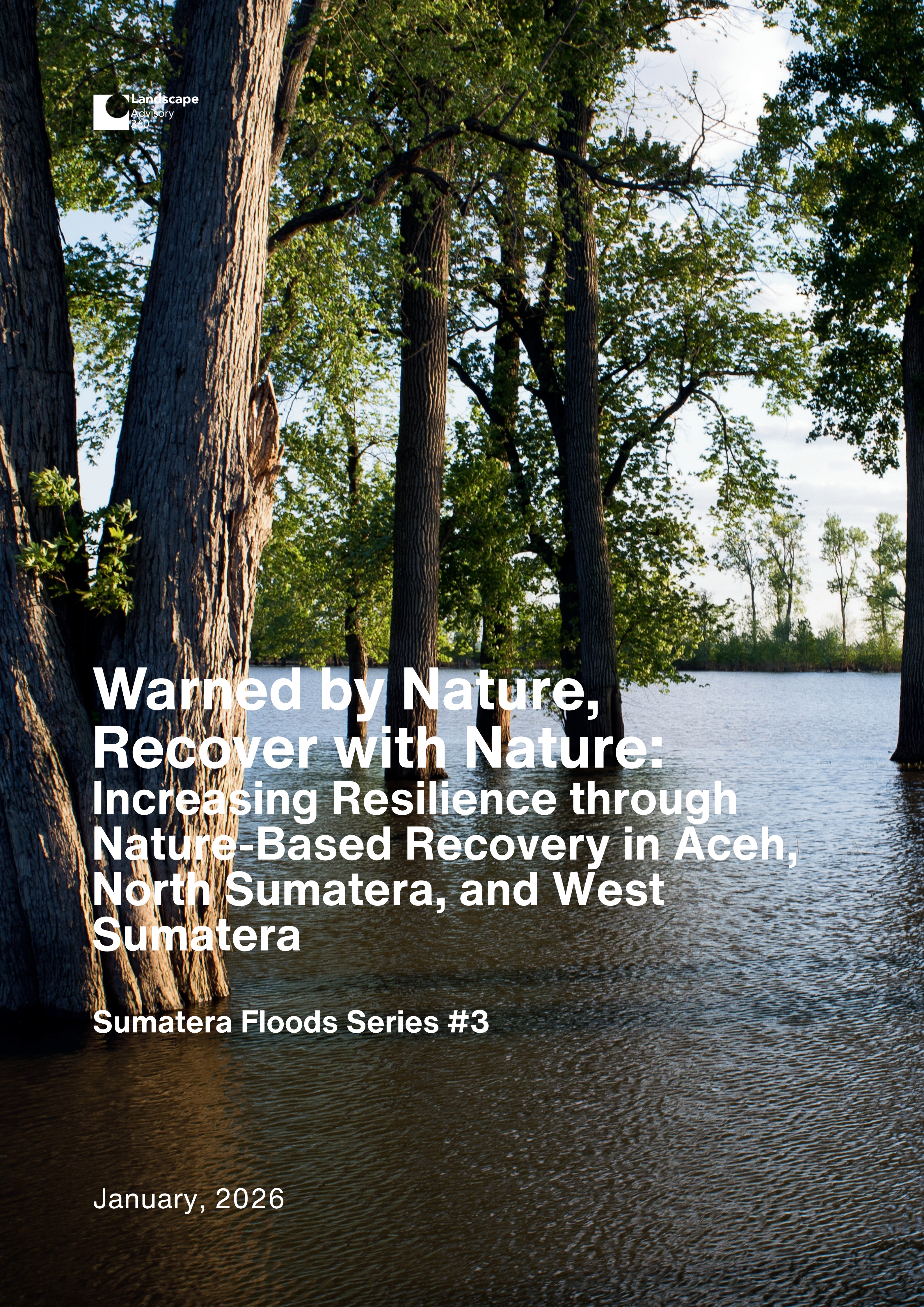

Landscape Advisory 360

Warned by Nature, Recover with Nature:
Increasing Resilience through Nature-Based Recovery in Aceh, North Sumatera, and West Sumatera

Sumatera Floods Series #3

January, 2026

Warned by Nature, Recover with Nature:

Increasing Resilience through Nature-Based Recovery in Aceh, North Sumatera, and West Sumatera

January 2026

Landscape Advisory

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Executive Summary

The late-November 2025 floods and landslides across Aceh, North Sumatera, and West Sumatera were a systems failure revealed by weather. Extreme rainfall was the trigger, but the scale of loss reflected accumulated risk — weakened watersheds and unstable slopes upstream, and dense settlement and critical assets concentrated in floodplains and corridors downstream. In a warming climate, heavy precipitation is expected to intensify; designing for yesterday's rainfall baseline is no longer conservative.[1]

This report advances a *Recover with Nature* portfolio: conserve remaining ecological infrastructure (headwater forests, peat, mangroves); rehabilitate mid-slope disturbance belts and riparian corridors to reduce runoff and sediment; and restore critical hydrological control surfaces in floodplains, peat hydrological units, and coastal buffers — paired with engineering calibrated by basin type, not applied as a uniform template.

Governance is the hinge. The operating unit of risk is watershed-to-coast, yet planning, licensing, budgeting, and enforcement still tend to fragment along administrative lines. The reforms proposed here focus on province-led watershed coordination; time-bound, risk-based permit audits in headwaters, steep slopes, riparian corridors, peat hydrological units, and floodplains; enforceable river setbacks and floodplain zoning; and early warning that links thresholds to protocols people can execute.

Financing must follow risk reduction, not just reconstruction. Indonesia's own climate commitments — the Long-Term Strategy for Low Carbon and Climate Resilience (LTS-LCCR 2050), the Second Nationally Determined Contribution, and the Forestry and Other Land Use (FOLU) Net Sink 2030 agenda — provide a credible platform to align adaptation and mitigation, and to make the case for international support for adaptation and loss-and-damage needs. The choice is not whether the next storm arrives; it is whether it meets a landscape that has learned.[2]. [234]

[1] IPCC (Intergovernmental Panel on Climate Change), 2021. *Climate Change 2021: The Physical Science Basis*. Cambridge University Press, Cambridge.

[2] RI (Government of the Republic of Indonesia), 2021a. *Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050)*. Government of Indonesia, Jakarta; RI, 2025. *Republic of Indonesia Second Nationally Determined Contribution*. Ministry of Environment, Jakarta; MOEF (Ministry of Environment and Forestry), 2023. *FOLU Net Sink: Indonesia's Climate Actions Towards 2030*. MOEF, Jakarta.

1 The Disaster That Has Been

1.1 The Deadly Disaster

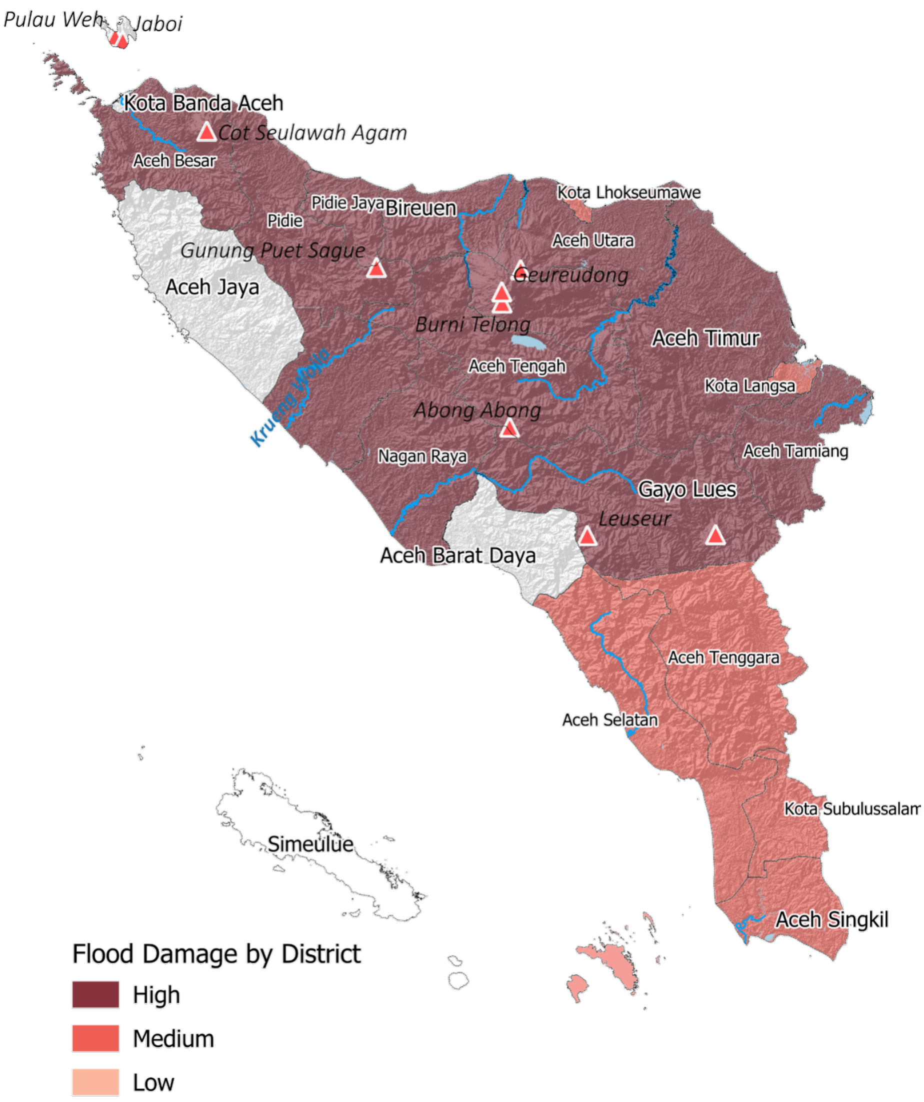
It has been more than one month since the disastrous flood destroyed much of Aceh, North Sumatera, and West Sumatera. Torrential rain indundated the northern Sumatera region on November 25, 2025.[3] As of January 6, 2025, reported impacts across Aceh, North Sumatera, and West Sumatera include 1,178 deaths, 147 missing persons (31 in Aceh, 42 in North Sumatera, and 74 in West Sumatera), and 242,174 displaced people.[4]

The wider economic losses, as estimated by Center for Economic and Law Studies (CELIOS), have been estimated at almost Rp70 trillion (Rp.68.6-68.7 trillion).[5] Meanwhile, preliminary reconstruction needs are estimated at almost Rp52 trillion (Rp 51.82 trillion).[6] CELIOS further assessed that the cost of damages far outweigh the income from the mining production sales of Rp16.6 trillion as per October 2025. Aceh showed a deficit of at least Rp2 trillion, which is larger than Aceh's non-tax contribution of almost Rp1 trillion as per August 2025. It is also larger than the benefit sharing fund of palm oil industry of Rp12 billion and mining sector of Rp56 billion in 2025.[7]

The floods and landslides were characterised by intense precipitation, accelerated surface runoff, rising river levels, debris flows, and recurrent flooding of low-lying communities and transport routes. The occurrence of tropical cyclones, previously considered rare extreme weather events, now appears to represent an emerging pattern of climatic normality.[8] Then, such tropical cyclones Senyar and Koto caused torrential rains in Aceh, North Sumatera, and West Sumatera.[9]

The disaster can be read as a three-part equation: (1) an extreme rainfall pulse; plus (2) weakened watershed storage and slope stability; plus (3) settlement and asset exposure in places that floods routinely reclaim.

[3] "Banjir dan Tanah Longsor Sumatera Disebabkan Cuaca atau Kerusakan Hutan? Ini Penjelasan BMKG dan Pakar," *Kompas.com* (December 4, 2025). https://amp.kompas.com/tren/read/2025/12/04/123000865/banjir-dan-tanah-longsor-sumatera-disebabkan-cuaca-atau-kerusakan-hutan-ini (accessed on December 5, 2025).
[4] BNPB (Badan Nasional Penanggulangan Bencana), 2026. "BNPB laporkan jumlah pengungsi bencana Sumatera terus turun," *Antara News* (January 6, 2026)
[5] Huda, N., and B.Y. Adhinegara, 2025. Dampak Kerugian Ekonomi Bencana Banjir Sumatera: Hasil modelling tim CELIOS menggunakan data per 30 November 2025. Center for Economic and Law Studies, Jakarta.
[6] Mawangi, G.T., 2025. "BNPB: Biaya perbaikan kerusakan bencana Sumatra tembus Rp51,82 triliun", *Antara News* (December 8, 2025).
[7] Huda and Adhinegara, 2025, op cit.
[8] Blašković, T., 2025. "Exceptionally rare Tropical Cyclone Senyar kills more than 300 across Indonesia, Malaysia and Thailand", *The Watchers* (November 28, 2025). https://watchers.news/2025/11/28/rare-tropical-cyclone-senyar-kills-more-than-300-indonesia-malaysia-thailand-november-2025/ (accessed on January 7, 2026); Sun, Y., G. Ramstein, A.V. Fedorov, L. Ding, B. Liu, 2025, "Tropical Indian Ocean drives Hadley circulation change in a warming climate," *National Science Review*, 12 (1); Roxy, M.K., J.S. Saranya, A. Modi, A. Anusree, W. Cai, L. Resplandy, J. Vialard, and T.L. Frolicher, 2024. "Chapter 20, Future projections for the tropical Indian Ocean" in Ummenhofer, C.C., and R.R. Hood (eds.), *The Indian Ocean and its Role in the Global Climate System*. Elsevier, Amsterdam; Liu, M., G.A. Vecchi, J.A. Smith, and T.R. Knutson, 2019. "Causes of large projected increases in hurricane precipitation rates with global warming" *Nature Climate and Atmospheric Science* 2 (38).
[9] Pedroletti, B., 2025. "Torrential rains in Indonesia destroy villages and leave more than 600 dead", *Le Monde* (December 2, 2025); Chang, C.-P., C.H. Liu, and H.C. Kuo, 2003. "Typhoon Vamei: An equatorial tropical cyclone formation", *Geophysical Research Letters*, 30 (3), p. 1150; "Extreme Rainfall from Tropical Cyclone Senyar Triggers Widespread Flooding and Infrastructure Damage Across Aceh", TDMRC (Tsunami and Disaster Mitigation Research Center). https://tdmrc.usk.ac.id/2025/11/29/extreme-rainfall-from-tropical-cyclone-senyar-triggers-widespread-flooding-and-infrastructure-damage-across-aceh/ (November 29, 2025); https://tdmrc.usk.ac.id/2025/11/29/extreme-rainfall-from-tropical-cyclone-senyar-triggers-widespread-flooding-and-infrastructure-damage-across-aceh/ (accessed on January 7, 2026).



Indicators	Low	Medium	High
Human impacts			
Death	<50	51-99	≥100
Missing	<100	100-2999	≥3000
Injured	<100	100–2999	≥3000
Evacuated	<1000	1000-6999	≥7000
Environmental damages			
Damaged houses	<500	500-2999	≥3000
Damaged infrastructures	<50	50–499	≥500
Damaged land (ha)	<100	100-1999	≥2000

Figure 1.1. The extent of damages in Aceh. Most areas have been considered highly damaged with a few in the southern area considered moderately damaged.

1.2 Climate Crisis is Here

Only the first term sounds "natural." The other two are clearly policy outcomes — produced slowly, permit by permit, road by road, and parcel by parcel. But even the first term in the "three-part equation" — the extreme rainfall pulse — is not a purely natural variable anymore. In a warming world, the atmosphere carries more moisture and releases it more readily as heavy rain. The Intergovernmental Panel on Climate Change (IPCC) has assessed, with high confidence, that heavy precipitation intensifies with additional warming and that the intensification of extreme daily precipitation is about six to seven percent per one degree Celsius of global warming. This is physics applied at scale. Human-driven warming has also loaded the hydrological cycle with more available moisture and energy, and the ocean is central to that story: it absorbs the bulk of excess heat in the climate system, raising ocean heat content and sustaining higher evaporation and moisture supply to storms.[10] In practical terms, the storm that would have been "bad" in a cooler climate becomes "wetter" in today's climate — and water, as the affected provinces learned, is often the most lethal payload.

This matters directly for cyclone-linked rainfall. Tropical cyclones are not manufactured events, but their ceiling is being raised by anthropogenic warming. IPCC notes that precipitation events — including those associated with tropical cyclones — increase with global warming, consistent with the thermodynamic intensification of heavy rainfall.[11] The National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory similarly summarizes the assessed direction of change: tropical-cyclone rainfall rates are projected to increase with warming, even as changes in cyclone frequency remain more uncertain.[12]

During the disaster window (roughly November 25–27), the rainfall was not merely "heavy" — it was BMKG's "extreme" class, meaning more than 150 millimeters per day, and in several places it went far beyond that threshold. Station records compiled in the assessments show 24-hour totals up to 411 millimeters (Kuala, Bireuen), 397.4 millimeters (Karang Baru, Aceh Tamiang), and 382 millimeters (Langsa Baro), with other stations in the same 24-hour window recording around 376.6 millimeters. Across the three affected provinces, the same episode includes documented daily totals such as 310.8 millimeters per day (Aceh Utara), 262.2 millimeters per day (Medan), 229.7 millimeters per day (Tapanuli Tengah), and 154 millimeters per day (Padang Pariaman). Against a typical Aceh monthly rainfall range of roughly 150–320 millimeters, the event delivered what is, in practical terms, a month's rain in a day — and the watersheds were expected to cope as if it were business as usual.[13]

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[10] IPCC (Intergovernmental Panel on Climate Change), 2021a. *Climate Change 2021: The Physical Science Basis* — Chapter 12: Climate Change Information for Regional Impact and for Risk Assessment. IPCC, Geneva; "How is climate change impacting the world's ocean," *United Nations*. https://www.un.org/en/climatechange/science/climate-issues/ocean-impacts (accessed on January 7, 2026).

[11] IPCC, 2021, *op cit*.

[12] NOAA GFDL (National Oceanic and Atmospheric Administration Geophysical Fluid Dynamics Laboratory), 2025. "Global Warming and Hurricanes," *NOAA GFDL* (n.d.). https://www.gfdl.noaa.gov/global-warming-and-hurricanes/ (accessed on January 7, 2026).

[13] BMKG (Badan Meteorologi, Klimatologi, dan Geofisika), 2025. *Ikhtisar Cuaca 22 Desember 2025*. BMKG, Jakarta, "Karakteristik Iklim Aceh", Informasi Iklim, BMKG. https://www.bmkgaceh.org/pages/iklim.html#:~:text=Karakteristik%20Iklim%20Aceh,berdasarkan%20topografi%20dan%20lokasi%20geografis. (accessed on December 22, 2025); TDMRC, 2025, *op cit*.; Damanik, R.A., 2025. "Prospek Cuaca Mingguan Periode 28 November–4 Desember 2025: Siklon Tropis 'SENYAR' Punah, Gelombang Atmosfer Pengaruhi Cuaca

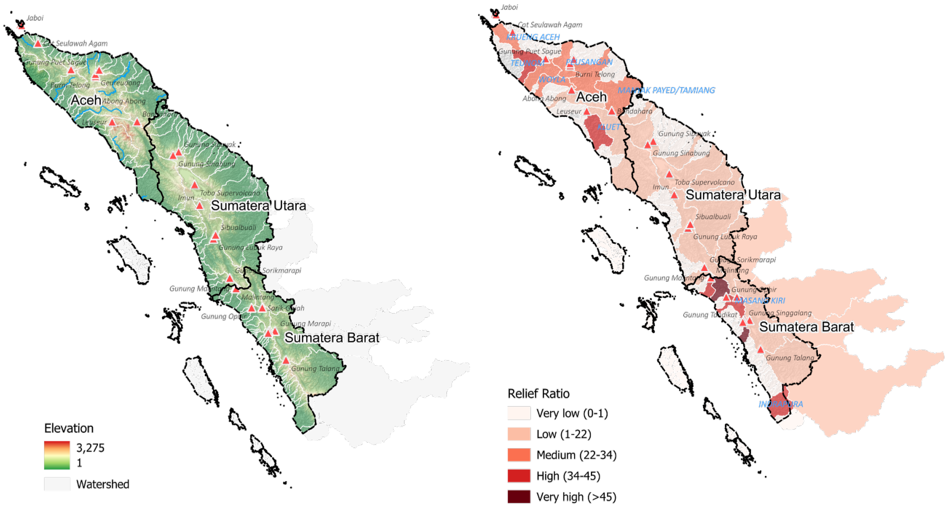

Figure 1.2. Elevation and relief ratio in Aceh, North Sumatera, and West Sumatera. Elevation idicates the height of the area, whereas the relief ratio indicates the steepness of the slopes.

1.3 Degraded Watersheds

A watershed (daerah aliran sungai, DAS) does not fail in one night. It is usually trained to fail over decades — as land cover is thinned, slopes are opened, roads and extraction corridors fragment the upper catchment, and rivers become more sediment-laden and less forgiving. In hydrological terms, the shift is painfully simple: rainfall that used to be intercepted, stored, and released more slowly is converted faster into hazardous surface runoff, while disturbed hillsides contribute more sediment and debris that can choke channels and amplify overbank flooding downstream.

It is also important to be precise about what forests do and do not do. Forests are not a magical flood wall, and under cloudburst-level rainfall even intact soils can saturate. But degradation changes how quickly saturation is reached, how sharp the peak flow becomes, and how destructive the flood wave is when it arrives in the lowlands.[2] This is why the late-November rainfall pulse became lethal so quickly in northern Sumatera: the storm did not fall onto an "anonymous landscape," but onto a land-use map — logged-over areas, plantation and mining expansion, and opened corridors — that had already reduced the catchment's capacity to slow, store, and stabilize water and soil.

The implication is uncomfortable but operationally useful: legacy risk is already "priced in." Even if new clearing stopped tomorrow, the hydrological consequences of past land-use change will remain for years unless restoration is carried out at scale in the headwaters, mid-slopes, and river corridors that control runoff and sediment delivery. In that sense, the disaster was not only a weather event — it was also an audit of watershed condition, delivered at full volume.

The elevation map (Figure 1.2) is a reminder that northern Sumatera is not a flat stage waiting for rainfall — it is a steep "spine-to-plain" landscape. The Bukit Barisan mountain belt concentrates headwaters, shortens travel time from ridge to river, and creates long downslope pathways where runoff accelerates, channels incise, and slopes fail. In this setting,

Signifikan di Indonesia," BMKG (Badan Meteorologi, Klimatologi, dan Geofisika) (November 27, 2025) (accessed on December 22, 2025).

floods are rarely just "high water" — they are often fast water, carrying sediment, timber, and debris that turns inundation into impact.[14]

The relief ratio map (also Figure 1.2) makes that topographic story measurable. Relief ratio (total basin relief divided by basin length) is a standard geomorphology index: higher values generally indicate steeper, more compact basins where water and sediment move quickly, and where peak flows can rise with very little polite warning.[15] In practical flood terms, steep and mountainous terrain produces rapid runoff and quick stream response; narrow valleys can amplify flow depth and velocity; and the erosive power of the flood depends heavily on slope and flow depth rather than discharge alone.[16]

The two maps help explain why destruction clusters the way it does. In Aceh, most watersheds fall in the moderate relief-ratio band, with high-relief basins concentrated in steep mountain-to-coast catchments (for example Teunom and Kluet/ Aceh Selatan), while low-relief systems are concentrated in coastal-plain landscapes such as Singkil.[17] That matters because the hazard "flavor" changes by relief regime: high-relief basins are structurally prone to flash flooding, landslides, and debris flows; moderate "spine-to-plain" systems can deliver a compound disaster (flash response upstream, prolonged inundation downstream); and low-relief basins tend to flood slowly but linger longer, driven by backwater effects, floodplain storage limits, and drainage bottlenecks.[18] In short, the maps pre-sort the hydrological argument, and they strongly suggest that risk reduction must be calibrated by watershed morphology, not applied as a one-size-fits-all checklist.[19]

Land-use change and deforestation do not "create" an extreme-rainfall event, but they help decide whether that event becomes a manageable flood or a destructive cascade.

In Aceh, the linkage is not just conceptual. A recent peer-reviewed study using village-level data (2011–2018) found flood events were more likely where upstream tree cover was lower and oil palm area was higher (with precipitation still a key driver), and that poorer communities were hit hardest.[20] That is precisely the risk architecture you saw play out in late November 2025: extreme rain fell onto catchments that, in many places, have been progressively stripped and

[14] Andriyani, T., 2025. ""UGM Experts Explain Causes of Flash Floods in Sumatra," Universitas Gadjah Mada (December 18, 2025). https://ugm.ac.id/en/news/ugm-experts-explain-causes-of-flash-floods-in-sumatra/ (accessed on January 7, 2026); Wilopo, W., and Faisal. 2021. "The Mechanism of Landslide-Induced Debris Flow in Geothermal Area, Bukit Barisan Mountains of Sumatra, Indonesia," *Journal of Applied Engineering Science*, 19 (3).

[15] Schumm, S.A. 1956. "The evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey," *Geological Society of America Bulletin*, 67(5), pp. 597–646.

[16] NWS (National Weather Service). 2026. "Flood Safety Week," National Weather Service. (accessed on January 7, 2026); Costa, J.E. 1987. "Hydraulics and basin morphometry of the largest flash floods in the conterminous United States," *Journal of Hydrology*, 93(3–4), pp. 313–338.

[17] Alfian, M., I. Meilianda, J. Opdyke, and K. Munadi. 2023. "Flood simulation to determine flood hazard susceptibility in Singkil downstream watershed," *E3S Web of Conferences* (2023).

[18] "Backwater Flooding; Backwater Effect," NWS (National Weather Service). https://www.weather.gov/ggw/GlossaryB (accessed on January 7, 2026.

[19] Víg, B., S.Á. Fábian, S. Czigány, E. Pirkhoffer, Á. Halmai, I.P. Kovács, G. Varga, J. Dezső, G. Nagy, and D. Lóczy, 2022. "Morphometric analysis of low mountains for mapping flash flood susceptibility in headwaters," *Natural Hazards* 114 (2022), pp. 3235–3254.

[20] Lubis, M.I., M. Linkie, and J.S.H. Lee. 2024. "Tropical forest cover, oil palm plantations, and precipitation drive flooding events in Aceh, Indonesia, and hit the poorest people hardest," *PLOS ONE* 19 (10); Rahmi, R., A. Achmad, A. Yulianur, and I. Ramli. 2023. "Sustainable land use and land cover management model for flood mitigation in Krueng Baro Watershed, Aceh, Indonesia," *International Journal of Energy and Environment* (April 30, 2025), pp. 401–413; Nurhamidah, A. Junaidi, and M. Kurniawan, 2018. "Tinjauan Perubahan Tata Guna Lahan Terhadap Limpasan Permukaan. Kasus: DAS Batang Arau Padang," *Jurnal Rekayasa Sipil (JRS-Unand)*, 14(2), pp. 131–138.

fragmented, reducing infiltration and increasing quick runoff and sediment delivery. Hydrological work on the Krueng Aceh watershed similarly concludes that land-use change increases runoff and reduces infiltration, consistent with more severe downstream flooding.[21]

West Sumatera shows the same mechanism in a different costume. Peer-reviewed work on the Batang Arau watershed (Padang) finds that conversion from non-built land cover to built-up cover increases runoff and flood discharge — a direct pathway from land conversion to higher flood peaks in a steep "spine-to-plain" setting.[22] A larger Sumatra example from the Batanghari watershed, modeled using SWAT, shows land-use change tends to increase surface runoff and sediment loading over time — which is exactly how rivers become shallower and floods become more frequent companions rather than rare visitors.[23]

For the November 2025 disaster itself, contemporary reporting and expert commentary in Indonesia described deforestation and upstream degradation from logging, mining, and plantation expansion as major contributors to the severity of floods and landslides in Sumatra, alongside climate-amplified rainfall — including the very visible signature of logs and formal event attribution modeling, but it does place the burden of proof where it belongs: if catchments are being opened "permit by permit," it is not surprising that floods arrive "river by river".[24]

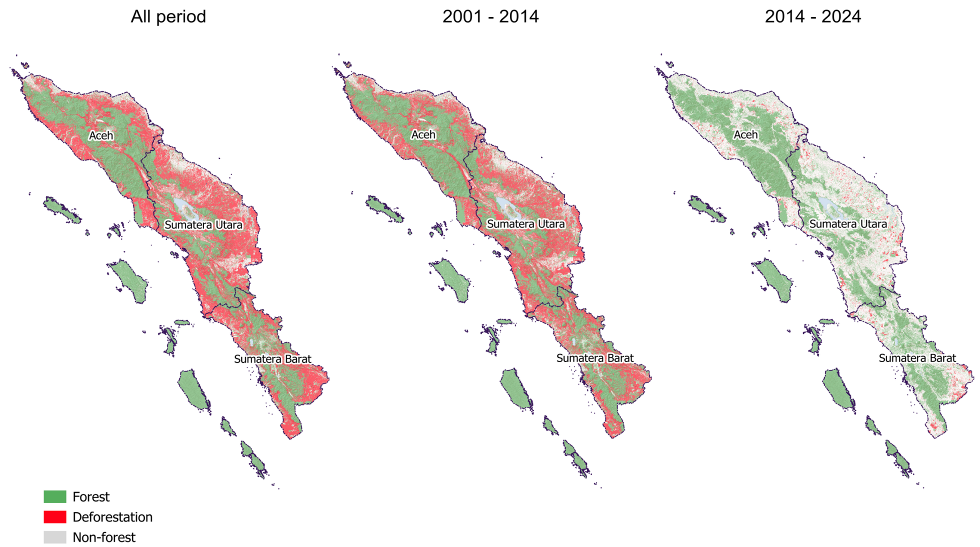

Figure 1.3. Deforestation in Aceh, North Sumatera, and West Sumatera, in the periods of 2001-2014 and 2014-2024.

[21] Muis, B.A. 2019. "Impact of Land Use Change on Hydrological Response of Krueng Aceh Watershed in Aceh Province, Indonesia," *Nature Environment and Pollution Technology* (2019);
[22] Nurhamidah, et al., 2018, *op cit*.
[23] Ridwansyah, I., A. Apip, H. Wibowo, A. Rahmadya, S. Susiwidiyaliza, U. Handoko, F. Setiawan, and N. Utami, 2023. "The Impact of Land-Use and Climate Change on Water and Sediment Yields in Batanghari Watershed, Sumatra, Indonesia," *Sains Malaysiana*, 52(3), pp. 705–721.
[24] Teresia, A., and Yudhistira, 2025. "'Mischievous hands': Indonesians blame deforestation for devastating floods," *Reuters* (December 2, 2025); Andriyani, T., 2025, *op cit*.

1.4 The Human Face of Damage: Settlement and Asset Exposure

Damage patterns follow the logic of rivers and people: lowland floodplains and deltaic corridors suffered repeated inundation; steep catchments delivered flash floods and landslides; and coastal nodes absorbed both physical damage and supply-chain disruption.

So, when the assessments refer to a rare near-equatorial tropical cyclone as part of the event context, the analytically correct framing is this: the cyclone's existence is not "human-made," but the moisture and heat environment that makes such systems capable of delivering extraordinary rainfall is increasingly human-influenced. In other words, we are no longer arguing about whether nature can produce extreme storms; we are arguing about how much extra water we have paid to put into the atmosphere.

If degraded watersheds are the hazard amplifier, then settlement and asset exposure is the casualty multiplier — and November 2025 showed exactly how. Much of the damage footprint sat where people and critical assets naturally cluster: low-lying floodplains, river corridors, and the transport links that tie production areas to markets. When the rivers rose, they did not merely inundate houses; they also tore at connectivity. By early December, the Ministry of Public Works recorded 253 landslide points and 86 flood points along national roads across the three provinces — with 35 national-road sections and 14 bridges affected in Aceh, 25 national-road sections and 4 bridges in North Sumatera, and 30 national-road sections and 3 bridges in West Sumatera. In other words, the disaster's first act was not only water in neighborhoods — it was the quiet closing of the routes that make relief, trade, and recovery possible.[25]

Exposure is not only about density; it is also about geometry. Some of the hardest-hit areas were lowland corridors where floods routinely reclaim space, but severe impacts also occurred where steep headwaters feed constrained valleys and downstream plains that transmit flood peaks and sediment with little delay. That "steep-to-flat" coupling matters because it converts upstream slope failures into downstream flooding and debris impacts — the kind of event where the river arrives carrying parts of the watershed with it. *Reuters*' field reporting from Aceh Tamiang captured the lived version of this geometry: communities cut off, people walking over scattered logs and wreckage just to reach an aid point, and relief operations leaning on temporary bridges and improvised logistics because roads could not do their job.[26]

The economic consequence is straightforward: many heavily affected districts are not just places where people live; they are also working landscapes. The Ministry of Agriculture reported flood impacts on around 90,000 hectares of paddy cultivation in Aceh, North Sumatera, and West Sumatera, alongside impacts on around 300,000 hectares of plantation land — the kind of shock that does not stay politely on-farm.[27] At the district scale, local government reporting in Padang Pariaman alone described damaged bridges and disrupted access, plus 341 hectares of rice fields and 106 hectares of maize

[25] Sulistiyandari, R., 2025. "Indonesia races to restore roads after Sumatra floods," *Antara News* (December 2, 2025).
[26] Ulfiana, A., and Yudhistira, 2025. "Indonesians climb over logs in walk to aid centre as flood deaths exceed 900," *Reuters* (December 6, 2025) (accessed on January 7, 2026);
[27] "Kementerian Pertanian percepat LTT Desember 2025 dan mitigasi dampak banjir di sejumlah daerah," BRMP (Balai Penerapan Modernisasi Pertanian), MAG (Ministry of Agriculture, Kementerian Pertanian) (December 20, 2025). https://papuabarat.brmp.pertanian.go.id/berita/kementerian-pertanian-percepat-ltt-desember-2025-dan-mitigasi-dampak-banjir-di-sejumlah-daerah (accessed on January 7, 2026).

affected during the same extreme-weather week.[28].[4] When roads and bridges fail, losses propagate through production, storage, processing, and distribution — and communities get a blunt lesson in "isolation economics": prices rise where goods cannot arrive, and farmgate prices fall where products cannot leave. In short, the floodwater did not just find homes; it found supply chains.[29]

Behind the statistics is a familiar pattern with unfamiliar scale: households displaced from riverbanks and floodplains; schools and clinics functioning as shelters; damaged roads severing access to markets and services; and communities returning home to rebuild with less savings and more debt.[30] Recovery policy should treat psychosocial support, public health, and livelihood restoration as essential infrastructure, not as "nice-to-have" add-ons.

Flood impacts intersect with core livelihood systems: lowland paddy; oil-

Production system	**Primary vulnerability channel**
Lowland rice belts	Repeated inundation; irrigation and drainage damage; paddy bund failure; sediment deposition; planting-calendar disruption
Secondary food crops (corn and mixed annuals)	Crop failure from waterlogging; topsoil loss; seed and input loss; access disruption for harvest and replanting
Smallholder oil-palm lowlands (incl. replanting blocks)	Drainage failure; prolonged waterlogging; erosion; farm access-road and bridge failure; fresh fruit bunch collection disruption
Mixed plantation mosaics (oil palm–rubber–cacao mix)	Waterlogging and stand damage; slope and riverbank erosion; feeder-road failure; prolonged income shock (perennials recover slowly)
Highland Arabica coffee landscapes	Slope failure; landslides; gully and terrace erosion; road closure; post-harvest logistics disruption (wet mills, drying, transport)
Cacao smallholder agroforestry mosaics	Waterlogging and root disease; riverbank erosion; access disruption; damage to drying/fermentation assets; cashflow shock during recovery lag
Coconut coastal plains and deltaic systems	Prolonged inundation; localized salinity and backwater effects; tree stress/mortality; landing-site and road access disruption; replanting finance constraint
Sago and wetland smallholder mosaics	Backwater flooding; canal/ditch failure; contamination of processing sites; prolonged access disruption
Highland horticulture	Landslides and slope washout; road closure; terrace/drainage failure; market-access disruption (spoilage risk)
Peri-urban horticulture and food-distribution nodes	Urban drainage bottlenecks; market and warehouse disruption; bridge/road cuts; short, sharp price spikes and supply interruptions
Coastal fisheries and aquaculture (ponds/estuaries)	Pond overtopping and embankment failure; seed/stock loss; water-quality shock; landing-site damage; cold-chain disruption; river-mouth sedimentation/backwater
Small-scale capture fisheries (nearshore/river mouth)	Vessel and gear damage from debris and surge; port/landing-site downtime; access disruption; lost fishing days and working-capital squeeze
Salt ponds and coastal microenterprises (where present)	Berm failure and inundation; salinity imbalance; access disruption; working-capital losses

Table 1.1. Production system vulnerability of various commodities in Aceh, North Sumatera, and West Sumatera.

[28] Laila, R., 2025. "Kerugian banjir di Padang Pariaman capai Rp268,5 miliar," *Antara News* (November 29, 2025),

[29] Sulistiyandari, 2025, *op cit*.; Ulfiana and Yudhistira, 2025, *op cit*.; MAG, 2025, *op cit*.; Laila, 2025, *op cit*.

[30] Washington, J., 2025. "Deadly floods devastate Indonesia, leaving families displaced and homeless", *Aljazeera* (January 6, 2026).

palm corridors; highland coffee and horticulture; and coastal fisheries and aquaculture. The policy implication is not “protect commodities.” It is “protect the landscapes that keep commodities productive” — drainage, riparian buffers, slope stability, and logistics nodes.

2 Long-Term Ecological Recovery and Reform Agenda

“I don’t have moses’ staff”, President Prabowo addressed the flood survivors, expressing regret that immediate relief was not possible, but assuring them that reconstruction efforts are expected to be completed within two to three months.[31] Meanwhile, earlier, Minister of Forestry Raja Juli Antoni announced that the government will initiate a comprehensive review of forest management practices in response to recent disasters, acknowledging significant shortcomings in current environmental management strategies.[32]

Not all watersheds fail the same way. High-relief basins can deliver fast, debris-rich flows. Moderate systems deliver sustained river flooding across large lowlands. Low-relief plains can trap water through drainage backflow, tides, and subsidence. Engineering and nature-based measures should be calibrated to this geomorphology.

2.1 Conserve Remaining Ecological Infrastructure

The cheapest flood infrastructure is the one already on the balance sheet of nature: intact headwaters, remaining primary forests, peatlands, and mangrove belts. These are natural and nature-based features that reduce flood and storm damage while delivering co-benefits that engineered assets typically cannot — biodiversity, livelihoods, and carbon storage.[33] In a landscape where extreme rainfall is increasingly plausible, conservation should be mapped and enforced as risk reduction with biodiversity benefits, not treated as a separate conservation agenda that happens only when budgets feel generous.

Operationally, this means protecting remaining headwater forests and water-tower landscapes, safeguarding peat and mangroves as protective buffers, and enforcing “no new high-risk conversion” in delineated headwater and mid-slope zones where the hydrological penalties of clearance are highest.[34]

2.2 Rehabilitate Mid-Slope Belts and Riparian Corridors

High-leverage rehabilitation sits in the mid-slope belt where roads, smallholder mosaics, and commercial land uses intersect with steep terrain and headwater streams. This is the

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31 Prayudhia, M.C.G., and F. Rochman, 2025. “Prabowo targetkan dampak bencana Sumatera pulih 2-3 bulan”, *Antara News Jawa Timur* (December 15, 2025).
32 Safitri, K., and J. Carina, 2025. “Menhut Raja Juli Janji Evaluasi Total Tata Kelola Hutan Usai Banjir Beruntun di Sumatera”, *Kompas* (November 29, 2025).
33 ERDC (US Army Engineer Research and Development Center), 2021. “USACE announces launch event for International Guidelines on Natural and Nature-Based Features for Flood Risk Management”, USACE (September 7, 2021). https://www.erdc.usace.army.mil/Media/News-Stories/Article/2766136/usace-announces-launch-event-for-international-guidelines-on-natural-and-nature/ (accessed on January 7, 2026).
34 Dodman, D., B. Hayward, M. Pelling, V. Castan Broto, W. Chow, E. Chu, R. Dawson, L. Khirfan, T. McPhearson, A. Prakash, Y. Zheng, and G. Ziervogel, 2022. “Cities, Settlements and Key Infrastructure”, In *Climate Change 2022: Impacts, Adaptation and Vulnerability*, Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Pörtner, H.-O., D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 907–1040.

zone where small changes in slope stability and vegetative cover can translate into large downstream consequences — faster runoff, more sediment, and higher flood peaks. Rehabilitating this belt is therefore not only an ecological program; it is a flood-risk program with roots.

The practical emphasis should be on slope stabilization and assisted natural regeneration in high-risk sub-catchments, plus continuous riparian recovery along priority river corridors — tied to enforceable land-use rules, not voluntary good intentions.[35]

2.3 Restore Hydrological Control Surfaces

Flood risk is also a floodplain, peat, and coast problem. When floodplains are blocked, peat is drained, and coastal wetlands are removed, water loses safe places to go. Coastal ecosystems, including mangroves and other wetlands, have robust evidence for reducing impacts from coastal flooding and storms, and nature-based approaches increasingly show measurable avoided-damage value.[36]

For peatlands, rewetting is not a hydrological intervention. Evidence from tropical peatland restoration modeling in Sumatera shows canal blocking can raise water tables and alter hydrological behavior — with clear implications for reducing drainage-driven vulnerability and restoring water storage functions when designed and monitored correctly[37].[4] The operational package is therefore threefold: reopen and protect floodplain corridors where feasible; rewet peat hydrological units through canal management and water-level control; and rehabilitate mangrove belts as protective buffers linked to livelihoods.[38]

2.4 Engineering with Nature, Calibrated by Basin Type

Engineered measures are necessary — but they should be prescribed with diagnosis, dose, and monitoring. International guidance on natural and nature-based features emphasizes combining engineered and nature-based measures to create space for water, detain and retain floodwaters, and reduce flood risk while avoiding the unintended consequences of purely "hard" approaches.[39]

A straightforward calibration follows watershed morphology. High-relief basins need debris and sediment management and slope protections, paired with flash-flood warning capacity. Moderate relief systems need river-corridor capacity management, enforceable setbacks, controlled flood storage, and riparian restoration. Low-relief plains need drainage and backwater control, coastal wetland restoration where relevant, and subsidence-aware planning.[40]

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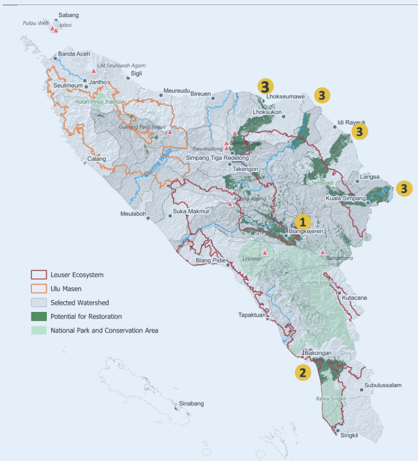
[35] ERDC, 2021, *op cit*.
[36] Dodman, *et al*., 2022, *op cit*.; Beck, M., G.M. Lange, S. Narayan, 2019. "The miracle of mangroves for coastal protection in numbers," World Bank Blogs, World Bank (May 31, 2018). https://blogs.worldbank.org/en/voices/miracle-mangroves-coastal-protection-numbers (accessed on January 7, 2026).
[37] Höglund, A., M. Menberu, D. Turetsky, and others, 2023. "A process-based model for quantifying the effects of canal blocking on water table and CO2 emissions in tropical peatlands," *Biogeosciences*, 20, pp. 2099–2121.
[38] Dodman, *et al*., 2022, *op cit*.; Höglund, A., M. Menberu, D. Turetsky, and others, 2023. "A process-based model for quantifying the effects of canal blocking on water table and CO2 emissions in tropical peatlands," *Biogeosciences*, 20, pp. 2099–2121.
[39] ERDC, 2021, *op cit*.
[40] Dodman, *et al*., 2022, *op cit*.

Box 1: Recover with Nature in Aceh

Aceh's ecological recovery strategy can be framed as a simple, discipline-driven sequence: conserve what still works, rehabilitate what has been weakened, and restore what has been lost. The table below shows such sequence into a spatial plan anchored in the province's remaining ecological infrastructure — the Leuser ecosystem, the Ulu Masen forest block, the Singkil swamp forests, and the east-coast mangrove belt — and then connect it to the hydrological logic of floods: slow the runoff pulse upstream, reduce sediment and debris mobilization in mid-slopes, and create safe "storage and buffering surfaces" in floodplains, peat, and coasts.

Conserve what we still have. The Leuser ecosystem covers more than 2.6 million hectares and still retains about 1.8 million hectares (around 70 percent) of primary and secondary dryland forest, representing Aceh's most valuable "risk infrastructure" — intact headwaters and humid forests that stabilize slopes and regulate the timing of runoff. The Ulu Masen forest block (about 738,000 hectares) is identified as a Provincially Strategic Area with largely intact forest cover; the slides note that a gold mining permit in the area expired in 2024, which is a governance opportunity: keep the area intact rather than allowing the next permit cycle to reopen risk. The Singkil landscape (around 65,000 hectares of swamp forest) and the east-coast mangroves (22,204 hectares, largest in Aceh Tamiang and also in Aceh Timur and Kota Langsa) are presented as priority coastal-risk infrastructure: lose them and the coast becomes more exposed to flooding, backwater effects, and storm impacts. In short, conservation here is not an "environment" program; it is the least expensive line item in flood risk reduction.

Rehabilitate damaged ecologically sensitive areas that we still have. The slides emphasize the mid-slope and headwater transition zones — where steep terrain meets roads, smallholder mosaics, and commodity corridors — as high leverage for reducing hazard amplification. A key example is the buffer around Ulu Masen, where about 5,300 hectares of deforestation is detected and flagged for rehabilitation. The slides also identify watersheds showing recent forest-loss signals that may increase future flood potential, including Peusangan, Mane, Woyla, Meureubo, Geukuh, Jambo Aye, Tamiang, Tripa, and Teunom. The analytic implication is straightforward: these are candidate basins for an enforceable "rehabilitation-plus-compliance" package — assisted natural regeneration and slope stabilization tied to land-use rules, permit conditions, and corridor protection, so restoration is not voluntary, episodic, or donor-dependent.



Restore ecologically sensitive areas that we lost. The slides identify restoration priorities that function as hydrological control surfaces: peat hydrological restoration (18,500 hectares across broader Leuser and Singkil peat landscapes) and lowland river corridors in Aceh Tamiang (23,000 hectares), Aceh Timur (38,300 hectares), and Aceh Utara (12,700 hectares). Restoration is targeted to where risk reduction "pays twice": peat rewetting reduces drainage-driven vulnerability and restores water regulation, while lowland corridor restoration increases floodplain function and reduces recurring inundation impacts. The slides also note that recent forest loss signals are concentrated in the 500–2,000 meter elevation belt and in high-relief basins (relief ratio 34–45) such as Kluet, Jambo Aye, Tamiang, Tripa, and Teunom — which is exactly where slope instability and debris-flow risks tend to compound rainfall hazards.

Box 1 Figure. Ecological recovery of Aceh: Conserve, rehabilitate, and recover all ecological and hydrological assets.

2.5 Early Warning That Actually Warns

Early warning fails when thresholds are not linked to local risk, and alerts are not linked to actions people can execute. A text message is not a system. World Meteorological Organization (WMO)'s *Early Warnings for All* framing is explicit that effective systems require end-to-end capacity — monitoring and forecasting, warning dissemination, preparedness, and response — rather than isolated technology upgrades.[41]

The operational design should therefore define actionable triggers per watershed (linked to response tiers), standardize village protocols and evacuation routes, and invest in last-mile redundancy — sirens, radio, and safe shelters — with drills that make procedures real rather than aspirational.[42]

2.6 Safer Settlements and River Setbacks

Some settlements are exposed because they are poor; others are exposed because planning and enforcement allowed risk to accumulate. Either way, the river will eventually collect the debt. Indonesia already has a clear legal basis for river setbacks through the Ministry of Public Works and Public Housing regulation on river and lake setback lines — the missing piece is consistent enforcement and the political willingness to prevent re-occupation of floodways.[43]

Where repeated inundation is unavoidable, managed retreat should be treated as risk restructuring, not defeat — implemented with fair compensation, livelihood transition support, and enforceable spatial plans that prevent "build back in the floodway" as the default recovery policy.

2.7 Watershed-to-Coast Governance

The governing unit of this disaster is not the district boundary — it is the watershed-to-coast system. Rivers do not stop at administrative borders, sediment does not ask for a permit, and flood peaks do not wait for coordination meetings. Indonesia's own watershed governance framework already treats the *daerah aliran sungai* (watershed) as a management unit that must be planned, monitored, and restored as a connected system from headwaters to downstream receiving areas.[44] The practical gap is that budgets, licensing, spatial plans, and enforcement still tend to operate in fragments — which is precisely how upstream risk becomes downstream catastrophe.

A workable reform is province-led coordination built around priority watersheds — with clear operating authority to align (1) spatial plans and zoning, (2) river setbacks and floodplain rules, (3) restoration priorities, and (4) emergency protocols across the connected ridge–river–plain–coast chain. This is fully consistent with the disaster-risk-governance logic in the Sendai Framework: risk is managed through governance systems that can coordinate across sectors and scales, not through post-disaster improvisation.[45]

Two implementation points matter. First, river setbacks and floodplain

[41] "Early Warnings for All," WMO (World Meteorological Organization) (2022). https://wmo.int/activities/early-warnings-all (accessed on January 7, 2026).
[42] ibid.
[43] MPWH (Ministry of Public Works and Housing, Kementerian Pekerjaan Umum dan Perumahan Rakyat), 2015. Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat No. 28/PRT/M/2015 tentang Penetapan Garis Sempadan Sungai dan Garis Sempadan Danau.
[44] RI, 2012. Peraturan Pemerintah Republik Indonesia No. 37/2012 tentang Pengelolaan Daerah Aliran Sungai.
[45] UNDRR (United Nations Office for Disaster Risk Reduction), 2015. Sendai Framework for Disaster Risk Reduction 2015-2030 (March 18, 2015).

zoning must be made enforceable through spatial planning instruments, not left as "nice-to-have" technical guidance.[46] Second, each priority watershed needs a single public risk register — the authoritative list of permits, hotspots, restoration obligations, and critical assets — so everyone argues from the same map and the same facts (and so accountability has something concrete to attach to).[47]

2.8 Permit Integrity and Risk-Based Licensing

Risk is often permitted into existence. The uncomfortable truth is that many "natural" disasters are also administrative products: licenses issued in headwaters, roads cut into steep slopes, drainage canals opened in sensitive hydrological units, and riparian buffers quietly traded away — each decision small on paper, cumulative in the river. Indonesia's environmental governance framework already requires that environmental safeguards and approvals sit inside the licensing architecture, including the Analisis Mengenai Dampak Lingkungan (AMDAL) and the Kajian Lingkungan Hidup Strategis (KLHS).[48] The reform agenda is to make those instruments do what they were meant to do: assess real risk (including cumulative watershed hydrology and sediment), impose enforceable conditions, and stop high-risk conversion before the bill arrives.

That points directly to time-bound, risk-based permit auditing — focused on headwaters, steep slopes, riparian corridors, peat hydrological units, and known floodplain encroachment zones. Where permits fail the public-safety test, suspend, amend, or revoke — and publish the reasons. This is not radical; it is basic licensing integrity. It is also aligned with the Corruption Eradication Commission's (Komisi Pemberantasan Korupsi, KPK) repeated warnings that subnational permitting remains a major vulnerability channel for governance failure and corruption risk.[49]

Finally, transparency must be structural, not cosmetic. Risk-based licensing cannot work on conflicting maps and partial registries. The One Map Policy (Kebijakan Satu Peta) exists precisely to reduce overlap, ambiguity, and opportunistic interpretation — which is another way of saying it helps reduce risk-by-paperwork.[50]

There is no need for a provincial blame-map. There is only a needs for a risk map. The relevant question is whether land-use decisions reduced storage, increased runoff, and placed assets in harm's way — and whether those decisions are still being repeated.

2.9 Fiscal Realignment and Blended Finance

This disaster is a fiscal event as much as a hydrological one. When risk accumulates upstream, the bill lands downstream — on emergency budgets, reconstruction, lost output, and household balance sheets. Indonesia's intergovernmental fiscal

[46] MPWH, 2015, Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat No. 28/PRT/M/2015 tentang Penetapan Garis Sempadan Sungai dan Garis Sempadan Danau.
[47] RI, 2016. Peraturan Presiden Republik Indonesia No. 9/2016 tentang Percepatan Pelaksanaan Kebijakan Satu Peta pada Tingkat Ketelitian Peta Skala 1:50.000.
[48] RI, 2021b. Peraturan Pemerintah Republik Indonesia No. 22/2021 tentang Penyelenggaraan Perlindungan dan Pengelolaan Lingkungan Hidup
[49] "Perizinan Daerah Masih Rawan Korupsi, KPK, Kemendagri, Kejagung, Polri, dan Bappisus Sepakat Perkuat Pengawasan", KPK (Komisi Pemberantasan Korupsi, Corruption Eradication Commission) (February 4, 2025). https://kpk.go.id/id/ruang-informasi/berita/perizinan-daerah-masih-rawan-korupsi-kpk-kemendagri-kejagung-polri-dan-bappisus-sepakat-perkuat-pengawasan (accessed on January 7, 2026).
[50] RI, 2016, *op cit*.

system already provides instruments that can be oriented toward performance and risk reduction, including transfers and fiscal incentives governed through national regulations.[51] The reform move is to reward provinces, districts, and villages for measurable risk reduction and restoration — not simply to reimburse losses after disaster. (Incentives that arrive *before* the flood are cheaper than compensation that arrives after.)

A credible recovery program therefore needs blended finance: public budgets for core protective works, restoration, and social protection; development partners and philanthropy for flexibility and innovation; and private investment where cashflows exist (for example, resilient agriculture value chains, verified restoration outcomes, and risk-reducing infrastructure tied to service delivery). This logic is consistent with the Sendai Framework's emphasis on investing in disaster risk reduction as a development and resilience strategy — not as an afterthought.[52]

Institutionally, Indonesia already has a national environmental fund architecture. The governance framework for environmental funding and its management arrangements (including the Environmental Fund Management Agency, Badan Pengelola Dana Lingkungan Hidup, BPDLH) is set out in presidential and finance-ministry regulations.[53] This creates a plausible anchor for pooled finance windows that can support watershed-to-coast recovery portfolios — provided governance is transparent, criteria are risk-based, and monitoring is public-facing (because finance without credibility is just another form of runoff).[54]

2.10 Accountability: Enforcement, Transparency, and Anti-Corruption

Floods expose not only rivers, but institutions. When permits can be bent, data can be hidden, and enforcement is optional, risk becomes a governance product — and the public eventually pays for it in casualties and reconstruction. That is why accountability is not a "governance annex"; it is a risk-reduction tool. The KPK's prevention agenda — including the Monitoring Center for Prevention (MCP) framework and its explicit focus on transparency, regulation, and accountability — reflects the reality that weak local governance systems create predictable corruption and service-delivery failures, including in licensing-heavy sectors.[55]

Practically, accountability in a flood-recovery reform agenda comes down to three enforceable moves. First, publish watershed-level permit registries and audit outcomes, with clear legal follow-up and timelines. Second, link enforcement to restoration orders in high-risk zones (riparian recovery, slope stabilization, peat rewetting) so sanctions and remedies travel together. Third, make transparency operable — through One Map-aligned geospatial disclosure and accessible grievance channels — so communities can report risky activities early, and so regulators cannot claim they "did not see" what the map plainly shows.[56]

2.11 Climate Crisis: The New Baseline

Climate change is no longer a "special circumstance" that shows up only

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[51] RI, 2023. Peraturan Pemerintah Republik Indonesia Nomor 37 Tahun 2023 tentang Pengelolaan Transfer ke Daerah.
[52] UNDRR, 2015, *op cit*.
[53] RI, 2018. Peraturan Presiden Republik Indonesia Nomor 77 Tahun 2018 tentang Pengelolaan Dana Lingkungan Hidup; MOF (Ministry of Finance), 2020. Peraturan Menteri Keuangan Nomor 124/PMK.05/2020 tentang Tata Cara Pengelolaan Dana Lingkungan Hidup.
[54] RI, 2017. Peraturan Pemerintah Republik Indonesia Nomor 46 Tahun 2017 tentang Instrumen Ekonomi Lingkungan Hidup.
[55] "KPK Luncurkan Indikator MCP 2025 untuk Perkuat Pencegahan Korupsi di Daerah," KPK (March 5, 2025).
[56] RI, 2016, *op cit*.

when the weather feels dramatic. It is the baseline that is quietly moving under our feet — and, in a country built on water, that matters. The Intergovernmental Panel on Climate Change (IPCC) finds (with high confidence) that heavy precipitation intensifies with warming at roughly the Clausius–Clapeyron rate, about six to seven percent per one degree Celsius — meaning the odds of very wet days, and the volumes delivered on those days, trend upward as temperatures rise.[57] In practice, this is why it is increasingly unhelpful to treat recent flood disasters as statistical misbehavior by the atmosphere. The physics is no longer neutral, and "extreme" is starting to look uncomfortably familiar.

That does not mean countries are helpless; it means they have homework. Under the Paris Agreement, Parties are expected to both reduce emissions and strengthen resilience — adaptation is not charity work, it is core climate governance.[58] For Indonesia, this is not theoretical. The Government of Indonesia has submitted its Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050), which frames a long-run development pathway that is explicitly low-carbon and climate-resilient.[59] Indonesia has also submitted its Second Nationally Determined Contribution, which positions mitigation and adaptation together and explicitly aligns the Second Nationally Determined Contribution with LTS-LCCR 2050, including a vision of "archipelagic climate resilience" by 2030.[60] And in the Forestry and Other Land Use (FOLU) sector, Indonesia has operationalized the FOLU Net Sink 2030 agenda through a dedicated operational plan and policy instruments — with a stated trajectory toward net removals by 2030 and detailed measures centered on reducing deforestation and forest degradation, strengthening sustainable forest management, and protecting and restoring peatlands and mangroves.[61]

These commitments matter for two reasons. First, they set a clear standard for domestic consistency: if climate risk is the new normal, then spatial planning, permitting, watershed protection, and public investment must stop pretending otherwise. Second, they position Indonesia to credibly pursue international support for adaptation and resilience — including finance linked to climate impacts and loss and damage — but credibility is earned in implementation. The international regime has moved in that direction, including decisions at the Twenty-Seventh Conference of the Parties (COP27) to establish new funding arrangements and a dedicated fund for loss and damage for vulnerable developing countries.[62] For Indonesia, the strategic point is simple:

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[57] Douville, H., K. Raghavan, J. Renwick, R.P. Allan, P.A. Arias, M. Barlow, R. Cerezo-Mota, A. Cherchi, T.Y. Gan, J. Gergis, D. Jiang, A. Khan, W. Pokam Mba, D. Rosenfeld, J. Tierney, and O. Zolina, 2021. "Water Cycle Changes", in *Climate Change 2021: The Physical Science Basis*, Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1055–1210

[58] UNFCCC (United Nations Framework Convention on Climate Change), 2015. Paris Agreement.
[59] RI, 2021, *op cit*.
[60] RI, 2025, *op cit*.. *Republic of Indonesia Second Nationally Determined Contribution* (submitted on October 27, 2025). Ministry of Environment, Jakarta.
[61] MOEF (Ministry of Environment and Forestry of the Republic of Indonesia), 2023. *FOLU Net Sink: Indonesia's Climate Actions Towards 2030.* Ministry of Environment and Forestry, Jakarta.
[62] "COP27 Reaches Breakthrough Agreement on New 'Loss and Damage' Fund for Vulnerable Countries." UNFCCC (United Nations Framework Convention on Climate Change (November 20, 2022). https://unfccc.int/news/cop27-reaches-

adaptation and mitigation are not competing priorities. They are the same policy, viewed from different ends of the river.

3 Concluding Note: Recover with Nature, Govern with Integrity

The late-November 2025 floods were not a "once-in-a-generation surprise." They were a systems failure revealed by weather. A warmer climate is already making heavy rainfall more intense, and this is not a temporary phase we can wait out.[63] The practical implication is simple: Indonesia must plan for a much wetter, more volatile baseline, and then remove the avoidable amplifiers that turn rain into disaster — degraded watersheds, fragile slopes, blocked floodplains, and settlements placed where rivers routinely reclaim space.

This is why "tobat ekologis" (ecological repentance) has to be treated as a program, not a slogan. It is not a speech, a press release, or a one-off tree-planting ceremony. It is a disciplined shift in how decisions are made: what gets licensed, what gets enforced, what gets restored, and what gets rebuilt differently. In other words, it is public safety policy — expressed through land-use governance, watershed recovery, infrastructure standards, and institutional accountability. If that sounds "political," it is — because flood risk is not only produced by hydrology, but by choices, budgets, and incentives.

Indonesia is not starting from zero. The country has already committed to a long-term pathway for low-carbon development and climate resilience and has updated its Nationally Determined Contribution (NDC) framework, including adaptation priorities and sectoral mitigation pathways.[64] These commitments sit under the Paris Agreement's global direction of travel.[65] In parallel, Indonesia's FOLU Net Sink 2030 agenda anchors a credible mitigation-and-landscape platform — and, if implemented with integrity, it can also become a resilience platform, because the same forests, peatlands, and mangroves that store carbon also regulate water.[66] The point is consistency: Indonesia should adapt to protect lives and livelihoods, mitigate to reduce the severity of future hazards, and credibly position itself to access international support for adaptation and for loss-and-damage needs.[67]

Operationally, the reform test is not complicated, but it is demanding. The Sendai Framework is blunt about what works: understand risk, govern risk, invest in risk reduction, and be ready before the next shock arrives.[3] The floods therefore leave a checklist that is boring in the best way — because boring is what functioning institutions look like:

- Treat priority watersheds (ridge-to-river-to-coast) as the main unit for planning, budgeting, monitoring, and enforcement, rather than hoping administrative boundaries will behave hydrologically.[68]
- Run time-bound, risk-based permit audits in headwaters, steep mid-slopes, riparian corridors, peat hydrological units, and floodplains — and

breakthrough-agreement-on-new-loss-and-damage-fund-for-vulnerable-countries (accessed on January 7, 2026); UNFCCC, 2023. Decision 2/CP.27 (Funding arrangements for responding to loss and damage). UNFCCC, Bonn.

[63] IPCC, 2021b. *Climate Change 2021: The Physical Science Basis*. Cambridge University Press, Cambridge.

[64] RI, 2022. *Enhanced Nationally Determined Contribution — Republic of Indonesia*. Ministry of Environment, Jakarta.

[65] UNFCCC, 2015, *op cit*.

[66] RI, 2022, *op cit*.

[67] UNFCCC, 2015, *op cit*.; RI, 2022, *op cit*.

[68] UNDRR, 2015, *op cit*.

publish decisions with reasons.

- Restore ecological infrastructure at scale (headwaters, peat, mangroves, riparian buffers) and pair it with engineering calibrated to basin type — because one-size-fits-all is not a strategy, it is a procurement plan.
- Enforce river setbacks and protect floodplain corridors; where repeated inundation is unavoidable, implement managed retreat with fair compensation and livelihood transition support.
- Build early warning that actually warns: thresholds linked to protocols, drills, shelters, and last-mile redundancy — so alerts become action, not notification fatigue.
- Finance recovery as risk reduction: combine public budgets, partner finance, and private capital where cashflows exist, but keep transparency and safeguards non-negotiable — because floods are expensive, and corruption is an unaffordable luxury.

If these steps feel strict, that is because the river is stricter. The next storm will arrive on schedule — climate volatility does not wait for institutional readiness. The choice is whether it meets a landscape that has learned, or one that keeps paying tuition in lives, livelihoods, and public funds.

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Annex: Damaged Districts/ Cities and Their Priority Commodities

Kabupaten/Kota (Aceh)	Damage class	Dominant agricultural and food-system commodities most likely affected
Aceh Barat	High	Oil palm; paddy/rice; mixed smallholder crops
Aceh Besar	High	Paddy/rice; aquaculture/coastal fisheries (peri-coastal livelihoods)
Aceh Tamiang	High	Oil palm; paddy/rice (east-coast lowland systems)
Aceh Tengah	High	Arabica coffee (Gayo highlands); horticulture (upland)
Aceh Timur	High	Oil palm; paddy/rice (east-coast lowland systems)
Aceh Utara	High	Paddy/rice; oil palm (major lowland food and cash-crop corridor)
Bener Meriah	High	Arabica coffee (Gayo highlands); horticulture (upland)
Bireuen	High	Paddy/rice (key food-belt); secondary food crops
Gayo Lues	High	Arabica coffee (Gayo highlands); secondary mixed upland crops
Nagan Raya	High	Oil palm; mixed lowland agriculture
Pidie	High	Paddy/rice; mixed smallholder crops
Pidie Jaya	High	Paddy/rice; mixed smallholder crops
Aceh Selatan	Medium	Oil palm and other smallholder plantation crops; mixed agriculture
Aceh Singkil	Medium	Oil palm (lowland/peat-adjacent systems); fisheries/aquaculture
Aceh Tenggara	Medium	Upland mixed agriculture (coffee/cacao/horticulture mix in practice)
Kota Langsa	Medium	Coastal fisheries and peri-urban food supply chains
Kota Lhokseumawe	Medium	Fisheries and services (limited primary agriculture, but critical supply-chain node)
Kota Subulussalam	Medium	Oil palm (plantation-smallholder landscape)

Kabupaten/Kota (North Sumatera)	Damage class	Dominant agricultural and food-system commodities most likely affected
Deli Serdang	High	Paddy/rice (major producer); horticulture (market-facing)
Tapanuli Selatan	High	Mixed plantation agriculture (oil palm/rubber commonly material); mixed food crops
Tapanuli Tengah	High	Coastal fisheries; mixed agriculture (river-to-coast systems)
Serdang Bedagai	High	Paddy/rice (major producer); oil palm (lowland cash crop)
Batu Bara	Medium	Oil palm; mixed lowland agriculture
Humbang Hasundutan	Medium	Highland horticulture (notably vegetables); mixed upland crops
Kota Sibolga	Medium	Coastal fisheries (landing and services)
Langkat	Medium	Oil palm; mixed lowland agriculture
Tapanuli Utara	Medium	Upland agriculture (coffee/horticulture mix in practice)
Asahan	Low	Oil palm; mixed agriculture
Kota Binjai	Low	Peri-urban horticulture and food distribution functions
Kota Medan	Low	Food distribution hub; peri-urban horticulture; fisheries value chains

Kota Padang Sidempuan	Low	Mixed upland agriculture (horticulture/coffee mix in practice)
Kota Tebing Tinggi	Low	Peri-urban horticulture and food distribution functions
Mandailing Natal	Low	Upland mixed agriculture (coffee/plantation mix in practice)
Nias	Low	Coconut and mixed smallholder crops; fisheries
Nias Selatan	Low	Coconut and mixed smallholder crops; fisheries
Pakpak Bharat	Low	Upland mixed agriculture (coffee/horticulture mix in practice)

Kabupaten/Kota (West Sumatera)	**Damage class**	**Dominant agricultural and food-system commodities most likely affected**
Agam	High	Paddy/rice (documented as a major food area); horticulture
Padang Pariaman	High	Paddy/rice; coastal fisheries and coconut (mixed coastal livelihoods)
Pasaman Barat	High	Oil palm (very large plantation area); mixed food crops (including upland rice initiatives)
Kepulauan Mentawai	Medium	Fisheries; coconut; sago and mixed smallholder crops
Kota Padang	Medium	Food distribution hub; coastal fisheries value chains
Kota Pariaman	Medium	Coastal fisheries; peri-urban food supply chains
Kota Solok	Medium	Peri-urban horticulture/food distribution (limited primary production)
Lima Puluh Kota	Medium	Paddy/rice; horticulture
Pasaman	Medium	Paddy/rice; mixed upland agriculture
Pesisir Selatan	Medium	Coastal fisheries; mixed agriculture (including plantation–food crop mosaic)
Solok	Medium	Paddy/rice; horticulture
Tanah Datar	Medium	Paddy/rice; horticulture
Kota Bukittinggi	Low	Market/services hub for surrounding horticulture areas
Kota Padang Panjang	Low	Peri-urban horticulture (limited area, but supply-chain role)
Kota Payakumbuh	Low	Peri-urban horticulture and food distribution functions
Solok Selatan	Low	Plantation agriculture (oil palm commonly material); mixed upland crops

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