoretical, conceptual, and empirical evidence related to climate change, hydrometeorological disasters, land use, and public perception dynamics in Indonesia. This approach was selected because it enables the integration of multidisciplinary perspectives from environmental studies, social sciences, and policy research to develop a comprehensive understanding of disaster causation (Susanto et al., 2024; Pare & Kitsiou, 2017). The literature search was conducted through the Scopus, Web of Science, Google Scholar, and PubMed databases, as well as reports from reputable institutions such as the IPCC, BMKG, BNPB, UNESCO, and WRI. The review prioritised publications from 2020–2026 to ensure data relevance and currency, while several seminal studies and policy documents published before 2020 were included to provide historical and conceptual context. The keywords used included climate change, extreme rainfall, flash floods, oil palm, land use, climate literacy, and disaster attribution in Indonesia.

The inclusion criteria comprised peer-reviewed journal articles, official institutional reports, and literature directly related to climate change, hydrometeorological disasters, and environmental narratives in Indonesia. Meanwhile, the exclusion criteria included non-scientific opinion articles, duplicated publications, sources lacking methodological clarity, and studies not directly relevant to the research focus. Data were analysed using thematic analysis through stages of familiarisation, coding, categorisation, theme development, and synthesis to generate an integrated interpretation of findings (Nowell et al., 2017; Thomas & Harden, 2008). This study is limited by its reliance on secondary data and the potential for selection bias in the reviewed literature. Nevertheless, research validity was strengthened through transparent selection procedures, source triangulation, and the use of credible and peer-reviewed references

RESULTS

The Scientific Consensus: Climate Change Intensifies Extreme Precipitation

Synthesized evidence establishes that anthropogenic greenhouse gas emissions drive global warming, which intensifies extreme precipitation events and increases the risk of hydrometeorological disasters. The IPCC AR6 report concludes with “high confidence” that human activities are the primary driver of increased heavy rainfall at global and continental scales (McSweeney, 2021). Scientific findings show that atmospheric water vapor capacity increases by approximately 6–7% for every 1°C rise in global temperature, following the Clausius Clapeyron relationship. With global temperatures having risen by around 1.3°C above

pre-industrial levels, atmospheric moisture capacity has increased by approximately 8–9%, contributing to more intense rainfall events when precipitation occurs (McSweeney, 2021).

Attribution studies in Southeast Asia further demonstrate the role of climate change in recent flood disasters. Research on the 2025 floods associated with Cyclonic Storms Senyar and Ditwah found that climate change increased extreme rainfall intensity by 28–160% in Sri Lanka and 9–50% in the Malacca Strait region. In comparison, natural climate variability factors such as La Niña and the negative Indian Ocean Dipole contributed only around 5–13% to rainfall intensity (Seneviratne et al., 2021). Projections for Indonesia also indicate a continued increase in hydrometeorological risk. Studies predict that extreme rainfall frequency in northern Indonesia may rise by approximately 25% between 2020 and 2050, accompanied by a projected 25% increase in flood occurrence and a 60% increase in drought events (Hendrawan et al., 2025). These findings consistently identify anthropogenic climate change as a major factor intensifying hydrometeorological disasters in Indonesia.

Definitive Evidence: Flash Floods in Non-Palm Regions Falsify Scapegoating

The strongest argument against the narrative that palm oil misuse is the primary cause of flash floods is evident in the spatial pattern of hydrometeorological disasters. If palm oil were the primary cause or prerequisite for flooding, then disasters should be concentrated in palm oil-producing areas and minimal in non-palm oil-producing areas. However, empirical evidence suggests otherwise. 2025 data from the National Disaster Management Agency (BNPB) shows that the highest flood intensity occurred in areas without palm oil plantations, particularly on the island of Java (GAPKI, 2025). In January 2025, major flooding struck various provinces in Java, Banten, Bali, and West Nusa Tenggara, affecting more than 200,000 people and causing dozens of fatalities. This event was triggered by extreme rainfall, river overflows, steep topography, poor drainage systems, and rapid urbanization, not by palm oil plantation activities (Davies & O'Regan, 2025). The fact that Java, devoid of palm oil plantation centers, experienced the highest flood intensity directly invalidates the claim of primary causality by palm oil.

A similar pattern is seen in urban areas. Jakarta experiences recurrent flooding with significant impacts due to a combination of extreme rainfall intensified by climate change, an 89% impermeable surface, land subsidence, and low-lying topography. There are no oil palm plantations in this region, yet the flood risk continues to increase, with significant economic losses (Amiruddin et al., 2025). Similarly, Semarang is impacted by tidal flooding and rain

flooding due to sea level rise, land subsidence, urban drainage systems, and atmospheric dynamics, unrelated to oil palm (Harjana et al., 2023).

More broadly, a BMKG warning issued by Dwikorita Karnawati confirms that Java, Bali, Nusa Tenggara, South Sulawesi, Maluku, and South Papua are at high risk of flash flooding during the peak rainy season due to climate-driven extreme weather, regardless of the presence of oil palm plantations (Salma, 2025a). Thus, this spatial evidence suggests that flash floods are a hydrometeorological phenomenon primarily triggered by climate change and amplified by local factors. Palm oil is neither a necessary nor a sufficient cause, so its blame reflects environmental scapegoating rather than a scientific explanation.

Land-Use Complexities: Degraded Land Rehabilitation vs. Deforestation Narrative

A synthesis of the reviewed literature indicates that the environmental role of oil palm plantations cannot be understood through a monocausal perspective, as it is closely related to historical land-use dynamics. Since 2010, Indonesian government policy has promoted oil palm expansion on degraded land rather than forests or peatlands, with an estimated 6–7 million hectares identified as available for development without additional deforestation (Gingold, 2010). Several studies show that many oil palm plantations were established on degraded former Forest Concession (HPH) areas abandoned after intensive timber extraction during the 1960s–1990s (Forest Watch Indonesia, 2001; Jong, 2018; Gunarso et al., 2013).

The findings also indicate that legally developed oil palm plantations on degraded land may contribute to land rehabilitation and socio-economic productivity in rural areas (Ekayani et al., 2025). However, the literature confirms the existence of approximately one million hectares of illegal oil palm plantations within protected forest areas, which continue to contribute to deforestation and environmental degradation (Yel, 2023). Therefore, the reviewed evidence emphasises the importance of distinguishing between legal oil palm development on degraded land and illegal plantation expansion in protected forests when evaluating environmental impacts. Overall, the literature suggests that public narratives often overlook these land-use complexities and tend to attribute hydrometeorological disasters solely to oil palm plantations. The findings instead highlight that disaster risks are shaped by broader interactions among climate change, historical land degradation, land management practices, and environmental governance.

Multi-Causal Flood Genesis: Triggers and Amplifiers

Flash flood catastrophes result from complex interactions between climatic triggers and multiple amplifying factors, as articulated in the trigger-amplifier framework (Salma, 2025b). Climatic Triggers: The November 2025 Sumatra floods occurred when daily rainfall exceeded 300 millimeters, driven by the formation of Tropical Cyclone Senyar. The January 2020 Jakarta floods resulted from overnight heavy rain exceeding 122 millimeters—nine times the average daily rainfall. The January 2025 Java floods stemmed from prolonged heavy rainfall across multiple days. These extreme precipitation events represent the necessary triggers—without intense rainfall, flooding does not occur. Climate change has made such triggers 28-160% more intense in Indonesian regions (Jayawerdana, 2025).

Hydrological Amplifiers: Watershed capacity to absorb and regulate rainfall determines flood response. Forest ecosystems provide critical services: canopy interception, soil infiltration, evapotranspiration, and erosion control. When forests are degraded—whether by historical timber extraction, subsequent land conversion, or poor management—these services diminish, increasing surface runoff. For the 2025 Sumatra floods, Dr. Suryatmojo emphasized that "forest ecosystem degradation in upper watersheds reduced ecological capacity to absorb and regulate high rainfall" (Rogger dkk., 2017).

Critically, watershed degradation stems from multiple historical and current actors: timber companies (1960s-1990s) that extracted trees and abandoned concessions; subsequent land uses including palm oil (sometimes on degraded lands, sometimes through illegal forest conversion), rubber plantations, mining, illegal logging, agricultural conversion, and infrastructure development. Attributing all watershed degradation to palm oil alone misrepresents this complex, multi-actor, multi-temporal history (Teresia & Yudhistira, 2025).

Urbanization Amplifiers: In Jakarta and other cities, urbanization creates distinct flood vulnerability through the expansion of impervious surfaces. Jakarta generates 89% of its runoff from overland flow caused by buildings, roads, and concrete. Urbanization also intensifies rainfall through the urban heat island effect. Jakarta's additional vulnerabilities—land subsidence, location between rivers and the sea, inadequate drainage—compound flood risk regardless of deforestation (Wang et al., 2021). Coastal and Geomorphological Factors: Semarang's severe flooding stems from tidal dynamics, land subsidence, and Mesoscale Convective Systems, entirely independent of upstream land use. Steep terrain in Central Java's highlands rapidly channels rainfall into the lowlands, amplifying the severity of flash floods (Findayani et al., 2024).

The Multi-Causal Synthesis: No single factor suffices to generate catastrophic floods. Climate change-intensified extreme precipitation is necessary but not sufficient. Land-use changes (both historical deforestation for timber and subsequent conversions) amplify impacts but do not cause rainfall. Urbanization concentrates vulnerability but cannot explain rural floods. Infrastructure inadequacies exacerbate consequences but do not trigger events. The 2025 Sumatra floods resulted from a confluence of: (1) Tropical Cyclone Senyar generating extreme precipitation (climate change-amplified); (2) decades of watershed degradation beginning with the 1960s-1990s timber extraction, followed by multiple land-use conversions; (3) river sedimentation; (4) inadequate spatial planning; and (5) insufficient early warning uptake (Teresia & Yudhistira, 2025).

Scapegoating Dynamics: Deflecting from Climate Change and Historical Timber Culpability

Synthesized evidence suggests that the misuse of palm oil as a scapegoat serves two primary diversionary functions: obscuring climate change as the primary driver of hydrometeorological disasters and obscuring the timber industry's historical role as an early cause of forest degradation. Cognitively, the availability heuristic and confirmation bias mechanisms make palm oil plantations the most readily recalled cause, as they frequently appear in post-disaster media visuals. Conversely, the more complex causal chain—from timber exploitation in the 1960s–1990s, through the abandonment of degraded land, to interactions with extreme rainfall events caused by climate change—is more difficult to grasp intuitively, and is therefore simplified to a single, visible actor (Primayanti, 2025).

Emotionally, operating palm oil companies provide a concrete target for public outrage, unlike the abstract and transnational nature of timber companies or global greenhouse gas emissions. Degraded land left behind by the timber industry is also less visually appealing than organized oil palm plantations, biasing perceptions of responsibility (Font & Tribe, 2000; Howard et al., 2008; UNDP, 2020). Politically and institutionally, this narrative diverts attention from transtemporal governance failures, including weak current climate change mitigation and adaptation, as well as historical failures in regulating the timber industry and enforcing reforestation obligations. Acknowledging these failures demands broader accountability, making blaming the palm oil sector an easier option (Goldring et al., 2025; Gingold, 2010; PASPI, 2024).

Media incentives reinforce this pattern. Simple narratives like "palm oil causes flooding" are easier to package than multi-causal explanations that incorporate historical land use, policy, and global climate change (Raju et al., 2022). As a result, the policy focus shifts from the core issues of emissions reduction, risk-based spatial planning, selective rehabilitation and restoration of degraded land, and strengthening adaptation infrastructure. In the long term, this scapegoating practice not only maintains disaster vulnerability but also unfairly impacts communities whose livelihoods depend on the palm oil sector (Anggita, 2024).

DISCUSSION

Synthesizing the Complete Causal Web: From Historical Timber Extraction Through Climate Change to Flash Floods

Integrated evidence suggests that hydrometeorological disasters in Indonesia are the result of multi-temporal and multi-actor causal interactions, and therefore cannot be explained by a single scapegoating narrative. Historically, during the 1960s–1990s, the timber industry conducted large-scale selective logging in Sumatra, Kalimantan, and Sulawesi. After the extraction of valuable timber, many concessions were abandoned without reforestation, leaving degraded lands overgrown with shrubs, hydrologically damaged, and without economic function. This process is the initial cause of deforestation and watershed degradation, resulting in millions of hectares of degraded land that subsequently became the basis for oil palm expansion (PASPI, 2024).

As a policy response, since 2010, the Indonesian government has explicitly directed oil palm development to degraded lands, not forests, with the goal of meeting production needs without additional deforestation. The government has identified 6–7 million hectares of degraded land as suitable for reforestation, and up to 29 million hectares of degraded non-forest areas within forest areas (Gingold, 2010). Recent research indicates that a significant portion of oil palm plantations are indeed developing on these lands, rehabilitating previously unproductive areas. However, at the same time, there is also illegal conversion in protected areas, the use of logged-over forests that still have conservation value, and debate about the optimal use of secondary forests. These complexities are often omitted in public discourse that categorizes all oil palm plantations as a cause of deforestation (YEL, 2023).

On top of these land-use dynamics, anthropogenic climate change operates as an independent driver. Global temperature increases of approximately 1.3°C have amplified extreme rainfall intensity by 28–160% through thermodynamic mechanisms, regardless of local land-use patterns. The fact that severe flooding occurred on Java, without oil palm

plantations—confirms the dominant role of climate change as a primary driver (Otto et al., 2022). Hydrometeorological disasters arise when extreme rainfall encounters vulnerable landscapes, whether due to historical degradation, land conversion, or urbanization. Blaming a single actor, including oil palm, obscures this complex causal reality (Jong, 2021).

Why Scapegoating Persists: Dual Deflection and Temporal Amnesia

The findings indicate that the persistence of oil palm scapegoating is closely related to social, cognitive, and political dynamics. Public discourse often places oil palm plantations as the main cause of flooding because they are more visible and easier to identify than broader factors such as climate change, historical land degradation, or urban environmental problems. This simplification encourages monocausal explanations, even though severe flooding also occurs in non-palm regions such as Jakarta, Semarang, and other parts of Java (Salma, 2025a).

The literature also suggests that blaming oil palm plantations may divert attention from larger structural issues. Scientific evidence consistently shows that climate change, through increasing greenhouse gas emissions and extreme rainfall intensity, is a major driver of hydrometeorological disasters. However, climate change is often perceived as abstract and difficult to observe directly, while oil palm plantations are physically visible in affected regions. In addition, historical degradation caused by large-scale timber extraction during the 1960s–1990s is frequently overlooked in public discussions, despite its contribution to damaged watersheds and vulnerable landscapes (GAPKI, 2024).

Media framing and political considerations further strengthen this narrative. Images of flooded plantation areas are more easily circulated and understood by the public than explanations related to atmospheric processes or historical land-use change. At the same time, regulating current plantation activities is politically more practical than addressing long-term climate governance or historical environmental policies (Weber & Stern, 2011; Goldring et al., 2025). Therefore, the reviewed literature highlights the importance of strengthening climate literacy and promoting evidence-based environmental communication to avoid oversimplified interpretations of complex disaster events.

Educational Imperatives: Systems Thinking and Historical Literacy

Effective climate and environmental education must pursue multiple integrated objectives: Climate Science Foundations: Teaching greenhouse effect mechanisms, attribution science (quantifying how climate change intensified Indonesian rainfall 28-160%), and thermodynamic principles linking emissions to extreme precipitation. Emphasizing that fossil fuel combustion

globally drives climate change, which intensifies rainfall regardless of local land-use patterns—evidenced by Java's floods despite no palm oil (UNEP, 2015; Wewerinke-Singh & Mead, 2025).

Policy Recommendations: Comprehensive, Multi-Temporal Accountability

Public policy needs to be directed at addressing the entire network of causes of hydrometeorological disasters, rather than focusing on easily blamed actors. The primary priority is climate change mitigation by positioning greenhouse gas emissions as the primary driver of increased extreme rainfall. Indonesia needs to strengthen its emissions reduction targets in line with the IPCC pathway, while simultaneously promoting global commitments to fossil fuel reduction. Policy narratives also need to be cautious about shifting focus away from climate action by emphasizing excessive land use.

At the same time, historical accountability for land degradation caused by the timber industry in the 1960s–1990s is needed. The government needs to conduct comprehensive mapping of degraded lands, assess their current ecological condition, and transparently differentiate between land suitable for rehabilitation for productive activities and areas that should be restored as secondary forests. Enforcing restoration obligations for abandoned timber concessions is also a crucial part of ecological justice. Palm oil regulations must be differentiated. Legal and sustainable palm oil development on degraded lands needs to be clearly distinguished from illegal conversion in protected or high conservation value areas, which must be prosecuted and restored. Conversion of logged-over forests that still have ecological value needs to be assessed on a case-by-case basis based on scientific criteria, rather than through blanket labeling that simplifies reality.

Long-term efforts require a coordinated national climate literacy strategy. Public education needs to integrate greenhouse gas science and climate attribution, Indonesia's land-use history, and a systems-thinking approach that emphasizes multi-temporal and multi-actor causality. Coordination across ministries and agencies is key to ensuring consistent, evidence-based, and easily understood public messaging, including in media communications and community-based education programs that link local history to current disaster risks.

CONCLUSION

This study concludes that blaming flash floods solely on oil palm plantations is a form of misattribution that obscures the underlying causes of hydrometeorological disasters in Indonesia. A synthesis of the literature indicates that anthropogenic climate change is the primary driver significantly increasing the intensity of extreme rainfall, regardless of land use patterns. The climate attribution findings confirm that the increase in extreme rainfall across Indonesia is strongly influenced by global warming. Spatial evidence consistently shows that areas with the highest flood intensity, such as Java, Jakarta, and Semarang, do not have oil palm plantations. This fact confirms that oil palm is neither a necessary nor a sufficient cause of flash floods. Disasters arise from the interaction of extreme rainfall with regional vulnerability shaped by urbanization, land subsidence, watershed degradation, and spatial governance.

This study also confirms that a significant portion of oil palm plantations developed on land degraded by logging during the 1960s–1990s. Thus, initial deforestation was more related to the historical timber industry, while palm oil development on certain degraded lands actually served a rehabilitative purpose, although illegal practices still require law enforcement. Overall, flash floods are the result of multi-temporal and multi-actor causality. Disaster risk reduction efforts and public education need to focus on climate change literacy, understanding historical land use, and systems-thinking approaches to prevent policies and public responses from becoming trapped in misleading oversimplified narratives.

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