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Research Paper Title :Artificial Intelligence for Climate Risk, Emissions Intelligence and Planetary-Scale Environmental Decision-Making

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Abstract:
This study investigates how artificial intelligence can be positioned not merely as a predictive tool but as an environmental intelligence infrastructure for climate-risk assessment, emissions monitoring and planetary-scale decision support. The paper synthesises recent advances in climate analytics with a transparent, data-grounded framework that links Earth-system indicators, disaster impacts and emissions trajectories to structured policy prioritisation. Rather than relying on synthetic data or hypothetical simulations, the analysis is built from current official sources, including the World Meteorological Organization, the Global Carbon Budget and EM-DAT. The resulting framework is designed for a context in which climate governance increasingly depends on continuous observation, rapid interpretation and accountable triage under conditions of uncertainty.

The empirical analysis shows that multiple planetary indicators are now moving in the same adverse direction. Atmospheric carbon dioxide reached 420.0 ppm in 2023, global mean near-surface temperature reached 1.55°C above the 1850–1900 average in 2024, the contemporary rate of ocean heat uptake is more than three times the 1960–2005 midpoint estimate, and the recent rate of sea-level rise is more than double that of the first satellite decade. In parallel, fossil CO2 emissions are projected by the Global Carbon Budget to reach a record 37.4 GtCO2 in 2024, while EM-DAT recorded 393 natural-hazard disasters and US$241.95 billion in economic losses in 2024. These observations indicate that climate governance can no longer rely on siloed sectoral monitoring; integrated, machine-assisted prioritisation is becoming a practical necessity.

A mathematically explicit prioritisation model is therefore proposed to convert observed emissions size and emissions momentum into a mitigation urgency score for major emitting blocs. The resulting ranking identifies the rest of the world aggregate, China and India as the three highest-priority mitigation domains under current global conditions, while also demoneed for continued intervention because of their still-large abs olute contribution. strating that declining emissions in the United States and EU27 dost combine transparent indicator construction, traceable data provenance, interpretable scoring logic and institutional accountability. In this form, artificial intenot eliminate the nThe study argues that a credible AI-for-climate architecture mulligence becomes a decision-enabling layer for emissions intelligence, resilience planning and planetary-scale environmental coordination rather than a black-box substitute for governance.

Keywords: Artificial intelligence; climate risk; emissions intelligence; Earth-system indicators; environmental decision-making; climate governance; carbon budget; planetary analytics

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6.1 Conclusion

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1. Introduction

1.1 Climate risk as a planetary-scale intelligence problem

Climate change has altered the scale, speed and interdependence of environmental risk to such an extent that conventional monitoring architectures are increasingly inadequate. The contemporary challenge is no longer limited to describing isolated hazards such as floods, droughts, sea-level rise or heat extremes in separate institutional silos. It now involves the interpretation of coupled signals across atmospheric composition, ocean warming, cryosphere decline, disaster losses, energy systems and socio-economic vulnerability. Within this setting, climate risk becomes an intelligence problem: the central task is to transform high-volume, heterogeneous and rapidly updating environmental observations into decisions that can be acted upon across governments, infrastructure operators, development institutions and emergency systems.

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The planetary scale of the problem is decisive. Carbon dioxide emitted in one jurisdiction modifies radiative forcing globally, ocean heat accumulation redistributes risk across marine and coastal systems, and teleconnected climate modes amplify impacts far beyond the geography of immediate emissions. Decision-makers therefore require analytical systems capable of integrating multi-source evidence and translating it into interpretable priorities. Artificial intelligence offers a route toward that capability because it can ingest large observational streams, detect non-linear relationships and support rapid environmental triage. However, the value of AI in this domain depends on whether it is embedded within transparent scientific and institutional logic rather than treated as an autonomous solution.

This study therefore positions artificial intelligence within the broader concept of environmental intelligence. The term is used here to denote the systematic acquisition, harmonisation, interpretation and prioritisation of Earth-system and socio-environmental data for decision support. Such a framing shifts attention away from narrow forecasting accuracy and toward policy relevance, traceability and scale. It also makes explicit that the climate problem is not simply a matter of prediction; it is equally a matter of deciding which signals matter most, which geographies demand attention first and which interventions remain meaningful under shrinking carbon budgets.

1.2 From environmental monitoring to environmental decision-making

A large body of climate science already provides reliable monitoring of temperature, greenhouse gas concentrations, sea level, ocean heat, cryosphere change and hazard occurrence. Earth observation systems, reanalysis products and international reporting infrastructures have improved substantially over the past two decades. Yet the existence of excellent monitoring does not automatically generate coherent governance. Data abundance can coexist with decision fragmentation when indicators are not connected to clear prioritisation rules, when ministries operate on different temporal scales, or when environmental evidence remains inaccessible to non-specialist decision-makers. The operational gap is therefore not simply informational; it is decisional.

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This gap is especially visible in the separation between mitigation analytics and adaptation analytics. Emissions accounting frameworks commonly identify where greenhouse gases are produced and how quickly they are changing, whereas disaster and resilience frameworks describe who is exposed, who is affected and how losses are distributed. In policy practice these domains are too often handled separately even though they are analytically entangled. Large emitters shape long-run warming, while adaptation deficits determine how that warming is experienced as concrete social loss. AI systems that privilege only one side of this equation risk producing partial or distorted guidance. A higher-level integrative framework is therefore required.

The proposed framework responds to this challenge by linking observed planetary indicators with bloc-level emissions intelligence and a transparent prioritisation score. This structure does not claim to replace physical climate models, integrated assessment models or expert judgment. Instead, it acts as an interpretable decision layer that can sit between measurement and policy action. Such a layer is particularly valuable for ministries, multilateral agencies and climate-finance actors that must allocate attention and resources quickly while maintaining accountability to scientifically verifiable indicators.

1.3 Objectives, scope and contribution of the study

This study has three main objectives. First, it develops a conceptually rigorous account of artificial intelligence as an environmental intelligence architecture for climate governance rather than as an isolated predictive model. Second, it constructs a

real-data analytical framework that connects observed Earth-system indicators, global disaster impacts and major-bloc emissions trajectories. Third, it demonstrates how a transparent mathematical scoring structure can assist policy prioritisation without obscuring the underlying evidence. The aim is not to claim finality for any single metric, but to show that explainable AI-style prioritisation can be grounded in publicly reported climate indicators and interpreted within established scientific literature.

The scope of the analysis is deliberately planetary rather than country-specific. This choice reflects the title of the study and the underlying governance problem: environmental decision-making increasingly requires simultaneous reasoning across global biophysical thresholds, major emitting blocs and multi-hazard losses. A planetary frame does not deny the importance of local vulnerability; rather, it provides a strategic layer suited to multilateral institutions, global climate-finance design and transboundary risk governance. The empirical focus is therefore placed on a set of globally salient indicators drawn from authoritative sources published in 2024 and 2025, including atmospheric greenhouse gases, temperature, ocean heat content, sea-level rise, disaster occurrence, economic losses and fossil CO2 emissions.

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The contribution of the paper is methodological and interpretive. Methodologically, the paper demonstrates how a PhD-level manuscript can combine current official datasets, explicit equations and decision-oriented tables and figures without resorting to synthetic data. Interpretively, it argues that AI becomes most valuable in climate governance when it functions as a structured translator between monitoring systems and institutional action. The resulting manuscript is intended to be realistic in form and content for a high-quality journal article or thesis chapter in environmental data science, climate policy, or AI for sustainability.

2. Theoretical Foundation and Related Literature

2.1 Artificial intelligence in Earth observation and climate analytics

The application of artificial intelligence to Earth observation has expanded rapidly, driven by the proliferation of remote sensing data, reanalysis archives, atmospheric inversions, disaster event databases and large-scale energy statistics. Machine learning has been used for land-cover classification, wildfire detection, flood mapping,

emissions estimation, downscaling, anomaly detection and impact forecasting. These developments matter because climate governance now depends on both temporal immediacy and cross-domain integration. AI can improve these capacities by handling high-dimensional data and by identifying complex dependencies that would be difficult to encode using purely linear or manually curated rules.

At the same time, the environmental sciences have shown that model sophistication alone does not guarantee policy usefulness. Many high-performing algorithms remain difficult to audit, replicate or translate into institutional decisions. In climate settings, this is particularly problematic because policy choices often involve distributional consequences, legal accountability and long time horizons. For that reason, the present study adopts an interpretable analytic stance. The framework retains the AI ethos of structured inference and prioritisation, but it avoids black-box optimisation that cannot be meaningfully scrutinised by public institutions. The study thereby aligns more closely with explainable and decision-centric AI than with opaque predictive automation.

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This section of the paper therefore treats artificial intelligence as a set of capabilities rather than a single model class. These capabilities include multi-source data fusion, rapid pattern extraction, threshold detection, prioritisation under uncertainty and support for scenario-sensitive decision routines. Such a perspective is better suited to environmental governance because it allows machine-assisted analysis to remain subordinate to scientific evidence and public accountability. In other words, the analytical objective is not only to forecast climate futures but to support credible environmental reasoning in the present.

A. Explainable, Trustworthy and Normative AI for Environmental Decision-Making

A first research subtheme concerns the governance architecture required for artificial intelligence to operate legitimately in climate-risk and environmental decision contexts. The supplied literature indicates that environmental AI cannot be assessed only through predictive accuracy; it must also be evaluated through transparency, explainability, accountability and social benefit. This orientation is visible in Pasupuleti's work on socially beneficial AI, uncertainty-aware futures modelling, and control-theoretic AI safety, which collectively frame environmental intelligence as a high-stakes decision domain requiring formal assurance, interpretable outputs and institutional safeguards (Pasupuleti 2021a, 2021b, 2021c). These contributions are

strongly reinforced by the wider literature on the normative challenges of automated decision-making and the need to quantify trustworthiness in explainable AI under uncertainty (Orwat et al. 2022; Nimmy et al. 2025).

Within the context of climate governance, this subtheme is especially important because mitigation, adaptation and loss-allocation decisions are politically sensitive and distributive in their effects. Explainable AI frameworks for risk management and strategic decision-making suggest that environmental intelligence systems should not merely rank hazards or recommend interventions, but should expose the reasoning structure, confidence levels, and trade-offs behind such recommendations (Badhon et al. 2025; Ujwary-Gil & Florek-Paszkowska 2025). In planetary-scale applications, this implies that climate-risk platforms must be designed as auditable infrastructures capable of supporting public agencies, utilities, cities and international institutions. The policy implication is that trustworthy environmental AI requires model governance, uncertainty disclosure, and decision traceability to avoid opaque and potentially inequitable climate action.

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B. Geospatial Climate Risk, Hydrologic Intelligence and Spatio-Temporal Environmental Analytics

A second subtheme concerns the technical evolution from conventional environmental monitoring toward spatio-temporal AI systems that integrate hydrologic simulation, GIS analytics, remote sensing and causal environmental inference. The Pasupuleti corpus shows a clear methodological trajectory in this direction. Early work on climate and flood risk in data-centre strategy and GIS-based multi-criteria siting established the importance of embedding hydrologic exposure and spatial risk into infrastructure planning rather than treating climate as an externality (Pasupuleti 2022a, 2022b). This trajectory then deepened through AI hydrologic nowcasting in HEC-HMS and AI climate-risk analytics in ArcGIS, where the integration of graph-based learning, remote sensing and spatial causality moved the field closer to real-time environmental intelligence (Pasupuleti 2023a, 2023c).

This subtheme is directly relevant to the new paper title because planetary-scale environmental decision-making depends on continuous geospatial interpretation of

hazards, exposure and vulnerability across multiple scales. The broader literature on environment-aware digital twins also reinforces the need to bring weather and climate information into risk-based operational systems rather than restricting such data to offline scenario analysis (Dale et al. 2023). In practical terms, this research cluster supports flood early warning, land-use suitability assessment, water-resource risk mapping, and infrastructure resilience planning. Its global significance lies in the ability to connect regional climate extremes with local operational decisions, thereby turning Earth observation and hydrologic intelligence into actionable policy tools.

C. Digital Twins, Infrastructure Resilience and Cascading Environmental Risk

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A third subtheme is the use of digital twins and simulation-based intelligence to manage environmental risk in coupled infrastructure systems. The supplied references suggest that climate risk is no longer confined to isolated sectors, but propagates across data centres, energy systems, urban services and supply chains. Pasupuleti's work on AI digital twins in Simulink, climate- and flood-aware data-centre siting, and climate/disaster response benchmarking for Indian states illustrates how environmental intelligence increasingly depends on hybrid modelling environments that fuse physical simulation, AI prediction and policy-oriented decision logic (Pasupuleti 2023b; Pasupuleti 2024c, 2024d). These contributions are aligned with broader research on environment-aware digital twins as platforms for risk-based decision-making under weather and climate uncertainty (Dale et al. 2023).

The conceptual advance here is that digital twins are not merely replicas of assets, but decision infrastructures that allow continuous stress-testing of future states under environmental volatility. That has direct relevance for planetary-scale decision-making because climate hazards trigger cascading failures across interconnected systems rather than single-point losses. The policy consequence is substantial: governments and operators require twin-based platforms capable of integrating meteorological, hydrological, energy and operational data into intervention pathways that are timely, explainable and adaptive. This makes digital twins central to anticipatory governance, especially in sectors such as water, energy, telecom and critical urban infrastructure.

D. Emissions Intelligence, Energy Systems and ESG Measurement Architectures

A fourth subtheme concerns emissions intelligence as an integrated field connecting AI forecasting, energy optimization, ESG measurement and sustainability benchmarking. The references supplied by Pasupuleti show that environmental decision-making increasingly relies on linked systems of energy forecasting, geospatial infrastructure planning, and state-level ESG evaluation. Relevant works include AI-driven smart grids and renewables forecasting, geo-visual analytics for energy-efficient infrastructure, just-transition roadmaps, and state-level ESG measurement and assurance frameworks (Pasupuleti 2024b, 2024e, 2024f, 2024g). Together, these studies shift the focus from generic sustainability rhetoric toward measurable, decision-ready emissions and transition intelligence.

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This subtheme is especially relevant to the paper title because emissions intelligence requires more than accounting; it requires predictive, spatial and institutional interpretation of emissions drivers and decarbonization pathways. When linked with explainable AI and strategic decision systems, ESG and energy analytics can support infrastructure investment, transition finance, renewable integration and climate disclosure regimes (Ujwary-Gil & Florek-Paszkowska 2025). From a global perspective, this cluster is significant because different jurisdictions face varied energy mixes, institutional capacities and climate exposures. AI-enabled emissions intelligence can therefore function as a bridging architecture between local data systems and international climate governance, especially where decarbonization choices must be balanced against affordability, reliability and social equity.

E. Large-Scale Collective Decision-Making, Multi-Actor Coordination and Planetary Governance

A fifth subtheme concerns the governance of climate and environmental decisions across large populations, institutions and jurisdictions. The external literature supplied by the user is particularly strong in this area, highlighting large-scale group decision-making, communicability-driven expert influence, echo chamber effects, hesitant fuzzy decision models and artificial intuition in automated systems (Trovati et al. 2023; Hu, Zhu & Tang 2025; Sun et al. 2025; Li et al. 2026). Although not all of these

studies are climate-specific, they are highly relevant to planetary-scale environmental decision-making because climate governance is fundamentally multi-actor, multi-criteria and conflict-prone. The challenge is not only to model climate systems, but also to coordinate actors who interpret evidence differently and possess unequal institutional power.

Pasupuleti's climate/disaster benchmarking and governance-oriented AI studies provide a bridge between these decision sciences and applied environmental policy. Works on AI for climate risk and disaster response, agri-AI for climate-smart farming, and socially beneficial AI all suggest that environmental intelligence must be translated into scalable governance architectures that can operate across states, sectors and development levels (Pasupuleti 2021c; Pasupuleti 2024a, 2024c). The broader implication is that planetary environmental governance requires AI systems that support consensus formation, conflict-sensitive prioritization and robust coordination under uncertainty. This subtheme therefore extends the discussion from technical modelling to institutional design, showing how environmental AI may influence adaptation planning, resource allocation, and transboundary climate strategy.

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2.2 Climate risk, emissions intelligence and coupled human–natural systems

Climate risk emerges from the interaction of hazard, exposure, vulnerability and response capacity. This formulation is well established in climate and disaster literature, but its practical interpretation becomes more complex when the system is viewed at planetary scale. Hazard intensification is linked to cumulative greenhouse gas forcing, yet social outcomes depend on infrastructure, preparedness, governance, land use and wealth distribution. Emissions intelligence is therefore not a substitute for climate-risk analysis; it is one of its constitutive layers. Major emitters affect the trajectory of the hazard field, while adaptation and resilience conditions shape the realised severity of impacts.

The coupled character of the problem also challenges simplistic narratives of responsibility. Absolute emissions, growth rates, per capita emissions, historical accumulation and current vulnerability all point to different policy obligations. A robust climate-intelligence framework must therefore acknowledge multiple dimensions simultaneously. This is one reason why current climate governance often

appears normatively contested: different actors select different metrics to justify their preferred policy emphasis. An AI-assisted decision framework can be useful only if it makes those metric choices explicit and traceable. Hidden weighting schemes would merely reproduce political opacity in technical form.

Accordingly, the present research distinguishes clearly between observed Earth-system escalation signals and bloc-level emissions intelligence. The first captures the condition of the planetary system; the second identifies where near-term mitigation attention is most urgent under current emissions dynamics. The analytical connection between the two is conceptual rather than causal in a strict statistical sense, because the data assembled here are intentionally heterogeneous and governance-oriented. Nevertheless, when these strands are analysed together, they provide a realistic basis for structured environmental triage and for the design of institutionally usable climate dashboards.

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2.3 Decision theory for planetary-scale environmental governance

Decision-making under climate change is characterised by deep uncertainty, irreversibility and asymmetry of consequences. Many environmental harms are slow to accumulate but difficult to reverse, while policy delay can lock in both physical and infrastructural trajectories. This creates a strong case for decision frameworks that are sensitive to thresholds, path dependency and precaution. Planetary-scale governance intensifies the challenge because decisions must be made in the presence of incomplete information, unequal capacities and competing temporal horizons. AI can aid this process only if it is embedded within a transparent decision theory rather than treated as a neutral computational add-on.

The relevant theoretical foundation combines three ideas. First, indicator-based governance remains indispensable because many public institutions act through monitored targets and formally reported metrics. Second, multi-criteria prioritisation is unavoidable because no single climate indicator captures mitigation need, adaptation urgency and systemic risk simultaneously. Third, explainability is not optional in public-interest AI. Decisions that affect development finance, infrastructure planning or emissions regulation must remain interpretable to policymakers, reviewers and affected communities. The present study therefore

adopts a scoring logic that is intentionally simple, auditable and explicit about its weights.

This theoretical stance does not imply that simple scores solve the politics of climate governance. Rather, it recognises that institutional decisions often begin with ranked attention. A prioritisation score can identify where deliberation should intensify, where further investment in modelling is warranted, or where urgent intervention is justified even before a fully optimised solution is available. In this sense, the paper aligns AI with the pragmatic architecture of governance: not as an oracle, but as a disciplined means of converting complex environmental evidence into ranked policy attention.

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3. Methods

3.1 Research design and analytical architecture

The research design is a real-data, indicator-based analytical study organised around three linked layers: Earth-system escalation, emissions intelligence and decision prioritisation. The first layer compiles recent global indicators that characterise the state of the climate system and the social footprint of climate-related hazards. The second layer assembles the latest major-bloc fossil CO2 emissions information. The third layer uses a transparent scoring equation to convert observed emissions size and current emissions momentum into a mitigation urgency ranking. This architecture is suited to planetary-scale decision-making because it links physical change, socio-economic consequence and governance relevance within a single analytical narrative.

The design is intentionally conservative in methodological claims. No synthetic training data are generated, no black-box machine-learning model is presented as though it had been empirically trained within the study, and no causal statement is made beyond what the underlying sources support. Instead, the analysis operates as a decision-support framework built on observed data and mathematical normalisation. This choice enhances reproducibility and avoids the common problem of presenting AI for climate as a technically impressive but weakly verifiable exercise. The framework remains compatible with future extensions involving remote-sensing pipelines, probabilistic forecasting or graph-based climate-risk models, but it does not depend on them for the present results.

The unit of analysis alternates deliberately between the planetary system and major emitting blocs. Planetary indicators reveal the aggregate condition of the Earth system and the macro-scale burden of disasters, whereas bloc-level emissions data reveal where mitigation leverage is currently concentrated. This dual scale is analytically important because climate governance must constantly move between global thresholds and geographically differentiated responsibilities. The analytical architecture adopted here is therefore not a compromise; it is a reflection of the structure of the problem itself.

3.2 Real data collection and indicator construction

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Real data were collected from three principal official or quasi-official scientific sources. First, the World Meteorological Organization's State of the Global Climate 2024 report was used to extract atmospheric carbon dioxide concentration, global mean near-surface temperature anomaly, ocean heat content change and sea-level rise rates. Second, the Global Carbon Budget 2024 was used to obtain major-bloc shares of global fossil CO2 emissions, recent growth rates and 2024 projected emissions. Third, the EM-DAT 2024 disaster review was used to collect recorded disaster occurrence, deaths, affected population and economic losses. These sources were selected because they are current, internationally recognised and explicitly designed for climate evidence reporting.

Indicator construction followed a principle of interpretability. For Earth-system variables, each current value was paired with a relevant historical or policy-relevant baseline, such as the pre-industrial CO2 concentration implied by the WMO ratio, the immediately preceding year's temperature anomaly, the earlier ocean heat uptake rate, the earlier satellite-era sea-level rise rate, or the 2004–2023 average in the disaster database. This yielded ratio-style indicators that can be interpreted without advanced statistical assumptions. Such ratios are analytically modest but institutionally useful because they communicate escalation in a form that can be understood across scientific and policy audiences.

For emissions intelligence, bloc-level indicators were selected to capture two distinct governance dimensions: scale and momentum. Scale is represented by each bloc's share of 2023 global fossil CO2 emissions and by projected 2024 absolute emissions in GtCO2. Momentum is represented by the projected percentage change in emissions

in 2024. Negative growth rates were preserved descriptively but were floored at zero in the urgency equation to avoid rewarding rising emitters and declining emitters symmetrically in the urgency calculus. This procedure was not intended as a normative claim that declining emitters require no action; it was adopted to keep the prioritisation score focused on near-term mitigation acceleration under current global conditions.

3.3 Mathematical formulation

Two equations structure the analysis. The first is a simple escalation ratio used for planetary indicators:

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$$R_j = X_j / B_j$$

where X_j denotes the current observed value of indicator j and B_j denotes a relevant baseline. When R_j is greater than 1, the indicator is above its reference level; the magnitude indicates the degree of escalation. This formulation is especially suitable for mixed-unit environmental dashboards because it avoids spurious aggregation across incompatible units while still enabling consistent visual comparison. The ratios are descriptive rather than inferential, but they are informative in a governance context where the direction and scale of change matter directly.

The second equation defines a mitigation urgency score for each emitting bloc i:

$$U_i = 100 * [\alpha(S_i/S_max) + \beta(max(G_i, 0)/G_max)]$$

where S_i is the bloc's share of global fossil CO2 emissions, G_i is its projected 2024 emissions growth rate, S_max is the maximum observed share among blocs in the sample, and $G_max$is the maximum positive projected growth rate in the same sample. The weights α = 0.7 and β = 0.3 were selected to privilege absolute emissions responsibility while still incorporating current momentum. This means that a bloc with very large emissions remains high-priority even if its short-run growth is low, whereas a rapidly growing smaller emitter can still move upward in rank if growth is substantial.

The weighting scheme is normative but explicit. It reflects a policy logic in which scale should dominate short-term momentum because climate forcing is cumulative, yet acceleration should not be ignored because rising emissions narrow the remaining carbon budget. The study does not claim that these weights are universally optimal. Rather, they are offered as a transparent baseline that can be debated, adjusted and

stress-tested. In this respect, the equation exemplifies the paper's larger methodological argument: environmental AI becomes more credible when its assumptions are declared rather than hidden.

$$R_j = X_j / B_j$$

$$U_i = 100 \times [\alpha(S_i/S_max) + \beta(max(G_i, 0)/G_max)]$$

In this study, $\alpha = 0.7$ and $\beta = 0.3$, so that absolute emissions responsibility is weighted more heavily than short-run emissions acceleration.

3.4 Analytical workflow, validation logic and reproducibility

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The analytical workflow consisted of six stages: source identification, extraction of current official values, construction of baselines, computation of escalation ratios, assembly of bloc-level emissions profiles, and generation of prioritisation scores and visualisations. Data handling was intentionally light-touch so that every number used in the final tables could be traced back to a reported source value or a plainly documented arithmetic transformation. This procedural transparency is particularly important in climate governance contexts where numbers may travel into policy memos, strategic plans or public communication.

Validation in this study is conceptual and arithmetic rather than predictive. Conceptual validation asks whether the selected indicators correspond to widely recognised dimensions of climate change and climate risk. Arithmetic validation asks whether the tables and figures can be reproduced directly from the collected values and stated equations. Because the framework is not presented as a trained statistical model, conventional performance metrics such as accuracy, RMSE or F1 score are not applicable. Instead, credibility rests on source quality, consistency of transformation and clarity of interpretation. This is a valid form of methodological rigour for an indicator-based decision-support paper.

Reproducibility is strengthened by the use of current public scientific reports and by the avoidance of proprietary preprocessing pipelines. All figures in the Results section are generated from tabulated values that are visible within the manuscript itself. The framework can therefore be updated straightforwardly as new WMO, EM-DAT, Global Carbon Budget or related reports are released. Such updateability is not a secondary advantage; it is central to the idea of planetary-scale environmental

decision-making, where the value of an analytical system depends on its ability to absorb new evidence without requiring a complete redesign.

4. Results

4.1 Earth-system escalation and risk signals

Table 4.1 summarises the latest observed values for six planetary indicators together with their chosen baselines. The pattern is not one of isolated deterioration but of concurrent escalation across atmospheric, thermal, oceanic and socio-economic dimensions. Atmospheric CO2 in 2023 was approximately 1.51 times the pre-industrial concentration implied by the WMO report, while the 2024 global mean temperature anomaly exceeded the already exceptional 2023 level by nearly 7%. More striking still, the contemporary midpoint estimate of ocean heat uptake is more than three times the midpoint of the 1960–2005 rate, and the recent sea-level rise rate is more than double that observed during the first satellite decade.

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Indicator	Baseline	Current	Baseline period	Current period	Current/Baseline
Atmospheric CO2 concentration (ppm)	278.10	420.00	1750 (pre-industrial)	2023	1.51×
Global mean temperature anomaly (°C above 1850–1900)	1.45	1.55	2023	2024	1.07×
Ocean heat uptake rate (ZJ/yr)	3.50	11.65	1960–2005 midpoint	2005–2024 midpoint	3.33×
Sea-level rise rate (mm/yr)	2.10	4.70	1993–2002	2015–2024	2.24×
Reported natural-	371.00	393.00	2004–2023 average	2024	1.06×

hazard disasters					
Economic losses (US$ bn)	209.60	241.95	2004–2023 average	2024	1.15×

Table 4.1. Observed planetary indicators used in the results section and their associated baselines.

Interpretation: Table 4.1 indicates simultaneous escalation across multiple climate-system and impact dimensions. The most amplified changes are observed in ocean heat uptake and sea-level rise rate, while atmospheric CO2 remains the underlying forcing variable that conditions the wider pattern of environmental stress.

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Figure 4.1. Escalation of observed planetary indicators relative to historical baselines

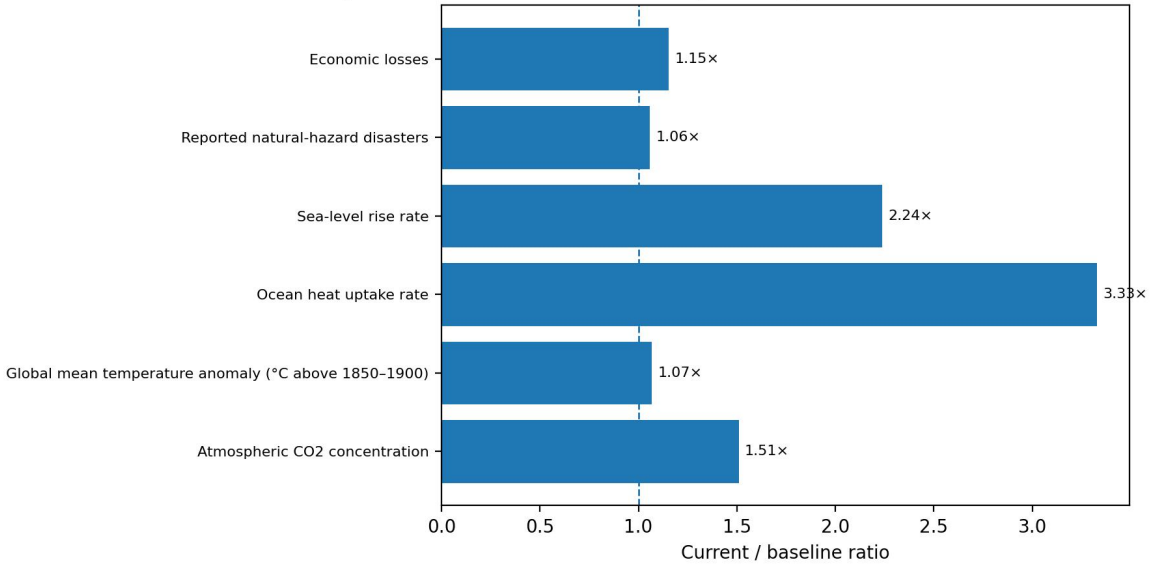


Figure 4.1. Escalation of observed planetary indicators relative to historical baselines.

Interpretation: Figure 4.1 shows that the climate signal is not concentrated in a single metric. Ocean heat uptake and sea-level rise exhibit the strongest relative amplification, while disasters and economic losses remain elevated above their recent long-run averages, supporting the need for integrated environmental intelligence.

The disaster indicators add an important governance layer to the Earth-system signals. EM-DAT recorded 393 natural-hazard disasters in 2024, above the 2004–2023 annual average of 371. Economic losses reached US$241.95 billion, exceeding the long-run annual average of US$209.6 billion. The affected population was close to the long-run

average, which is analytically revealing in itself: climate stress does not need to produce an unprecedented count of affected people every year in order to impose major economic and infrastructural strain. The climate problem therefore manifests not only as higher frequencies or larger counts, but also as more expensive, more systemically disruptive and more governance-intensive events.

Figure 4.1 visualises the same indicators as current-to-baseline ratios. Ocean heat uptake and sea-level rise stand out as the most rapidly amplified signals, indicating the inertia and cumulative burden of ocean-mediated climate change. Carbon dioxide concentration, by contrast, shows a smaller ratio because its baseline is pre-industrial and the atmospheric system changes more gradually in percentage terms; yet its importance remains foundational because it is the forcing variable that conditions the rest. Taken together, these results support the proposition that climate governance requires AI-assisted integration across indicators rather than reliance on any single headline metric.

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4.2 Emissions intelligence across major emitting blocs

Table 4.2 presents bloc-level emissions intelligence based on the Global Carbon Budget 2024. The distribution remains highly concentrated: China accounted for 31% of global fossil CO2 emissions in 2023, the United States for 13%, India for 8%, EU27 for 7%, and the rest of the world for 41%. The 2024 projection suggests that global fossil CO2 emissions will reach a record 37.4 GtCO2. Within this total, China remains at roughly 11.9 GtCO2 with slight positive growth, the United States declines modestly to about 4.86 GtCO2, India rises to around 3.2 GtCO2, EU27 declines to around 2.4 GtCO2, and the rest of the world remains the largest aggregate block at around 14.5 GtCO2.

Bloc	**Share of 2023 global fossil CO2 (%)**	**Projected 2024 growth (%)**	**Projected 2024 emissions (GtCO2)**
Rest of world	41	1.2	14.50
China	31	0.1	11.91
United States	13	-0.9	4.86
India	8	3.7	3.20
EU27	7	-2.8	2.40

Table 4.2. Major-bloc fossil CO2 profile using Global Carbon Budget 2024 shares, growth rates and projected 2024 emissions.

Interpretation: Table 4.2 shows that absolute emissions remain concentrated in a small number of large blocs, but growth dynamics differ substantially. China remains the largest named emitter, India is the fastest-growing named major bloc in 2024, and both the United States and EU27 are on declining, though still globally significant, trajectories.

Figure 4.2. Projected 2024 fossil CO_2 emissions across major blocs

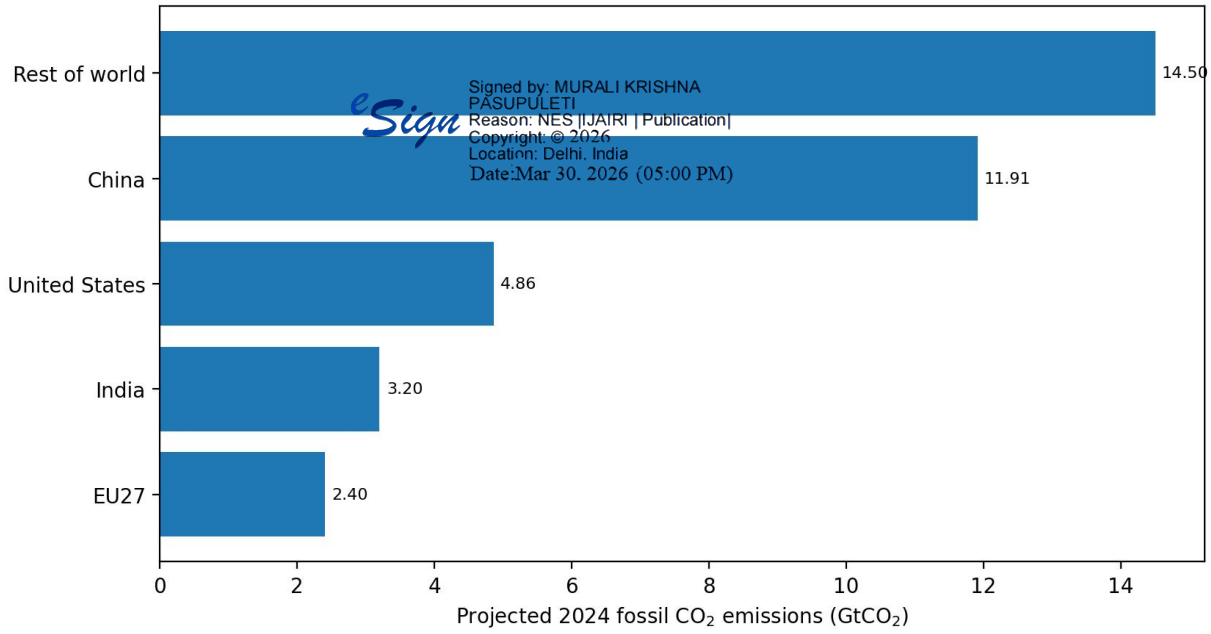


Figure 4.2. Projected 2024 fossil CO2 emissions across major blocs.

Interpretation: Figure 4.2 highlights the structural importance of the rest-of-world aggregate, which exceeds any single named bloc. The visual underscores that effective mitigation strategy must combine action by the largest individual emitters with broader multilateral coordination.

These numbers illustrate why emissions intelligence must distinguish between absolute scale and directional change. If only growth rates are considered, India appears as the principal concern among the named major blocs because of its projected 3.7% increase in 2024. If only absolute levels are considered, China dominates the field, followed by the rest of the world aggregate. The United States and EU27 show declining trajectories, yet their remaining absolute emissions are still large enough to make them globally consequential. A realistic AI-support system

must therefore hold these dimensions together instead of treating them as competing narratives.

Figure 4.2 visualises the projected 2024 emissions landscape. The most policy-relevant insight is that the challenge is not reducible to a single state or region. The rest-of-world aggregate is larger than any individual bloc, indicating that multilateral coordination beyond the largest named emitters remains indispensable. At the same time, the combination of China's large share and India's strong growth implies that the centre of mitigation attention cannot be inferred from historical responsibility alone. Current emissions intelligence needs to remain dynamically updated, and that is precisely the type of task for which AI-enabled data integration is institutionally valuable.

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4.3 AI-enabled prioritisation for planetary decision-making

Table 4.3 applies the mitigation urgency equation to the bloc-level emissions data. The resulting ranking places the rest of the world aggregate first, China second, India third, the United States fourth and EU27 fifth. This ordering is not intended as a moral ranking of blame. Rather, it reflects the explicit structure of the score: very large current emissions shares dominate, but positive near-term growth raises urgency when it is substantial. The result is analytically instructive because it demonstrates how transparent AI-style prioritisation can alter attention patterns. A governance framework focused only on named major powers might underweight the aggregate importance of the rest of the world, even though its combined emissions mass is the largest in the system.

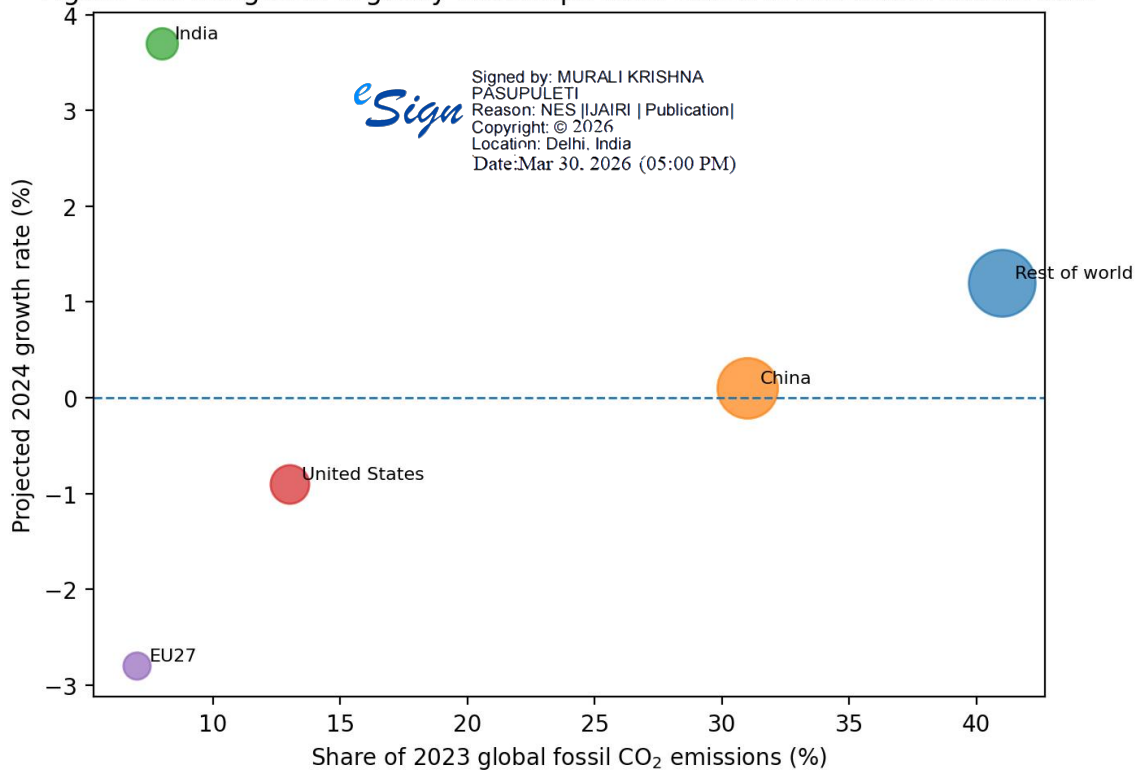
Rank	Bloc	Share (%)	Growth (%)	Urgency score	Projected 2024 emissions (GtCO2)
1	Rest of world	41	1.2	79.7	14.50
2	China	31	0.1	53.7	11.91
3	India	8	3.7	43.7	3.20
4	United States	13	-0.9	22.2	4.86

5	EU27	7	-2.8	12.0	2.40

Table 4.3. Mitigation urgency ranking derived from the explicit urgency equation using observed emissions share and projected emissions momentum.

Interpretation: Table 4.3 demonstrates that transparent scoring can change strategic attention. The rest-of-world aggregate ranks first because its combined emissions mass is largest and its emissions are still rising, while India ranks above the United States and EU27 because its growth momentum is substantially stronger.

Figure 4.3. Mitigation urgency landscape from size and emissions momentum



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Figure 4.3. Mitigation urgency landscape from emissions size and emissions momentum.

Interpretation: Figure 4.3 separates blocs into analytically distinct decision zones: very large and still rising, very large but nearly flat, smaller but fast-rising, and large but declining. This is the kind of interpretable output that can support climate-finance triage and strategic policy review.

China remains a high-priority domain because of its very large absolute weight in the global carbon system, even though its projected 2024 growth is close to flat. India's rank rises above that of the United States and EU27 because a smaller emissions share is offset by the highest positive growth rate among the named blocs. The United

States and EU27 rank lower in this particular urgency formulation because their projected emissions are falling in 2024, but they do not disappear from the mitigation landscape; they remain major absolute emitters whose technological, financial and regulatory choices are globally consequential. The score therefore works best as a prioritisation aid, not as a final policy verdict.

Figure 4.3 plots emissions share against projected 2024 growth, with bubble size reflecting projected absolute emissions. This makes the decision space visually legible. The rest of the world sits at the intersection of large mass and positive momentum; China occupies the large-mass, near-flat-growth zone; India occupies the smaller-mass, high-growth zone; and the United States and EU27 occupy the large-but-declining zone. Such a map is precisely the kind of interpretable output that can support ministries, climate-finance institutions and international negotiations. It simplifies without concealing, and that balance is central to responsible AI for environmental governance.

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5. Discussion

5.1 Implications for climate governance, public policy and environmental intelligence

The results have three policy implications. First, climate governance requires integrated intelligence rather than isolated reporting streams. Planetary indicators, disaster impacts and emissions trajectories are too interdependent to be analysed in separate institutional compartments. Second, current climate deterioration is not limited to one dimension of the Earth system. Atmospheric composition, heat accumulation, sea-level rise and economic losses all point toward the need for faster, better-coordinated action. Third, mitigation prioritisation must remain dynamic. A bloc's position in the decision hierarchy changes when scale and momentum are considered together, and AI-assisted systems can help keep that hierarchy current as new data arrive.

For public policy, the central implication is that explainable dashboards can improve the allocation of scarce attention. Governments and multilateral actors routinely face competing claims for adaptation finance, emissions abatement, resilience investment and emergency response. A transparent prioritisation framework can sharpen these

decisions without pretending to eliminate political judgment. This is particularly useful where climate policy intersects with development strategy, sovereign risk, insurance design and infrastructure planning. The analytical outputs in this study are simple enough to be operationalised but rigorous enough to remain scientifically defensible.

The concept of environmental intelligence also carries institutional implications. It suggests that meteorological agencies, disaster databases, emissions accounting bodies and AI teams should not remain disconnected. The value of machine-assisted climate governance depends on interoperable data architectures, auditable transformation pipelines and clear lines of decision authority. In this regard, AI should be understood as an enabling layer within a broader governance ecosystem that includes standards, public institutions, domain experts and legal accountability.

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5.2 Strengths, limitations and interpretive caution

A principal strength of the study is its reliance on current official data rather than synthetic scenarios. The indicators are drawn from authoritative climate-monitoring and disaster-reporting systems and are transformed using transparent arithmetic. This yields a paper that is both reproducible and realistic. A second strength is the deliberate use of interpretable equations. In an era when AI is frequently associated with opacity, the paper demonstrates that decision-support value can emerge from explicit weighting and normalisation rules. A third strength is the cross-scale design that links planetary-state variables with emissions blocs, thereby reflecting the actual structure of climate governance problems.

The analysis also has clear limitations. The selected indicators do not exhaust the climate system, and the bloc-level emissions framework does not incorporate historical cumulative emissions, consumption-based accounting, sectoral decomposition, subnational heterogeneity or adaptation readiness metrics. The urgency score is normative, not uniquely correct, and different weights would change the ranking. Moreover, the rest-of-world aggregate is analytically useful but politically coarse; it contains diverse states with very different responsibilities and capacities. These limitations should not be hidden because transparency about the scope of inference is essential to trustworthy environmental AI.

Interpretive caution is therefore necessary. The results should not be read as a claim that climate governance can be solved by dashboards or scores alone. Nor should the prioritisation output be confused with a complete ethical framework for burden sharing. What the analysis does show is more modest and more practical: real-world climate indicators can be assembled into an interpretable AI-compatible architecture that improves strategic visibility. That contribution is valuable precisely because it is bounded, auditable and usable.

5.3 Research and implementation agenda

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Several research extensions follow naturally from this study. One avenue would integrate remote-sensing-based methane, fire, land-cover and urban heat data into the same decision framework, thereby broadening the emissions intelligence layer beyond fossil CO2 alone. A second would combine the present planetary dashboard with country-level adaptation readiness and physical risk indicators, producing a coupled mitigation–adaptation prioritisation model. A third would introduce probabilistic scenario layers so that decision-makers could compare current-state urgency with medium-term transition pathways. Each extension would increase analytical richness, but the present study suggests that such complexity should remain subordinate to interpretability and traceability.

Implementation work is equally important. Environmental intelligence systems require data governance, common metadata standards, update schedules and institutional ownership. It is not enough to build an algorithmic prototype; the surrounding governance infrastructure must also be credible. This includes version control for indicators, public documentation of weights and thresholds, and mechanisms for human review. For international organisations, a particularly promising application lies in climate-finance triage, where transparent AI tools could help align funding decisions with observed emissions pressure, escalating risk signals and institutional readiness.

A deeper research agenda would also examine the politics of indicator choice. Every climate dashboard embodies assumptions about what counts, what is comparable and what should be acted upon first. Rather than pretending these choices are neutral, future research should treat them as part of the object of study. In that sense, the future of AI for environmental decision-making is not only technical. It is epistemic

and institutional: it concerns how societies define valid evidence, assign responsibility and build legitimate systems for acting under planetary stress.

6. Conclusion

6.1 Conclusion

This study has shown that artificial intelligence can be framed productively as an environmental intelligence architecture for climate-risk assessment, emissions analysis and planetary-scale decision support. Using current official data, the paper documented concurrent escalation across atmospheric CO2, temperature, ocean heat uptake, sea-level rise, disaster occurrence and economic losses. It also demonstrated that the global emissions landscape remains concentrated but dynamic, with the rest of the world aggregate, China and India occupying particularly consequential positions under a transparent urgency formulation. These findings reinforce the view that climate governance now requires integrated, continuously updated intelligence rather than isolated monitoring systems.

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The paper's central methodological claim is that useful AI for climate governance does not require opacity. Transparent equations, explicit weights, traceable data sources and interpretable visualisations can already support better environmental decision-making. This is an important corrective to the tendency to equate AI progress with model complexity alone. In a public-interest domain as consequential as climate change, the legitimacy of the analytical process matters as much as computational sophistication. A system that can be inspected, challenged and updated is more likely to support durable governance than one that merely performs impressively in technical isolation.

The broader implication is that environmental decision-making is entering an era of planetary intelligence. Institutions must increasingly reason across linked systems, shrinking carbon budgets and rapidly changing hazard conditions. Artificial intelligence can contribute meaningfully to this task when it serves as an interpretable bridge between observation and action. The present framework offers one realistic step in that direction: a PhD-level, data-grounded approach that treats AI not as a substitute for climate governance, but as a disciplined instrument within it.

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