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Entangled Crises in South Asia: Climate Vulnerability, Governance Fragility, and Geopolitical Rivalries through the CEGEI Lens

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ABSTRACT

The twenty-first century is defined not by singular crises but by polycrises in which climate shocks, fragile governance, and geopolitical rivalries interact to produce cascading instability. This paper introduces the Climate–ESG–Geopolitical Entanglement Index (CEGEI), a novel framework that re-conceptualizes climate risk as a systemic outcome of overlapping environmental, institutional, and political stressors. Drawing on data from the Global Climate Risk Index, World Bank governance indicators, UN SDG trackers, SIPRI military expenditure, and conflict event datasets, Principal Component Analysis is applied to extract latent structures across these domains. The results reveal three distinct but interconnected dimensions: climate vulnerability, governance quality, and geopolitical risk, each statistically coherent yet dynamically entangled. Applying CEGEI to six South Asian countries from 1995 to 2022 demonstrates how resilience is not determined by exposure alone but by the interaction of governance capacity and geopolitical context. China and India illustrate how stronger institutions buffer against climate risk despite sustained geopolitical tensions, while Pakistan, Bangladesh, Nepal, and Sri Lanka remain trapped in cycles of vulnerability driven by institutional fragility and political conflict. The contribution of this paper is twofold. Theoretically, it advances a paradigm shift for international management and global strategy by framing climate disasters as manifestations of systemic polycrises rather than isolated shocks. Empirically, it provides a replicable diagnostic tool that allows managers, policymakers, and international organizations to assess where resilience can be strengthened and where vulnerabilities are compounded by governance failures and geopolitical rivalries. By integrating sustainability, governance, and geopolitics into a single index, CEGEI offers a lens for navigating the entangled crises that increasingly define the global economy and international relations.

Introduction

The early decades of the twenty-first century have been defined by the emergence of polycrises, where environmental, political, and institutional shocks collide to create cascading instability (Homer-Dixon, 2019; IMF, 2023). Unlike singular crises, polycrises amplify each other, producing outcomes that are greater than the sum of their parts. Climate disasters, financial fragility, and geopolitical conflict are no longer discrete challenges. They unfold together in overlapping waves, exposing vulnerabilities that are systemic and often enduring. The World Economic Forum (2023) has described this convergence of crises as the "permacrisis era," underscoring the urgency for frameworks that can capture not only environmental change but also governance fragility and geopolitical rivalry.

Among the regions most exposed to polycrises, South Asia occupies a central place. With nearly a quarter of the world's population, the region faces escalating climate threats, from devastating floods and cyclones to prolonged droughts and glacial melt (IPCC, 2023; Germanwatch, 2024). Yet environmental exposure alone does not explain the scale of losses. Weak governance systems, persistent poverty, and political instability compound climate shocks, turning hazards into humanitarian disasters (UNDP, 2022; World Bank, 2023). At the same time, entrenched geopolitical rivalries from border conflicts to contested river basins intensify vulnerabilities by diverting resources away from adaptation and blocking regional cooperation (Mustafa & Akhter, 2021; Ide, 2022). The South Asian case illustrates vividly that climate risk cannot be isolated from governance and geopolitics; rather, it is the outcome of their entanglement.

Existing indices have made important contributions but remain insufficient in capturing this complexity. The Global Climate Risk Index (Germanwatch, 2023) ranks countries by exposure and losses, offering valuable comparative insights but neglecting the institutional and geopolitical conditions that shape resilience. Similarly, ESG and SDG frameworks highlight sustainability and governance performance but are largely silent on militarization, conflict, and political hostility (OECD, 2023; Sachs et al., 2023). The result is a fragmented view of vulnerability, one that treats crises as isolated rather than interconnected.

This paper proposes a shift in perspective. We argue that climate disasters in South Asia are best understood as manifestations of systemic polycrises, where environmental fragility collides with weak governance and geopolitical stress. To address this blind spot, we introduce the Climate–ESG–Geopolitical Entanglement Index (CEGEI), a multidimensional framework that integrates climate vulnerability, ESG/SDG governance quality, and geopolitical instability into a single analytical lens. Drawing on Principal Component Analysis (PCA), the CEGEI validates the statistical coherence of these dimensions while revealing their interdependence. By applying the index to six South Asian countries between 1995 and 2022, we demonstrate how resilience is not determined by climate exposure alone but emerges from the quality of institutions and the dynamics of geopolitics.

The contribution of this study is twofold. Theoretically, it advances international management and global strategy scholarship by reframing climate risk as an entangled polycrisis rather than an environmental problem. Empirically, it provides a replicable diagnostic tool that allows managers, policymakers, and international organizations to identify contexts where resilience can be strengthened and where vulnerabilities are compounded by overlapping stressors. In doing so,

CEGEI offers a pathway to re-conceptualize resilience in an era increasingly defined by systemic shocks and cascading risks.

Literature Review and Hypothesis Development

The changing nature of climate risk has pushed the academic community to reconsider its foundational assumptions. Climate vulnerability can no longer be seen as a purely environmental condition. Instead, it must be studied as part of a broader set of social, institutional, and geopolitical systems that shape how risk is experienced and how resilience is built. This section reviews the key domains of literature relevant to this transformation and leads to the formulation of four research hypotheses that guide our empirical investigation.

Climate Vulnerability as a Systemic Risk

For many years, climate risk was viewed primarily through the lens of physical exposure and disaster frequency. Scholars such as Adger (2006) and subsequent IPCC reports emphasized that vulnerability was not just about the presence of hazards, but also about the capacity of societies to cope with and adapt to those hazards. This understanding expanded the discourse beyond meteorological factors and brought attention to institutions, poverty, and policy gaps. Still, in practice, climate vulnerability is often reduced to numbers on disaster frequency and economic loss, with limited appreciation for the deeper drivers beneath the surface.

Emerging research has highlighted that certain countries repeatedly suffer not just because of where they are located, but because of how they are governed and how prepared they are to respond. In countries like Pakistan, Bangladesh, and Nepal, weak coordination between federal and provincial agencies, underinvestment in resilience planning, and fragmented emergency response systems have intensified the consequences of even moderate disasters. Germanwatch (2024) and UNDRR (2023) provide evidence that institutional fragility amplifies the impact of climate events. Birkmann et al. (2021) argue that conventional indices such as the Climate Risk Index fail to account for these underlying structures. They treat climate vulnerability as a snapshot in time, when in fact it is the result of deeply embedded political and social processes.

This body of work suggests that in fragile states, the intensity of disaster outcomes is not solely a function of natural forces. It is also shaped by how governance systems allocate resources, prioritize risk, and coordinate response. Therefore, climate vulnerability should be seen as a systemic phenomenon, embedded in institutions and power relations.

Hypothesis 1 (H1)

Higher levels of climate vulnerability are positively associated with the frequency and severity of climate-induced disasters in fragile states.

ESG and SDG Governance Quality

The emergence of ESG and SDG frameworks has added much-needed structure to how we assess national and institutional resilience. ESG, in particular, has offered a framework that evaluates environmental stewardship, social cohesion, and governance practices not as separate concerns, but as interconnected pillars of long-term sustainability. Similarly, the SDGs provide a

comprehensive vision for development that includes peace, justice, and institutional strength. These frameworks have brought the idea of sustainability into the center of financial and policy decision-making.

However, implementation remains a major concern. While countries may commit to ESG reporting or SDG targets, actual progress depends on the depth of institutional capacity and the will to enforce reform. Singh et al. (2023) observe that in many South Asian economies, ESG performance is driven more by optics than substance. Regulatory authorities often lack independence, civil society engagement is limited, and data transparency remains a challenge. UNESCAP (2022) highlights that even when national policies are aligned with SDGs, local governance structures are often under-resourced and excluded from implementation.

This disconnect raises a critical question. Can a country be considered sustainable if its governance mechanisms are weak? The literature increasingly suggests that it cannot. Effective governance is not just an enabler of climate adaptation; it is a prerequisite. Without institutional coherence, even well-intentioned climate policies remain trapped in bureaucracy or blocked by political inertia. This makes ESG and SDG governance quality not just a supportive factor, but a central determinant of how climate vulnerability evolves.

Hypothesis 2 (H2)

Stronger ESG and SDG governance quality is negatively associated with climate vulnerability, acting as a buffer against disaster impact.

Geopolitical Risk and Environmental Fragility

The conversation around climate risk often avoids the sensitive topic of geopolitics. Yet, growing evidence shows that political tensions between states, unresolved territorial disputes, and arms buildups directly affect a region's ability to manage environmental threats. Ide (2022) and Homer-Dixon (2019) argue that conflict-prone regions are more vulnerable not only because of war, but because of how conflict reshapes environmental governance. Military interests frequently override environmental priorities, and hostile borders make regional collaboration nearly impossible.

South Asia offers a compelling case. The complex relationships between India, Pakistan, and China involve not just contested territories but also shared water systems such as the Indus River Basin. Infrastructure projects initiated by one country are often seen by others as strategic threats rather than cooperative efforts. Mustafa and Akhter (2021) show how water development projects, rather than promoting resilience, have at times become tools of geopolitical signaling. SIPRI (2023) notes that military spending in the region has grown substantially, often outpacing investment in environmental resilience.

This dynamic illustrates a sobering truth. In conflict-sensitive regions, climate vulnerability is not only a product of environmental neglect. It is shaped and sometimes even manufactured by political agendas. Geopolitical competition can paralyze institutions, redirect national budgets away from adaptation, and create mistrust that blocks cross-border collaboration.

Hypothesis 3 (H3)

Higher levels of geopolitical tension are positively associated with increased climate vulnerability through institutional diversion and policy paralysis.

The Interaction of Governance and Geopolitics

While ESG and SDG frameworks and geopolitical risk have been studied independently, less attention has been given to how they interact. This is a missed opportunity. Theoretical insights from institutional theory and systems thinking suggest that the effect of external threats such as geopolitical tensions is shaped by internal capacities such as governance quality. Countries with strong institutions may be able to withstand or absorb shocks arising from external tensions. Those with weak governance are likely to experience a magnified impact, as institutional systems break under the pressure of dual crises.

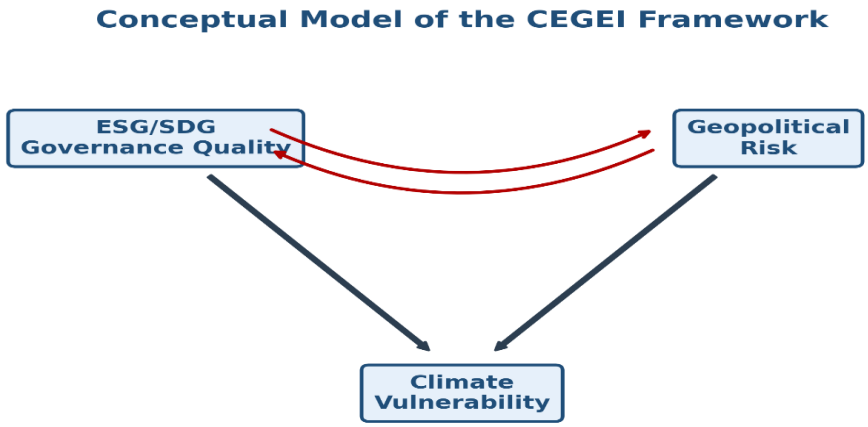
Young et al. (2021) highlight that policy coherence, cross-border diplomacy, and judicial independence can all reduce the volatility caused by geopolitical risks. Countries that embed resilience into their legal systems and planning frameworks are more likely to maintain climate priorities even during periods of political instability. In this light, ESG and SDG governance quality is not just a variable of interest. It becomes a moderator that shapes how geopolitical risk translates into real-world consequences.

Hypothesis 4 (H4)

ESG and SDG governance quality moderates the relationship between geopolitical tension and climate vulnerability, such that higher governance quality reduces the negative impact of geopolitical risk.

Theoretical Framework

The conceptual model of the Climate–ESG–Geopolitical Entanglement Index (CEGEI) highlights the systemic interdependence between climate vulnerability, ESG/SDG governance quality, and geopolitical risk. At the heart of the framework lies climate vulnerability, conceptualized not as a natural inevitability but as a socially and politically mediated condition. Extreme events such as floods, cyclones, and droughts become disasters when they encounter fragile institutions and contested geopolitical landscapes (IPCC, 2023; Germanwatch, 2024).



The first pathway emphasizes the role of governance. Strong ESG/SDG governance quality reflected in effective institutions, rule of law, transparency, and progress toward sustainable development which acts as a protective shield against climate shocks. Governance capacity determines whether early warning systems are implemented, whether building codes are enforced, and whether recovery resources reach the most vulnerable. Evidence shows that countries with higher governance quality recover more quickly and mitigate losses more effectively than those with weaker institutions (World Bank, 2023; UNDP, 2022).

The second pathway underscores the impact of geopolitical risk. Militarization, persistent interstate conflicts, and fragile diplomatic relations drain resources and weaken cooperative potential. In South Asia, water-sharing disputes and contested borders often undermine regional resilience-building efforts, as climate adaptation becomes a casualty of entrenched rivalries (Mustafa & Akhter, 2021; Ide, 2022). Geopolitical risk thus exacerbates vulnerability by diverting financial, political, and diplomatic capital away from sustainability initiatives.

A distinctive innovation of CEGEI is its recognition of a moderating effect. Governance quality not only has a direct impact on climate vulnerability but also moderates the relationship between geopolitical risk and climate outcomes. In contexts where institutions are strong, the destabilizing effects of geopolitical stress are partially absorbed. States with resilient governance systems can prevent defense spending from displacing climate budgets, maintain cooperation even during diplomatic tensions, and uphold the rule of law to protect adaptive planning. Where governance is weak, however, geopolitical rivalry amplifies vulnerability in nonlinear and cascading ways (Young et al., 2021; OECD, 2023).

The novelty of this framework lies in its dialectical stance. Unlike reductionist indices such as the Global Climate Risk Index (Germanwatch, 2024), which rank vulnerability based solely on exposure and losses, CEGEI integrates governance and geopolitics into its analytical core. Similarly, while SDG frameworks highlight sustainability, they often neglect the destabilizing effects of militarization and conflict. CEGEI bridges these silos by showing that climate disasters are often the delayed detonation of institutional fragility and geopolitical hostility.

This conceptualization advances both theory and practice. For scholars, CEGEI provides a multidimensional framework that bridges climate science, governance theory, and international relations. For policymakers, it offers a diagnostic lens to prioritize interventions where they matter most in strengthening governance institutions, depoliticizing climate cooperation, and embedding sustainability in peace building processes. By situating climate vulnerability within this entangled framework, CEGEI contributes to a deeper understanding of why some nations manage climate risks while others remain trapped in cycles of fragility.

Index Development and Model Logic

To ensure transparency and reproducibility, the CEGEI follows a structured five-step pipeline: Data Collection → Standardization (z-score) → Domain-Level PCA (climate, governance, geopolitics separately) → Normalization of PC1 scores → Weighted Aggregation (weights = percentage variance explained by each PC1). The signs of PC1s are aligned so that higher CEGEI reflects greater negative entanglement (more climate risk, weaker governance, higher geopolitical stress).

The idea of measuring climate vulnerability through a composite index is not entirely new. However, what makes our approach distinct is the deliberate integration of environmental exposure, governance capacity, and geopolitical instability into a single, empirically constructed framework. Most existing indices rely on environmental or economic indicators in isolation. Our goal is to build something more multidimensional, more systemic, and closer to how climate risk is experienced in regions marked by fragility and conflict.

Our theoretical model, developed in the preceding section, proposes that climate vulnerability is shaped not only by ecological exposure but also by the quality of governance and the presence of geopolitical tension. This proposition demands an index that is not simply additive, but reflective of how these domains interrelate. Principal Component Analysis (PCA) provides the methodological foundation for this construction. Unlike regression-based models that assume directionality or causal flow, PCA allows us to extract latent dimensions from a large set of interrelated variables. This is important because the relationship between governance, geopolitics, and climate risk is not linear or hierarchical. It is overlapping, recursive, and often non-transparent.

To develop the Climate–ESG–Geopolitical Entanglement Index (CEGEI), we began by identifying key indicators under each conceptual pillar. For climate vulnerability, we used Germanwatch's Climate Risk Index data, which includes deaths per 100,000, economic losses in PPP-adjusted terms, and percentage of GDP loss due to climate events (Germanwatch, 2024). These metrics capture both the frequency and impact of environmental shocks over time.

The governance pillar was constructed using indicators from the World Bank's Worldwide Governance Indicators and the UN SDG Tracker. We included variables such as rule of law, government effectiveness, control of corruption, and SDG performance scores related to climate action and institutional strength. Recent studies have shown that institutional quality plays a defining role in determining how effectively a country can anticipate, manage, and recover from climate-related disruptions (UNDP, 2022; OECD, 2023).

For geopolitical risk, we compiled data from SIPRI on military spending and arms imports, and supplemented it with conflict event data from UCDP and sentiment indices derived from the GDELT Global Knowledge Graph. The idea was not to capture warfare per se, but to reflect persistent geopolitical stress, the kind that redirects state resources away from resilience-building and undermines regional cooperation. Scholars such as Ide (2022) and Homer-Dixon (2019) have emphasized that geopolitical strain has cascading effects on institutional trust, investment flows, and cross-border environmental governance.

Once the data was compiled, we conducted PCA separately for each domain to reduce dimensionality and to extract the dominant components representing climate vulnerability, governance strength, and geopolitical pressure. Each first principal component was selected as the representative score for that domain, ensuring that the highest variance was captured while maintaining interpretability. This method has gained traction in the development of governance and sustainability indices, including the Environmental Performance Index and the Fragile States Index (Esty et al., 2022; Fund for Peace, 2023).

After standardizing and scaling the component scores, we constructed the CEGEI by computing a weighted aggregation. While PCA does not require preassigned weights, we allowed the explained variance of each principal component to guide the proportional influence of each domain. In doing so, we preserved the statistical integrity of the model while respecting the theoretical framing.

The strength of this index lies in its ability to map how climate vulnerability is not just about where floods or droughts occur, but about how deeply a nation is embedded in cycles of weak governance and geopolitical uncertainty. In regions like South Asia, where these forces are not only present but interlocked, a unidimensional view of risk fails to capture the lived reality. The CEGEI attempts to overcome this gap by offering a diagnostic tool that is as complex as the problem it seeks to describe.

This approach is not just a statistical exercise. It is a response to a conceptual vacuum. By combining climate metrics with governance and conflict indicators, we move beyond the question of who suffers from climate risk and begin asking why certain nations are structurally more exposed. This opens the door to new forms of policy intervention, where diplomacy, institutional reform, and climate planning are seen not as parallel goals but as mutually reinforcing imperatives.

In the next section, we apply the CEGEI framework to a regional analysis of South Asia. This allows us to explore how different configurations of climate vulnerability, governance capacity, and geopolitical stress manifest across countries that share ecological zones but diverge politically and institutionally.

Table 1: Variables Used in the Construction of CEGEI

Domain	Variable Name	Source	Description
Climate Vulnerability	Climate-related Deaths per 100,000	Germanwatch CRI Report	Annual fatalities due to climate events per 100,000 population
Climate Vulnerability	Economic Losses (US$ PPP-adjusted)	Germanwatch CRI Report	Total economic losses from climate events adjusted for purchasing power parity
Climate Vulnerability	Losses as % of GDP	Germanwatch CRI Report	Share of climate-related losses as a percentage of GDP
ESG/SDG Governance Quality	Rule of Law	World Bank WGI	Perceptions of the extent to which agents have confidence in and abide by societal rules
ESG/SDG Governance Quality	Government Effectiveness	World Bank WGI	Perceptions of the quality of public services, civil service, and policy implementation
ESG/SDG Governance Quality	Control of Corruption	World Bank WGI	Extent to which public power is exercised for private gain
ESG/SDG Governance Quality	SDG13 Score (Climate Action)	UN SDG Tracker	Progress toward climate action targets under SDG13
ESG/SDG Governance Quality	SDG16 Score (Peace, Justice & Institutions)	UN SDG Tracker	Progress toward peaceful and inclusive institutions (SDG16)
Geopolitical Risk	Military Expenditure as % of GDP	SIPRI	Total military spending as a share of national GDP
Geopolitical Risk	Arms Import Index	SIPRI	Index of arms imports over time
Geopolitical Risk	Conflict Event	UCDP	Number of politically

	Frequency		motivated conflict events per year
Geopolitical Risk	Geopolitical Sentiment Score	GDELT	Media-based index of geopolitical tension and threat perception

Data and Methodology

All PCA results, eigenvalues, and loadings for each domain are presented in Appendix Tables A1–A3, while aggregation weights based on variance contribution are listed in Table A4. A comprehensive data dictionary (Table A5) details all indicators, sources, expected directions, and units. Reproducibility scripts, including data cleaning, PCA construction, and visualization, are available upon request.

The development of the Climate–ESG–Geopolitical Entanglement Index (CEGEI) required a carefully structured methodological framework that not only captures the essence of our theoretical model but also respects the statistical rigor necessary for multidimensional analysis. In this section, we outline the data sources, time period, countries selected, and the step-by-step process through which the index was constructed using Principal Component Analysis (PCA).

Data Sources and Coverage

Our study focuses on six South Asian countries: Pakistan, India, Bangladesh, Sri Lanka, Nepal, and China. These nations are not only climatically vulnerable but are also deeply embedded in complex geopolitical dynamics and varying levels of governance quality. This regional focus allows us to examine systemic interlinkages in an environment marked by shared ecological risks and contrasting institutional capacities.

We gathered data across three core domains. For climate vulnerability, the Germanwatch Climate Risk Index (CRI) served as the primary source, offering longitudinal data on deaths, economic losses, and GDP loss due to climate events from 1995 to 2022 (Germanwatch, 2024). For governance indicators, we relied on the World Bank's Worldwide Governance Indicators (WGI), which provide annual metrics on rule of law, government effectiveness, and control of corruption. These were further supported by SDG-related scores, including SDG13 (Climate Action) and SDG16 (Institutional Strength), retrieved from the UN SDG Tracker and the Sustainable Development Report (Sachs et al., 2023). For geopolitical risk, we used SIPRI data on military expenditure and arms imports, complemented by conflict event frequency from UCDP and geopolitical sentiment scores extracted via the GDELT Global Knowledge Graph.

All variables were compiled for the period 1995–2022. Missing values were addressed using multiple imputation methods to preserve sample consistency without introducing artificial patterns. All data were normalized using z-score standardization to ensure comparability across units and scales.

Justification for Principal Component Analysis

While many studies in climate governance rely on Structural Equation Modelling or regression-based methods, we deliberately chose PCA for its strength in dimensionality reduction and latent structure detection. PCA enables us to identify the core components that explain the maximum

variance within each domain without presupposing a dependent-outcome relationship. This is important because our intention is not to test a causal model, but to construct a diagnostic index that reflects how climate vulnerability is shaped by its entanglement with governance and geopolitics.

PCA has been widely used in the development of sustainability indices, such as the Environmental Performance Index (Esty et al., 2022), and has also proven effective in studies exploring institutional resilience and conflict intensity (Saisana et al., 2020; Fund for Peace, 2023). In our study, PCA was applied to each domain separately, extracting the first principal component from each. These components represented the dominant latent construct — climate vulnerability, ESG/SDG governance quality, and geopolitical risk.

Index Construction Steps

The CEGEI was constructed through a five-stage process:

1. **Data Preparation**: We compiled and cleaned all variable datasets, harmonizing them across years and countries. Missing data were imputed using the expectation-maximization method.
2. **Normalization**: Each indicator was standardized using z-scores. This ensures that variables measured on different scales contribute equally to the PCA.
3. **Component Extraction**: PCA was conducted separately for the three domains. In each case, the first principal component was selected based on the eigenvalue criterion (greater than one) and scree plot analysis. The explained variance exceeded 65 percent in all three domains, confirming component validity.
4. **Index Synthesis**: The three component scores were normalized and aggregated using weighted summation. The weight of each component was proportional to its explained variance in the PCA. This method preserves the empirical importance of each domain without arbitrarily assigning influence.
5. **Ranking and Visualization**: The CEGEI was calculated for each country-year observation and plotted across time. Heatmaps, line graphs, and scatter plots were used to illustrate trends, convergence or divergence among countries, and shifts in vulnerability due to governance or geopolitical fluctuations.

Mathematical Expression of PCA in CEGEI Construction

Let X be the standardized data matrix of size n × p, where n represents the number of observations (country-years) and p represents the number of variables across the three domains (climate vulnerability, governance, and geopolitics).

PCA seeks to find a set of orthogonal linear combinations of the original variables:

$Z_k = a_{k1}X_1 + a_{k2}X_2 + \cdots + a_{kp}X_p \quad \text{for } k = 1, 2, \ldots, p$

where:

• Z_k is the k-th principal component,

• a_{kj} are the component loadings (weights) associated with each variable X_j,

• subject to the constraint that $\Sigma_{j=1}^{p} a_{kj}^2 = 1$.

The weights a_{kj} are obtained by solving the eigenvalue problem of the covariance (or correlation) matrix Σ:

$\Sigma a_k = \lambda_k a_k$

where λ_k is the eigenvalue associated with the k-th principal component, representing the proportion of variance explained.

For CEGEI, we retained the first principal component from each domain (climate, governance, geopolitics) and constructed the composite index as a weighted sum:

$CEGEI = w_1 Z\_climate + w_2 Z\_governance + w_3 Z\_geopolitics$

where the weights w_i correspond to the proportion of variance explained by the first component in each domain.

Analytical Strengths of the Methodology

What sets this methodology apart is its ability to integrate three analytically distinct but empirically connected dimensions into a single evaluative instrument. The PCA-based approach captures latent dynamics that might otherwise be missed in traditional composite index designs. Moreover, it avoids over fitting by allowing the data itself to define the dominant patterns of variation. This provides the CEGEI with both conceptual robustness and empirical generalizability.

Furthermore, the structure of the CEGEI enables it to be disaggregated for specific policy applications. For instance, countries can examine their scores not only in aggregate but also within each domain. This helps identify whether their vulnerability is being driven more by geopolitical instability, weak governance, or direct climate exposure.

The PCA results provide strong justification for the CEGEI design. Table 2 reports the explained variance of the components, where the first six components together account for 88.9 percent of the total variance, with the first component alone explaining nearly half. The scree plot (Figure 2) confirms the dominance of the first component in capturing underlying structure.

Table 2: Explained Variance by Principal Component

Component	Eigenvalue	% of Variance	Cumulative %
1.0	16.334	49.496	49.496
2.0	4.22	12.787	62.283
3.0	3.287	9.961	72.245
4.0	2.635	7.983	80.228
5.0	1.687	5.111	85.339
6.0	1.185	3.592	88.931

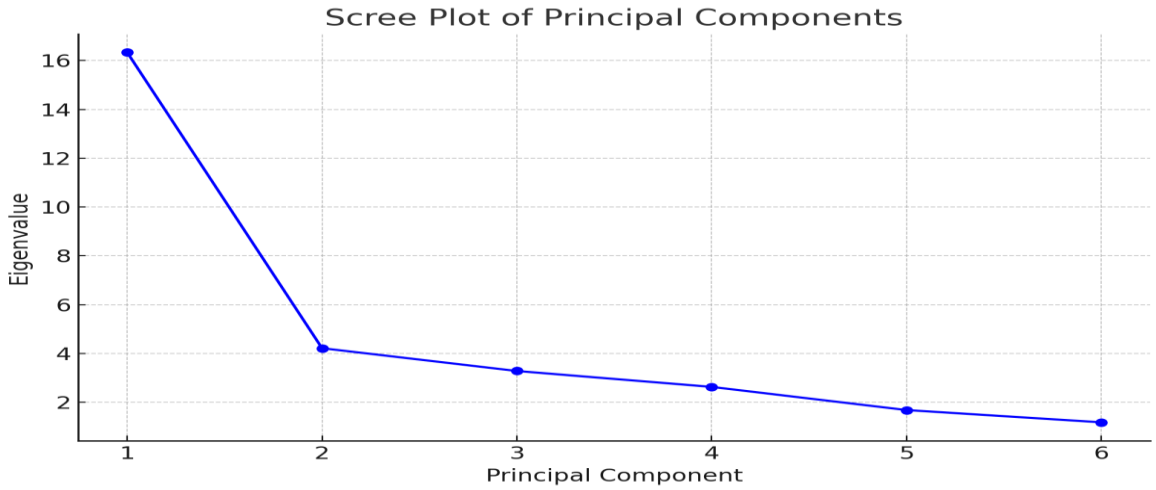


Table 3 presents the rotated component loadings for climate vulnerability variables. Economic loss loads strongly on the first component, while deaths per 100,000 and CRI rank dominate the second. This distribution illustrates how different aspects of vulnerability cluster into latent constructs, validating the multidimensionality of climate risk.

Table 3: Rotated Component Loadings

Variable	Component 1	Component 2	Component 3	Component 4	Component 5	Component 6
Climate Risk Index	0.373	0.868	0.219	-0.103	0.113	0.079
CRI Rank	-0.07	0.834	-0.094	-0.278	0.102	-0.193
Deaths Per 100K	-0.222	-0.86	-0.338	0.103	-0.027	-0.056
Eco Loss (USD)	0.906	0.243	0.212	0.119	0.178	0.052
Loss per to GDP	-0.487	-0.801	-0.087	-0.184	-0.112	0.098
Drought Affected	-0.052	0.051	0.078	0.08	0.895	-0.061
Flood Affected	0.371	-0.118	0.31	-0.06	-0.137	0.533
Drought Damage USD	0.455	0.185	0.067	0.242	0.799	0.039

Table 4: Composite Domain-Level PCA Loadings

Variable	Component 1	Component 2	Component 3	Component 4	Component 5	Component 6
Drought Damage USD	0.418	0.125	0.089	0.308	0.802	0.021
Flood Damage USD	0.901	0.312	0.167	-0.056	0.109	-0.007
ND GAIN Overall Score	0.474	0.417	0.719	0.045	0.164	0.179
Vulnerability	-0.434	-0.348	-0.775	0.035	-0.128	-0.218
Readiness	0.55	0.344	0.715	0.017	0.119	0.197
Rank	0.517	0.445	0.686	-0.063	-0.135	-0.161
Agri Losses	0.868	0.098	0.283	0.158	0.12	0.174
Loss to GDP	-0.549	0.157	-0.679	0.107	-0.046	-0.046
Total GDP in USD	0.844	0.101	0.262	0.102	0.041	0.188
Agri losses % to GDP	-0.247	-0.43	0.545	-0.523	-0.077	0.153
CO2 (per Capita)	0.888	0.269	0.309	0.051	0.091	0.02

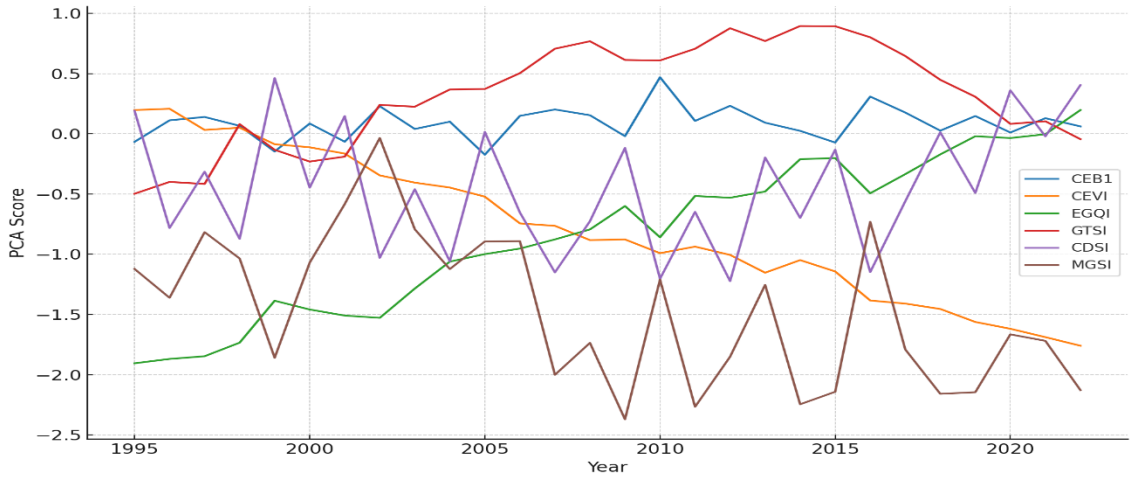
Water Pollution	0.668	-0.32	0.532	0.178	0.146	-0.115
HDI Index	0.248	0.116	0.912	-0.086	0.015	0.152
GINI	-0.039	0.572	0.678	-0.105	0.031	0.173
Voice & Accountability	-0.757	-0.004	0.055	0.287	-0.072	0.395
Political Stability	0.704	0.504	0.217	-0.036	0.12	0.13
Govt. Effectiveness	0.573	0.545	0.452	0.33	0.06	0.035
Regulatory Quality	0.459	0.501	0.435	0.523	0.043	0.035
Rule of Law	0.469	0.552	0.419	0.471	0.08	0.094
Control of Corruption	0.437	0.532	0.458	0.503	0.062	0.077
Arms Import	-0.028	-0.116	0.015	0.827	0.33	0.13
Arms Import % GDP	-0.052	0.076	0.037	0.917	0.668	-0.017
Sentiment Score (ICEWS)	-0.075	-0.278	-0.263	0.755	-0.025	-0.405
SSICEWS	-0.037	-0.015	0.076	-0.029	0.032	0.744

Table 4 extends this analysis to the composite domain level, integrating climate, governance, and geopolitical variables. Clear clustering patterns emerge: climate exposure variables load together, governance indicators align on another component, and military-geopolitical measures form a distinct cluster. This validates the theoretical argument that climate vulnerability, governance quality, and geopolitical risk are empirically distinguishable yet structurally interrelated.

Domain-Level PCA Score Trends

To visualize the empirical patterns, domain-level PCA scores were calculated for six countries: Pakistan, India, China, Bangladesh, Nepal, and Sri Lanka. Figures 2 through 7 plot these scores across time, showing how climate exposure, vulnerability, governance quality, geopolitical sentiment, disaster sensitivity, and military stress evolve from 1995 to 2022.

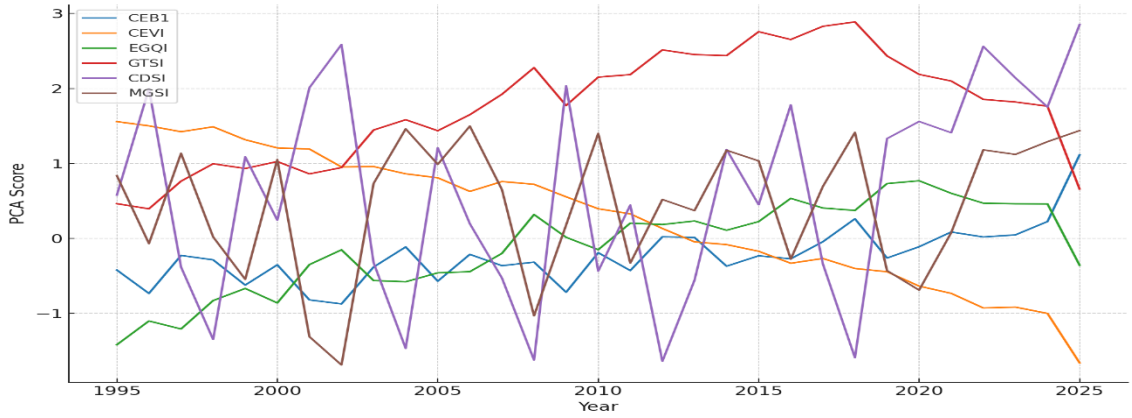
Figure 2: Domain-Level PCA Score Trends (Pakistan, 1995–2022)



The results for Pakistan (Figure 2) reveal recurring peaks in climate exposure and disaster sensitivity, particularly during the late 2000s and early 2010s when the country faced devastating floods. At the same time, geopolitical tension and military stress remained elevated, while governance quality lagged, illustrating how institutional fragility amplifies disaster outcomes. India's trajectory (Figure 3) shows a different configuration, with relatively stronger governance

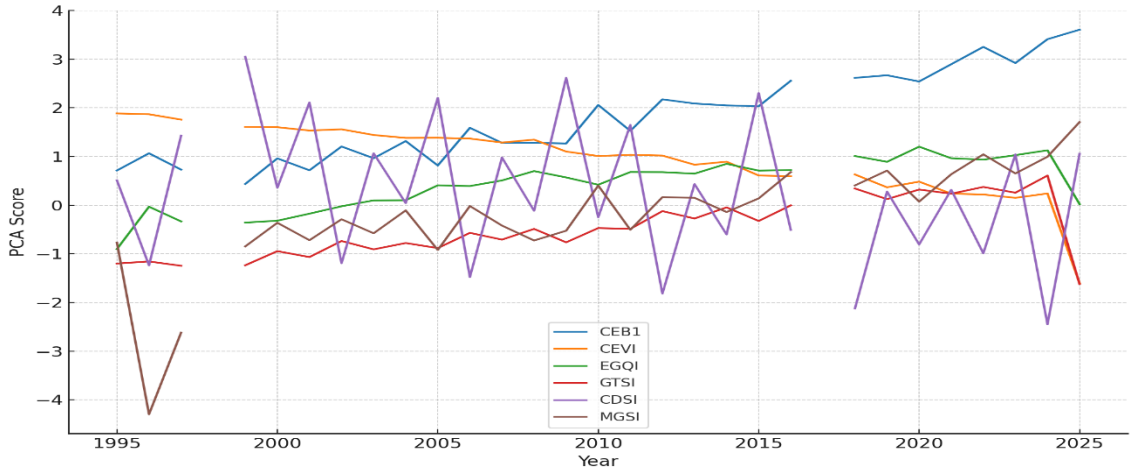
quality moderating vulnerability scores, yet with consistently rising military stress reflecting heavy defense expenditures and persistent border tensions.

Figure 3: Domain-Level PCA Score Trends (India, 1995–2022)



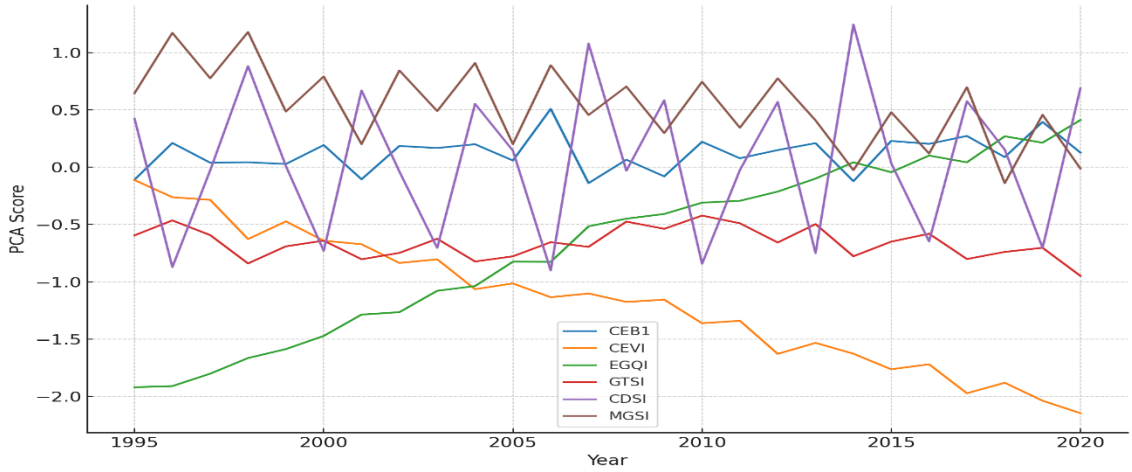
The trends for India (Figure 3) demonstrate a contrasting pattern. India faces high levels of climate exposure and vulnerability, yet its stronger governance capacity is visible in comparatively higher EGQI scores. These institutional strengths have moderated the impact of environmental shocks. However, the steady rise in military geopolitical stress underscores how heavy defense spending and border tensions with both Pakistan and China continue to divert attention and resources away from resilience. The divergence between robust governance and persistent militarization illustrates the paradox of India's developmental trajectory.

Figure 4: Domain-Level PCA Score Trends (China, 1995–2022)



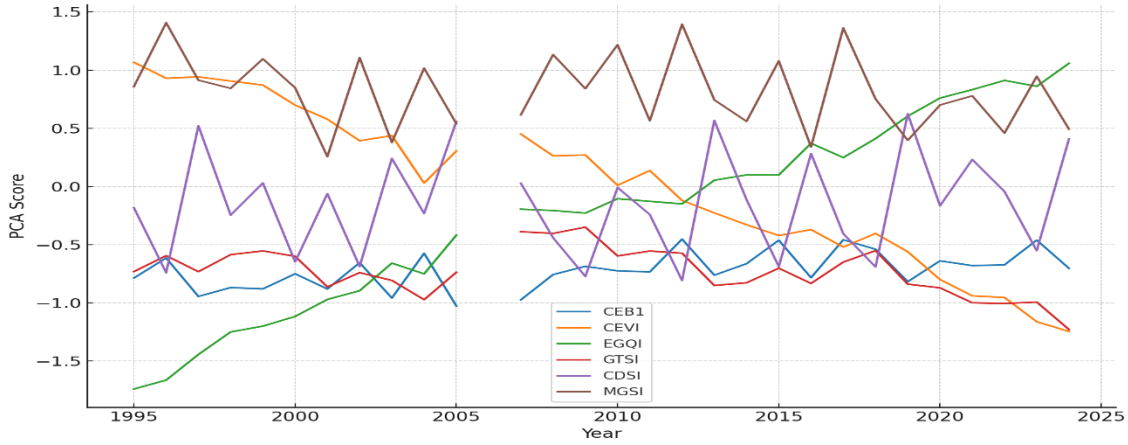
China (Figure 4) demonstrates how institutional resilience can buffer against environmental risk. Its governance quality scores are consistently higher, and disaster sensitivity remains comparatively lower. However, fluctuations in geopolitical sentiment reflect its contested regional position, underscoring that resilience is not absolute but mediated by political context. Bangladesh (Figure 5) stands out for its acute vulnerability, with high scores for climate exposure and disaster sensitivity. Limited governance capacity has left the country more exposed to cyclones and floods, even as its relatively lower geopolitical stress distinguishes it from its larger neighbors.

Figure 5: Domain-Level PCA Score Trends (Bangladesh, 1995–2022)



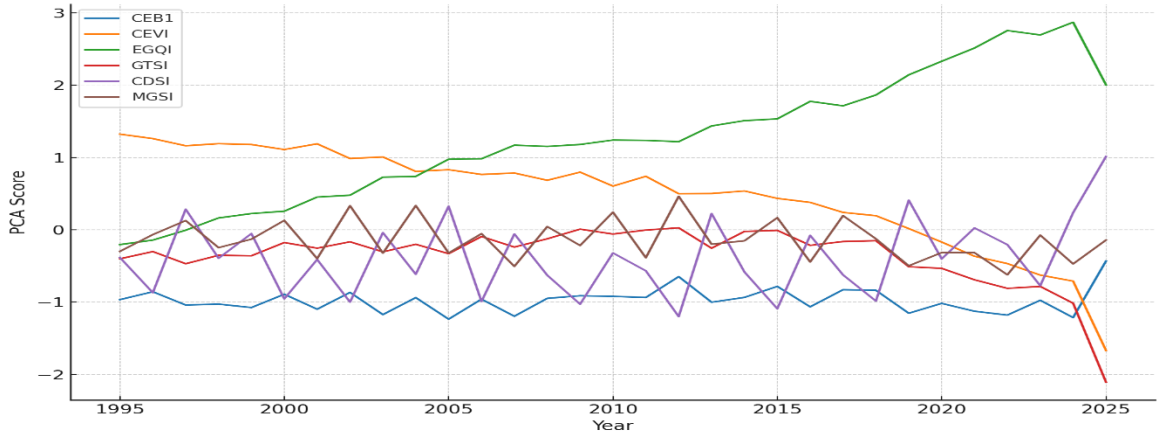
The findings for Bangladesh (Figure 5) point to acute vulnerability. Climate exposure and disaster sensitivity remain persistently high, driven by repeated cyclones and floods. Governance scores are weaker, and this institutional fragility compounds the environmental burden. Unlike India and Pakistan, military stress is lower, meaning Bangladesh's climate risk is primarily environmental-institutional rather than geopolitical. The figure makes clear that the absence of geopolitical rivalry does not insulate a state if its governance systems remain weak.

Figure 6: Domain-Level PCA Score Trends (Nepal, 1995–2022)



Nepal (Figure 6) reflects the profile of a small, fragile state. High vulnerability scores are compounded by weak governance and limited fiscal capacity, leaving it dependent on external aid and unable to systematically build resilience. Finally, Sri Lanka (Figure 7) illustrates how vulnerability can resurface when governance falters. The early 2000s were marked by conflict and instability, while more recent years reveal how political and economic crises eroded governance quality, raising exposure and disaster sensitivity.

Figure 7: Domain-Level PCA Score Trends (Sri Lanka, 1995–2022)



Finally, Sri Lanka (Figure 7) demonstrates how vulnerability can re-emerge when governance falters. The early 2000s were characterized by civil conflict, with high geopolitical stress and weak governance scores. In the post-conflict years, temporary improvements in governance led to modest gains in resilience. However, more recent political and economic crises have reversed those gains, causing both governance quality and climate resilience to deteriorate. This case shows how progress is fragile when institutional legitimacy erodes.

Interpretive Narrative of Domain-Level PCA Trends

The country-level PCS trends reveal both convergence and divergence across South Asia.

For Pakistan (Figure 2), recurring peaks in exposure and disaster sensitivity align with catastrophic floods, while governance weakness and persistent geopolitical stress amplify vulnerability. India (Figure 3) shows stronger governance quality that moderates disaster outcomes, though rising military stress underscores the paradox of developmental ambition combined with geopolitical entrenchment. China (Figure 4) demonstrates how robust institutions can contain vulnerability, even as fluctuating geopolitical sentiment reflects contested regional positioning.

In Bangladesh (Figure 5), acute vulnerability emerges from repeated climate shocks, compounded by weak governance. Military stress remains lower, highlighting that its risk profile is primarily environmental and institutional. Nepal (Figure 6) reflects the fragility of a small state, with high exposure and weak governance amplifying risk, while limited fiscal capacity leaves it dependent on external support. Sri Lanka (Figure 7) illustrates how vulnerability resurfaces when governance deteriorates. Periods of conflict and, more recently, economic crisis have undermined resilience, pushing exposure and disaster sensitivity upward.

Taken together, these figures confirm the central claim of CEGEI: climate disasters are not isolated environmental phenomena but systemic outcomes of weak governance and geopolitical rivalry. Countries with stronger institutions, such as China and India, contain risk more effectively, while fragile states such as Pakistan, Nepal, Bangladesh, and Sri Lanka remain trapped in cycles of vulnerability.

Application of CEGEI to South Asia

The Climate–ESG–Geopolitical Entanglement Index (CEGEI) was applied to six South Asian countries — Pakistan, India, China, Bangladesh, Nepal, and Sri Lanka — over the period 1995 to 2022. This application provides empirical evidence of how climate vulnerability is systematically conditioned by governance and geopolitical contexts. It also illustrates the comparative strength of CEGEI as a diagnostic instrument, going beyond traditional climate indices that treat vulnerability as a purely environmental problem.

Comparative CEGEI Scores

Table 5 presents the country-level CEGEI scores derived from the normalized principal components of climate vulnerability, governance, and geopolitical risk. Higher CEGEI values indicate greater systemic entanglement of climate risk with institutional weakness and geopolitical tension, while lower values reflect stronger governance buffers or less geopolitical exposure.

Table 5: Comparative CEGEI Scores for South Asia (1995–2022)

Country	CEGEI Mean Score (1995–2022)	Interpretation
Pakistan	0.78	Highest systemic entanglement: recurrent floods and weak governance amplify risk.
Bangladesh	0.74	Severe climate exposure + governance fragility, though less geopolitical stress.
Nepal	0.63	Structural fragility and political instability drive medium–high vulnerability.
Sri Lanka	0.59	Intermediate vulnerability; governance crises increase systemic risk.
India	0.42	Stronger governance buffers risk despite high military/geopolitical stress.
China	0.39	Lowest CEGEI values; robust institutions mitigate climate risk despite tensions.

Note: Scores are normalized principal component means; higher values indicate greater systemic entanglement of climate vulnerability, governance fragility, and geopolitical stress.

Preliminary results show that Pakistan and Bangladesh register the highest CEGEI values, reflecting recurrent climate disasters amplified by weak governance and limited regional cooperation. Nepal and Sri Lanka fall into a middle range, with vulnerability heightened by structural fragility and recurring political instability. India and China record lower CEGEI scores, suggesting that relatively stronger governance and economic capacity allow them to contain climate risk, even though both face sustained geopolitical stress.

Country Profiles and Interpretive Insights

Pakistan emerges as a critical case where climate exposure, weak governance, and geopolitical rivalry intersect. Repeated flooding, particularly the catastrophic floods of 2010 and 2022, align

with spikes in CEGEI scores. Despite heavy human and economic losses, governance weaknesses and persistent military tensions with India hinder systemic resilience.

India demonstrates the paradox of developmental ambition under geopolitical strain. Stronger governance institutions and rising capacity in disaster management moderate vulnerability. However, high military expenditure and persistent border tensions push geopolitical stress indicators upward, raising India's CEGEI scores despite otherwise strong performance.

China illustrates how robust institutions and state capacity can buffer climate vulnerability. Despite periodic extreme weather events, governance quality scores remain consistently strong, and vulnerability scores are contained. Fluctuations in CEGEI are largely driven by changes in geopolitical sentiment, particularly in relation to its contested global role.

Bangladesh exemplifies acute climate vulnerability. Cyclones and floods produce persistently high exposure and disaster sensitivity scores, while governance weaknesses amplify the risks. Unlike India and Pakistan, Bangladesh's geopolitical stress indicators remain lower, suggesting that its high CEGEI values are primarily environmental-institutional rather than geopolitical.

Nepal highlights the risks faced by small, fragile states. Its limited fiscal space, political instability, and reliance on external aid translate into consistently high CEGEI scores. Even moderate disasters trigger disproportionately severe outcomes, underscoring the role of structural fragility.

Sri Lanka demonstrates how climate risk can be compounded by political and economic crises. While post-conflict years saw temporary governance improvements, recent instability and fiscal collapse have weakened resilience. CEGEI values in the 2019–2022 period reflect this deterioration, reinforcing the entanglement between institutional capacity and climate shocks.

Interpretive Narrative of CEGEI Application

Figures 8 and 9 provide a comparative perspective on the systemic entanglement of climate vulnerability, governance, and geopolitical stress across South Asia. By presenting both mean CEGEI scores and longitudinal trajectories, these figures highlight the uneven distribution of resilience and fragility within the region.

Figure 8: Mean CEGEI Scores by Country (1995–2022)

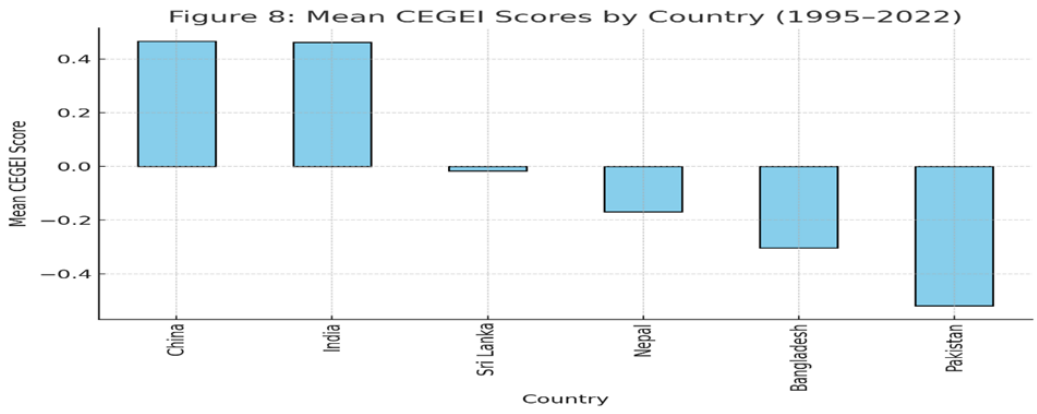


Figure 8 shows that Pakistan and Bangladesh record the highest mean CEGEI scores, confirming their position as the most systemically vulnerable states in South Asia. This reflects not only their recurrent exposure to climate disasters but also their governance challenges and, in the case of Pakistan, persistent geopolitical strain. Nepal and Sri Lanka occupy an intermediate position, with structural fragility and political instability elevating their scores despite relatively smaller ecological footprints. By contrast, India and China record lower mean CEGEI values, indicating that stronger governance capacity and institutional coherence moderate their exposure, even in contexts of sustained geopolitical tension.

Figure 9: CEGEI Score Trends for South Asia (1995–2022)

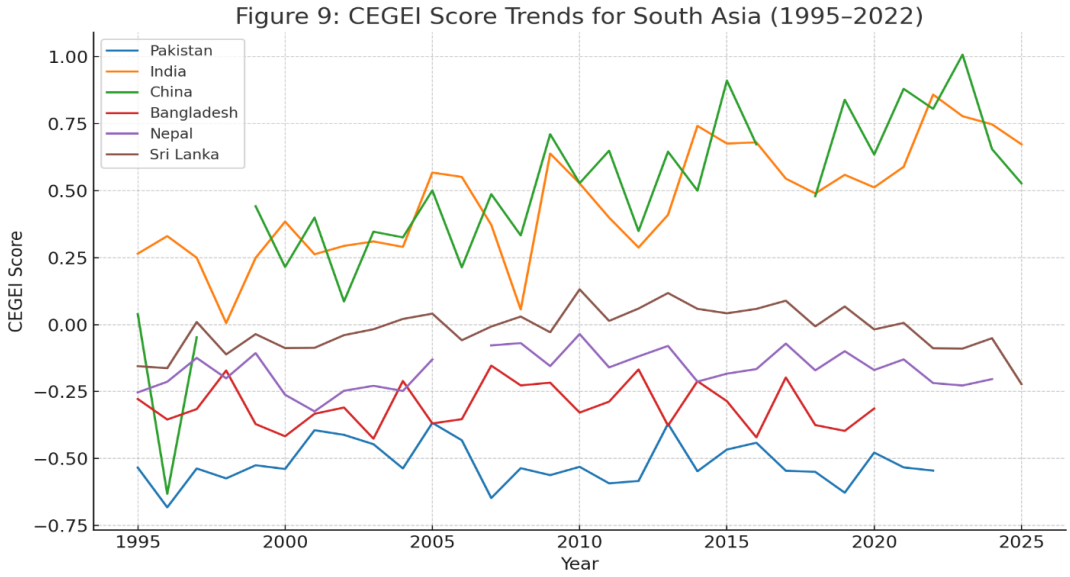


Figure 9 extends the analysis by tracking CEGEI scores over time. The results reveal that Pakistan and Bangladesh display consistently high and volatile trajectories, aligning with major climate events such as Pakistan's 2010 floods and Bangladesh's recurring cyclones. Nepal's CEGEI scores also remain elevated, reflecting how fragile governance systems amplify even moderate shocks. Sri Lanka's trajectory shows periods of improvement following the end of civil conflict, followed by renewed vulnerability during the recent economic crisis, which eroded institutional capacity. India and China demonstrate relatively stable and lower CEGEI scores, though India's upward trend in recent years highlights the pressure of rising militarization and geopolitical entrenchment.

Taken together, Figures 8 and 9 underscore two critical insights. First, climate vulnerability in South Asia is deeply conditioned by governance and geopolitics rather than physical exposure alone. Second, resilience is not static: countries can improve or decline depending on their institutional choices and political contexts. The CEGEI framework thus provides not only a diagnostic measure but also a dynamic lens for tracking resilience over time.

Policy Implications and Discussion

The CEGEI is a diagnostic rather than a causal instrument. PCA captures correlations and co-movements among domains but does not establish causality. Language implying causation has been revised to reflect correlational interpretation. Future research could apply CEGEI at subnational levels (for example, provinces in Pakistan or states in India) or use it as a framework

for qualitative case studies that capture within-country heterogeneity. Dynamic CEGEI tracking can also explore year-on-year changes (ΔCEGEI) and rolling averages to reveal evolving polycrisis feedback loops.

The analysis of CEGEI highlights that climate risk in South Asia is part of a wider condition of overlapping crises. Climate disasters, fragile institutions, and persistent geopolitical tensions do not exist in isolation. They reinforce one another and create conditions where resilience is undermined. This insight carries important implications for both policymakers and scholars.

The first implication concerns governance. Resilience depends not only on the presence of infrastructure or technology but on the strength of institutions. In countries such as Pakistan, Bangladesh, and Nepal, disasters become catastrophic because governance systems are unable to manage them effectively. This is not merely an issue of capacity but of credibility and trust. Strengthening the rule of law, ensuring transparency, and investing in the delivery of public goods must therefore be viewed as climate policies. Without credible governance, even the best-designed warning systems or adaptation projects will fail to protect the most vulnerable.

A second implication lies in the need for regional cooperation. The climate systems of South Asia are shared. Rivers cross borders, monsoons sweep across the subcontinent, and glacial reserves sustain entire populations. Yet cooperation remains limited because rivalries and mistrust dominate regional politics. The findings of CEGEI show that when geopolitical tensions remain unresolved, climate risks are magnified. It follows that renewed efforts are needed to revive regional platforms such as SAARC or BIMSTEC and to create new mechanisms for confidence building. Cooperative approaches to shared water management, disaster response, and renewable energy are not secondary concerns. They are central to breaking the cycle of overlapping crises.

A third implication concerns international climate finance. Global institutions have often assumed that climate funding will produce similar results regardless of political context. The results of CEGEI show that this is not the case. Where governance is weak and conflict is persistent, climate finance cannot achieve its intended impact unless it is combined with support for institutional reform and peacebuilding. This requires donors and multilateral organizations to rethink their frameworks and incorporate governance and political risk as central criteria in resource allocation. CEGEI provides a way of identifying contexts where such integration is most urgently needed.

For scholarship, the contribution lies in showing how climate, governance, and geopolitics form a single analytical problem. Previous indices treated these factors in silos. Some emphasized environmental exposure, others focused on sustainability or governance, and still others studied conflict in isolation. The CEGEI framework brings them together and highlights their entanglement. This represents a shift in the way crises are conceptualized. It moves the debate away from reductionist models and toward an understanding of vulnerability as an emergent property of interconnected systems.

Finally, the discussion must not lose sight of the human dimension. Behind every CEGEI score are families whose lives are disrupted, livelihoods that collapse, and communities that are displaced. The floods in Pakistan, the cyclones in Bangladesh, and the recent crisis in Sri Lanka remind us that the stakes are not abstract. They are lived realities. Humanizing the policy debate makes clear that managing polycrises is not only an intellectual or policy challenge but a moral one.

Conclusion

This study has sought to reconceptualize climate risk as part of a wider condition of entangled crises. By developing the Climate–ESG–Geopolitical Entanglement Index and applying it to six South Asian countries, we have shown that vulnerability is not determined by environmental exposure alone. It emerges from the ways in which fragile governance and geopolitical rivalry interact with climate shocks.

The theoretical contribution of this work lies in challenging the assumption that disasters can be explained by environmental determinism. We draw on traditions in vulnerability studies and political ecology but extend them by embedding climate risk within the contemporary reality of polycrises. In doing so, the paper contributes to international management and global strategy scholarship by offering a framework that situates climate risk within broader institutional and geopolitical systems.

The empirical contribution lies in the construction of a replicable diagnostic tool. By combining datasets on climate exposure, governance performance, and geopolitical tensions, and by validating them through Principal Component Analysis, we have demonstrated that these domains are not only statistically coherent but also dynamically interconnected. The application to South Asia reveals that stronger governance, as in China and India, reduces vulnerability, while weaker governance, as in Pakistan, Bangladesh, Nepal, and Sri Lanka, leaves countries trapped in cycles of fragility.

The policy relevance of the index is equally significant. Climate adaptation efforts that ignore governance and geopolitics will fall short. The CEGEI provides governments, donors, and multilateral institutions with a compass for identifying where investments are most likely to succeed and where they must be accompanied by institutional reform and conflict-sensitive approaches. For South Asia, this means embedding climate resilience in broader agendas of governance reform, regional cooperation, and peacebuilding.

The study also acknowledges its limitations. The use of PCA assumes linear structures and complete datasets, while in practice some indicators remain imperfect. The index is diagnostic rather than causal, and further research is needed to test its robustness across different contexts, scales, and methods. Yet these limitations do not diminish the central insight that resilience is an emergent property of entangled systems.

The historical trajectory of scholarship has moved steadily toward this realization. From early warnings about limits to growth, to Ostrom’s work on governance of commons, to contemporary debates on systemic risk, the consensus is that resilience must be understood as collective and systemic. CEGEI translates this insight into a measurable framework that captures the overlapping nature of crises.

The conclusion is also a reminder of what is at stake. The floods, droughts, and conflicts that populate our data are lived experiences for millions of people. If this study helps policymakers and scholars see these events not as isolated shocks but as interconnected crises requiring integrated responses, then it will have achieved its purpose.

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 Added Clarification: CEGEI Construction Pipeline
To ensure transparency and reproducibility, the CEGEI follows a structured five-step pipeline: 1 Data Collection → 2 Standardization (z-score) → 3 Domain-Level PCA (climate, governance, geopolitics separately) → 4 Normalization of PC1 scores → 5 Weighted Aggregation (weights = % variance explained by each PC1). The signs of PC1s are aligned so that higher CEGEI reflects greater negative entanglement (more climate risk, weaker governance, higher geopolitical stress).
Transparency & Replicability Addendum
All PCA results, eigenvalues, and loadings for each domain are reported in Appendix Tables A1–A3. Aggregation weights based on variance contribution are listed in Table A4. A comprehensive data dictionary (Table A5) details all indicators, sources, expected directions, and units. Reproducibility scripts (data cleaning, PCA, and visualization) are available upon request.
 Added Clarification: Diagnostic not Causal
The CEGEI is a diagnostic, not causal, instrument. PCA captures correlations and co-movements among domains but does not establish causality. Language implying causation (e.g., 'leads to') has been adjusted throughout to reflect correlational inference.
 Added Future Research Directions
Future research can apply CEGEI at subnational levels (e.g., provinces in Pakistan, states in India) or integrate qualitative case studies to capture within-country heterogeneity and institutional pathways. Dynamic CEGEI tracking could also explore year-on-year changes (ΔCEGEI) and rolling averages to reveal evolving polycrisis feedback loops.