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CLIMATE RESILIENCE BEYOND NET ZERO: COMPARING EMERGING GOVERNANCE PATHWAYS FOR SUSTAINABLE ENVIRONMENTAL MANAGEMENT IN CHINA AND PAKISTAN

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Abstract

Net-zero commitments have become central to climate policy, yet emissions-reduction targets alone do not ensure resilience to intensifying climate risks or sustainable environmental management. This study examines how governance systems can move beyond net-zero commitments by integrating mitigation, adaptation, ecosystem protection, institutional learning, climate finance, stakeholder participation, and digital environmental governance. Using a qualitative comparative case-study approach, the study analyses the emerging climate-governance pathways of China and Pakistan through documentary evidence covering national climate policies, adaptation strategies, environmental frameworks, institutional arrangements, and implementation mechanisms. The study's principal novelty is the development of a Climate Resilience Governance Framework (CRGF) that integrates adaptive governance, climate-resilient development, and polycentric governance across six interrelated dimensions: institutional coordination, adaptive capacity, climate finance, ecosystem-based environmental management, stakeholder participation and climate justice, and digital environmental governance. The comparative findings demonstrate that China's pathway is characterised by strong central coordination, long-term strategic planning, substantial domestic investment, technological capacity, and large-scale environmental implementation, while challenges remain in locally differentiated adaptation, stakeholder participation, and continuous institutional learning. Pakistan has increasingly embedded adaptation, vulnerability, ecosystem restoration, and climate justice within its policy framework, but implementation is constrained by fiscal limitations, fragmented federal-provincial responsibilities, institutional discontinuity, and uneven subnational capacity. The analysis further identifies institutional coordination as a connecting mechanism

through which finance, information, ecosystem management, participation, and adaptive learning can generate resilience outcomes. The study concludes that progress beyond net zero depends less on the adoption of ambitious targets alone than on the development of coordinated, adequately financed, adaptive, inclusive, and context-sensitive governance capabilities. The CRGF provides an analytical basis for comparing such pathways across developing and emerging economies without assuming a universal governance model

1. INTRODUCTION

Climate change has come from the horizon of the prospect of an environmental challenge to the forefront of the challenge of multidimensional governance. While it is still essential to cut greenhouse-gas emissions, the technical need of adaptation to climate change is becoming increasingly evident, as can be seen within the context of rising temperatures, intensifying floods and droughts, ecosystem degradation and the rising pressure of water and food systems. The Intergovernmental Panel on Climate Change highlights that climate change is already having widespread negative effects, and the options for effective adaptation are narrowing as climate change worsens [1]. International climate policies, therefore, must move beyond merely accounting carbon emissions and setting long-term net zero goals to focus on institutional, ecological and socioeconomic capabilities to deal with climate risks. This more comprehensive perspective is represented by the concept of climate-resilient development, which combines climate change mitigation and adaptation and sustainable development, equity, and human well-being [2].

Net zero has emerged as a prevailing framework in today's climate policy discourse. As emissions reductions targets, renewable-energy transitions, carbon markets and carbon-removal strategies become more commonplace in the work of governments, corporations and international institutions, they are increasingly expected to align development with the goals of the Paris Agreement [3]. However, commitments to 'neutral' can still be inadequate if they are not linked to adaptation planning, ecosystem protection, disaster preparedness and institutional coordination and vulnerable community needs. The first Global Stocktake under the Paris Agreement was held in 2023, pointing to the need for more action on mitigation, adaptation, finance, technology and capacity building [4]. At COP28, there was also an advance in how the Global Goal on Adaptation is being formulated, as recognition of the need to boost resilience alongside emissions reduction in climate policy grows around the world [5].

Achieving net-zero is a governance challenge and the shift to climate resilience is the same. In addition to financial and technological tools, the ability of institutions to coordinate policies, learn from environmental changes, distribute responsibilities, involve affected communities and adapt interventions as the environment changes, plays a critical role in climate resilience [6]. Adaptive governance is thus a relevant lens through which to understand how governments react to social-ecological uncertainty, complexity and change. It moves away from the rigid concept of policy commitments and puts place-based and context-specific environmental management measures, multi-level coordination, iterative learning and flexible institutional arrangements on the agenda. This change is particularly relevant in developing and emerging economies where the fiscal constraint and administrative capacity and social vulnerability may be uneven, making it difficult to achieve ambitious climate pledges. The estimated needs for adaptation finance for developing countries is US$310 billion per year by 2035, and current international public financing is still low [7, 8].

China and Pakistan offer analytically useful examples to explore governance pathways to net zero. China is the largest developing economy in the world, and has been running a ‘centralised climate agenda' involving emissions mitigation, environmental long-term planning, environmental restoration, renewables development and ‘ecological civilisation' [9, 10]. It

has formulated its National Climate Change Adaptation Strategy 2035, which focuses on monitoring climate risks, regional differences, climate-resilient infrastructure, ecosystem protection and embedding adaptation into its economic and social development [11, 12]. These are examples of the synergies between long-term planning, central direction and technologic capacity towards a large-scale environmental action. But differences in implementation across provinces and in coordination between successive administrative levels and a conflict between economic development, energy security and ecological goals are important governance issues [13].

Pakistan has a contrasting governance context where the vulnerability to climate change is very high, historical emissions are relatively low, fiscal space is limited, institutional fragmentation exists between the federal and province and exposure to floods, droughts, heatwaves, glacier-related hazards and water insecurity is high. (The National Adaptation Plan (NAP [14]) is committed to incorporating adaptation into development planning and enhancing the socio-economic and environmental resilience of vulnerable communities by taking a holistic and sustainable approach [15, 16]. However, weak financial resources, institutional discontinuity, uneven provincial capacity, weak coordination and reliance on international climate financing impede policy implementation. The comparison should not be used to judge or as an example of how one form of governance can be applied to another. Instead, it allows to analyse the effects of various political, institutional and developmental settings on the translation of climate goals into environmental-management results.

Previous research has widely studied the concept of carbon neutrality and the transition to renewable energy or national mitigation commitments [17]. But comparatively less focus has been on the linkage between the themes of mitigation and adaptation, ecosystem management, climate finance, public participation and digital monitoring and institutional learning by China [18] and Pakistan [19]. Further, research often considers climate policies separately, without considering the interdependent governance processes by which resilience is created. This leaves both conceptual and empirical gaps in the ability of national climate systems to go beyond the setting of a net zero target to integrated and adaptive environmental governance.

For this purpose, the current research makes a comparison between emerging climate-governance pathways of China and Pakistan, and assesses their role in sustainable environmental management. How are the priorities for climate resiliency embedded in the governance systems that go beyond the national mitigation and net-zero pledges of China and Pakistan? (2) What is the status of institutional coordination, adaptive capacity, climate finance, ecosystem management, participation of stakeholders and digital governance in implementation in the two countries? (3) What are the governance lessons that are transferable to other developing economies, and which depend on the national context? The study develops a comparative Climate Resilience Governance Framework that provides an integrated analytical approach to explain the linkage between governance arrangements and commitments to climate and institutional adaptability, ecological resilience and sustainable environmental outcomes.

2. Literature Review

2.1 Climate Resilience and Sustainable Environmental Management

The concept of climate resilience has evolved from a more limited focus on resilience to climatic shocks and stresses to one that includes anticipation, preparedness, absorption, adaptation and institutional transformation. Resilience is not just about being able to bounce back to pre-disruption conditions, but also to maintaining key functions and learning and reorganising in response to new risks in social-ecological systems [20, 21]. [22, 23] linked resilience and adaptive governance and showed that flexible institutions, social learning, leadership, networks and the mobilization of various types of knowledge are necessary to support environmental systems. Scholarship has also developed since this remarkable time, which

has examined resilience as a governance capability, not an environmental condition. The notion of 'climate-resilient development' also meshes adaptation and mitigation with sustainable development, human well-being, ecosystem integrity, equity and justice. The Intergovernmental Panel on Climate Change (IPCC) states that climate-resilient development relies on Governments, communities, businesses and civil-society actors taking coordinated action across political, economic, ecological and technological spheres [24, 25].

Preserving biodiversity and ecosystems plays a key role in this process, as ecosystems simultaneously mitigate, sustain livelihoods and decrease climatic risks [24, 26, 27]. Climate resilience is thus more than just pollution prevention, or resource conservation; it involves environmental institutions being prepared for uncertainty, and adapting policies to changing climate [28]. Although policies are becoming more aware, adaptation is still incremental and uneven. Current interventions often take place in short-term projects in silo sectors and are not linked to national development plans. As warming increases, adaptation is increasingly limited and can be less effective, whereas maladaptation can compound vulnerability and inequality and ecosystem degradation [29]. Therefore, sustainable environmental management should always be based on long-term risk assessment, flexibility in planning as well as continuous assessment, but not just on static conditions based on past climates.

2.2 Net-Zero Governance: Achievements and Limitations

A key tenet of global climate governance is 'Net Zero'. It sets out a long-term trajectory for anthropogenic greenhouse-gas emissions which can be reduced and residual emissions can be balanced by removals. National pledges have driven the growth of renewables, decarbonisation of industry, development of carbon markets, and investments in low-carbon technologies. Despite this, the net zero governance is mostly mitigation focused, which does not necessarily decrease exposure or vulnerability to floods, heatwaves, droughts, sea level rise and ecosystem disruption. To achieve the goal of net zero, they propose that meaningful, actionable solutions need to be legally committed, have near-term targets with clear milestones, have clear and transparent emissions accounting, are equitable in terms of burden sharing, and rely on limited carbon removal of uncertain efficacy.

The commitments are poorly designed, thereby delaying immediate reduction in emissions, or relying on excessive offsets or hiding ongoing fossil fuel use. Likewise, [30] point out that the coverage, time horizon, equity and treatment of removals in net-zero targets are highly variable. A headline target thus tells little about the presence of institutions, finance and implementation mechanisms to provide a sustainable transition in a country. The fact that mitigation and adaptation are separated also introduces an added governance failure. While emission reductions will reduce future climate risks, adaptation is already necessary due to committed warming and existing climate change. The Global Goal on Adaptation of the Paris Agreement aims to increase adaptive capacity, promote resilience and decrease vulnerability, among other things, in the pursuit of sustainable development [31]. The UAE Framework for Global Climate Resilience was then followed by thematic and policy-cycle targets in the areas of risk assessment, planning, implementation, and monitoring and learning [4, 32].

The developments are indicative of a progressive shift from a primarily mitigation-driven climate governance to a more comprehensive governance model, where the development of implementation and measurement is still weak. The literature thus argues for a “beyond net zero” approach instead of giving up on the concepts of “net zero.” While mitigation is critical, preparedness and adaptation, ecological protection and distributive justice should also be considered in its effectiveness. It is not a matter of putting resilience in place of decarbonisation, but rather of how both goals could be implemented in coherent environmental-governance systems.

2.3 Adaptive Environmental Governance

Adaptive governance provides a valuable conceptual underpinning for the governance of

complex and uncertain climate risks. It focuses on flexibility of institutions, experimentation, learning, collaboration and the ability to adapt decisions over the course of time as social and ecological conditions change. Some conditions for adaptive ecosystem governance mentioned by [33] are leadership, knowledge integration, institutional memory and bridging organisations. Finally, [34] define adaptive governance as a "emergent process in which multiple actors at different institutional levels respond to environmental uncertainty". But adaptive governance is not necessarily inclusive and inclusive. Theoretical multiplicity is required, as theory is not a tool for adaptive-governance research to exclude political conflict, institutional history and unequal power [35].

Evidence also suggests that ideas emerging from more-capable governance systems don't necessarily transfer when it comes to informality, resource limitations, centralisation and lack of public participation in the system, as seen in the Global South. According to [36] adaptive governance in developing settings is closely reliant on political commitment, institutional coordination, local knowledge and capacities taking into account context-specific factors. The concept of adaptive governance is especially appropriate for China and Pakistan because they are facing a rapidly evolving environment, yet have very different institutional structures. China's governance system can be able to mobilise resources and implement the national priorities at a relatively large scale, but this might limit experimentation and participation from below. Pakistan has decentralisation in its constitution and administration, but the lack of coordination due to divided responsibilities and unequal capacity of provinces may hinder the effective implementation [37, 38]. Adaptive governance needs to be implemented in a way that is unique to each situation, not as a blueprint template.

2.4 Polycentricity and Institutional Capacity

Polycentric governance complements adaptive governance by recognising that climate action occurs through multiple, partly autonomous centres of authority. [39] rejected the assumption that complex environmental problems can be addressed only through a single centralised authority. Polycentric systems may encourage experimentation, mutual learning and solutions tailored to local conditions while retaining coordination through shared rules. More recent analysis nevertheless stresses that the state remains important in providing legal authority, finance, accountability and coordination among local initiatives [40].

Polycentricity also creates risks. Overlapping authority may generate duplication, inconsistent standards and accountability gaps. [41] caution that polycentric-governance research often insufficiently addresses power, including who controls resources, defines environmental problems and participates in decision-making. Thus, institutional multiplicity produces resilience only when mechanisms exist for coordination, transparency, conflict resolution and equitable participation.

Institutional capacity connects these theoretical insights to implementation. Climate policies require technical expertise, reliable data, administrative continuity, cross-sectoral coordination and the ability to mobilise finance. [42] observes that many governments have adopted national adaptation strategies but continue to face implementation and evaluation gaps. Institutional capacity should therefore be assessed not by the existence of policy documents alone but by whether authorities can translate commitments into funded, monitored and enforceable action.

2.5 Environmental Justice and Inclusive Adaptation

Climate impacts and policy responses are unevenly distributed. Vulnerability is shaped by income, gender, geographic location, livelihood dependence, political representation and access to public services. Climate justice therefore requires attention to procedural justice, distributive justice and recognition. Procedural justice concerns participation in decisions; distributive justice examines how climate costs and benefits are allocated; and recognition justice considers whether the knowledge, identities and needs of

marginalised groups are respected.

[43] argue that a just transition must move beyond employment impacts in the energy sector to address broader questions of power, development and inequality. [44] similarly show that urban adaptation can reproduce inequality where investments prioritise economically valuable areas while shifting risks towards marginalised populations. Adaptation should therefore be evaluated not only by aggregate reductions in climate exposure but also by who receives protection, who pays and who participates.

This issue is particularly important for Pakistan, where climate vulnerability intersects with poverty, livelihood insecurity and uneven access to infrastructure. It is also relevant to China because rapid urbanisation, regional inequality and differentiated local capacity affect the distribution of climate risks. Inclusive resilience requires participatory planning, locally appropriate interventions, gender responsiveness and mechanisms through which vulnerable groups can influence implementation.

2.6 Climate Finance and the Green Transition

Finance is a decisive constraint on the transition from policy ambition to climate resilience. Adaptation projects often provide dispersed and long-term public benefits, making them less attractive to private investors than revenue-generating mitigation projects. [45] estimates that developing countries may require approximately US$310-365 billion annually for adaptation by 2035, while international public adaptation finance amounted to only about US$26 billion in 2023. This difference illustrates that adaptation remains structurally underfunded despite growing recognition of climatic losses.

Climate finance is also shaped by access, governance and absorptive capacity. Developing countries may face complex application procedures, limited project-preparation capacity, debt constraints and fragmented funding channels. The OECD Climate Adaptation Investment Framework stresses that mobilising investment requires supportive domestic policies, reliable climate-risk information, appropriate financial instruments and coordination between public and private institutions [46].

China possesses greater domestic financing and technological capacity to support large-scale mitigation and adaptation programmes. Pakistan, by contrast, relies more heavily on concessional finance, multilateral development institutions and external capacity support. This difference makes finance an essential comparative dimension: it shapes not only the scale of interventions but also national policy autonomy, continuity and the ability to prioritise locally defined resilience needs.

2.7 Ecosystem-Based Environmental Management

Ecosystem-based adaptation and nature-based solutions seek to protect, sustainably manage or restore ecosystems while addressing climatic and societal challenges. Such measures include wetland restoration, urban green infrastructure, watershed rehabilitation, mangrove protection, agroforestry and climate-resilient landscape management. Nature-based solutions may simultaneously reduce hazards, sequester carbon, protect biodiversity and support livelihoods. [47] Nevertheless stresses that they must supplement rather than substitute rapid emissions reduction.

[48] Identify governance, financing, stakeholder engagement and appropriate monitoring as key conditions for scaling nature-based solutions. Poorly designed interventions may promote monocultures, displace communities or prioritise carbon storage at the expense of biodiversity. China's ecological-restoration programmes and Pakistan's afforestation and ecosystem-restoration initiatives provide relevant comparative cases, but their resilience benefits depend on ecological suitability, maintenance, community participation and long-term monitoring.

2.8 Digital Technologies and Climate Governance

Artificial intelligence, remote sensing, geographic information systems, digital twins, sensor networks and big-data analytics are increasingly used for environmental monitoring and climate-risk management. These technologies can improve hazard forecasting, identify vulnerable areas, monitor land-use change and support the

allocation of adaptation resources. The UNFCCC's work on artificial intelligence for climate action highlights applications in early warning, agriculture, infrastructure, ecosystem monitoring and decision support, particularly for developing countries.

Digital governance nevertheless raises concerns about data quality, unequal technical capacity, privacy, transparency and technological dependence. Climate models and automated systems may reproduce existing biases when local data are incomplete or affected communities lack influence over system design. Digital innovation must therefore be accompanied by institutional accountability, open standards, human oversight and investment in local technical capacity. It should operate as an enabling component of adaptive governance rather than as a substitute for political judgment or community participation.

2.9 Comparative Climate Governance in China and Pakistan

China's climate policy combines national planning, carbon-peaking and neutrality commitments, industrial transformation, ecological civilisation and adaptation. Its "1+N" policy framework coordinates carbon-peaking and carbon-neutrality objectives across sectors, while the National Climate Change Adaptation Strategy 2035 emphasises risk monitoring, resilient infrastructure, ecosystem protection, regional differentiation and integration of adaptation into socioeconomic development [49, 50]. China's model demonstrates the advantages of long-term planning, administrative mobilisation and technological investment, but scholarship identifies continuing tensions involving fossil-fuel dependence, local implementation and the balance between economic growth and climate ambition [51].

Pakistan's climate framework places greater emphasis on vulnerability, adaptation, disaster-risk reduction and external climate finance. Its Updated Nationally Determined Contribution presents a vision of a low-carbon and climate-resilient economy, while the National Adaptation Plan identifies priority actions in water, agriculture, urban resilience, ecosystems, health and disaster management [52]. The plan also acknowledges that adaptation and resilience requirements between 2023 and 2030 may reach approximately US$152 billion. However, implementation is constrained by fiscal limitations, fragmented federal-provincial responsibilities and uneven institutional capacity.

The literature on both countries remains dominated by country-specific assessments of emissions, energy, vulnerability or individual policies. Direct comparison of the governance mechanisms connecting net-zero ambitions with adaptation, ecosystem management, finance, participation and digital capacity remains limited. Furthermore, policy adoption is frequently treated as evidence of progress without systematic attention to implementation capacity and environmental outcomes.

2.10 Research Gap and Theoretical Positioning

Three gaps emerge from the literature. First, net-zero and adaptation scholarship often develops in parallel, limiting understanding of how mitigation and resilience can be institutionally integrated. Second, studies of China and Pakistan rarely employ a common framework capable of explaining how different political and administrative systems translate climate commitments into environmental-management outcomes. Third, existing assessments insufficiently integrate institutional capacity, climate finance, ecosystem management, environmental justice and digital governance within one comparative model.

This study addresses these gaps through a Climate Resilience Governance Framework that combines adaptive and polycentric governance with six operational dimensions: institutional coordination, adaptive capacity, climate finance, ecosystem management, stakeholder participation and digital environmental governance. The framework treats climate resilience as an outcome produced through interacting governance pathways rather than as an automatic consequence of policy adoption or net-zero commitment.

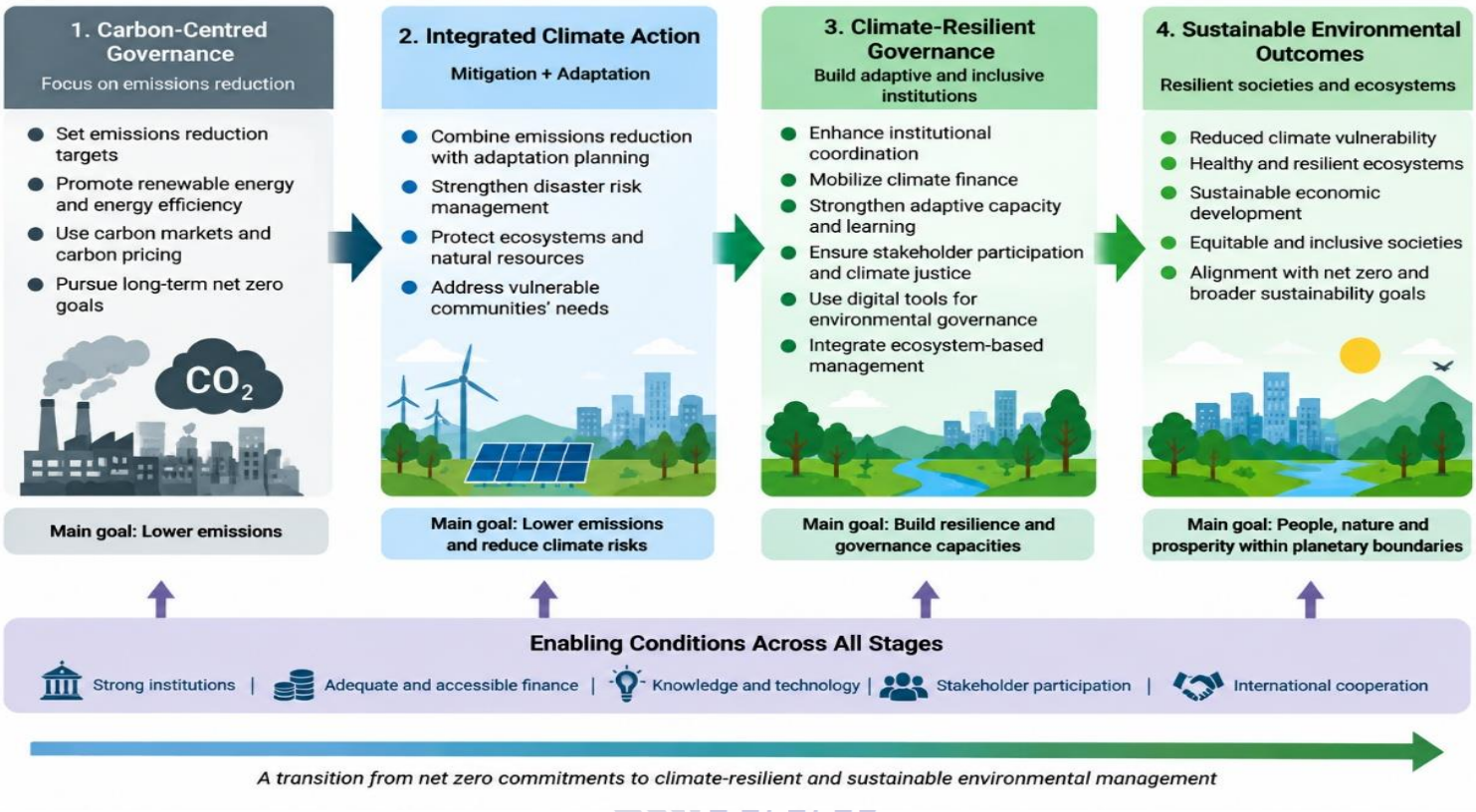


Figure 1. Beyond Net Zero: Conceptual Transition from Carbon-Centred Climate Action to Climate-Resilient Environmental Governance

3. Theoretical Framework

3.1 Climate Resilience as a Governance Outcome

Climate resilience is commonly understood as the capacity of interconnected social, economic and ecological systems to anticipate climate-related risks, absorb disturbances, adapt to changing conditions and reorganise without losing their essential functions. Resilience is therefore not merely a technical property of infrastructure or an environmental system. It is also produced through institutions, public policies, knowledge systems, financial arrangements and relationships among governmental and non-governmental actors. From this perspective, climate resilience represents a governance outcome rather than an automatic consequence of economic development or technological investment.

The concept of social-ecological resilience provides the first theoretical foundation for this study. Social and ecological systems are interdependent, meaning that environmental degradation can intensify social vulnerability while weak institutions and unequal development can reduce the capacity of ecosystems to recover from climatic disturbances. Folke et al. (2005) argue that the governance of social-ecological systems require institutions capable of learning, reorganising and responding to unexpected change. Their work identifies leadership, knowledge integration, institutional memory, networks and bridging organisations as important sources of adaptive capacity. Resilience consequently depends on whether governance systems can modify their decisions when established policies become ineffective under changing climatic conditions.

This understanding corresponds with the concept of climate-resilient development advanced by the Intergovernmental Panel on Climate Change. Climate-resilient development integrates greenhouse-gas mitigation and climate adaptation

with sustainable development, ecological integrity, equity and human well-being. It recognises that mitigation and adaptation cannot be treated as separate policy domains because the feasibility of resilient development depends on choices made simultaneously across political, economic, ecological, technological and social systems [53]. Accordingly, the present study treats net-zero commitments as only one component of a broader governance process. Their contribution to sustainable environmental management depends on whether they are supported by adaptation planning, ecosystem protection, inclusive decision-making and institutional capacity.

3.2 Adaptive Governance Theory

Adaptive governance provides the central theoretical lens for explaining how institutions respond to uncertainty and environmental change. Unlike conventional governance approaches based on stable conditions, fixed administrative responsibilities and predetermined policy instruments, adaptive governance emphasises flexibility, experimentation, monitoring, institutional learning and periodic policy revision. It assumes that climate risks cannot be predicted or controlled completely and that environmental institutions must therefore develop the capacity to adjust as new information and unexpected conditions emerge.

[54] Conceptualise adaptive governance as a system connecting actors, organisations and institutions across multiple levels to support ecosystem-based management during periods of change. [55] Extend this perspective by describing adaptive governance as an evolving institutional response to complex social-ecological problems. They identify collaboration, decentralised decision-making, scientific and local knowledge, social learning and flexible institutions as recurring features of adaptive-governance systems. Adaptive governance is especially relevant to climate resilience because decisions must frequently be made despite incomplete scientific knowledge. Flood risks, water availability, ecosystem responses and socioeconomic vulnerability may change faster than formal policies can be revised. Effective governance therefore requires monitoring mechanisms that produce new information and institutional arrangements that allow this information to influence subsequent decisions. [56] Further explain that adaptive governance may pass through phases of emergence, institutionalisation and renewal. This suggests that governance systems should not be assessed solely by whether adaptation institutions exist, but also by whether they remain capable of renewal when established arrangements become rigid or ineffective.

Nevertheless, adaptive governance should not be interpreted as unrestricted institutional flexibility. Excessive informality may weaken legal accountability, policy continuity and procedural fairness. [57] Emphasise that adaptive-governance processes are shaped by power, institutional histories and competing meanings. Similarly, [58] Challenge assumptions that flexibility, participation and collaboration necessarily produce equitable or effective outcomes. Adaptive governance must therefore combine flexibility with legal authority, accountability, social inclusion and transparent evaluation.

In this study, adaptive governance is operationalised through four observable capacities: institutional learning, policy flexibility, climate-risk monitoring and the ability to revise environmental interventions. These capacities allow an assessment of whether China and Pakistan are moving beyond static climate commitments towards governance systems capable of responding to evolving climatic risks.

3.3 Polycentric Environmental Governance

Polycentric governance provides a complementary explanation of how authority is distributed across governmental levels and social actors. [59] Defines polycentric systems as arrangements involving multiple centres of decision-making that operate with a degree of autonomy while interacting through shared rules, learning and coordination. Such arrangements may be particularly suitable for climate governance because climate risks occur across local, provincial, national and international scales. Polycentric systems can encourage policy experimentation, enable locally appropriate interventions and allow successful practices to be

transferred between jurisdictions.

However, a greater number of decision-making centres does not automatically produce effective governance. Fragmented authority can create policy duplication, inconsistent standards, unclear accountability and competition over resources. [41, 60] Argue that polycentric environmental-governance research often underestimates power relations and the possibility that influential actors may dominate decision-making. Their analysis shows that systems involving multiple authorities may still struggle to cope with the scale and speed of environmental change. Consequently, polycentricity must be accompanied by vertical coordination, information sharing, common policy objectives and mechanisms for resolving institutional conflict.

This theoretical tension is particularly relevant to the China-Pakistan comparison. China possesses a relatively centralised governance system in which national authorities establish climate priorities that are implemented through provincial and local institutions. Pakistan has a federal structure in which major environmental responsibilities are distributed among federal and provincial governments. China may therefore possess stronger capacity for national coordination but encounter problems relating to local discretion and participation. Pakistan may offer greater opportunities for context-specific provincial action but experience greater fragmentation and unequal institutional capacity. Polycentric governance enables these differences to be analysed without assuming that either centralisation or decentralisation is inherently superior.

3.4 Proposed Climate Resilience Governance Framework

Drawing on these theoretical foundations, this study proposes a Climate Resilience Governance Framework comprising six interrelated dimensions:

1. Institutional coordination refers to the distribution of authority, horizontal cooperation among sectors and vertical coordination among national, provincial and local institutions.
2. Adaptive capacity concerns policy learning, institutional flexibility, climate-risk monitoring and the ability to revise strategies in response to new evidence.
3. Climate finance includes the mobilisation, allocation, accessibility and continuity of financial resources for mitigation, adaptation and ecosystem resilience.
4. Ecosystem-based environmental management examines whether climate policies protect biodiversity, water systems, forests, wetlands and other ecological assets that support long-term resilience.
5. Stakeholder participation and climate justice address the involvement of communities, civil society, businesses and vulnerable groups, as well as the equitable distribution of climate-policy costs and benefits.
6. Digital environmental governance covers early-warning systems, remote sensing, environmental databases, artificial intelligence and other technologies used to produce and apply climate-risk information.

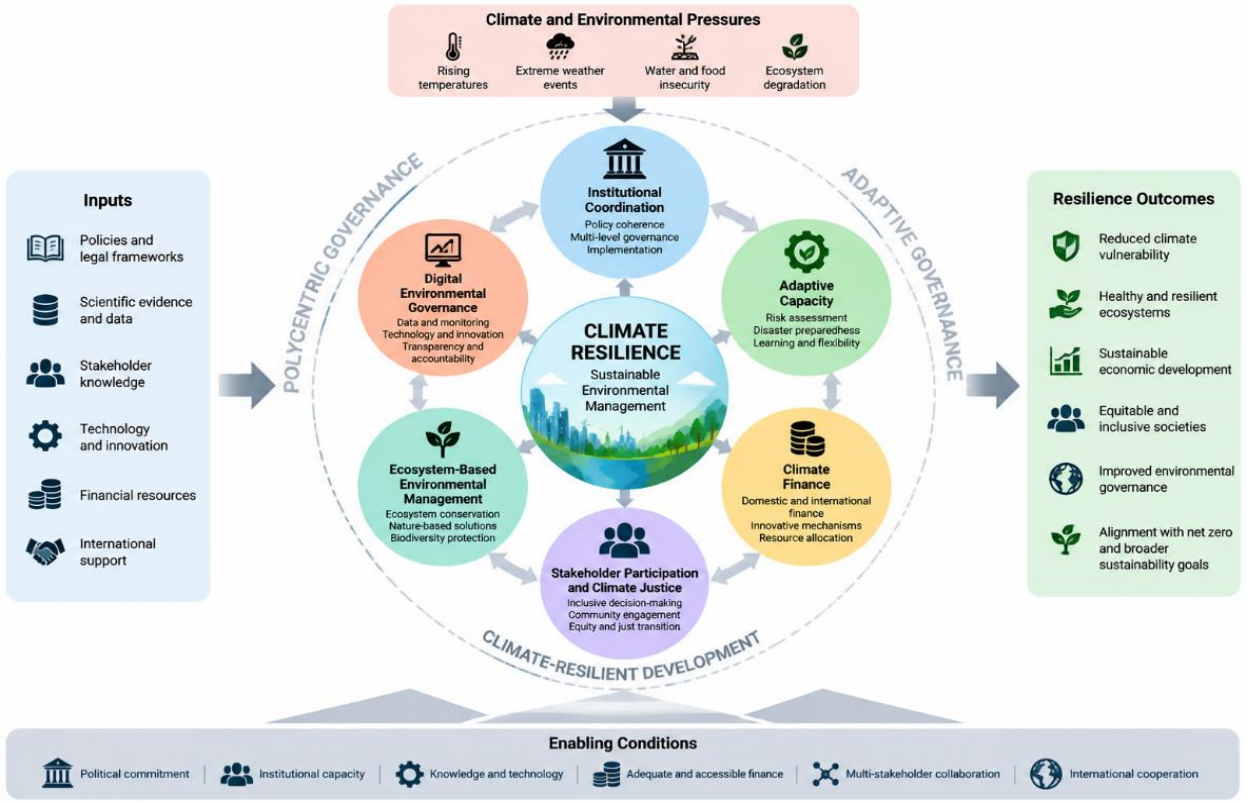


Figure 2. Proposed Climate Resilience Governance Framework

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The framework proposes that these dimensions do not operate independently. Institutional coordination determines whether finance, knowledge and responsibilities can move effectively across governance levels. Digital monitoring contributes to resilience only where institutions can interpret and apply its findings. Ecosystem-based measures are more likely to be sustained where communities participate in their design and receive a fair share of their benefits. Climate finance is similarly more effective when funding priorities are connected to reliable risk assessments and transparent implementation arrangements.

The expected outcomes of the framework are reduced climate vulnerability, increased institutional adaptability, strengthened ecosystem resilience and improved sustainable environmental management. Climate resilience is therefore treated as an intermediate governance outcome connecting institutional arrangements with environmental and societal performance. The framework also recognises possible negative pathways. Weak coordination, insufficient finance, exclusionary decision-making, poor-quality information and rigid institutions may create implementation gaps or maladaptive outcomes even where ambitious climate policies formally exist.

Table 1. Operational Dimensions of the Climate Resilience Governance Framework

CRGF dimension	Core governance function	Observable evidence / analytical indicators	Expected contribution to climate resilience	Potential failure pathway
Institutional coordination	Connects authority, responsibilities, knowledge and implementation across sectors and national, provincial/subnational and local levels.	Clearly assigned institutional mandates; vertical and horizontal coordination mechanisms; interagency platforms; policy coherence; shared planning processes; information exchange; conflict-resolution mechanisms.	Converts fragmented climate commitments into coordinated implementation; improves policy coherence; connects finance, information and implementation across governance levels.	Fragmented authority; overlapping mandates; implementation gaps; policy duplication; weak intergovernmental coordination; disconnect between national ambition and local implementation.

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Adaptive capacity and policy learning	Enables governance systems to anticipate changing risks, learn from implementation and revise policies as climatic and socioeconomic conditions evolve.	Climate-risk assessment; monitoring and evaluation; policy-review mechanisms; institutional learning; experimentation and pilot programmes; integration of new scientific/local knowledge; evidence of policy adjustment.	Improves responsiveness to uncertainty; supports anticipatory rather than reactive governance; reduces institutional rigidity and strengthens long-term adaptive capacity.	Static planning; failure to incorporate monitoring evidence; repeated reactive responses; institutional discontinuity; maladaptation; inability to respond to emerging risks.

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Climate finance	Mobilises, allocates and sustains financial resources required to translate mitigation, adaptation and ecosystem-resilience objectives into implementation.	Dedicated climate budgets; domestic and international financing; adaptation investment; financing continuity; project-preparation capacity; transparent allocation; expenditure monitoring; access to financial instruments.	Expands implementation capacity; supports resilient infrastructure, adaptation and ecosystem interventions; increases continuity and scale of climate action.	Chronic underfunding; mitigation-adaptation financing imbalance; fragmented project-based funding; dependence on unstable external finance; weak absorptive capacity; discontinuity after project completion.

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Ecosystem-based environmental management	Integrates ecosystem integrity and nature-based approaches into mitigation, adaptation and environmental-management strategies.	Ecosystem restoration; watershed and wetland management; forest and mangrove protection; biodiversity safeguards; nature-based solutions; ecological monitoring; long-term maintenance arrangements.	Reduces climate hazards while strengthening biodiversity, ecosystem services, livelihood resilience and carbon sequestration; creates mitigation-adaptation co-benefits.	Ecologically inappropriate interventions; monocultures; inadequate maintenance; weak biodiversity safeguards; displacement of communities; ecosystem projects disconnected from wider land and water governance.

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Stakeholder participation and climate justice	Incorporates affected communities, vulnerable groups, civil society, businesses and other actors into climate decision-making while addressing distributional and procedural equity.	Participatory planning; representation of vulnerable groups; locally led adaptation; gender responsiveness; access to decision-making; integration of local knowledge; transparent benefit and burden distribution.	Improves legitimacy and contextual relevance; incorporates diverse knowledge; strengthens social acceptance; reduces inequitable distribution of climate risks and adaptation benefits.	Tokenistic consultation; exclusion of vulnerable groups; unequal distribution of benefits; elite capture; locally inappropriate interventions; adaptation that reproduces existing inequalities.

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Digital environmental governance	Generates, integrates and applies climate and environmental information to risk assessment, monitoring, early warning, planning and adaptive decision-making.	Remote sensing; GIS; early-warning systems; environmental databases; sensor networks; artificial intelligence; interoperable data platforms; climate services; mechanisms linking information to policy decisions.	Improves risk anticipation, spatial targeting, monitoring and evidence-informed adaptation; strengthens feedback between environmental change and governance responses.	Fragmented or inaccessible data; weak interoperability; technical-capacity gaps; biased/incomplete datasets; technology disconnected from decision-making; insufficient institutional use of generated information.

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The CRGF extends existing theory in two respects. First, it integrates mitigation and adaptation within a single governance model, consistent with the IPCC's understanding of climate-resilient development. Second, it converts broad governance theories into dimensions that can be systematically compared across countries with markedly different political, fiscal and administrative systems. The framework will consequently guide document selection, thematic coding and the cross-case comparison of China and Pakistan.

4. Research Methodology

4.1 Research Approach and Design

This study adopts a qualitative, interpretive research approach to examine how climate-resilience objectives are incorporated into the environmental-governance systems of China and Pakistan beyond their net-zero and mitigation commitments. A qualitative approach is appropriate because governance pathways are expressed through legislation, policy strategies, institutional responsibilities, implementation mechanisms and relationships among public and non-governmental actors that cannot be adequately evaluated through numerical indicators alone. The study does not seek to calculate which country performs "better." Instead, it investigates how differences in political organisation, institutional capacity, financing and environmental priorities shape climate-resilience governance in each national context.

A comparative case-study design is employed, with

China and Pakistan treated as two distinct but analytically connected cases. Case-study research is suitable for investigating contemporary governance processes within their institutional and policy contexts, particularly where the boundaries between the phenomenon and its surrounding conditions are not clearly separable (Yin, 2018). The comparison follows a structured and focused design: the same research questions, documentary criteria and analytical dimensions are applied to both cases. This creates comparability without assuming that identical policies should produce identical outcomes.

4.2 Case Selection and Comparative Logic

China and Pakistan are selected through purposive case selection. They are appropriate for comparison because both are developing countries exposed to substantial climate and environmental pressures, but they possess markedly different governance structures, economic capacities and climate-policy resources. China combines strong central policy direction, long-term development planning, extensive technological capacity and large-scale environmental investment. Pakistan operates through a federal system characterised by shared federal-provincial responsibilities, greater fiscal constraints, high climate vulnerability and stronger dependence on international climate finance.

The cases therefore represent a contrast between different institutional pathways rather than a controlled comparison of otherwise similar countries. Comparative case research can generate analytical insight by examining how a common problem is governed under different political and institutional conditions. The purpose is analytical generalisation: findings will be used to refine the proposed Climate Resilience Governance Framework rather than to claim statistical representativeness for all developing countries [61].

4.3 Data Sources and Document Selection

The study relies on documentary evidence drawn from four categories:

1. national legislation and legally relevant regulatory instruments;
2. climate, adaptation, environmental and development-policy documents;
3. reports issued by recognised international organisations; and
4. peer-reviewed academic studies addressing climate governance in China or Pakistan.

The primary documentary corpus includes Nationally Determined Contributions, national adaptation strategies and plans, climate-change policies, environmental legislation, development plans, disaster-risk policies, climate-finance frameworks and official implementation reports. International sources may include reports from the Intergovernmental Panel on Climate Change, United Nations Framework Convention on Climate Change, United Nations Environment Programme, World Bank, Asian Development Bank and Organisation for Economic Co-operation and Development.

Document analysis is appropriate because official texts provide evidence of policy objectives, institutional responsibilities, implementation mechanisms and the formal meanings assigned to climate resilience. [62] Describes document analysis as a systematic process of reviewing and interpreting documentary material to develop understanding and empirical knowledge. Documents are nevertheless treated critically rather than as neutral descriptions of actual performance. Official policies may communicate governmental intentions while understating implementation failures, institutional conflict or resource constraints. Policy claims are therefore compared with independent academic assessments and institutional reports.

The temporal scope begins in **2015**, corresponding with the adoption of the Paris Agreement, and extends to the final search date in **2026**. Older sources are included only where necessary to establish theoretical concepts, legal development or institutional background. Documents are eligible where they: directly concern China or Pakistan; address mitigation, adaptation, resilience or sustainable environmental management; identify governance institutions or implementation mechanisms; and are available in an authoritative and verifiable form. News articles, opinion pieces, duplicated

documents, unsupported advocacy materials and sources lacking a clear institutional or scholarly origin are excluded.

4.4 Data Collection and Screening Procedure

Documents are identified through targeted searches of government repositories, international-organisation databases and academic databases such as Scopus and Web of Science. Search combinations include terms such as "climate resilience," "net zero," "climate adaptation," "environmental governance," "climate finance," "ecosystem-based adaptation," "digital environmental governance," "China" and "Pakistan."

The screening process consists of four stages: identification, removal of duplicates, title and abstract or executive-summary screening, and full-text eligibility assessment. A document-selection log should record its title, year, issuing body, country, source category, inclusion decision and reason for exclusion. The final manuscript should report the exact number of documents identified, screened and retained only after this procedure has been completed. This prevents the study from presenting an invented or retrospectively adjusted corpus.

4.5 Qualitative Content Analysis and Thematic Coding

The selected documents are analysed through directed qualitative content analysis. This method enables researchers to systematically interpret the meanings contained in qualitative material through a structured coding framework [63]. The initial coding categories are derived deductively from the six dimensions of the Climate Resilience Governance Framework:

- institutional coordination;
- adaptive capacity and policy learning;
- climate finance;
- ecosystem-based environmental management;
- stakeholder participation and climate justice; and
- digital environmental governance.

Directed analysis is suitable because the study begins with theoretically informed categories while remaining open to new themes emerging from the documentary evidence. The coding framework will therefore combine deductive and inductive reasoning. Deductive codes operationalise the theoretical dimensions, whereas inductive subcodes capture country-specific mechanisms that are not adequately represented by the original framework.

The analytical procedure follows six broad stages adapted from [64]: familiarisation with the documents, initial coding, identification of thematic patterns, review of themes, definition of themes and production of the comparative interpretation. Their approach provides a flexible means of identifying recurring patterns across qualitative material. Each relevant passage is assigned to one or more codes, accompanied by a short analytical note explaining its significance. Coding may be conducted manually or with qualitative-analysis software such as NVivo, MAXQDA or ATLAS.ti; however, interpretive decisions must remain under researcher control.

4.6 Cross-Case Comparative Analysis

Analysis proceeds in two stages. First, a within-case analysis reconstructs the climate-governance pathway of each country. This identifies the formal governance architecture, major policy priorities, institutional strengths, implementation barriers and relationships among the six framework dimensions. Second, a cross-case synthesis compares China and Pakistan using an identical analytical matrix.

The complete analytical sequence, from documentary evidence identification and CRGF-based coding to within-case assessment and cross-case synthesis, is illustrated in Figure 3, demonstrating how a common analytical architecture was maintained while preserving the institutional and policy context of each country.

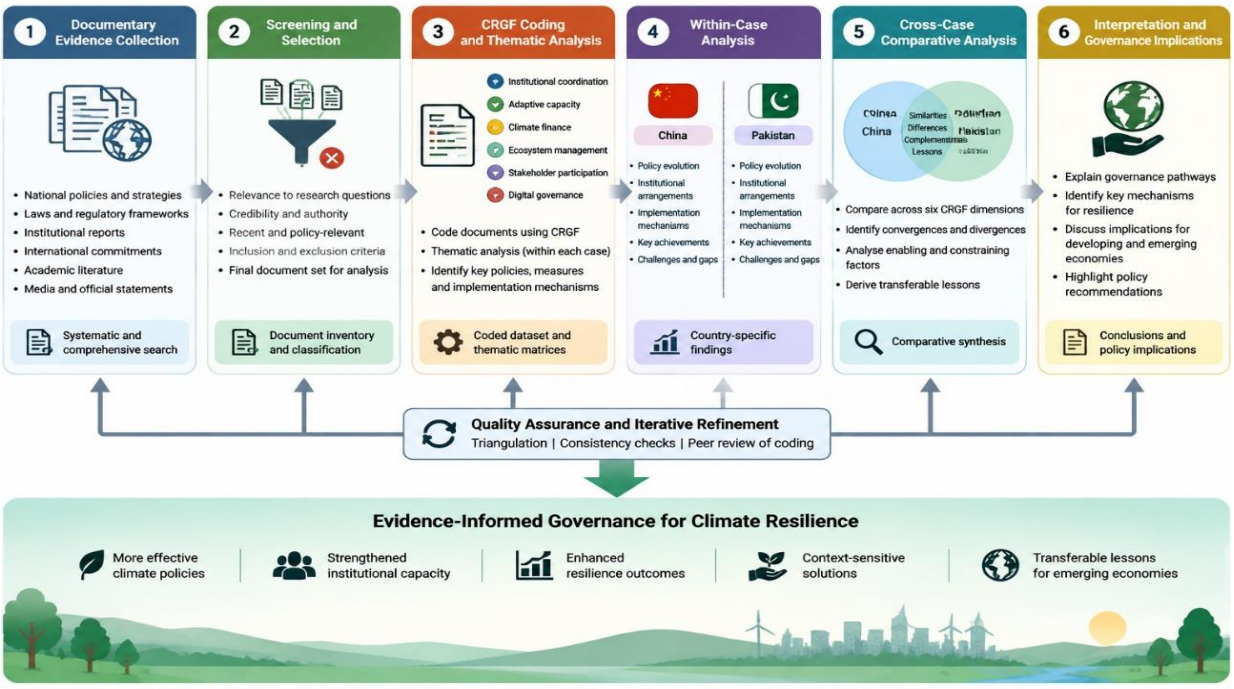


Figure 3. From Documentary Evidence to Comparative Insight: A CRGF-Guided Analytical Pathway for Cross-National Climate Governance Assessment

For each dimension, the comparison examines:

- formal policy commitment;
- responsible institutions and distribution of authority;
- implementation instruments;
- evidence of financial and administrative capacity;
- monitoring and policy-learning arrangements;
- participation and equity considerations; and
- documented implementation gaps.

Cross-case synthesis is intended to identify similarities, differences, causal mechanisms and context-dependent outcomes rather than merely catalogue national policies. [65] Support the use of matrices and structured displays to reduce qualitative material and compare patterns across cases. The assessment does not convert qualitative evidence into arbitrary country rankings. Instead, governance performance is interpreted through documented evidence of policy integration, institutional coordination, adaptability, inclusion and implementation.

Table 2. CRGF Coding and Cross-Case Assessment Matrix

CRGF dimension	Main analytical focus	Evidence examined in documents	China assessment focus	Pakistan assessment focus
Institutional coordination	Distribution of authority and coordination across governance levels and sectors	Institutional mandates, interagency mechanisms, policy integration, national-subnational responsibilities	Central coordination, sectoral integration, provincial/local implementation	Federal-provincial coordination, decentralised responsibilities, institutional fragmentation
Adaptive capacity and policy learning	Ability to monitor climate risks, learn and adjust policies	Risk assessments, monitoring systems, policy reviews, pilot programmes, learning mechanisms	Regional risk monitoring, policy experimentation, local feedback and adaptation	Vulnerability assessment, disaster learning, policy continuity and subnational capacity
Climate finance	Mobilisation, allocation and continuity of climate-related financial resources	Climate budgets, investment mechanisms, external finance, project financing and expenditure arrangements	Domestic investment, adaptation financing and mitigation-adaptation balance	International finance, fiscal constraints, project preparation and financing continuity

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Ecosystem-based environmental management	Integration of ecosystems into climate resilience	Restoration programmes, forests, wetlands, watersheds, biodiversity and nature-based solutions	Ecological restoration, conservation scale and long-term ecological quality	Afforestation, watershed and mangrove restoration, community-based management
Stakeholder participation and climate justice	Inclusion, equity and representation in climate governance	Consultation mechanisms, community involvement, vulnerable-group recognition, gender responsiveness and locally led adaptation	Local participation, regional inequality and distributional implications	Vulnerable communities, gender responsiveness, local participation and climate justice
Digital environmental governance	Use of climate information and digital technologies in decision-making	Remote sensing, GIS, early-warning systems, environmental databases, AI and data-sharing systems	Technological integration, monitoring capacity and application to planning	Data availability, interoperability, technical capacity and institutional use

Cross-dimensional interactions	How the six CRGF dimensions reinforce or constrain one another	Evidence linking finance, institutions, information, ecosystems, participation and learning	Interaction between strong strategic capacity and locally responsive implementation	Interaction between adaptation priorities and financial/institutional constraints

4.7 Research Quality, Reflexivity and Limitations

Research credibility is strengthened through source triangulation, transparent selection rules, consistent application of the coding framework and maintenance of an audit trail. Triangulation involves comparing governmental claims with international reports and peer-reviewed research. A coding manual should define every category, specify inclusion and exclusion rules and provide representative examples. A sample of the documents should be recoded after an interval or independently coded by a second researcher where possible to identify inconsistent interpretations.

Trustworthiness is evaluated through credibility, dependability, confirmability and transferability, consistent with the criteria discussed by [66]. The researcher should also document interpretive decisions and actively examine evidence that challenges initial assumptions. [67] Emphasises that rigorous case-study research requires clarity concerning case selection, the unit of analysis and the basis of comparison.

The methodology has several limitations. Documentary evidence may reveal formal governance arrangements more clearly than actual local implementation. The availability and detail of official information may differ between the two countries, while translation may affect the interpretation of Chinese-language documents. The two cases also differ substantially in territorial scale, economic capacity and administrative structure. These limitations are addressed by contextualising rather than ranking the cases, triangulating policy claims and distinguishing carefully between formal commitments, implementation mechanisms and demonstrated outcomes.

5. Comparative Analysis of Climate-Resilience Governance in China and Pakistan

5.1 Climate-Governance Architecture in China

China's climate-governance architecture combines central strategic direction, sectoral planning and implementation through provincial and local authorities. Its climate agenda has historically prioritised mitigation, energy transition and emissions-intensity reduction, but adaptation and resilience have become increasingly visible components of national environmental policy. China's updated nationally determined contribution strengthened targets related to carbon intensity, non-fossil energy, forest stock and installed renewable-energy capacity, while connecting these objectives with the longer-term goals of peaking carbon dioxide emissions before 2030 and achieving carbon neutrality before 2060 [68].

The **National Climate Change Adaptation Strategy 2035** represents a significant effort to move climate policy beyond emissions reduction. It aims to establish a climate-resilient society by 2035 through improved risk assessment, early-warning systems, resilient infrastructure, ecosystem protection and differentiated adaptation measures for cities, agriculture, water resources, coastal areas and ecologically vulnerable regions. The strategy was jointly issued by 17

national departments, illustrating an attempt to institutionalise cross-sectoral coordination rather than confine adaptation to a single environmental authority [69, 70].

China's governance pathway is therefore characterised by strong vertical steering. National objectives are translated into sectoral plans, technical standards, pilot programmes and subnational responsibilities. This structure can facilitate large-scale mobilisation, long-term infrastructure planning and the integration of climate priorities into development policy. Recent official reporting indicates continued implementation of adaptation measures in agriculture, transport infrastructure, ecosystem conservation, flood-risk management and climate-related monitoring and early-warning systems [71, 72].

Nevertheless, formal central coordination does not eliminate implementation challenges. China's territorial scale and socioeconomic diversity mean that local authorities possess unequal financial, technical and administrative capacities. Provincial governments must also reconcile climate goals with economic growth, industrial competitiveness, employment and energy-security priorities. The World Bank identifies both decarbonisation and resilience as necessary for sustaining China's long-term development, warning that insufficient adaptation could threaten development gains and increase economic exposure to climate risks [73, 74].

5.2 Climate-Governance Architecture in Pakistan

Pakistan's climate-governance architecture reflects its federal political system, high exposure to climate hazards and comparatively limited fiscal capacity. Climate responsibilities are distributed among the federal government, provincial governments, local authorities and specialised disaster-management institutions. This distribution creates opportunities for policies adapted to provincial ecological and socioeconomic conditions, but it also increases the importance of coordination across governmental levels.

Pakistan's **National Climate Change Policy 2021** presents adaptation as a national priority and identifies agriculture, water, forestry, biodiversity, coastal areas, health, disaster preparedness and vulnerable ecosystems as major areas of intervention. It also calls for climate considerations to be mainstreamed across development planning and recognises the role of the National Adaptation Plan process in strengthening the adaptation component of the country's climate commitments [15, 75].

The **Updated Nationally Determined Contribution 2021** linked mitigation with adaptation, nature-based solutions and green recovery. It established a conditional emissions-reduction ambition dependent substantially on international financial and technological support and identified ecosystem restoration, renewable energy, transport reform and climate-resilient development as major policy directions [76]. Pakistan subsequently submitted its NDC 3.0 in September 2025, reinforcing the continuing evolution of its climate-policy commitments within the Paris Agreement framework [77].

The **National Adaptation Plan 2023** provides a more systematic resilience framework. It identifies priority sectors including agriculture and food security, water resources, urban resilience, human capital, disaster-risk management, biodiversity and ecosystem restoration. It also emphasises inclusive planning, locally informed adaptation and the integration of climate risk into national and provincial development processes [78, 79].

However, Pakistan's principal challenge lies less in the absence of climate-policy documents than in the implementation environment. Fiscal constraints, competing development priorities, institutional turnover, limited local capacity and uneven federal-provincial coordination restrict the continuity and scale of adaptation. The World Bank's Pakistan Country Climate and Development Report concludes that climate resilience requires substantial changes in development policy and major investment in people-centred adaptation, infrastructure and institutional capability [80].

5.3 Institutional Coordination and Administrative Capacity

Institutional coordination constitutes the first major point of comparison. China's system relies on centrally defined targets supported by sectoral ministries, planning instruments and implementation through provincial and local administrations. The involvement of numerous national departments in the Adaptation Strategy 2035 indicates a relatively formal mechanism for horizontal coordination. This arrangement can support consistency between climate policy, infrastructure development, ecological restoration and economic planning.

However, central coordination may produce a predominantly top-down implementation model. Local governments may prioritise nationally measurable targets while giving less attention to locally specific vulnerability, social inclusion or community-based adaptation. Moreover, the effectiveness of central direction depends on whether local officials have sufficient incentives, expertise and financial resources to incorporate resilience into routine decision-making.

Pakistan's institutional structure is more decentralised and fragmented. Following the constitutional devolution of several environmental responsibilities, provincial governments have become central actors in environmental regulation and climate implementation. This creates scope for locally tailored policy but may also generate differences in administrative capacity, priorities and regulatory consistency. Federal ministries retain responsibility for international climate commitments and national coordination, while provincial institutions control many areas directly relevant to adaptation.

The comparison therefore reveals different coordination risks. China faces a potential gap between central ambition and territorially differentiated implementation. Pakistan faces a potential gap between national policy formulation and coordinated provincial execution. In CRGF terms, China demonstrates stronger vertical policy direction, whereas Pakistan requires more robust intergovernmental platforms, clearer assignment of responsibilities and sustained provincial and local capacity building.

5.4 Adaptive Capacity and Policy Learning

China has invested heavily in climate-risk monitoring, meteorological observation, remote sensing and early-warning infrastructure. Its adaptation strategy promotes regular assessment, regional risk differentiation and the incorporation of climate projections into infrastructure, urban development, agriculture and ecosystem management. Official reporting also identifies pilot programmes and sector-specific resilience initiatives, suggesting that experimentation forms part of the national adaptation pathway [81].

Yet adaptive capacity requires more than data collection. Information must influence budgetary choices, planning standards and policy revision. China's central planning system can potentially incorporate scientific evidence rapidly once a risk is politically prioritised, but policy learning may be constrained where local reporting is oriented primarily towards demonstrating compliance with central targets.

Pakistan possesses considerable practical experience in responding to floods, droughts, heatwaves and water insecurity, but disaster response has not always been converted into long-term institutional learning. The severe floods of 2022 exposed the interaction between climate hazards, land-use practices, poverty, infrastructure vulnerability and weak service delivery. The World Bank reported that approximately 33 million people were affected and emphasised that future resilience would require integrated investments rather than repeated post-disaster reconstruction [82].

Pakistan's NAP provides a basis for shifting from reactive disaster management towards anticipatory adaptation. Nevertheless, its effectiveness depends on regular vulnerability assessment, reliable subnational data, monitoring indicators and institutional mechanisms that use evaluation findings to revise policy. Compared with China, Pakistan's adaptive pathway is less constrained by excessive centralisation but more severely limited by discontinuity, financial dependence and uneven technical capacity.

5.5 Climate Finance and Investment Capacity

Climate finance represents one of the clearest differences between the two cases. China can mobilise domestic public finance, state-owned financial institutions, commercial investment and industrial policy to support renewable energy, resilient infrastructure and ecological restoration. Its large domestic market and technological capacity also enable climate policy to be integrated with economic modernisation and industrial competitiveness.

However, mitigation investment remains more commercially attractive than adaptation. Resilient infrastructure, ecosystem protection and community-level adaptation may generate long-term public benefits without producing immediate financial returns. Consequently, even a comparatively well-resourced state must establish dedicated budgetary and evaluation mechanisms to prevent adaptation from remaining secondary to energy and industrial-transition objectives.

Pakistan has much less domestic fiscal space and relies more extensively on multilateral development banks, international climate funds, bilateral partners and concessional finance. Its climate commitments are consequently structured partly around conditional actions requiring external support. The NAP estimates very substantial adaptation needs across the remainder of the decade, reflecting the scale of investment required in water, agriculture, cities, ecosystems and disaster resilience [83].

The problem is not limited to the quantity of funding. Pakistan also requires stronger project preparation, transparent allocation, intergovernmental coordination and capacity to monitor climate expenditures. External project-based finance may produce fragmented interventions when programmes are not embedded in long-term public planning. The comparative evidence therefore indicates that China's primary challenge is the balanced allocation of substantial resources across mitigation and adaptation, while Pakistan's challenge concerns both resource scarcity and the institutional capacity to secure, coordinate and sustain climate finance.

5.6 Ecosystem-Based Environmental Management

China incorporates ecosystem protection into its broader policy of ecological civilisation. Afforestation, watershed management, wetland restoration, protected areas and ecological-conservation zoning have been presented as measures supporting biodiversity, carbon sequestration and climate adaptation. Official reports also describe improvements in mangrove conservation and the integration of biodiversity with climate policy [84, 85].

The scale of China's programmes is a major institutional advantage. Nevertheless, the resilience value of ecological restoration depends on biodiversity quality, ecological appropriateness and long-term maintenance rather than on area-based planting targets alone. Large projects may be less effective where they rely on unsuitable species, overlook water availability or fail to incorporate local ecological knowledge.

Pakistan has similarly promoted ecosystem restoration through afforestation, mangrove rehabilitation, watershed interventions and protected-area initiatives. Its NDC and NAP treat nature-based solutions as important for both mitigation and adaptation. These interventions are particularly significant because agriculture, forests, wetlands, coastal ecosystems and freshwater systems directly support vulnerable livelihoods.

Pakistan's ecosystem pathway nevertheless faces risks from weak land-use enforcement, short project cycles and insufficient community participation. Ecosystem restoration will support resilience only where it is connected with watershed governance, livelihood security, biodiversity protection and sustained monitoring. Both countries therefore recognise ecosystems as climate assets, but China possesses greater implementation scale while Pakistan has a stronger need to integrate ecosystem programmes with local development and community-based management.

5.7 Stakeholder Participation and Climate Justice

Stakeholder participation differs significantly

between the two governance systems. China's policy process is led predominantly by state institutions, technical agencies and planning authorities. Consultation, pilot programmes and local implementation can provide some opportunities for stakeholder input, but civil-society participation is comparatively structured and state-directed. This may support policy consistency but can limit the independent articulation of local concerns or the identification of distributional effects.

Pakistan's policy documents place stronger formal emphasis on inclusion, vulnerable communities, gender responsiveness and locally led adaptation. Its federal and plural institutional structure also creates potential space for civil society, provincial institutions, development organisations and local communities. Yet formal commitments to participation are not always reflected in stable decision-making authority or access to resources.

Climate justice has different implications in the two cases. In China, major concerns include regional inequality, rural-urban differences and the social consequences of industrial and energy transition. In Pakistan, justice concerns are more closely associated with low historical responsibility for global emissions, high exposure to loss and damage, poverty, informal settlements, gender inequality and unequal access to resilient infrastructure. Pakistan's vulnerability despite contributing a small share of global emissions strengthens its claim for international climate finance and equitable burden sharing [86].

5.8 Digital Environmental Governance

China possesses a comparatively advanced digital foundation for climate governance. Satellite observation, meteorological networks, remote sensing, big-data platforms and artificial intelligence are increasingly used for environmental monitoring, disaster warning, land-use assessment and urban management. These systems can support the regional differentiation and risk-based decision-making required by the Adaptation Strategy 2035.

Pakistan has also expanded early-warning systems, digital mapping, remote sensing and climate-information services, often with support from international development institutions. However, data fragmentation, uneven geographical coverage, limited interoperability and shortages of trained personnel constrain the systematic use of climate information across federal, provincial and local institutions.

Digital governance therefore reinforces existing institutional differences. China's advantage lies in technological scale and integration, but accountability, accessibility and the use of local knowledge remain important. Pakistan's priority is not merely acquiring new technologies but establishing shared data standards, stable maintenance funding and institutional processes through which climate information directly influences planning.

5.9 Comparative Assessment of Emerging Governance Pathways

The comparison demonstrates that neither centralisation nor decentralisation automatically produces climate resilience. China's pathway is distinguished by strategic continuity, administrative mobilisation, domestic investment and technological capability. These characteristics enable climate policy to be implemented at a scale that Pakistan cannot easily reproduce. However, China's system must strengthen local responsiveness, social participation and the integration of adaptation with mitigation-dominated development planning.

Pakistan's pathway is shaped by acute vulnerability, federal diversity, growing adaptation planning and significant engagement with international climate institutions. Its policies increasingly recognise justice, ecosystem restoration and locally informed resilience. Nevertheless, implementation remains restricted by fiscal limitations, fragmented authority, inadequate local capacity and dependence on external finance.

The CRGF comparison therefore identifies complementary lessons rather than a single superior model. China demonstrates the importance of long-term planning, coordinated investment, digital monitoring and integration of resilience into infrastructure and development policy. Pakistan demonstrates the importance of vulnerability-centred planning, international

climate justice, provincial differentiation and the explicit prioritisation of adaptation. For both countries, progress beyond net zero ultimately depends on connecting formal commitments with accountable institutions, stable finance, ecosystem protection, policy learning and meaningful participation.

Table 3. Comparative Climate-Resilience Governance Pathways in China and Pakistan

CRGF dimension	China	Pakistan	Key implementation challenge	Comparative insight
Institutional coordination	Strong central policy direction supported by sectoral ministries and provincial/local implementation	Federal-provincial distribution of responsibilities with greater institutional fragmentation	China: translating central objectives into locally responsive action; Pakistan: strengthening intergovernmental coordination and continuity	Different institutional structures create different coordination gaps between national policy and subnational implementation
Adaptive capacity and policy learning	Extensive climate-risk monitoring, early-warning capacity and technological support for adaptation	Strong vulnerability and adaptation orientation, but uneven provincial and local capacity	China: strengthening local learning and feedback; Pakistan: maintaining institutional continuity and implementation capacity	Adaptive capacity depends on both technical information and institutions capable of learning from it
Climate finance	Greater domestic fiscal and investment capacity, with substantial resources directed toward climate and development priorities	More limited domestic fiscal space and greater reliance on international and concessional climate finance	China: balancing mitigation and adaptation investment; Pakistan: securing, coordinating and sustaining adaptation finance	Financial volume alone is insufficient; institutional capacity determines how effectively climate finance supports resilience
Ecosystem-based environmental management	Large-scale afforestation, watershed management, wetland restoration and ecological conservation	Afforestation, mangrove rehabilitation, watershed interventions and nature-based solutions linked closely to vulnerable livelihoods	China: ensuring ecological quality and long-term appropriateness; Pakistan: strengthening continuity, monitoring and community integration	Ecosystem restoration contributes to resilience when scale is combined with ecological quality, local context and sustained management

Stakeholder participation and climate justice	Predominantly state-led and technically organised participation, with concerns around regional and distributional differences	Stronger formal emphasis on vulnerable communities, gender responsiveness, locally led adaptation and climate justice	China: expanding locally responsive participation; Pakistan: converting formal inclusion commitments into meaningful authority and resources	Participation becomes resilience-enhancing when stakeholders can influence implementation rather than being consulted only formally
Digital environmental governance	Advanced satellite observation, remote sensing, meteorological networks, big-data systems and growing use of AI	Expanding early-warning, remote-sensing, mapping and climate-information systems, often with international support	China: accessibility, accountability and integration of local knowledge; Pakistan: interoperability, coverage, maintenance and technical capacity	Digital technologies strengthen resilience only when information is institutionally integrated into planning and decision-making
Overall governance pathway	Strategic, centrally coordinated, investment- and technology-supported pathway	Vulnerability- and adaptation-oriented, multi-level pathway operating under stronger fiscal and institutional constraints	Connecting policy commitments with implementation, learning, participation and sustained resources	Both pathways show that resilience depends on interactions among the six CRGF dimensions rather than net-zero commitments alone

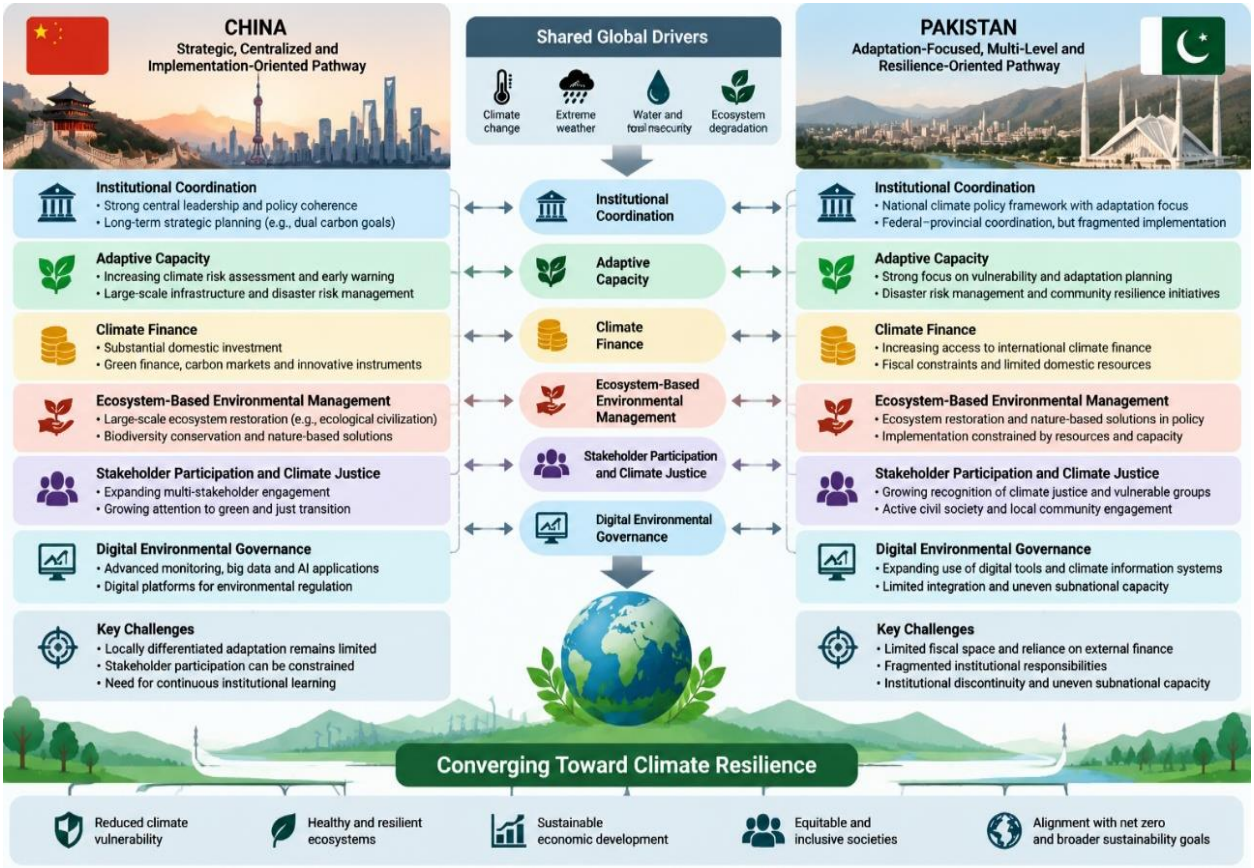


Figure 4. Divergent Pathways, Convergent Resilience: Comparative Governance Architectures of China and Pakistan Across the CRGF Dimensions

6. Discussion

6.1 Moving from Net-Zero Targets to Climate-Resilient Governance

The comparative findings demonstrate that net-zero commitments are necessary but insufficient foundations for sustainable environmental management. Emissions-reduction targets can establish long-term direction, stimulate technological change and support energy-system transformation, but they do not automatically reduce immediate exposure to floods, droughts, heatwaves, water insecurity or ecosystem degradation. Climate resilience emerges only when mitigation objectives are connected with adaptation planning, institutional coordination, ecosystem protection, financial capacity and the participation of vulnerable communities. This interpretation supports the argument that adaptation and mitigation must be integrated in policy and implementation rather than treated as separate climate-governance domains [87].

China and Pakistan illustrate different versions of the gap between policy ambition and resilient implementation. China possesses stronger central planning, technological infrastructure and domestic investment capacity. These advantages enable large-scale action and facilitate the incorporation of climate priorities into national development strategies. However, strong central direction does not itself guarantee locally responsive adaptation. Climate risks vary considerably among regions, sectors and communities; consequently, national objectives must be translated into locally differentiated measures supported by reliable feedback from subnational institutions.

Pakistan's challenge is different. Its principal climate documents increasingly recognise

adaptation, climate justice, ecosystem restoration and locally informed resilience, but implementation is limited by financial constraints, fragmented responsibilities and unequal provincial and local capacity. The comparison therefore shows that the central issue is not simply whether governance is centralised or decentralised. Climate resilience requires an effective relationship between national direction and subnational implementation. Central authority without local responsiveness can produce rigid or standardised interventions, while decentralisation without coordination and resources can produce fragmentation and policy inconsistency.

6.2 Context-Specific Governance Pathways

The findings also indicate that climate-resilient development cannot be reduced to a universal policy model. China's institutional scale, industrial capacity and political structure differ fundamentally from Pakistan's federal system, fiscal constraints and vulnerability profile. Governance practices must therefore be assessed according to their institutional context rather than transferred mechanically between the two countries.

[88] Caution that climate-resilient development may become a one-size-fits-all concept when differences in resources, inequality, political economy and institutional capacity are overlooked. They argue that its operationalisation in developing countries must account for barriers affecting adaptation, mitigation and climate finance. This insight is directly relevant to the present comparison. China's capacity to mobilise domestic finance, construct large infrastructure and deploy digital monitoring systems cannot be reproduced in Pakistan without accounting for major differences in fiscal space, technological resources and administrative continuity. Similarly, Pakistan's emphasis on vulnerability, loss and damage and international climate justice reflects circumstances that cannot be fully understood through China's mitigation-led development pathway.

Transferable lessons should therefore concern governance functions rather than institutional duplication. China demonstrates the value of long-term planning, strategic continuity, integrated monitoring and the alignment of environmental objectives with development policy. Pakistan demonstrates the importance of adaptation-centred planning, explicit recognition of vulnerable groups, provincial differentiation and international equity. These lessons can inform one another, but their implementation must be adjusted to national legal, financial and administrative conditions.

6.3 Institutional Coordination as the Connecting Mechanism

The Climate Resilience Governance Framework suggests that institutional coordination is the mechanism connecting the other five governance dimensions. Climate finance cannot produce durable resilience when projects are isolated from national and subnational planning. Digital information has limited value where agencies cannot share or apply it. Ecosystem restoration may fail where environmental authorities, land-use institutions and local communities operate independently. Participation may become symbolic when local actors are consulted but lack influence over budgets and implementation.

Evidence from multilevel climate-risk governance indicates that both vertical coordination among governmental levels and horizontal collaboration among neighbouring authorities, civil society and knowledge institutions are important for mobilising adaptation capacity. [89] Found that collaborative networks enabled local governments to share scarce resources, coordinate risk responses and connect local action with higher-level institutions, although representation and engagement of non-governmental actors remained incomplete. The relevance to China and Pakistan is clear. China requires stronger channels through which local experience can inform centrally established objectives, whereas Pakistan requires more stable mechanisms linking federal policy with provincial and local implementation.

Institutional coordination should therefore be understood as more than the formal distribution of responsibilities. Effective coordination requires shared data, compatible planning cycles, clearly assigned authority, stable financing and

mechanisms for resolving conflicts. It also requires institutional learning so that experience from disasters, pilot projects and ecosystem interventions can influence future decisions.

Table 4. Institutional Coordination Across the CRGF Dimensions

CRGF interaction	Role of institutional coordination	Weak-coordination pathway	Strong-coordination pathway	Resilience implication
Coordination × Adaptive capacity	Connects climate-risk information, monitoring, institutional learning and policy adjustment across agencies and governance levels	Knowledge remains fragmented; lessons from disasters and programmes are not incorporated into future decisions	Monitoring and experience inform coordinated policy revision and anticipatory planning	Greater capacity to respond and adapt to changing climate risks
Coordination × Climate finance	Aligns financial resources with national, subnational and sectoral resilience priorities	Isolated projects, duplicated expenditure and discontinuity after external funding ends	Finance is integrated with long-term planning, clearly assigned responsibilities and implementation priorities	More sustained and effective resilience investment
Coordination × Ecosystem management	Connects environmental authorities, land-use institutions, local governments and communities	Restoration projects operate separately from land, water and development planning	Ecosystem interventions are integrated with spatial planning, livelihoods and long-term environmental management	Stronger ecological resilience and more durable ecosystem benefits
Coordination × Stakeholder participation and climate justice	Creates institutional channels through which affected groups can influence planning and implementation	Consultation becomes symbolic and local actors have limited influence over resources or implementation	Stakeholder knowledge and vulnerability concerns influence priorities, budgets and implementation	More inclusive and context-sensitive resilience outcomes
Coordination × Digital environmental governance	Enables agencies to share, interpret and apply climate and environmental information	Data remain institutionally fragmented or disconnected from decisions	Shared information supports planning, early warning, monitoring and adaptive management	Stronger evidence-informed climate governance

Coordination × Multi-level governance	Links national objectives with provincial/subnational and local implementation	National commitments and local actions become disconnected	Vertical and horizontal collaboration aligns responsibilities, resources and implementation	Greater policy coherence across governance levels
Coordination × Adaptive learning	Connects monitoring, evaluation, implementation experience and subsequent policy adjustment	Policies remain static despite changing risks or implementation failures	Feedback from disasters, pilot projects and ecosystem interventions informs future decisions	Continuous improvement and long-term institutional resilience

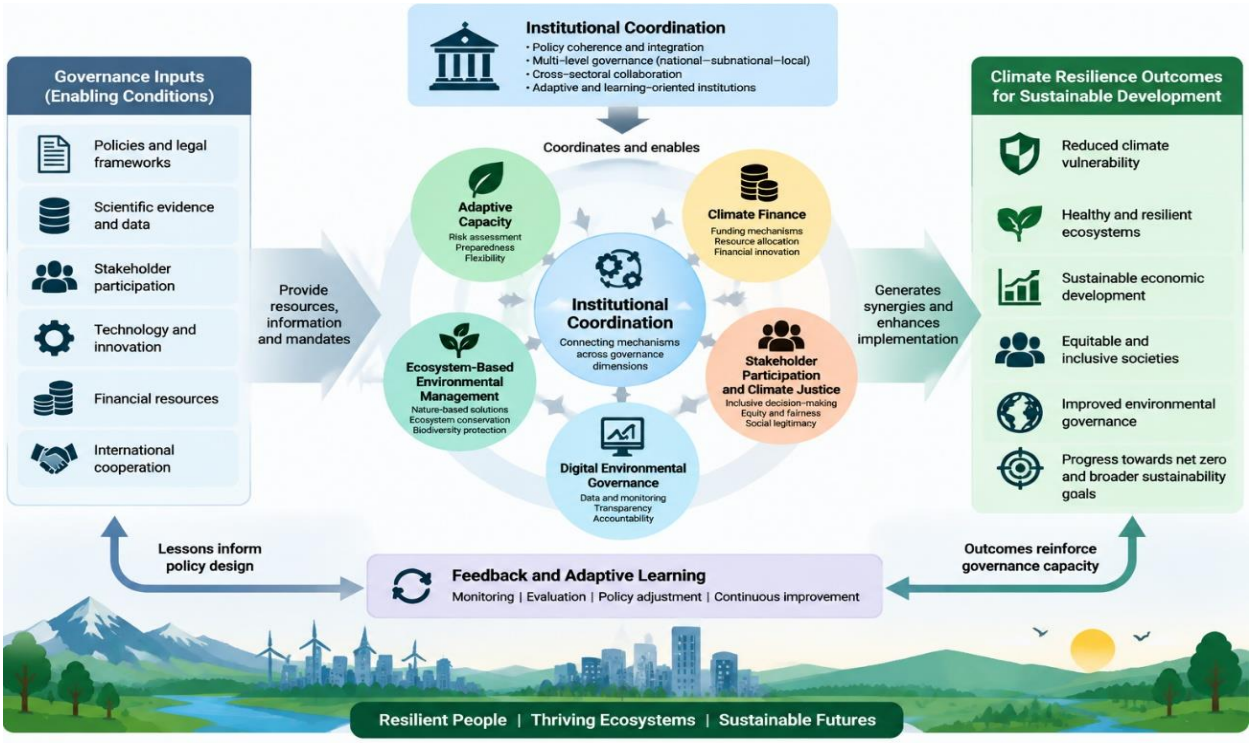


Figure 5. The Coordination-Resilience Nexus: Institutional Coordination as the Connecting Mechanism Across Climate-Resilience Governance Dimensions

6.4 Implications of the Climate Resilience Governance Framework

Application of the CRGF demonstrates that its six dimensions are mutually dependent rather than separate indicators. China performs comparatively strongly in strategic coordination, finance and digital capability, but the resilience value of these assets depends on participation, local adaptation and transparent policy learning. Pakistan possesses an increasingly comprehensive policy framework and stronger formal recognition of vulnerability and justice, but these commitments remain dependent on finance, administrative continuity and intergovernmental coordination.

The framework therefore explains why policy adoption should not be treated as equivalent to governance effectiveness. A country may publish ambitious strategies while lacking the institutional

capacity to implement them. Conversely, local adaptation practices may exist without being integrated into national planning or supported through stable finance. Sustainable environmental management occurs when governance dimensions reinforce one another: risk information guides investment; finance supports ecosystem and community priorities; institutions coordinate across levels; and monitoring leads to policy revision.

The comparison further suggests that climate resilience should be evaluated through implementation-oriented outcomes rather than through net-zero dates alone. Relevant outcomes include whether climate risks are incorporated into infrastructure and land-use decisions, whether adaptation funding reaches vulnerable areas, whether ecosystems retain protective functions, whether subnational institutions can respond to new information and whether affected communities influence policy choices.

Table 5 synthesises the transferable governance lessons emerging from the China-Pakistan comparison while distinguishing them from context-dependent institutional conditions

Table 5. Transferable Governance Lessons for Climate-Resilient Development

Governance area	Lesson from China	Lesson from Pakistan	Transferable governance principle	Context-dependent consideration
Institutional coordination	Long-term planning and strong vertical coordination can connect national climate objectives with sectoral implementation	Federal and provincial diversity highlights the need for clear responsibilities and stable intergovernmental coordination	Climate resilience requires clearly defined responsibilities, cross-sector coordination and links between national and subnational institutions	The appropriate degree of centralisation or decentralisation depends on national political and administrative structures
Adaptive capacity	Risk monitoring, early-warning systems and technological capacity can strengthen anticipatory climate governance	Vulnerability-centred adaptation demonstrates the importance of tailoring responses to exposed communities and regions	Adaptation should combine risk information, institutional learning, monitoring and continuous policy adjustment	Adaptive priorities vary according to climate exposure, institutional capacity and socioeconomic vulnerability
Climate finance	Strong domestic investment capacity can support large-scale and long-term climate implementation	Dependence on international finance demonstrates the importance of project preparation, coordination and sustained external support	Climate finance should be integrated with long-term planning, transparent allocation and implementation capacity	The balance between domestic and international finance depends heavily on fiscal capacity and development conditions

Ecosystem management	Large-scale restoration demonstrates the potential for integrating ecosystems into national climate and development strategies	Community-linked ecosystem restoration highlights connections among ecosystems, livelihoods and local resilience	Nature-based interventions should integrate biodiversity, adaptation, livelihoods and long-term ecological monitoring	Appropriate ecosystem interventions depend on local ecological conditions, land-use systems and community dependence on natural resources
Participation and climate justice	Experience highlights the importance of strengthening local responsiveness within centrally coordinated climate programmes	Strong policy attention to vulnerability, gender, locally led adaptation and climate justice demonstrates the value of explicitly recognising unequal climate impacts	Meaningful participation and equity considerations should be incorporated into climate planning and implementation	Participation mechanisms must reflect different political institutions, social structures and decision-making systems
Digital environmental governance	Large-scale digital monitoring demonstrates how advanced technology can support environmental management and climate-risk assessment	Expanding early-warning and climate-information systems demonstrates the value of strengthening basic data infrastructure and institutional access	Digital systems should produce usable information that is connected directly to planning, implementation and policy learning	Technology requirements differ according to infrastructure, financial resources, technical expertise and data availability
Integrated resilience governance	Strategic continuity, investment and technological capacity demonstrate the value of sustained implementation capability	Adaptation orientation, vulnerability awareness and climate-justice considerations demonstrate the importance of context-sensitive resilience planning	Effective resilience emerges from interaction among institutions, finance, ecosystems, participation, information and adaptive learning	Governance models should not be transferred wholesale between countries; functions should be adapted to national and local contexts

6.5 Broader Implications for Developing Countries

The experience of China and Pakistan shows that developing countries do not follow a single pathway beyond net zero. Some may possess strong state capacity but limited participatory governance, while others may adopt inclusive policies but lack the finance and administrative continuity required for implementation. Effective climate-resilience strategies must therefore combine national

ambition with context-sensitive institutional reform.

The broader contribution of this study is to reposition climate governance from a target-based model towards a capability-based model. Net-zero targets indicate intended destination, whereas climate-resilience governance determines whether institutions, ecosystems and communities can manage the transition and withstand unavoidable climatic impacts. For developing countries, progress beyond net zero will consequently depend on building coordinated, adequately financed, adaptive and socially legitimate systems of environmental governance.

7. Policy Implications

The comparative analysis indicates that climate resilience requires governance reforms extending beyond the adoption of net-zero targets and national climate strategies. China and Pakistan should develop implementation systems that connect emissions reduction with adaptation, ecosystem protection, public investment and institutional accountability. International evidence confirms that effective climate governance depends on coordination across public institutions, integration of climate objectives into government decision-making and clear mechanisms for monitoring implementation [90].

7.1 Policy Implications for China

China should strengthen the local adaptability and participatory dimensions of its centrally coordinated climate-governance system. National adaptation objectives should be translated into province-specific resilience indicators reflecting variations in water stress, flood exposure, ecosystem vulnerability, urbanisation and socioeconomic conditions. Provincial and municipal authorities should be required to demonstrate how climate-risk information influences land-use planning, infrastructure standards and public investment.

China should also establish more systematic mechanisms for incorporating local knowledge, scientific assessment and community feedback into the implementation of the National Climate Change Adaptation Strategy 2035. Dedicated adaptation budgets should be distinguished from general environmental and mitigation expenditure to prevent resilience objectives from being overshadowed by energy-transition targets. Digital monitoring systems should be linked to transparent evaluation and periodic policy revision rather than being used solely for administrative reporting.

7.2 Policy Implications for Pakistan

Pakistan's primary priority should be to close the gap between national policy formulation and provincial and local implementation. A permanent federal-provincial climate-resilience coordination mechanism should align National Adaptation Plan priorities with provincial development plans, sectoral budgets and local disaster-management arrangements. Responsibilities, financing sources and performance indicators should be clearly assigned to specific institutions.

Pakistan should also strengthen climate-budget tagging, project-preparation capacity and transparent monitoring of externally funded programmes. Adaptation finance should prioritise water security, climate-resilient agriculture, heat-risk management, flood-resilient settlements and ecosystem restoration. Provincial and local institutions require sustained technical capacity rather than short-term project-based training. Community participation should be connected to actual influence over project selection, implementation and benefit distribution.

7.3 Implications for Developing Countries

For developing countries more broadly, the central policy lesson is that no single governance structure guarantees resilience. Effective systems combine national strategic direction with adequately financed subnational implementation, reliable climate information, ecosystem protection and accountable public participation. Governments should institutionalise an iterative adaptation cycle consisting of risk assessment, planning, financing, implementation, evaluation and policy revision.

International climate finance should increasingly

support long-term institutional and administrative capacity rather than isolated infrastructure projects. Donors and multilateral institutions should simplify access procedures, strengthen nationally owned programmes and provide predictable resources for locally led adaptation. Climate resilience should ultimately be assessed through measurable improvements in institutional preparedness, ecosystem condition and reductions in the vulnerability of exposed communities-not merely through the existence of net-zero pledges or policy documents.

8. Conclusion

This study examined how climate resilience can be strengthened beyond conventional net-zero commitments through a comparative analysis of environmental-governance pathways in China and Pakistan. Although net-zero targets remain an essential component of global climate policy, the findings demonstrate that emissions-reduction commitments alone cannot ensure sustainable environmental management. Climate resilience depends on the interaction of institutional coordination, adaptive capacity, climate finance, ecosystem-based environmental management, stakeholder participation and digital environmental governance. Collectively, these governance dimensions determine whether climate policies are translated into effective implementation and long-term resilience outcomes.

The comparative analysis revealed that China and Pakistan follow distinct governance pathways shaped by different political, institutional and socioeconomic contexts. China benefits from strong central coordination, long-term strategic planning, substantial domestic investment and advanced technological capacity, enabling large-scale implementation of climate and environmental policies. However, future progress requires greater attention to locally differentiated adaptation, stakeholder participation and continuous institutional learning. Pakistan, by contrast, has increasingly integrated climate resilience, adaptation and environmental justice into its national policy framework, but implementation continues to be constrained by limited fiscal resources, fragmented institutional responsibilities and uneven provincial capacity. These findings indicate that climate resilience is determined not by the degree of governmental centralisation or decentralisation alone, but by the effectiveness of coordination across multiple governance levels and institutions.

A principal contribution of this research is the development of the **Climate Resilience Governance Framework (CRGF)**. By integrating adaptive governance, climate-resilient development and polycentric governance theories, the framework provides a systematic approach for evaluating how governance arrangements influence climate resilience beyond net-zero commitments. Unlike existing studies that primarily assess mitigation performance or emissions trajectories, the CRGF conceptualises climate resilience as an institutional process generated through the interaction of governance capacities rather than as a direct outcome of policy adoption. Consequently, the framework offers a practical analytical tool that can be applied in future comparative studies of climate governance across developing and emerging economies.

The study also provides important policy implications. Governments should strengthen institutional coordination, mainstream adaptation across national and subnational planning, expand sustainable climate finance, invest in ecosystem restoration and improve digital environmental-governance systems. Climate policies should be evaluated not only by the ambition of their emission-reduction targets but also by their capacity to reduce vulnerability, improve adaptive governance and enhance ecosystem resilience. International cooperation should likewise support long-term institutional capacity building, knowledge exchange and equitable climate finance to enable developing countries to implement resilient environmental strategies effectively.

Several limitations should be acknowledged. The analysis is based primarily on documentary evidence and therefore reflects formal governance arrangements more comprehensively than local implementation practices. Differences in institutional structure, administrative scale and

data availability between China and Pakistan may also influence comparative interpretation. Future research could extend the proposed framework through empirical field studies, stakeholder interviews, longitudinal policy evaluation or quantitative governance indicators. Comparative applications involving additional developing economies would further test the explanatory capacity and broader applicability of the CRGF.

Moving **beyond net zero** requires a transition from target-oriented climate policy to governance systems capable of continuous adaptation, institutional learning and sustainable environmental management. As climate risks become increasingly complex and interconnected, resilience should be regarded not simply as an environmental objective but as a fundamental characteristic of effective governance. Strengthening governance capacity will therefore be essential for achieving climate-resilient development and supporting the long-term sustainability objectives of both developed and developing countries (UNEP, 2025).

CRediT authorship contribution statement

All authors have an equal contribution.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

REFERENCE

1. Sarfaraz, S. and N. Faisal, *Climate change and its impacts across Pakistan: Climate change and its impacts across Pakistan.* International Journal of Economic and Environmental Geology, 2023. **14**(04): p. 28-39.
2. Schipper, E.L.F., et al., *Climate resilient development pathways*. 2022, Cambridge University Press.
3. Cochran, I. and A. Pauthier, *A framework for alignment with the Paris Agreement: why, what and how for financial institutions.* Institute for Climate Economics: Paris, France, 2019. **56**.
4. Melo, J., et al., *Satellite-based global maps are rarely used in forest reference levels submitted to the UNFCCC.* Environmental Research Letters, 2023. **18**(3): p. 034021.
5. Forster, P.M., et al., *Indicators of Global Climate Change 2023: annual update of key indicators of the state of the climate system and human influence.* Earth System Science Data, 2024. **16**(6): p. 2625-2658.
6. Cinner, J.E., et al., *Building adaptive capacity to climate change in tropical coastal communities.* Nature Climate Change, 2018. **8**(2): p. 117-123.
7. Citaristi, I., *United nations environment programme–UNEP*, in *The Europa directory of international organizations 2022*. 2022, Routledge. p. 193-199.
8. Pollution, U.P., *UNEP.* Nairobi, Kenya, 2025.
9. Malz, N., et al., *China's climate and energy policy paradox revisited–domestic and international implications of a carbon lock-in 'with Chinese characteristics'.* Energy Sources, Part B: Economics, Planning, and Policy, 2023. **18**(1): p. 2166164.
10. Chen, S., et al., *Analysis of the state of sustainable development and key targets: A case study of China and "Belt and Road" countries.* Heliyon, 2025. **11**(3).
11. Zhang, Y., et al., *Importance and main ecological and environmental problems of lakes in China.* Chinese Science Bulletin, 2022. **67**(30): p. 3503-3519.
12. Rubab, G., et al., *Hydro-Mechanical Behavior of Anisotropic Slate and Its Implications for Sustainable Slope Stability and Environmental Geo-Hazard Mitigation.* Journal of Computational and Experimental Science, 2026. **1**(1): p. 1-20.

13. Xue, L., L. Weng, and H. Yu, *Addressing policy challenges in implementing Sustainable Development Goals through an adaptive governance approach: A view from transitional China.* Sustainable Development, 2018. **26**(2): p. 150-158.
14. Mizuno, O. and N. Okano, *Reconsidering national adaptation plans (NAPs) as a policy framework under the UNFCCC.* Climate Policy, 2024. **24**(9): p. 1309-1321.
15. Shehzad, K., *Extreme flood in Pakistan: Is Pakistan paying the cost of climate change? A short communication.* Science of The Total Environment, 2023. **880**: p. 162973.
16. Rubab, G., et al., *The Social Construction of Floods and Droughts: Toward an Integrated Socio-Hydrological Framework.* The Critical Review of Social Sciences Studies, 2026. **4**(1): p. 3347-3372.
17. Chen, L., et al., *Strategies to achieve a carbon neutral society: a review.* Environmental chemistry letters, 2022. **20**(4): p. 2277-2310.
18. Li, X., P. Pattberg, and O. Widerberg, *China's climate governance from 2009 to 2019: motivations, instruments, actors, and geopolitics.* Climate Policy, 2024. **24**(3): p. 378-395.
19. Fazal Shah, P., et al., *Local adaptation policy responses to climate change: evidence from Gilgit Baltistan, Pakistan.* Development in Practice, 2026. **36**(2): p. 311-326.
20. Sharifi, A. and Y. Yamagata, *Resilience-oriented urban planning*, in *Resilience-oriented urban planning: theoretical and empirical insights*. 2018, Springer. p. 3-27.
21. Statsenko, L., R.S. Jayasinghe, and C. Soosay, *Supply network resilience capabilities: a social–ecological perspective.* Supply Chain Management: An International Journal, 2024. **29**(1): p. 1-26.
22. Chai, Y. and Y. Zeng, *Social capital, institutional change, and adaptive governance of the 50-year-old Wang hilltop pond irrigation system in Guangdong, China.* International Journal of the Commons, 2018. **12**(2).
23. Zhang, Q., et al., *How does social learning facilitate urban disaster resilience? A systematic review.* Environmental hazards and resilience, 2021: p. 180-202.
24. Kikstra, J.S., et al., *The IPCC Sixth Assessment Report WGIII climate assessment of mitigation pathways: from emissions to global temperatures.* Geoscientific Model Development, 2022. **15**(24): p. 9075-9109.
25. Pörtner, H.-O., et al., *Climate change 2022: Impacts, adaptation and vulnerability.* 2022.
26. Scott, D., et al., *A review of the IPCC Sixth Assessment and implications for tourism development and sectoral climate action.* Journal of Sustainable Tourism, 2024. **32**(9): p. 1725-1742.
27. Ali, S., et al., *AI-DRIVEN DECENTRALIZED HYBRID RENEWABLE ENERGY SYSTEMS FOR CLIMATE-RESILIENT URBAN DEVELOPMENT: A CASE STUDY OF KARACHI.* Spectrum of Engineering Sciences, 2026. **4**(4): p. 1795-1824.
28. Berkes, F., *Environmental governance for the anthropocene? Social-ecological systems, resilience, and collaborative learning.* Sustainability, 2017. **9**(7): p. 1232.
29. Calvin, K., et al., *IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)].* IPCC, Geneva, Switzerland. 2023.
30. Rogelj, J., et al., *Three ways to improve net-zero emissions targets.* Nature, 2021. **591**(7850): p. 365-368.
31. Kuyper, J., H. Schroeder, and B.-O. Linnér, *The Evolution of the UNFCCC.* Annual Review of Environment and Resources, 2018. **43**(1): p. 343-368.
32. Biesbroek, R., et al., *Assessment of existing datasets for tracking progress towards the Global Goal on Adaptation (and beyond).* Climate Policy, 2026. **26**(4): p. 535-549.

33. Schultz, L., et al., *Adaptive governance, ecosystem management, and natural capital.* Proceedings of the National Academy of Sciences, 2015. **112**(24): p. 7369-7374.
34. Cosens, B.A., et al., *The role of law in adaptive governance.* Ecology and society: a journal of integrative science for resilience and sustainability, 2017. **22**(1): p. 1.
35. Karpouzoglou, T., A. Dewulf, and J. Clark, *Advancing adaptive governance of social-ecological systems through theoretical multiplicity.* Environmental Science & Policy, 2016. **57**: p. 1-9.
36. Akther, S. and J. Evans, *Emerging attributes of adaptive governance in the global south.* Frontiers in Environmental Science, 2024. **12**: p. 1372157.
37. Zaidi, S.A., et al., *Health systems changes after decentralisation: progress, challenges and dynamics in Pakistan.* BMJ global health, 2019. **4**(1).
38. Waseem, M., *The federal project in Pakistan: Beyond fixing the design.* Commonwealth & Comparative Politics, 2024. **62**(3): p. 206-228.
39. Ostrom, E., *Beyond markets and states: Polycentric governance of complex economic systems.* American economic review, 2010. **100**(3): p. 641-672.
40. Kellner, A.W., *Anthropocene epoch proposal rejected-does it really matter?* 2024, SciELO Brasil. p. e2024962.
41. Morrison, G.R., et al., *Designing effective instruction*. 2019: John Wiley & Sons.
42. Schleicher, A., *Insights and interpretations.* Pisa 2018, 2018. **10**.
43. Newell, R., et al., *Global energy outlook 2021: Pathways from Paris.* Resources for the Future, 2021. **8**: p. 39.
44. Shi, T., et al., *Global, regional, and national disease burden estimates of acute lower respiratory infections due to respiratory syncytial virus in young children in 2015: a systematic review and modelling study.* The Lancet, 2017. **390**(10098): p. 946-958.
45. Neale, P.J., et al., *Environmental consequences of interacting effects of changes in stratospheric ozone, ultraviolet radiation, and climate: UNEP Environmental Effects Assessment Panel, Update 2024.* Photochemical & Photobiological Sciences, 2025. **24**(3): p. 357-392.
46. Milanez, A., A. Lemmens, and C. Ruggiu, *Algorithmic management in the workplace: New evidence from an OECD employer survey.* OECD Artificial Intelligence Papers, 2025.
47. Barnes, P.W., et al., *Environmental effects of stratospheric ozone depletion, UV radiation, and interactions with climate change: UNEP Environmental Effects Assessment Panel, Update 2021.* Photochemical & Photobiological Sciences, 2022. **21**(3): p. 275-301.
48. Calliari, E., et al., *Building climate resilience through nature-based solutions in Europe: A review of enabling knowledge, finance and governance frameworks.* Climate Risk Management, 2022. **37**: p. 100450.
49. Baumann, F., *The next frontier–human development and the anthropocene: UNDP human development report 2020.* Environment: Science and Policy for Sustainable Development, 2021. **63**(3): p. 34-40.
50. Ding, C., et al., *A dataset on the morphological, life-history and ecological traits of the mammals in China.* Biodiversity Science, 2022. **30**(2): p. 21520.
51. Carlson, C.J., et al., *The future of zoonotic risk prediction.* Philosophical Transactions of the Royal Society B: Biological Sciences, 2021. **376**(1837): p. 20200358.
52. Masud, S. and A. Khan, *Policy implementation barriers in climate change adaptation: The case of Pakistan.* Environmental Policy and Governance, 2024. **34**(1): p. 42-52.
53. Baig, M.A., et al., *Evaluation and projection of temperatures over pakistan: insights from the downscaled NEX-GDDP-CMIP6 models.* Earth Systems and Environment, 2025. **9**(4): p. 3425-3445.

54. Folke, C., et al., *Adaptive governance of social-ecological systems.* Annu. Rev. Environ. Resour., 2005. **30**: p. 441-473.
55. Chaffin, B.C., H. Gosnell, and B.A. Cosens, *A decade of adaptive governance scholarship: synthesis and future directions.* Ecology and society, 2014. **19**(3).
56. Chaffin, B.C., et al., *Transformative environmental governance.* Annual Review of Environment and Resources, 2016. **41**(1): p. 399-423.
57. Cleaver, F. and L. Whaley, *Understanding process, power, and meaning in adaptive governance.* Ecology and Society, 2018. **23**(2).
58. Christensen, D.V., et al., *2022 roadmap on neuromorphic computing and engineering.* Neuromorphic Computing and Engineering, 2022. **2**(2): p. 022501.
59. Ostrom, E., *Analyzing collective action.* Agricultural economics, 2010. **41**: p. 155-166.
60. Morrison, A.M., *Hospitality and travel marketing.* 2022: Taylor & Francis.
61. Tang, Y., et al., *Emerging pollutants in water environment: Occurrence, monitoring, fate, and risk assessment.* Water Environment Research, 2019. **91**(10): p. 984-991.
62. Bowen, D.E. and B. Schneider, *A service climate synthesis and future research agenda.* Journal of service research, 2014. **17**(1): p. 5-22.
63. Poetz, M.K. and M. Schreier, *The value of crowdsourcing: can users really compete with professionals in generating new product ideas?* Journal of product innovation management, 2012. **29**(2): p. 245-256.
64. Braun, V. and V. Clarke, *Using thematic analysis in psychology.* Qualitative research in psychology, 2006. **3**(2): p. 77-101.
65. Saldaña, J., *Coding techniques for quantitative and mixed data.* Vol. 151. 2021: The Routledge reviewer's guide to mixed methods analysis Abingdon.
66. Nowell, L.S., et al., *Thematic analysis: Striving to meet the trustworthiness criteria.* International journal of qualitative methods, 2017. **16**(1): p. 1609406917733847.
67. Gerring, J., *Is there a (viable) crucial-case method?* Comparative political studies, 2007. **40**(3): p. 231-253.
68. Chen, B., et al., *Challenges to achieve carbon neutrality of China by 2060: status and perspectives.* Science Bulletin, 2022. **67**(20): p. 2030-2035.
69. Ji, J.S., et al., *China's public health initiatives for climate change adaptation.* The Lancet Regional Health–Western Pacific, 2023. **40**.
70. Zhang, S., et al., *The 2023 China report of the Lancet Countdown on health and climate change: taking stock for a thriving future.* The Lancet Public Health, 2023. **8**(12): p. e978-e995.
71. Zenglein, M.J. and A. Holzmann, *Evolving made in China 2025.* MERICS papers on China, 2019. **8**: p. 78.
72. Tong, D., et al., *Dynamic projection of anthropogenic emissions in China: methodology and 2015–2050 emission pathways under a range of socio-economic, climate policy, and pollution control scenarios.* Atmospheric Chemistry and Physics, 2020. **20**(9): p. 5729-5757.
73. Owusu-Peprah, N.T., *World Development Report 2022: Finance for an Equitable Recovery: By World Bank, Washington, DC, World Bank Publications, 2022, 267 pp., $0.00 (E-Book), ISBN 9781464817311.* 2024, Taylor & Francis.
74. Orhan, E., *The effects of the Russia-Ukraine war on global trade.* Journal of International Trade, Logistics and Law, 2022. **8**(1): p. 141-146.
75. Yousaf, A., et al., *Climate change effects on rural livelihoods in Pakistan: legal and policy analysis.* GeoJournal, 2025. **90**(1): p. 25.
76. Waheed, A., T. Bernward Fischer, and M.I. Khan, *Climate change policy coherence across policies, plans, and strategies in Pakistan–implications for the China–Pakistan economic corridor plan.* Environmental Management, 2021. **67**(5): p. 793-810.
77. Rehman, S.A.U., et al., *Energy-environment-economy nexus in Pakistan: Lessons from a PAK-TIMES model.* Energy Policy, 2019. **126**: p. 200-211.

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78. Ahmad, I., A. Haider, and K. Ahmad, *The impact of judicial activism on environmental protection and justice in Pakistan: A statistical analysis.* Journal of Asian Development Studies, 2025. **14**(2): p. 1-10.
79. Khan, A., S. Safdar, and H. Nadeem, *Decomposing the effect of trade on environment: a case study of Pakistan.* Environmental Science and Pollution Research, 2023. **30**(2): p. 3817-3834.
80. Rehmat, A., et al., *Claiming reparation for loss and damage due to floods 2022: the case of Pakistan.* Sustainable Development Institute. https://sdpi.org/assets/lib/uploads/Claiming%20Reparation%20for%20Loss%20and%20Damage%20Due%20to%20Floods, 2023. **202022**.
81. Xueyuan, J., et al., *Synergies and differences between the China national biodiversity conservation strategy and action plan (2023–2030) and the Kunming-Montreal global biodiversity framework.* Biodiversity Science, 2025. **33**(3): p. 24575.
82. Sial, F., J. Jafri, and A. Khaliq, *Pakistan, China and the structures of debt distress: Resisting Bretton Woods.* Development and Change, 2023. **54**(5): p. 1226-1263.
83. Qadri, S.U., et al., *Green finance and foreign direct investment–environmental sustainability nexuses in emerging countries: new insights from the environmental Kuznets curve.* Frontiers in Environmental Science, 2023. **11**: p. 1074713.
84. Li, L., *China's manufacturing locus in 2025: With a comparison of "Made-in-China 2025" and "Industry 4.0".* Technological forecasting and social change, 2018. **135**: p. 66-74.
85. Xu, X., et al., *Safeguarding groundwater nitrate within regional boundaries in China.* Environmental Science & Technology, 2025. **59**(1): p. 467-477.
86. Adnan, M., et al., *Known and unknown environmental impacts related to climate changes in Pakistan: an under-recognized risk to local communities.* Sustainability, 2024. **16**(14): p. 6108.
87. Howarth, C. and E.J. Robinson, *Effective climate action must integrate climate adaptation and mitigation.* Nature Climate Change, 2024. **14**(4): p. 300-301.
88. Eriksen, S.H., et al., *Pathways for urgent action towards climate resilient development.* nature climate change, 2024. **14**(12): p. 1212-1215.
89. Hazards, E.P.o.B., et al., *Persistence of microbiological hazards in food and feed production and processing environments.* Efsa Journal, 2024. **22**(1): p. e8521.
90. Sonke, J.E., et al., *Global environmental plastic dispersal under OECD policy scenarios toward 2060.* Science Advances, 2025. **11**(16): p. eadu2396.