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Climate Security, Water Governance, and Resilience How Climate-Induced Water Stress and Migration Challenge State Capacity

FNU Zulqarnain[1];

[1]. Cardinal Masters in Public Administration, Lamar University Texas, Lamar University, Texas, USA; Email: zulniz@hotmail.com

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Abstract

This study examined how climate-induced water stress and migration pressures jointly influenced state capacity, and whether water governance quality and resilience capacity buffered institutional strain. A longitudinal panel dataset covering 148 sovereign states over 20 years (N = 2,960 country-year observations) was analyzed using fixed-effects regression models with cluster-robust standard errors. Climate-induced water stress was found to have a statistically significant negative association with state capacity ($\beta = -0.21$, $p < .001$), particularly within fiscal and service delivery domains. Migration pressure also demonstrated a significant negative effect ($\beta = -0.17$, $p = .005$), with stronger impacts observed in administrative coordination indicators. The interaction between water stress and migration was negative and significant ($\beta = -0.11$, $p = .006$), indicating that institutional strain intensified under compound stress conditions. Marginal effects analysis showed that the impact of water stress increased from −0.18 at low migration levels to −0.29 at high migration levels. Moderation analysis revealed that stronger water governance reduced the magnitude of the water stress effect ($\beta = 0.09$, $p = .025$), while resilience capacity significantly buffered compound pressure ($\beta = 0.12$, $p = .003$). The within-model R^2 increased from 0.47 in the baseline model to 0.57 in moderation models. Findings demonstrated that environmental scarcity and demographic redistribution operated both independently and interactively to challenge state capacity, while governance quality and resilience functioned as measurable institutional buffers.

Keywords

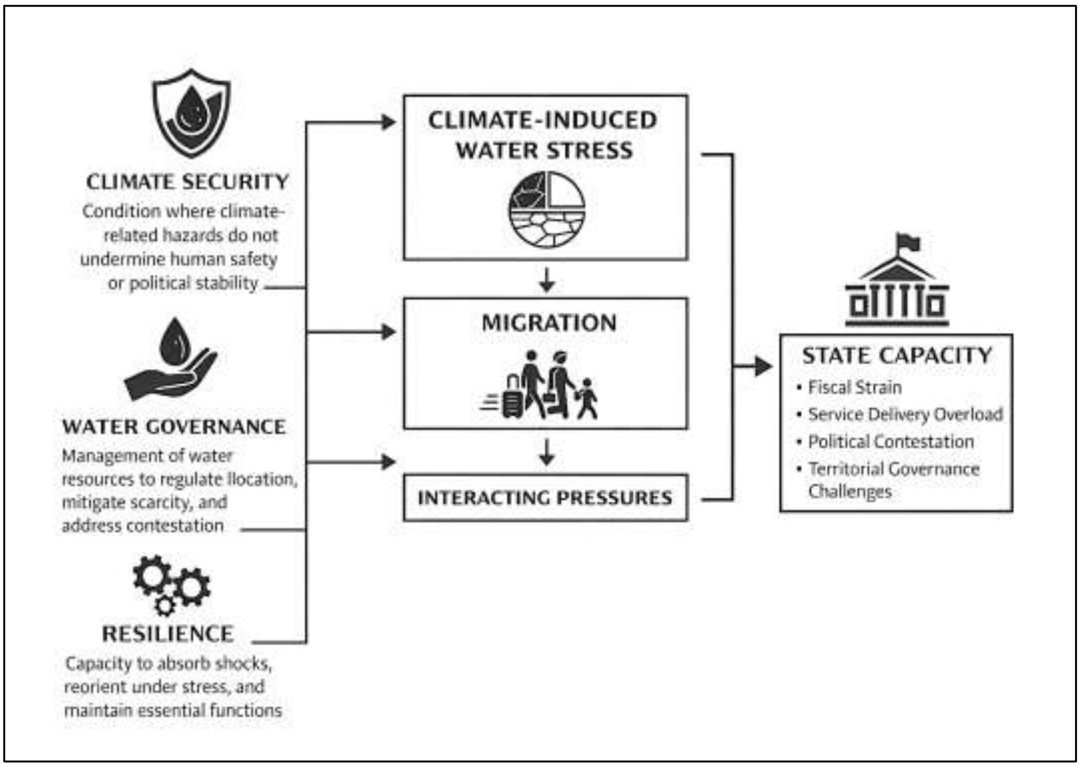
Climate Security, Water Governance, Resilience, Migration, State Capacity.

INTRODUCTION

Climate security is commonly defined as the condition in which climate-related hazards do not undermine human safety, social stability, or the functional integrity of political institutions. In the contemporary policy and academic landscape, climate security has expanded beyond environmental protection into a multidimensional framework linking climate variability to economic fragility, displacement, conflict risk, and institutional overload (Tuffuor & Tenkorang, 2022). Within this framing, water is positioned as one of the most critical climate-sensitive resources because it is foundational to food systems, public health, energy generation, and urban functionality. Climate-induced water stress refers to sustained or recurring conditions in which available water supply becomes insufficient to meet ecological and human demand due to climate-driven shifts in precipitation, temperature, evapotranspiration, snowmelt timing, groundwater recharge, and extreme events such as droughts and heat waves. Water stress is not only a hydrological condition; it is also a governance condition because the distribution of water, the regulation of access, and the enforcement of allocation rules determine who experiences scarcity and who is protected from it. Water governance is therefore defined as the institutional architecture through which water is planned, allocated, financed, regulated, monitored, and contested across multiple scales. This includes formal laws, informal practices, infrastructure regimes, pricing structures, administrative capacity, conflict-resolution systems, and accountability mechanisms. Resilience, within climate and governance research, refers to the ability of social and institutional systems to absorb shocks, reorganize under stress, and maintain essential functions such as service delivery, public safety, and economic coordination (Chigudu, 2024). Resilience becomes measurable in governance studies through institutional performance during disruptions, the continuity of services, and the adaptive capacity of public agencies. State capacity refers to the ability of a state to implement decisions, enforce rules, provide public goods, raise revenue, and manage crises across its territory. State capacity is not merely a legal attribute; it is operational, observable in the reliability of service provision, the legitimacy of authority, and the effectiveness of bureaucratic systems. In this quantitative study, climate-induced water stress and migration are conceptualized as interacting pressures that can disrupt state capacity through multiple channels, including fiscal strain, service delivery overload, political contestation, and territorial governance challenges (Rockström et al., 2024). This relationship holds international significance because water systems and migration patterns cross borders, and because climate-driven disruptions in one region can influence political stability, trade, humanitarian burdens, and security conditions across entire regions. The study is positioned within a global research agenda that increasingly treats climate security as a measurable governance problem rather than a purely ecological concern, and it focuses on how water governance and resilience shape the ability of states to manage climate-driven population and resource shocks.

The international significance of climate-induced water stress is rooted in the fact that water is a transboundary resource embedded in interconnected systems of agriculture, energy, trade, and human mobility. Water scarcity has historically been associated with development constraints, but under accelerating climatic variability it is increasingly linked to institutional instability and political insecurity. Globally, water stress is intensifying through multiple pathways: declining precipitation in some regions, increasing evapotranspiration in warmer climates, shrinking glaciers that regulate seasonal river flows, and the rising frequency of prolonged drought conditions (Upreti, 2023). These climatic pressures interact with demographic growth, urban expansion, and economic modernization, producing demand increases that often outpace supply even in historically water-secure states. As a result, water stress has become a systemic governance challenge, influencing national planning, regional diplomacy, and domestic stability. The security dimension emerges when water stress weakens the ability of governments to maintain reliable services and regulate distribution fairly, particularly when scarcity becomes visible through rationing, agricultural collapse, or conflict between rural and urban priorities. In many contexts, water stress triggers cascading impacts such as food insecurity, price volatility, unemployment, and loss of livelihoods, which can generate grievance dynamics and political contestation. International organizations increasingly treat water as a risk multiplier because water stress amplifies existing vulnerabilities including inequality, ethnic exclusion, corruption, weak service delivery, and contested territorial governance. Water scarcity can also reshape international relations through disputes over shared rivers and aquifers, especially where upstream infrastructure expansion alters downstream flows (Rokvić & Stanojević, 2024). The international dimension is also evident through economic linkages, since climate-driven water stress in major agricultural regions can influence global food markets and raise prices in import-dependent countries, generating political unrest even far from the site of the original climatic event. In addition, water stress can undermine economic growth, reducing fiscal resources available for public services and weakening administrative systems, which are central components of state capacity. The importance of quantitative investigation lies in the need to measure these relationships systematically across countries and time, distinguishing between physical water scarcity and governance-driven scarcity. A state's capacity to manage water stress depends not only on hydrology but also on institutional performance, investment strategies, infrastructure maintenance, and regulatory enforcement. Water governance therefore becomes a key mediator of climate security outcomes (Kangero, 2024). This study positions climate-induced water stress as a measurable, internationally relevant driver of governance strain, and it frames water governance and resilience as structural conditions that shape how water stress translates into migration and state capacity challenges across diverse political systems.

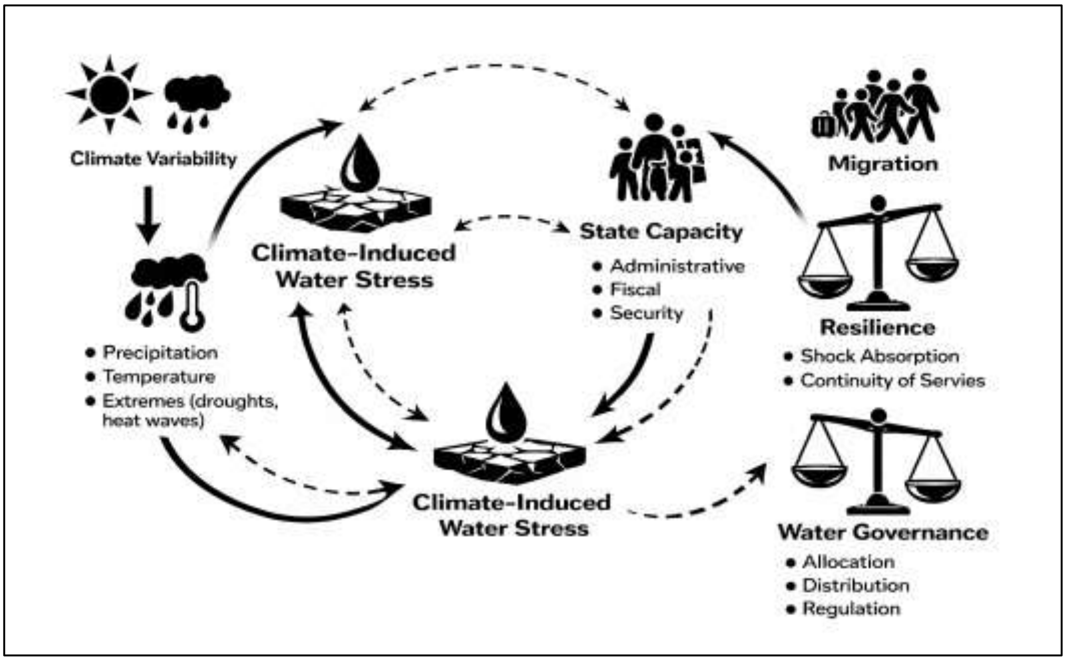
Figure 1: Climate Water Governance Resilience Capacity



Migration is a central component of climate security because it represents both an adaptive strategy for households and a governance challenge for states. Climate-induced migration refers to population movements that are shaped by climate-related stressors such as drought, water scarcity, livelihood collapse, and food insecurity. Migration can be internal, rural-to-urban, cross-border, temporary, seasonal, or permanent (Ferguson et al., 2021). It can also include forced displacement when environmental stress interacts with conflict, economic breakdown, or state repression. In quantitative research, migration is often treated as a mediating mechanism linking climate shocks to political instability, and it is also analyzed as an independent stressor that can affect state capacity through demographic and fiscal pressures. When climate-induced water stress reduces agricultural productivity and income, households may migrate to seek employment, access services, or secure survival. Such movements can alter the distribution of population density and demand for public goods, placing new burdens on receiving communities and administrative systems. Migration is therefore relevant to state capacity because states must manage registration, housing, employment regulation, public health, education, policing, and infrastructure expansion in response to population inflows. Large-scale internal migration can overwhelm municipal governance structures, particularly in rapidly growing cities where informal settlements expand faster than public services. Cross-border migration introduces additional governance challenges, including border management, humanitarian assistance, diplomatic tensions, and political contestation over national identity and resource allocation. Migration can also create political polarization when host communities perceive newcomers as competitors for jobs, housing, or water access (Nor & Mohamed, 2024). From a resilience perspective, migration can reduce vulnerability for migrant households while simultaneously increasing vulnerability in receiving areas if infrastructure and governance systems cannot scale. This duality makes migration a complex variable in climate security research, requiring careful quantitative modeling that accounts for both push factors (water stress, livelihood decline, insecurity) and pull factors (urban labor markets, service availability, political stability). Migration also interacts with water governance directly, since population inflows increase water demand, expand informal water markets, and raise the risk of unequal distribution. These dynamics can erode trust in government if water services become unreliable or if allocation is perceived as politically biased. In addition, migration can reduce the fiscal base of sending regions through labor loss and economic contraction, further weakening local administrative capacity (Beitelmal et al., 2024). The international significance of climate-induced migration lies in its ability to redistribute risk across borders, creating regional humanitarian burdens and security concerns. This study treats migration as both an outcome of water stress and a driver of state-capacity strain, positioning it as a key link in the broader climate security nexus that connects environmental change, governance performance, and institutional resilience.

State capacity is increasingly treated as a measurable outcome variable in climate-security research because it captures the operational strength of government institutions under stress. In political science and public administration, state capacity is often conceptualized through three interrelated dimensions: administrative capacity, fiscal capacity, and coercive or security capacity. Administrative capacity refers to the ability of bureaucracies to design and implement policy, manage service delivery, collect information, and coordinate across agencies (Morales-Muñoz et al., 2020). Fiscal capacity refers to the ability of the state to raise revenue and allocate expenditures effectively, particularly during crises. Security capacity refers to the ability of the state to maintain order, protect citizens, and manage conflict risks. Climate-induced water stress can challenge all three dimensions simultaneously. When drought reduces agricultural production and economic output, the state may experience declining tax revenues while facing rising demands for emergency spending, subsidies, or humanitarian relief. This creates fiscal strain, which can reduce investment in infrastructure and weaken long-term administrative performance. Water stress also increases the complexity of governance because allocation decisions must be made under scarcity, requiring monitoring systems, enforcement mechanisms, and dispute-resolution capacity (Cianconi et al., 2021). Weak governance can lead to corruption, elite capture, or inequitable distribution, which can reduce legitimacy and increase social contestation. In many states, water services are delivered through utilities or local agencies that depend on infrastructure maintenance, pricing systems, and technical expertise. Climate-induced shocks can expose vulnerabilities in these systems, producing service failures that citizens interpret as state failure. Migration compounds these pressures by increasing demand for services in receiving areas, raising the administrative burden on local governments and increasing the cost of infrastructure expansion. When migration flows are rapid or concentrated, public systems such as sanitation, health care, and schooling can become overstretched, leading to declines in service quality. Such declines can be measured through indicators such as access rates, reliability metrics, and public satisfaction proxies. In addition, migration can introduce security challenges when social tensions rise or when competition over water becomes politicized (Rahman, 2024). State capacity is therefore a relevant quantitative outcome because it captures how environmental and demographic pressures translate into governance performance. A central contribution of quantitative analysis is the ability to test whether water stress and migration have independent effects on capacity, whether their interaction produces amplified effects, and whether governance quality moderates these relationships. This study positions state capacity as a dependent variable influenced by climate-induced water stress and migration, while also recognizing that state capacity shapes resilience by determining how effectively governments can plan, respond, and recover. The global relevance of this focus lies in the increasing frequency of climate-driven disruptions and the growing recognition that institutional strength determines whether such disruptions produce manageable crises or systemic breakdowns.

Figure 2: Climate Security Water Stress Framework



Water governance is a central mediator in the relationship between climate-induced water stress and state capacity because governance determines how scarcity is experienced and managed. Scarcity becomes politically destabilizing when allocation systems are perceived as unfair, when services fail repeatedly, or when institutions cannot resolve disputes. Water governance includes legal frameworks for rights and entitlements, administrative structures for planning and regulation, financial mechanisms for pricing and investment, and social systems for participation and accountability (Faysal & Shamsunnahar, 2022; Kiyala, 2024). In many contexts, water governance is fragmented across ministries, local agencies, and private actors, producing coordination failures that reduce efficiency and equity. Climate-induced water stress increases the complexity of governance because it requires adaptive decision-making under uncertainty, rapid response to drought events, and long-term planning for infrastructure and demand management. Governance failures can emerge when institutions lack reliable data on water availability, when monitoring systems are weak, or when enforcement capacity is limited (Habibullah & Zaheda, 2022; Ratul, 2022). Groundwater governance is particularly challenging because extraction is often decentralized and poorly regulated, leading to depletion that becomes visible only after severe decline. In addition, water governance is shaped by political economy factors such as elite influence, corruption, and unequal bargaining power between sectors such as agriculture, industry, and urban households. These dynamics can create distributional conflict, especially when drought forces rationing or reallocations. Migration intensifies water governance challenges by increasing demand in receiving areas, expanding informal settlements, and raising the complexity of service delivery (Shahab & Aditya, 2023; Sciaccaluga, 2020). In cities experiencing rapid in-migration, informal water markets often grow, creating inequalities in price and access that can fuel grievance and undermine legitimacy. Water governance is also internationally significant because many major river basins are shared by multiple countries, requiring treaties, coordination mechanisms, and diplomatic negotiation. Climate-induced changes in flow regimes can intensify tensions in transboundary basins, especially where upstream infrastructure projects alter downstream access. The quantitative relevance of water governance lies in its measurable role as a moderating or mediating factor: governance quality can reduce the negative effects of water stress by improving allocation efficiency, expanding storage and distribution infrastructure, and maintaining service reliability. Governance can also influence migration by shaping livelihood resilience in rural areas and by determining whether urban systems can absorb inflows (Mostafa, 2023; Mostafa & Bhuya, 2023; Pasula, 2024). This study frames water governance as a key institutional mechanism that links environmental stress to state capacity outcomes. By treating governance not as a background variable but as a core explanatory factor, the study aligns with a growing body of research that emphasizes institutions as the primary determinants of climate-security outcomes across countries.

Resilience is increasingly conceptualized as an institutional and social property that determines how states and communities manage compound shocks such as drought combined with population displacement. In climate-security research, resilience extends beyond physical infrastructure to include governance flexibility, social cohesion, and the ability to maintain essential functions during disruptions. Resilience is measurable through indicators such as the continuity of water services, the speed of disaster response, the effectiveness of social protection systems, and the stability of administrative performance during crises (Ratul & Aditya, 2023; Rifat & Rebeka, 2023; Schutte et al., 2021). Climate-induced water stress challenges resilience by reducing supply reliability and increasing competition among users. When resilience is high, states can buffer scarcity through diversified supply systems, demand management, emergency planning, and equitable allocation. When resilience is low, scarcity can trigger service breakdowns, livelihood collapse, and social instability. Migration introduces additional resilience demands because it changes demographic patterns and increases service requirements in receiving regions. The resilience of local governance systems becomes critical in determining whether migration flows are absorbed smoothly or produce infrastructural collapse and political tension. In many cases, resilience is uneven across regions within the same state, with wealthier urban areas having stronger infrastructure and poorer rural areas experiencing higher vulnerability. This unevenness can drive migration and deepen regional inequality, creating additional governance challenges (Faysal & Bhuya, 2024; Towhidul & Uddin, 2024). Resilience is also shaped by institutional trust, since citizens are more likely to comply with rationing and emergency measures when they perceive government decisions as legitimate and transparent. When trust is low, scarcity policies can provoke protest and noncompliance, reducing governance effectiveness. Resilience therefore intersects directly with state capacity because capacity determines the ability to plan, coordinate, and enforce adaptive measures (Çakmakçı et al., 2023). Quantitative research often treats resilience as a moderating factor, examining whether institutional strength reduces the relationship between climate shocks and instability outcomes. This study integrates resilience into the climate–water–migration nexus by conceptualizing it as the capacity of governance systems to maintain function under the combined pressures of hydrological stress and demographic movement. The international significance of resilience lies in the reality that climate-induced shocks are increasingly multi-sectoral, affecting water, food, energy, health, and security simultaneously (Sazzadul & Rebeka, 2024; Tasnim & Anick, 2024). States that lack resilience may experience cascading failures where one sector's breakdown amplifies another, such as water scarcity producing food insecurity, which then drives migration, which then overloads urban services, which then weakens state legitimacy. This study positions resilience as a measurable institutional characteristic that shapes how water stress and migration interact to challenge state capacity across national contexts (Serbanica & Constantin, 2023).

The climate security nexus linking water stress, migration, and state capacity has become a central focus of quantitative governance research because it offers a structured way to analyze how environmental and demographic pressures interact with institutional performance (Amena Begum, 2025; Zaheda & Hamidur, 2024). Climate-induced water stress is increasingly measurable through standardized hydrological indicators and remote sensing datasets, allowing researchers to compare drought severity, groundwater depletion, and water availability across countries and time periods. Migration is also increasingly measurable through international databases on displacement, population movements, and urbanization patterns, enabling statistical analysis of how climatic stressors influence mobility (Cacciotti et al., 2021). State capacity, while multidimensional, can be operationalized through governance effectiveness indices, fiscal indicators, service delivery measures, and stability proxies. Water governance can be incorporated through institutional quality indicators, decentralization measures, regulatory performance proxies, and transboundary cooperation variables (Faysal & Aditya, 2025; Jahangir, 2025). By combining these measurable constructs, quantitative research can test whether climate-induced water stress is associated with declines in state capacity, whether migration mediates or amplifies that relationship, and whether governance and resilience moderate these effects. The international relevance of this approach is grounded in the global distribution of water stress and migration vulnerability . Many regions already experience chronic water scarcity, and climate variability increases the probability of acute shocks that strain institutions. At the same time, migration flows increasingly shape political dynamics across borders and within states, influencing electoral competition, public opinion, and policy responses. The state capacity dimension is essential because it determines whether governments can manage scarcity equitably, provide emergency relief, and maintain legitimacy during disruptions (Pereira et al., 2020). This study is positioned within a broad empirical literature that links climate shocks to economic decline, social unrest, and conflict risk, while emphasizing the role of governance quality in shaping outcomes. It also builds on migration research that examines how environmental stress interacts with livelihood systems, inequality, and urban absorption capacity. The synthesis presented in this introduction establishes a framework in which climate-induced water stress and migration are treated as interacting pressures that can challenge state capacity through fiscal, administrative, and service-delivery channels. The framework also highlights that water governance and resilience shape the intensity and direction of these relationships by determining how scarcity is managed and how demographic shocks are absorbed. The quantitative orientation of the study is therefore anchored in measurable relationships between environmental exposure, mobility patterns, and institutional performance across diverse contexts. The focus on climate security and state capacity is internationally significant because governance breakdowns and displacement crises do not remain confined to national boundaries; they affect regional stability, humanitarian systems, trade, and global security conditions (Ellis et al., 2024). This study contributes to a rigorous understanding of how climate-induced water stress and migration pressures intersect to challenge the functional capacity of states, using a structured and measurable approach that aligns with contemporary quantitative research standards.

The objective of this quantitative study is to examine how climate-induced water stress and migration pressures jointly challenge state capacity, with specific attention to the institutional roles of water governance and resilience in shaping this relationship. The study is designed to quantify the extent to which variations in climate-driven water stress are associated with measurable changes in state performance, including administrative effectiveness, service delivery stability, and fiscal strength across national contexts. A central objective is to evaluate whether migration functions as a direct governance stressor and also as an interaction factor that amplifies the institutional burden created by water scarcity. In this framework, climate-induced water stress is treated as a measurable environmental exposure that can disrupt agricultural productivity, raise livelihood insecurity, intensify competition over water access, and increase demand for public assistance, while migration is treated as a demographic and spatial process that redistributes service needs and administrative obligations. The study aims to assess whether states facing higher levels of water stress experience greater institutional strain when migration levels increase, particularly in contexts where public systems must expand rapidly to provide water, sanitation, health services, education, and housing to incoming populations. Another key objective is to test the role of water governance as an institutional mechanism that influences how water stress translates into political and administrative pressure. This includes examining whether stronger governance systems, reflected in clearer allocation rules, improved enforcement capacity, and higher service reliability, are associated with reduced capacity strain under water stress conditions. In addition, the study seeks to evaluate resilience as a measurable institutional property that reflects the ability of states to maintain functionality under compound shocks, including drought combined with displacement. The objective is not limited to identifying whether water stress and migration correlate with weaker state capacity, but also to determine how these pressures interact across diverse national environments and governance conditions.

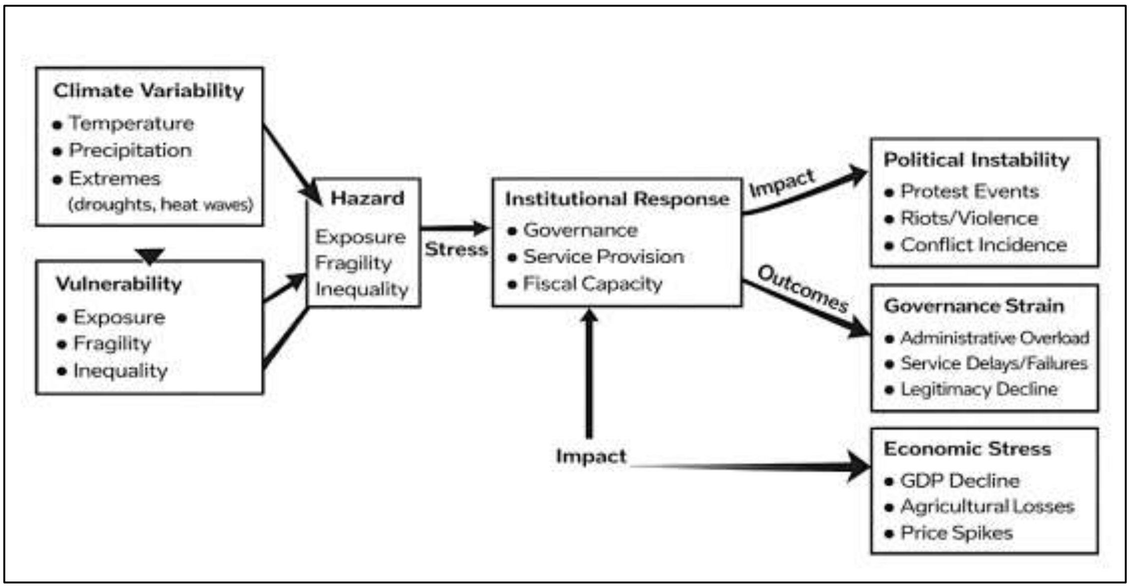
LITERATURE REVIEW

The literature review for this quantitative study organizes and synthesizes research that explains how climate-induced water stress and migration pressures translate into measurable variation in state capacity, and how water governance and resilience structure that relationship (Nonvide, 2023). Because the study is positioned at the intersection of climate security, hydro politics, mobility studies, and state-capacity research, the review is designed to do three things in a quantitative way: (a) define the core constructs as they are commonly operationalized in empirical work, (b) map the dominant causal pathways that connect water stress and migration to institutional performance outcomes, and (c) identify measurable moderators and mediators—especially water governance and resilience—that help explain cross-national and subnational differences in state-capacity outcomes under comparable climatic stress (Alfadel et al., 2023; Shahab, 2025; Syeedur, 2025). The section therefore emphasizes how scholars have measured drought and water stress (e.g., meteorological, agricultural, and hydrological indices), how migration is captured in quantitative datasets (e.g., internal mobility proxies, forced displacement events, net migration rates), and how state capacity is operationalized (e.g., government effectiveness, fiscal capacity, service delivery reliability, territorial reach). It also reviews evidence on interaction and compound-risk perspectives, where water stress and migration jointly intensify pressure on administrative systems, fiscal resources, and service provision. Consistent with the study's quantitative orientation, the literature review highlights the methodological approaches most frequently used in this domain—panel data models, multilevel designs, spatial econometrics, event-based approaches, quasi-experimental designs, and robustness strategies—and links each approach to the measurement and identification challenges that arise when environmental exposure, population movement, and governance quality are modeled together (Cergibozan, 2022). The aim is to establish a tightly specified empirical foundation that leads logically to the paper's variable framework, testable expectations, and model structure, while maintaining focus on measurable relationships among climate-induced water stress, migration, water governance, resilience, and state capacity.

Climate Security as an Empirical Research Program

Climate security has evolved into a structured empirical research program that conceptualizes climate change not as an automatic trigger of conflict but as a risk factor influencing social stability and institutional performance. Quantitative scholarship consistently frames climate security as a probabilistic relationship between climatic hazards and governance outcomes rather than as deterministic causation (Lin et al., 2022). Within this framework, climate variability—including temperature anomalies, precipitation deviations, prolonged drought, and extreme weather events—is treated as a hazard that interacts with social and institutional conditions. Researchers distinguish clearly between hazard, exposure, vulnerability, and institutional response to avoid conflating climatic events with political consequences. Hazard refers to measurable climatic shifts such as rainfall anomalies or warming trends; exposure captures the extent to which populations and economic systems depend on climate-sensitive sectors; vulnerability reflects socioeconomic fragility, inequality, and limited coping capacity; and institutional response encompasses governance quality, policy coordination, and service delivery capacity (Chen et al., 2022). This layered approach has become central in climate-security research because it allows for cross-national comparison without assuming uniform outcomes. Empirical work has demonstrated that climatic shocks are more likely to produce destabilizing outcomes where governance systems are weak, inequality is high, and economic dependence on climate-sensitive sectors is substantial. Studies examining rainfall shocks and temperature increases have shown associations with social unrest and conflict incidence under specific structural conditions, reinforcing the importance of mediating variables rather than simplistic climate–conflict narratives. Meta-analytical research has also emphasized variability in effect sizes, encouraging careful model specification and contextual controls. By distinguishing structural vulnerability from immediate hazard, the empirical program moves beyond environmental determinism and situates climate security within institutional analysis. This orientation aligns directly with the title of the present study, which positions climate-induced water stress and migration as pressures that interact with governance structures rather than as independent causes of instability (Ceballos et al., 2020). The emphasis on risk to institutional function supports the use of measurable state performance indicators as outcomes, grounding climate security in observable administrative, fiscal, and service-delivery dimensions.

Figure 3: Climate Security Institutional Stress Framework



Quantitative climate-security research has generated several dominant outcome families that guide empirical inquiry. Political instability outcomes represent one of the earliest and most widely studied categories, including protest events, riots, communal violence, and civil conflict incidence. Large-scale cross-national studies have examined whether deviations in rainfall or temperature correlate with increased conflict probability, while subnational analyses have explored local-level associations between drought exposure and violent events (Chen et al., 2024; Amin, 2025; Towhidul & Rebeka, 2025). Although findings vary across contexts, a recurring pattern indicates that climatic shocks may increase instability risks where governance is exclusionary, economic opportunities are limited, and prior conflict history exists. In parallel, governance-oriented outcomes have gained prominence, reflecting a shift from conflict-only measures toward broader assessments of institutional performance. Researchers increasingly examine how climatic stress affects government effectiveness, bureaucratic quality, regulatory enforcement, and public trust proxies. Administrative strain, delayed service provision, and declining legitimacy are treated as observable governance responses to environmental stress. Economic stress outcomes also feature prominently as intermediate channels. Empirical studies demonstrate that temperature and precipitation anomalies can influence GDP growth rates, agricultural productivity, and commodity prices, particularly in economies dependent on rain-fed agriculture (Mostafa, 2025; Ratul, 2025; Warsame et al., 2021). Food price spikes have been linked to social unrest in multiple contexts, reinforcing the argument that climate impacts can operate through economic transmission mechanisms rather than direct confrontation. The literature also highlights the importance of compound stressors, where economic shocks and environmental pressures coincide, increasing the probability of political instability. Methodologically, researchers rely on panel data, fixed-effects models, event-based datasets, and spatial analysis to isolate climatic impacts while controlling for structural factors. The cumulative evidence from these diverse outcome families establishes climate security as an empirically grounded domain concerned with measurable changes in political order, governance performance, and economic stability under environmental stress (Murshed, 2020; Rifat, 2025; Sazzadul, 2025).

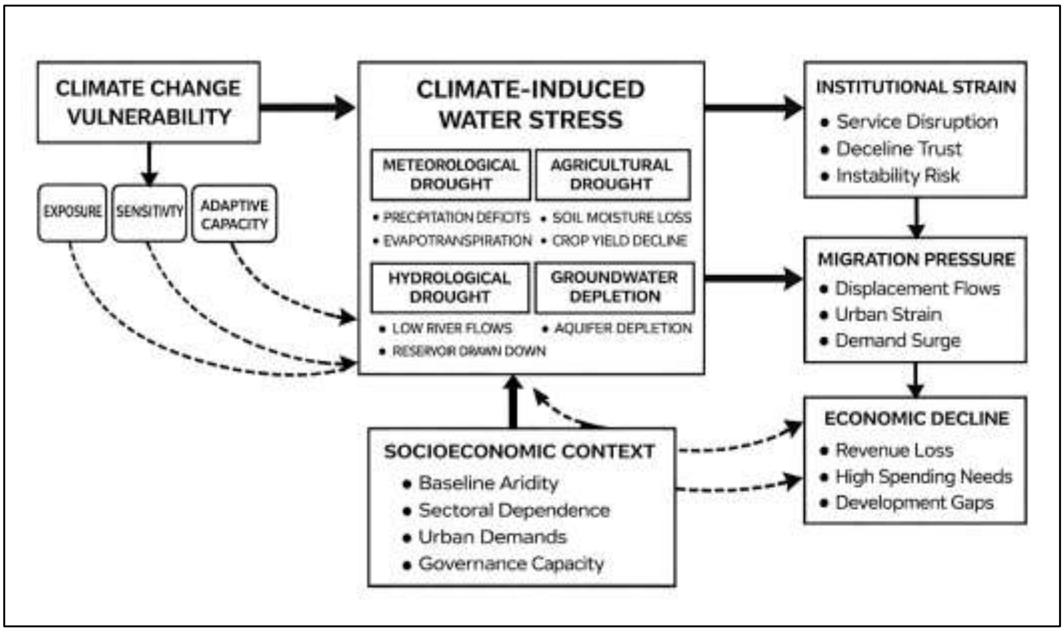
Within this expanding empirical landscape, state capacity has emerged as a central dependent variable because it captures the functional integrity of institutions under stress. State capacity is commonly conceptualized as the ability of governments to implement decisions, collect revenue, maintain order, and provide public goods. This multidimensional construct encompasses administrative competence, fiscal extraction capability, and territorial governance reach. Scholars argue that climatic shocks test state capacity by increasing service demands while constraining fiscal resources (Ren et al., 2022; Shamsunnahar, 2025; Yousuf et al., 2025). For instance, drought-related agricultural losses can reduce tax revenue in agrarian economies while simultaneously increasing the need for subsidies, relief programs, and infrastructure maintenance. This dual pressure exposes weaknesses in fiscal management and administrative coordination. Research on disasters and governance performance indicates that states with stronger bureaucratic systems and transparent institutions manage crises more effectively, maintaining service continuity and reducing social unrest. Conversely, weaker states often experience service breakdowns, corruption expansion, and legitimacy erosion following environmental shocks (Lee et al., 2024). The concept of capacity as institutional "throughput" highlights how states transform resources into stability and service provision. When throughput is disrupted by environmental and demographic stressors, the effects become visible through delayed policy responses, inconsistent enforcement, and declining public satisfaction. Empirical measures of capacity, including government effectiveness indices, tax-to-GDP ratios, and service coverage statistics, provide quantifiable outcomes that respond to stress. This responsiveness makes state capacity particularly suitable for quantitative modeling in climate-security research. By focusing on state capacity rather than solely on conflict incidence, the literature broadens its analytical lens to include subtler forms of institutional strain that precede overt instability (Chandio et al., 2020).

The integration of climate security with institutional performance research reflects a broader theoretical shift toward understanding environmental change as a governance challenge. Studies across political science, economics, and environmental policy demonstrate that institutional quality mediates the relationship between climatic hazards and social outcomes (Ngcamu, 2023). Economic analyses reveal that temperature increases can slow growth in lower-income countries, indirectly influencing state revenue and administrative resources. Governance research links corruption and weak regulatory systems to unequal resource allocation during scarcity, exacerbating social grievances. Public administration studies show that bureaucratic professionalism and coordination capacity improve crisis management outcomes (Abbas et al., 2023; Shofiul Azam, 2025; Akter & Aditya, 2025). Together, these strands reinforce the argument that environmental stress interacts with institutional design rather than operating independently. Climate-security scholarship has therefore expanded to include measures of governance performance, fiscal resilience, and administrative continuity. This shift aligns directly with the current study's emphasis on climate-induced water stress and migration as pressures that challenge state capacity. By situating climate security within an institutional throughput framework, the literature supports an empirical approach that measures how environmental hazards translate into governance strain across different structural contexts (Nguyen et al., 2023; Tasnim, 2025; Zaheda, 2025b). The cumulative evidence across multiple empirical domains—conflict research, economic analysis, disaster governance, and institutional theory—establishes a robust foundation for examining how climate variability affects the operational strength of states.

Climate-Induced Water Stress

Climate-induced water stress has become one of the most operationalized constructs in quantitative climate-security and governance research because it offers measurable indicators that can be aligned with institutional and socioeconomic outcomes. In empirical work, water stress is not treated as a single uniform variable; it is measured through multiple drought and hydrological frameworks that capture different dimensions of scarcity (Dehghani et al., 2024; Zaheda, 2025a). Meteorological drought is often defined through precipitation deficits and temperature-driven evapotranspiration anomalies, reflecting atmospheric conditions that reduce water input or increase water loss. These measures are frequently operationalized through standardized drought indices that allow comparison across time and space. Agricultural drought is conceptualized as the effect of climatic conditions on soil moisture availability and vegetation health, often captured through soil moisture datasets and satellite-based vegetation stress proxies. This type of drought is particularly relevant for studying rural livelihood impacts, as it directly affects crop growth cycles and pasture productivity. Hydrological drought extends beyond rainfall and soil moisture to include the condition of rivers, reservoirs, and surface-water storage systems, often measured through streamflow anomalies, reservoir level changes, and runoff deviations. Groundwater depletion is increasingly treated as a chronic form of water stress, particularly in regions where irrigation demand and urban extraction exceed recharge capacity (Almulhim et al., 2024). Empirical studies have used satellite gravimetry, groundwater monitoring systems, and modeled recharge estimates to quantify long-term depletion trends. This multidimensional measurement landscape has strengthened quantitative research by allowing scholars to test whether different drought types produce different governance outcomes. The literature also emphasizes that water stress must be interpreted in relation to demand, because scarcity is shaped not only by reduced supply but also by rising withdrawals from agriculture, industry, and urban growth (Ashraf et al., 2021). As a result, many studies integrate hydrological exposure measures with socioeconomic indicators such as irrigation intensity, population density, and agricultural dependence. The convergence of drought indices, remote sensing technologies, and global hydrological models has made climate-induced water stress one of the most empirically tractable climate variables for large-scale analysis, enabling systematic investigation of how climatic pressures translate into institutional strain across diverse national and subnational contexts.

Figure 4: Climate-Induced Water Stress Framework



A central theme in the literature is that water stress functions as a driver of institutional strain through multiple causal pathways that operate simultaneously across economic, administrative, and political domains. One prominent pathway involves public service disruption, where reduced water availability leads to rationing, unreliable supply, declining water quality, and failures in sanitation systems (Loiko & Islam, 2024). In many contexts, water services are highly visible public goods, and disruptions become direct signals of state performance. Empirical governance studies have shown that service unreliability is associated with declining public trust, increased grievance, and higher probability of protest events, particularly when rationing is perceived as unequal or politically biased. Water stress also affects institutions through rural livelihood pathways. When drought reduces yields in rain-fed and irrigation-dependent agricultural systems, households experience income decline, food insecurity, and debt accumulation. These economic shocks increase demands for state intervention, including relief programs, subsidies, emergency employment schemes, and food assistance. In low-capacity states, the administrative load created by these demands can overwhelm bureaucratic systems, reducing the effectiveness of policy implementation (Zisopoulou & Panagoulia, 2021). The fiscal pathway is equally prominent in quantitative research. Drought-related economic contraction can reduce government revenues through declining agricultural output, reduced trade, and lower economic growth. At the same time, governments often face increased expenditures for disaster response, infrastructure repair, water trucking, and public health interventions. This creates fiscal stress that can undermine the state's ability to sustain public goods provision and long-term development investment. Studies in political economy and disaster governance frequently emphasize that fiscal strain is a critical mediator between environmental shocks and institutional instability. When fiscal resources are constrained, governments may reduce spending on maintenance and public services, which can generate a cycle of infrastructure deterioration and further service disruption (Sultana et al., 2024). These pathways demonstrate that water stress is not merely an environmental condition but a systemic governance stressor. The literature therefore supports treating water stress as a structural driver of administrative and fiscal overload, which aligns directly with this study's focus on state capacity as an outcome.

Quantitative research also emphasizes that the effects of water stress on governance are heterogeneous, meaning that similar levels of drought exposure can produce very different institutional outcomes depending on baseline conditions and socioeconomic structure. One major source of heterogeneity involves baseline aridity versus anomaly shocks. In chronically arid regions, societies and institutions often develop coping mechanisms such as storage infrastructure, drought-resistant cropping systems, and established rationing regimes (Amnuaylojaroen & Parasin, 2024). In contrast, anomaly shocks in regions that are typically water-secure can produce sharper institutional disruption because infrastructure and governance systems may not be designed for scarcity. This distinction is important in empirical modeling because it suggests that drought severity must be interpreted relative to long-term climatic norms rather than absolute rainfall totals alone. Sectoral dependence is another key heterogeneity factor. Economies with high dependence on irrigated agriculture or rain-fed farming tend to experience stronger economic and livelihood impacts from drought, which increases the likelihood of migration, fiscal strain, and political contestation. In diversified economies, drought may still disrupt water services and food systems but may produce weaker direct effects on national revenue and employment. Urban versus rural exposure profiles also shape governance outcomes. Rural areas are often directly affected through crop losses and water scarcity for livestock, while urban areas experience stress through demand surges, supply disruptions, and infrastructure strain (Singh et al., 2023). Rapid urban growth and informal settlement expansion can intensify urban water stress even when regional hydrology is stable, because demand outpaces network expansion. The literature also highlights that governance systems often allocate water preferentially to politically powerful sectors, such as commercial agriculture or industry, leaving marginalized rural communities and informal urban neighborhoods more vulnerable. These distributional dynamics can increase grievance and contestation, influencing state legitimacy. By documenting these heterogeneity patterns, the literature provides a strong rationale for modeling water stress in interaction with structural moderators such as economic dependence, urbanization, and governance quality (Leal Filho et al., 2023). It also reinforces the importance of selecting water stress measures that match the theoretical mechanism being tested, such as agricultural drought for livelihood pathways or hydrological drought for service delivery pathways.

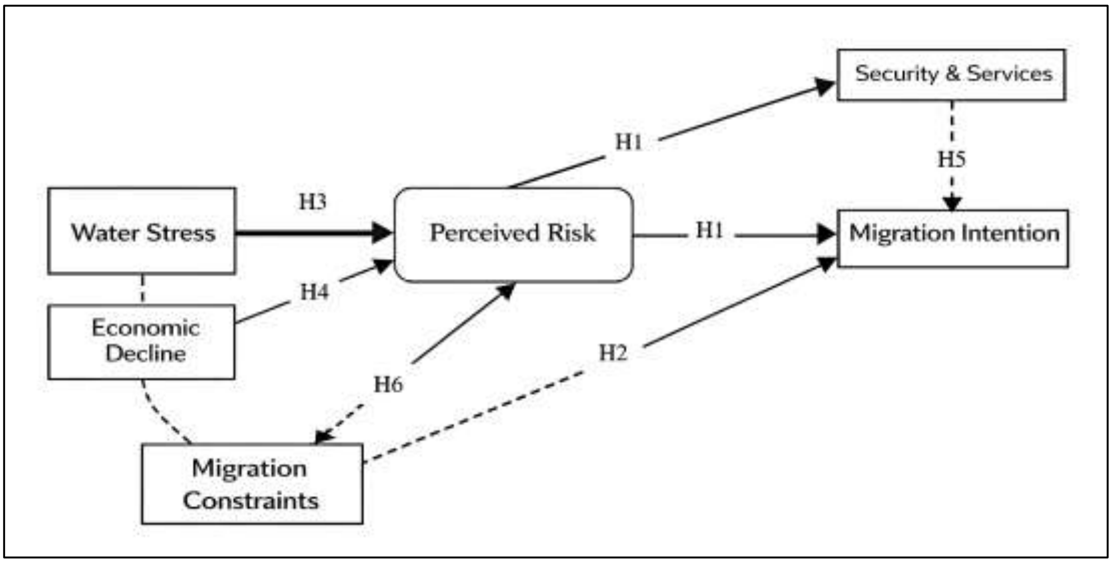
Methodologically, the literature on climate-induced water stress and governance outcomes has advanced through diverse quantitative modeling approaches that allow for stronger causal inference and more precise measurement alignment. Country-year panel designs remain common, using fixed effects to control for unobserved country characteristics and incorporating lag structures to capture delayed effects of drought on economic performance, migration, and institutional outcomes (Leal Filho et al., 2023). These designs enable broad comparative analysis across large samples, although they can mask subnational variation. As a result, a growing body of work uses subnational grid-cell or district-level panels, which align high-resolution drought exposure data with local conflict events, migration flows, and service delivery outcomes. These approaches improve spatial precision and allow researchers to test whether drought impacts concentrate in specific livelihood zones, border regions, or politically marginalized areas. The literature also emphasizes nonlinear and threshold modeling because drought impacts often intensify once severity exceeds coping capacity (Tiscornia, 2023). For example, mild drought conditions may be absorbed through household savings and local coping strategies, while severe multi-year drought can trigger livelihood collapse, displacement, and service breakdown. Empirical studies increasingly incorporate severity-based drought categories, interaction terms, and flexible functional forms to capture these nonlinearities. Spatial econometric approaches are also used to account for spillover effects, since drought impacts and migration pressures can cross administrative boundaries. Robustness strategies commonly include testing multiple drought indices, varying lag lengths, and using alternative dependent variables such as service reliability indicators or governance effectiveness metrics (Yang et al., 2020). Overall, the methodological literature demonstrates that water stress is measurable in multiple ways and that modeling choices strongly influence conclusions about its relationship with institutional strain. This study builds on that empirical foundation by treating water stress as a multidimensional exposure variable that interacts with migration pressures to challenge state capacity, while recognizing that governance outcomes depend on baseline aridity, sectoral structure, and urban-rural exposure patterns.

Migration and Displacement Under Water Stress

Migration and displacement under climate-induced water stress represent a core empirical domain within climate security and governance research because population movement links environmental pressures to measurable institutional strain (Bertassello et al., 2023). For quantitative consistency, the literature distinguishes migration types based on distance, voluntariness, duration, and legal status. Internal migration covers movements within national borders, including rural-to-rural, rural-to-urban, and urban-to-urban relocation, and it is often treated as the dominant form of mobility associated with slow-onset environmental stress. Rural–urban movement receives special attention because water stress commonly undermines agriculture and livestock-based livelihoods, increasing incentives to seek wage labor and services in towns and cities. Cross-border migration is usually measured separately because it is shaped not only by environmental push factors but also by visa regimes, border enforcement, regional politics, and conflict dynamics. Another essential distinction separates forced displacement from adaptive livelihood migration. Forced displacement refers to movements that occur under conditions of acute threat, insecurity, or crisis, including evacuation during disasters and flight from violence, and it is often captured through displacement event datasets and humanitarian records (Wrathall & Van Den Hoek, 2022). Adaptive livelihood migration is framed as a household strategy to manage risk and smooth consumption when environmental conditions reduce income opportunities, and it can include seasonal or circular migration linked to labor cycles. The literature also identifies "trapped populations," referring to households that face high environmental stress but remain immobile because they lack financial resources, social networks, legal documentation, transport access, or physical ability to move. This concept matters for quantitative work because immobility can produce selection bias: observed migration captures those who can move, while those who remain may face deeper vulnerability and higher mortality risk. Measurement consistency therefore requires researchers to specify whether outcomes represent net migration, gross flows, displacement incidence, or mobility probability at the household level. Across this scholarship, migration is not treated as an automatic response to water stress but as a conditional outcome shaped by asset constraints, labor demand, land tenure, gendered mobility norms, and the availability of public services in origin and destination locations (Almulhim et al., 2024). This framing supports quantitative models that embed migration within a broader vulnerability and governance context rather than treating it as a simple function of drought severity.

Quantitative studies operationalize migration and displacement using multiple metrics that vary in temporal resolution, spatial scale, and coverage, and the literature treats these measurement choices as theoretically consequential. Net migration rates and population change indicators are common in country-level datasets and administrative statistics, providing broad comparability but often masking short-term displacement and circular mobility (Sen, 2024). Internal mobility proxies include changes in subnational population counts, shifts in school enrollment, mobile phone mobility patterns, labor-force surveys, and census-based migration questions that capture "place of residence" changes over defined reference periods. Forced displacement events are often measured through incidence and intensity indicators, such as the number of newly displaced persons, displacement duration, and repeated displacement episodes, which are typically recorded by humanitarian agencies and displacement monitoring systems. These event-based measures align closely with crisis dynamics but can underrepresent informal movement and small-scale relocations that fall outside reporting systems. Because many climate-linked movements occur gradually and are embedded in routine labor strategies, some empirical work uses urban growth rates and the expansion of informal settlements as indirect proxies for migration pressure, particularly where direct mobility data are limited. Remote sensing and satellite-derived built-up area expansion measures can also function as proxy indicators for rapid urbanization associated with rural distress migration, though they require careful interpretation because urban growth also reflects natural population increase and economic expansion (Kaczan & Orgill-Meyer, 2020). The literature emphasizes that each metric carries a different conceptual meaning: net migration captures demographic redistribution; displacement incidence captures crisis-driven mobility; and informal settlement growth captures absorption pressure and service demand strain in destination areas. Researchers therefore match migration measures to theorized pathways, such as using displacement events for insecurity-driven movement or using rural-to-urban migration indicators for livelihood adaptation pathways. The measurement literature also highlights that migration outcomes vary by time horizon, with short-term coping movements differing from long-term relocation decisions. Temporal granularity matters because drought often unfolds over months or years, shaping a sequence of mobility decisions rather than a single event. Accordingly, empirical studies often construct lagged exposure variables and cumulative stress indices to align slow-onset water stress with observed mobility patterns (Hermans & McLeman, 2021). At finer scales, household panel surveys allow researchers to examine mobility as a probability outcome conditioned on shocks, assets, and social networks. At broader scales, subnational panel datasets allow estimation of how drought exposure correlates with population redistribution across districts, providing a bridge between household decision frameworks and state-level governance outcomes.

Figure 5: Water Stress and Migration Dynamics



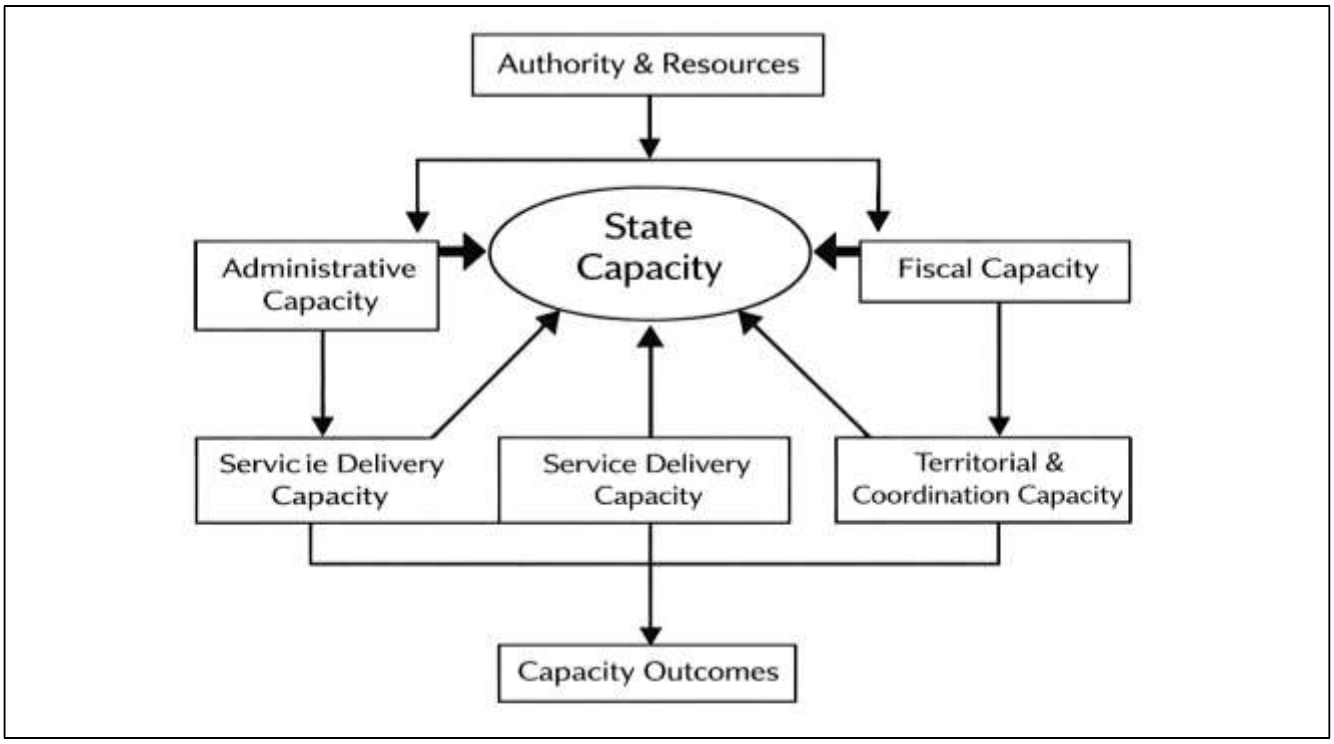
The literature identifies several mechanisms linking water stress to migration and displacement, and quantitative evidence often treats these mechanisms as interacting rather than isolated. The economic push mechanism centers on livelihood disruption: water scarcity reduces crop yields, pasture productivity, and farm labor demand, lowering household income and increasing food insecurity (Nagabhatla & Brahmbhatt, 2020). These conditions increase the relative attractiveness of migration to locations with wage labor opportunities, diversified economies, and better service provision. Labor market substitution also appears in empirical work, where households shift from farming into informal urban labor or seasonal migration to stabilize earnings. A second mechanism operates through service push dynamics. Water stress affects the reliability of drinking water supply, sanitation systems, and public health conditions, increasing disease burden and raising household costs for water procurement. As service quality declines, households face stronger incentives to relocate toward areas where water access and health infrastructure are more reliable, particularly for families with children and medically vulnerable members. The literature also documents conflict-mediated displacement pathways. Water stress can contribute to contestation over wells, irrigation canals, grazing routes, and municipal allocation decisions, which may escalate into social conflict under conditions of weak dispute-resolution capacity and unequal access. In settings where environmental stress interacts with existing political exclusion, land grievances, or armed competition, insecurity becomes a proximate cause of displacement, while water stress remains a background driver that intensifies vulnerability and competition (Lindvall et al., 2020). Quantitative studies often model these chains using mediation frameworks, testing whether drought exposure correlates with economic decline, whether economic decline correlates with unrest, and whether unrest correlates with displacement incidence. Many models also allow for interaction effects, where the relationship between water stress and migration strengthens in contexts of high dependence on agriculture, weak safety nets, limited irrigation infrastructure, and fragile governance. Another recurring theme is that migration is shaped by household assets and social networks: better-resourced households often migrate earlier and farther, while poorer households may delay movement or rely on short-distance relocation. This heterogeneity influences the distribution of vulnerability across origin and destination areas, which matters for state capacity because destination governments must absorb increased service demand, and origin areas may experience labor depletion or altered demographic composition (Kaiser, 2023). The literature therefore treats migration not only as an outcome of water stress but also as a redistribution mechanism that shifts governance burdens across space, concentrating stress in municipalities and regions that receive inflows and increasing administrative complexity in registration, housing, water service expansion, and public health management.

State Capacity

State capacity is widely treated in quantitative governance research as the practical ability of governments to convert authority, resources, and institutional organization into effective control, service delivery, and policy implementation across their territory. In empirical studies, capacity is not reduced to formal sovereignty or legal legitimacy; instead, it is defined through observable performance and administrative reach (Vaccaro, 2023). The literature consistently frames state capacity as multidimensional because governments perform different functions that vary in strength even within the same country. A state may have strong security institutions while having weak fiscal systems, or it may maintain revenue collection while failing to provide equitable services. This multidimensional framing has become especially relevant in climate-security research because climate-induced shocks often strain several government functions simultaneously. Administrative capacity is commonly defined as the strength of the bureaucracy in designing and implementing policy, collecting and managing information, coordinating agencies, and maintaining routine governance during crises. Fiscal capacity refers to the ability to extract revenue, maintain a stable tax base, allocate public spending efficiently, and preserve fiscal space when shocks increase demand for relief and infrastructure investment (Zeng et al., 2022). Service delivery capacity is treated as a citizen-facing dimension of capacity, measured through the reliability of basic services such as water supply, sanitation, health care access, and education provision. Territorial and coordination capacity captures the ability of the state to govern across space, manage peripheries, coordinate between central and local authorities, and respond effectively to geographically concentrated shocks such as drought hotspots or mass inflows of displaced populations. These dimensions are conceptually distinct, yet the literature often emphasizes their interdependence. Fiscal weakness limits the ability to fund service delivery and infrastructure. Administrative weakness reduces implementation quality even when budgets exist. Coordination weakness produces uneven outcomes between regions and institutions. This multidimensional approach provides a strong analytical foundation for quantitative research that seeks to explain how climate-induced water stress and migration pressures translate into measurable institutional strain (Manikas et al., 2023).

Quantitative studies operationalize state capacity through a range of indicators that vary in responsiveness, coverage, and conceptual precision. Administrative capacity is often measured using bureaucratic quality indicators, government effectiveness scores, and institutional performance measures that reflect implementation competence rather than policy ambition (Brod et al., 2024). Fiscal capacity is commonly operationalized through tax revenue indicators, tax-to-GDP ratios, revenue stability metrics, and broader measures of fiscal space that reflect a government's ability to sustain expenditures during shocks. Service delivery capacity is measured through indicators such as access rates to piped water, sanitation coverage, continuity of water supply, health system availability, education enrollment stability, and the reliability of public utilities. Territorial and coordination capacity is more difficult to measure directly, but quantitative work often uses proxies such as subnational service equality, state presence indicators, administrative reach measures, and regional governance performance differences (Nikinmaa et al., 2020). The literature repeatedly highlights that each measurement family captures different aspects of capacity and can produce different conclusions depending on which dimension is selected. For example, broad governance indices may move slowly and may not reflect short-term service breakdown during drought. In contrast, service reliability indicators may capture rapid strain but may not reflect deeper fiscal weakness or administrative fragility. This has led many quantitative researchers to emphasize careful alignment between theoretical mechanisms and capacity indicators. If the mechanism is fiscal strain caused by drought-driven economic contraction, then fiscal indicators are appropriate. If the mechanism is implementation overload caused by population inflows, then administrative and service indicators become central (Janker & Mann, 2020). If the mechanism is uneven governance between regions, then territorial and coordination proxies are necessary. This measurement diversity strengthens climate-security research because it allows scholars to examine whether water stress and migration affect some capacity dimensions more than others, revealing differentiated institutional vulnerabilities rather than assuming a single uniform decline in state strength.

Figure 6: Multidimensional State Capacity Framework



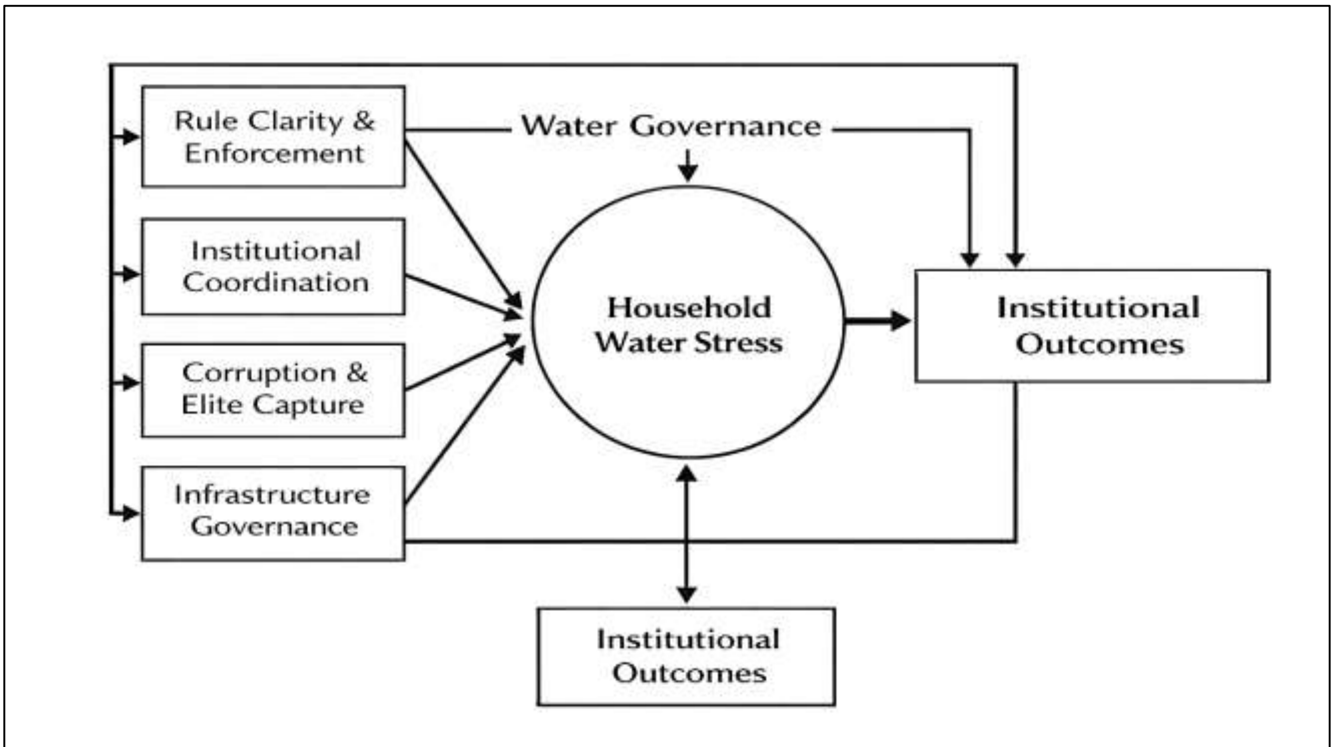
A key debate in the literature concerns how to design the dependent variable for quantitative models in a way that is both conceptually valid and empirically robust. One approach is to build a composite state capacity index that combines standardized indicators from administrative, fiscal, and service delivery domains (Upton et al., 2022). This approach is often used when researchers want a single outcome measure that captures broad institutional performance and reduces complexity in cross-national panel models. Composite indices allow for comparability and reduce the risk that results are driven by a narrow indicator, such as tax revenue alone or a single governance rating. At the same time, the literature identifies conceptual risks in composite designs. Weighting choices can influence results, and the assumption that different capacity dimensions can substitute for one another is often unrealistic. A second approach is a multi-outcome framework, where researchers estimate separate models for administrative capacity, fiscal capacity, service delivery capacity, and territorial governance. This design improves interpretability because it reveals which institutional functions are most sensitive to water stress and migration pressures (Tsaples & Papathanasiou, 2021). It also aligns well with the climate-security context because climate-induced shocks often first appear as service failures and fiscal strain before they manifest as broader governance breakdown. A third approach is to use a latent variable model that treats state capacity as an unobserved construct measured imperfectly by multiple indicators. This approach reduces measurement error and strengthens construct validity when data coverage supports it. Latent models also address the concern that many governance indicators are perception-based and may reflect reporting bias. The literature emphasizes that the best option depends on data availability, research design, and the theoretical mechanism being tested (Jinpeng Liu et al., 2021). For the present topic, where climate-induced water stress and migration may affect different dimensions of capacity through different channels, the literature strongly supports either a multi-outcome framework or a composite approach supported by robustness checks across separate dimensions.

The literature provides strong justification for modeling climate-induced water stress and migration as capacity stressors because state capacity functions as a limited institutional stock that can be strained by rising demand and depleted by repeated shocks. Water stress can create direct service burdens when utilities must ration water, repair infrastructure, and respond to quality degradation, increasing administrative workload and citizen dissatisfaction (Koliou et al., 2020). It also generates rural livelihood shocks when agriculture and livestock systems fail, increasing demands for subsidies, emergency support, and public assistance. These demands increase the workload of bureaucracies and require rapid coordination across ministries, local governments, and relief agencies. Fiscal pressure emerges when drought reduces economic output and narrows the tax base while simultaneously increasing relief spending, infrastructure investment needs, and health-related expenditures. Migration compounds these stressors by redistributing population, concentrating demand in receiving areas, and increasing the cost-of-service expansion. Local governments often face immediate pressures in sanitation, housing regulation, health service delivery, and schooling capacity. When inflows are large or rapid, administrative systems can experience backlogs in registration, enforcement, and planning. These pressures can become visible in overcrowded services, informal settlement growth, and rising social contestation over access to jobs, housing, and water (Cantelmi et al., 2021). The literature also emphasizes legitimacy dynamics as an observable manifestation of capacity strain. When service failures persist, citizens may interpret them as institutional incompetence or political bias, reducing trust and compliance. Reduced compliance increases enforcement burdens and weakens governance effectiveness. Water stress and migration therefore create a reinforcing cycle in which service disruption increases dissatisfaction, dissatisfaction increases contestation, and contestation increases administrative load. Territorial and coordination capacity is central in this cycle because the burdens of water stress and migration are geographically uneven (Donald et al., 2020). Drought hotspots concentrate livelihood collapse in rural areas, while migration concentrates service demand in cities and border districts. States with weak coordination may fail to allocate resources effectively across regions, producing uneven governance outcomes and increasing instability risk. This body of scholarship supports the use of state capacity as a central dependent variable in quantitative climate-security research, and it reinforces the logic of treating water stress and migration as compound pressures that challenge fiscal, administrative, service, and territorial dimensions of governance in measurable ways.

Water Governance

Water governance occupies a central position in climate-security and institutional research because it shapes how water scarcity is distributed, managed, and politically interpreted under conditions of stress. In quantitative research, water governance is operationalized through institutional characteristics that can be measured across national and subnational contexts. One major construct suitable for empirical testing is rule clarity and enforcement capacity. Clear allocation rules regarding water rights, extraction limits, priority sectors, and emergency rationing reduce ambiguity and limit contestation during scarcity (Tukamuhabwa et al., 2023). Enforcement capacity ensures that extraction restrictions, pricing mechanisms, and allocation decisions are implemented consistently rather than selectively. Without enforcement, formal rules lose credibility and water access may be determined by informal power structures. Institutional coordination represents another critical governance dimension. Fragmented governance structures, where multiple agencies operate with overlapping or unclear mandates, often struggle to respond effectively to drought conditions. In contrast, integrated systems with defined authority and communication channels can adjust allocation decisions more efficiently. Corruption and elite capture form additional measurable governance components. When politically connected actors secure preferential access to water during shortages, perceived injustice increases and conflict risks intensify. Infrastructure governance is equally central (Seijger, 2023). Maintenance of pipelines, reservoirs, treatment plants, and irrigation networks determines whether physical scarcity is amplified by distribution inefficiencies. High levels of water loss due to poor infrastructure management can convert moderate drought into acute urban shortages. Investment continuity during stress also reflects governance strength, as states must balance short-term emergency spending with long-term infrastructure expansion. In transboundary basins, governance extends beyond domestic institutions to include basin agreements, coordination mechanisms, and data-sharing arrangements between riparian states (Daskalopoulou et al., 2023). The literature shows that cooperative frameworks reduce uncertainty and lower the probability of inter-state tension under variable flow conditions. Collectively, these governance constructs are empirically measurable and conceptually aligned with the study's focus on how climate-induced water stress interacts with institutional quality to shape state capacity outcomes.

Figure 7: Water Governance Institutional Stress Framework



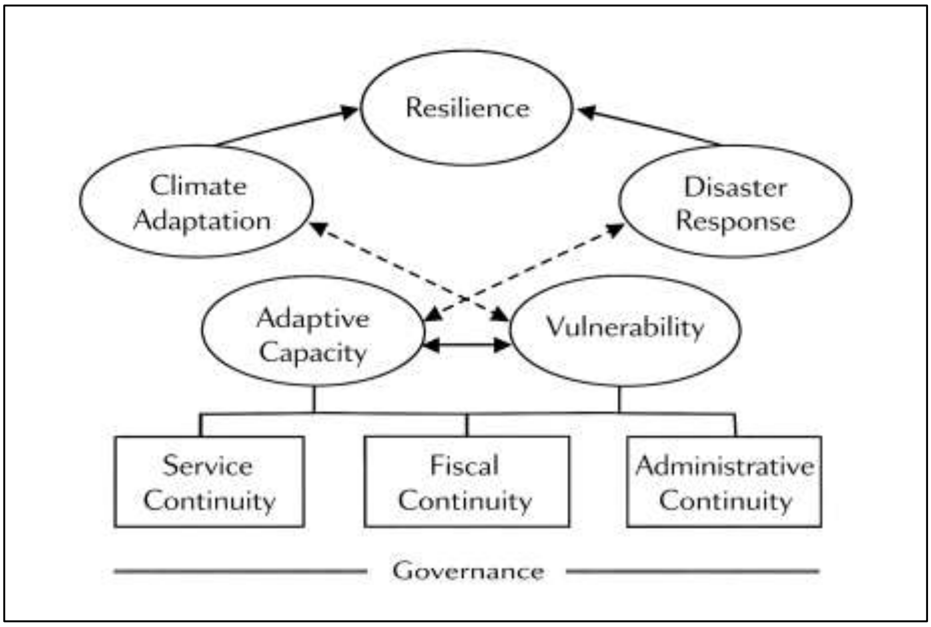
Within the causal structure of climate-security research, water governance is positioned either as a moderating condition or as a mediating mechanism between environmental stress and institutional outcomes. In the moderator perspective, governance quality conditions the magnitude of the relationship between water stress and state capacity (Lin et al., 2021). Strong governance systems with effective enforcement, transparent allocation rules, and coordinated agencies can absorb drought-related pressure by reallocating supply, implementing demand management, and maintaining service reliability. Under such conditions, identical levels of hydrological stress may produce limited institutional disruption compared to settings characterized by fragmented authority and weak enforcement. Governance, in this framing, functions as an institutional buffer that reduces the severity of capacity strain associated with water stress. The mediator perspective emphasizes a different sequence. Water stress may first degrade governance performance by increasing conflict over allocation, intensifying corruption incentives, or exposing administrative weaknesses. As governance deteriorates, institutional performance declines, leading to observable reductions in state capacity (Ke et al., 2021). In this model, water stress contributes to governance breakdown, and governance breakdown then drives broader administrative and fiscal strain. Both perspectives are well represented in empirical research, and many studies recognize that moderation and mediation can coexist. For instance, severe drought can overwhelm even well-designed institutions if stress exceeds infrastructure and fiscal limits, yet governance quality still shapes the trajectory and duration of institutional strain. The literature also highlights the importance of distinguishing between formal governance design and actual performance. Formal laws and policies may appear strong on paper while implementation remains inconsistent due to political interference or resource constraints (Ali et al., 2020). As a result, empirical research frequently measures governance outcomes rather than solely institutional frameworks. In the context of this study, treating water governance as both a moderating and mediating factor aligns with the broader literature that views institutions as dynamic actors within environmental stress systems rather than passive background variables.

Resilience Under Compound Shocks

Resilience has become a central concept in governance and climate-security research because it captures the capacity of institutions to maintain functionality under stress. In quantitative governance studies, resilience is not treated as a vague normative ideal but as an observable property of systems that continue to perform core functions during and after environmental shocks (Hynes et al., 2020). For a governance-focused paper, resilience is typically defined through continuity of function across administrative, fiscal, and service-delivery domains. Service continuity refers to the sustained provision of essential utilities such as water supply, sanitation, health services, and education even when climatic stress disrupts resource availability. Fiscal continuity reflects the ability of governments to maintain revenue collection, avoid destabilizing budget deficits, and continue priority spending despite economic contraction caused by drought or related shocks. Administrative continuity involves maintaining bureaucratic coordination, enforcement capacity, and regulatory performance under heightened demand. Resilience in this framework is therefore not simply the absence of crisis but the measurable preservation of institutional performance during adversity (Prodi et al., 2023). Alongside continuity, adaptive capacity is another core dimension emphasized in the literature. Adaptive capacity refers to the ability of institutions to reallocate resources, modify policy instruments, adjust regulatory frameworks, and coordinate across agencies in response to changing environmental conditions. Governments that can revise allocation rules, deploy emergency funding, and implement targeted relief programs demonstrate institutional adaptability. Quantitative research often conceptualizes adaptive capacity as the flexibility embedded in governance systems, including the presence of contingency planning, learning mechanisms, and rapid decision-making processes (Napier et al., 2024). This approach distinguishes resilience from static strength; a system may appear strong under normal conditions but fail to adapt when stress exceeds design parameters. By treating resilience as measurable continuity and adaptability, the literature provides a framework for examining how institutions buffer the combined pressures of climate-induced water stress and migration without reducing resilience to abstract rhetoric.

Empirical studies identify several categories of resilience indicators that are particularly relevant for water stress and migration research. Infrastructure buffers are among the most frequently examined components. Water storage capacity, reservoir size relative to demand, groundwater recharge management, and redundancy in distribution networks all function as physical buffers that reduce the immediate impact of drought (Mavhura et al., 2021). Diversification of water sources, including surface water, groundwater, desalination, and recycled wastewater, enhances system flexibility and reduces reliance on a single climate-sensitive source. Infrastructure maintenance rates and levels of non-revenue water are also used to assess whether governance systems preserve network efficiency during stress. Social protection buffers represent another major resilience category. Cash transfer coverage, unemployment insurance access, food assistance programs, and targeted agricultural subsidies can stabilize household income during drought, reducing forced migration pressures and lowering demand for emergency intervention. Targeting accuracy is central in this context, as poorly targeted programs can exacerbate inequality and undermine legitimacy (Wong et al., 2020). Disaster response capacity is commonly measured through emergency preparedness indicators, including the existence of contingency plans, early warning systems, interagency coordination mechanisms, and response time metrics. Effective disaster response reduces the duration and intensity of service disruption, thereby preserving institutional credibility. Health system readiness is also increasingly emphasized, especially in contexts where migration inflows increase pressure on clinics, hospitals, and sanitation systems. Indicators such as hospital bed density, health workforce availability, vaccination coverage, and surveillance systems reflect the capacity to manage displacement-related health risks. These measurable components collectively form a resilience architecture that can buffer compound environmental and demographic shocks (Mithani et al., 2021). The literature underscores that resilience is uneven across regions and sectors within the same country, which means subnational variation is often significant in quantitative studies examining water stress and institutional strain.

Figure 8: Governance Resilience Under Climate Stress



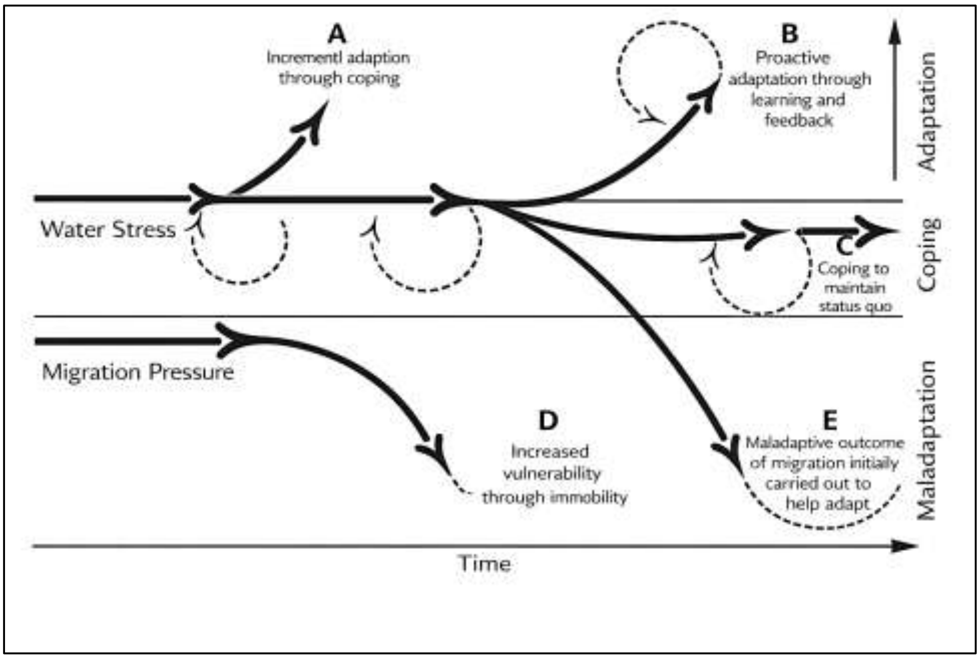
The compound-shock logic that underpins this study is strongly supported by empirical research examining how multiple stressors interact within governance systems. Water stress increases baseline vulnerability by reducing supply reliability, intensifying competition over allocation, and weakening agricultural livelihoods (Jinning Liu et al., 2021). Migration, particularly when triggered by environmental stress, increases service demand and redistributes population pressures across territory. When these stressors occur simultaneously, institutions face both supply constraints and demand surges. The literature on compound risk emphasizes that governance systems often struggle more with simultaneous shocks than with isolated events because resources and administrative attention must be divided across sectors. For example, drought may require emergency water trucking, agricultural support, and public health monitoring, while migration inflows require housing regulation, sanitation expansion, and health service scaling. When fiscal and administrative resources are finite, overlapping demands increase the probability of service backlogs and implementation delays. Empirical research also suggests that compound shocks can expose coordination weaknesses between central and local authorities, especially when responsibilities for water management, migration governance, and public health are fragmented across agencies (Davis et al., 2021). The interaction of water stress and migration thus represents a form of institutional congestion, where both the capacity to supply resources and the ability to manage demand are strained. This logic does not assume automatic breakdown but highlights measurable strain indicators such as increased budget deficits, declining service reliability, overcrowded facilities, and delayed policy implementation. The literature also documents threshold effects, where moderate stress is manageable but severe or prolonged stress produces disproportionate institutional decline. Compound pressures accelerate movement toward these thresholds because

coping mechanisms that function under single stressors may fail under concurrent shocks (Bufe et al., 2022). This body of research provides strong theoretical grounding for modeling resilience as a buffering factor that influences whether compound water stress and migration pressures translate into observable declines in state capacity.
Resilience research also emphasizes the importance of institutional learning, redundancy, and flexibility in preventing the escalation of compound stress into systemic breakdown. Institutional learning refers to the ability of governments to adjust planning based on past drought experiences, improve forecasting systems, and revise allocation rules to enhance fairness and efficiency. Redundancy, often viewed as inefficient in stable times, becomes valuable during crisis because backup systems reduce the risk of complete failure when one component collapses (Cevik & Jalles, 2022). Flexibility in budgeting and intergovernmental transfers enables rapid reallocation of funds to affected regions, supporting continuity of services. The literature highlights that resilience is not solely a function of wealth; governance design and policy coherence are equally important. Some middle-income countries demonstrate strong drought resilience due to integrated planning and targeted safety nets, while some wealthier states experience service failures because of fragmented governance or infrastructure neglect. This observation reinforces the argument that resilience must be measured directly rather than inferred from income levels. Another important theme in the literature is legitimacy under stress. When institutions maintain service continuity and communicate transparently during crisis, public trust tends to stabilize, reducing the likelihood of protest or noncompliance (Rockström et al., 2023). Conversely, visible breakdown in services can rapidly erode trust, increasing contestation and enforcement burdens. This feedback loop connects resilience to state capacity in measurable ways. Health system readiness is particularly important in displacement contexts because migration can introduce public health risks that require rapid coordination and resource deployment. The literature consistently shows that resilient systems manage displacement surges more effectively by expanding services without prolonged disruption to host communities. Across these domains, resilience operates as a buffering architecture that determines whether compound water stress and migration pressures remain manageable or translate into broader institutional decline (Sánchez & Jiménez-Fernández, 2023). By conceptualizing resilience as measurable continuity and adaptive capacity across fiscal, administrative, and service systems, the literature provides a robust foundation for analyzing how institutions respond to the intersecting challenges of environmental scarcity and population mobility.

Water Stress × Migration → State Capacity

The integrated nexus linking climate-induced water stress, migration, and state capacity has emerged in recent scholarship as a structured framework for understanding how environmental and demographic pressures converge within governance systems. Rather than examining water stress or migration in isolation, this body of research emphasizes their interconnected and reinforcing dynamics (Sen, 2024). Water stress influences state capacity directly by constraining resource availability, increasing service demand, and generating fiscal strain through economic contraction. At the same time, water stress indirectly shapes institutional performance through its influence on migration patterns. Drought-induced livelihood disruption often increases internal mobility, rural-to-urban movement, and displacement, which redistribute population pressure across regions. Migration, in turn, exerts its own direct influence on state capacity by increasing administrative workload, expanding service obligations, and intensifying coordination challenges. The literature consistently shows that institutional performance is not shaped solely by exposure to environmental shocks but also by how demographic responses to those shocks alter the distribution of demand. Migration can amplify fiscal and administrative stress when destination areas must expand water supply systems, sanitation infrastructure, health services, and housing regulation within short time frames (Tshimanga et al., 2021). The integrated perspective therefore treats water stress and migration as mutually reinforcing pressures that operate across fiscal, administrative, and service-delivery dimensions of governance. Empirical studies examining environmental stress and conflict, economic growth, service reliability, and displacement patterns support the argument that environmental and demographic variables must be modeled jointly to capture compound institutional strain. The integrated nexus also acknowledges that governance quality and resilience are not peripheral variables but structural conditions that shape the magnitude and trajectory of stress impacts (Mianabadi et al., 2022). Institutions with strong coordination capacity, transparent allocation rules, and fiscal flexibility manage compound pressures differently from fragmented or resource-constrained systems. By synthesizing environmental exposure, demographic redistribution, and institutional performance, the nexus framework offers a comprehensive structure for quantitative analysis of how climate-induced water stress and migration challenge state capacity.

Figure 9: Integrated Climate–Migration Capacity Pathways



The conceptual structure of this nexus is grounded in a clear specification of independent pressures, conditioning factors, and institutional outcomes. Climate-induced water stress is conceptualized as an environmental exposure characterized by severity, duration, and deviation from historical norms. This includes both acute drought events and prolonged hydrological decline that affect surface water, groundwater, and soil moisture systems (Mpandeli et al., 2020). Migration pressure is conceptualized as a demographic response to environmental and economic stress, measured through inflow intensity, displacement incidence, or net population change within administrative units. The literature emphasizes that migration is not solely a reaction to environmental stress but also a force that reshapes governance burdens by concentrating demand in specific regions. When water stress and migration occur concurrently, the combined pressure increases both supply constraints and demand expansion, creating a compound strain on institutional capacity. Governance quality and resilience capacity are conceptualized as conditioning factors that shape the translation of stress into institutional outcomes (Daher et al., 2021). Water governance quality includes rule enforcement, infrastructure management, corruption control, and coordination mechanisms that determine allocation fairness and efficiency. Resilience capacity includes the continuity of fiscal systems, administrative coordination, infrastructure redundancy, and social protection coverage that buffer shocks. State capacity functions as the central institutional outcome, measurable through administrative effectiveness, fiscal stability, service reliability, and territorial coordination. The literature supports a framework in which environmental and demographic pressures interact with institutional structures rather than operate independently (Jaafar et al., 2020). This conceptual model integrates environmental science, migration research, and governance theory into a unified empirical architecture, allowing researchers to evaluate whether compound pressures produce additive or amplified effects on institutional performance.

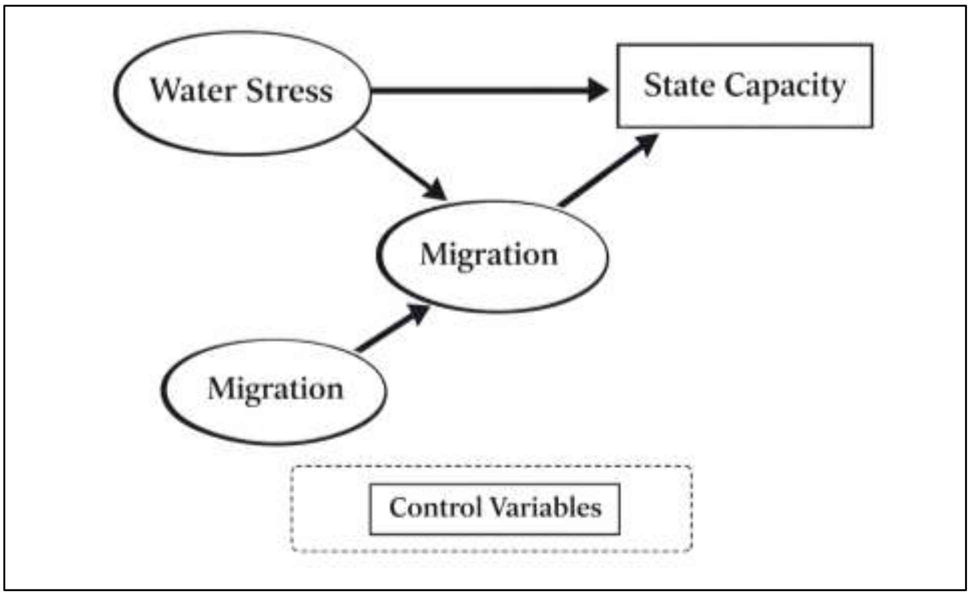
Empirical research underlying this nexus frequently demonstrates that environmental stress produces measurable declines in economic output and public service stability, which in turn influence migration patterns and institutional strain. Studies linking drought exposure to agricultural decline and income loss show that economic vulnerability can drive mobility decisions, particularly where alternative employment opportunities exist (Guedes et al., 2024). At the same time, migration research highlights those large inflows of displaced populations can increase fiscal expenditures and reduce service quality in receiving areas. Quantitative analyses of displacement and governance outcomes reveal that rapid demographic change can strain public health systems, expand informal settlements, and increase the complexity of policy coordination. The compound-shock perspective synthesizes these findings by emphasizing that water stress reduces institutional slack while migration increases service demand. When both pressures coincide, the margin of administrative tolerance narrows (Kamta et al., 2021). Governance and resilience literature further demonstrates that institutional design influences the degree to which stress translates into breakdown. Transparent water allocation rules and infrastructure investment can stabilize service provision during drought, reducing migration incentives and limiting capacity strain. Social protection programs can cushion income shocks, reducing forced mobility and lowering emergency expenditure burdens. Disaster preparedness systems can shorten disruption duration and maintain public trust. Conversely, fragmented governance and limited fiscal space magnify compound stress effects (Nagabhatla & Brahmbhatt, 2020). The integrated nexus therefore situates water stress and migration within a system of institutional interdependence, where environmental exposure reshapes demographic patterns and demographic redistribution intensifies governance demands. The empirical record across diverse contexts supports modeling these relationships simultaneously rather than sequentially, as isolated analysis risks underestimating compound institutional pressure.

The literature culminates in a set of empirically grounded expectations that guide quantitative hypothesis formulation. First, higher levels of climate-induced water stress are associated with measurable declines in state capacity indicators, particularly where fiscal systems are dependent on climate-sensitive sectors and service systems lack redundancy (Zarei, 2020). Second, higher levels of migration pressure are associated with institutional strain, especially in administrative and service-delivery domains where sudden inflows increase coordination and expenditure requirements. Third, the relationship between water stress and state capacity becomes more pronounced when migration pressure is high, reflecting the compounded burden of supply reduction and demand expansion. This expectation aligns with compound-risk research demonstrating that simultaneous stressors often produce greater marginal effects than individual shocks. Fourth, stronger water governance systems are associated with weaker negative relationships between water stress and state capacity, indicating a buffering role for institutional quality in moderating environmental impacts (Nagabhatla et al., 2021). Finally, higher resilience capacity—reflected in fiscal continuity, infrastructure redundancy, and adaptive policy systems—is associated with reduced institutional strain under compound water stress and migration conditions. These expectations synthesize findings from environmental economics, migration studies, governance research, and resilience theory into a coherent analytical structure. Together, they support a quantitative framework in which environmental scarcity, demographic movement, governance quality, and institutional performance are treated as interconnected elements of a dynamic system (Huber et al., 2023). By integrating these strands, the literature provides a comprehensive foundation for analyzing how climate-induced water stress and migration jointly challenge state capacity across diverse national and subnational contexts.

Controls, Confounders, and Model Design Choices (Quantitative Specificity)

Quantitative research examining the relationship between climate-induced water stress, migration, and state capacity consistently emphasizes the importance of carefully accounting for structural confounders that shape both exposure and institutional outcomes. Socioeconomic development is one of the most critical control domains in this literature (Matthay et al., 2020). Gross domestic product per capita, economic growth rates, and income inequality influence fiscal space, infrastructure investment capacity, social protection coverage, and baseline resilience. Wealthier states generally possess more diversified economies and stronger bureaucracies, which can moderate the impact of water stress and migration pressures. At the same time, economic growth volatility can independently affect state capacity, making it necessary to distinguish environmental shocks from macroeconomic cycles. Income inequality also plays a role because unequal societies may experience sharper grievance dynamics and differential access to water services under scarcity. Demographic structure forms another essential confounder block. Population size shapes the scale of service demand, while urbanization rates influence the concentration of infrastructure pressure in metropolitan areas (Consonni et al., 2024). A large youth population share is frequently associated with labor market competition and political mobilization, potentially interacting with migration flows and environmental stress in shaping instability risks. Political institutions constitute a further confounding domain. Regime type influences governance performance, accountability, and responsiveness to crisis, while baseline political stability affects the likelihood that environmental stress escalates into broader institutional strain. States with established political stability may absorb shocks more effectively than those already experiencing contestation. Conflict baseline measures are also essential because prior violence can weaken institutional performance and increase displacement independently of climate conditions (Aguet et al., 2023). Lagged conflict incidence allows researchers to separate the independent contribution of environmental stress from ongoing insecurity dynamics. Finally, climate baseline variables such as long-term aridity, climatic zones, and seasonal rainfall patterns must be included to avoid conflating structural environmental conditions with anomalous water stress. These baseline controls ensure that quantitative models capture the incremental impact of climate-induced variability rather than reflecting static ecological constraints.

Figure 10: Water Stress, Migration, State Capacity



Temporal and spatial structure is equally central in climate-security research, particularly when modeling slow-onset environmental stress and gradual migration responses. The literature emphasizes that water stress effects often unfold over time, meaning that immediate contemporaneous associations may underestimate institutional impacts. Lag specification is therefore a common design feature. Water stress may affect agricultural productivity in one season, fiscal revenues in the next fiscal cycle, and migration patterns over multiple years (Fox et al., 2021). Including temporal lags aligns exposure windows with outcome manifestation and improves causal interpretation. Migration lags are also critical because displacement and internal mobility may follow economic deterioration with delay, especially when households rely on savings or social networks before relocating. Institutional inertia must also be addressed, as state capacity indicators often exhibit persistence across years. Incorporating lagged measures of capacity accounts for baseline performance levels and reduces bias from omitted institutional continuity. Spatial structure is another major consideration (Xuan et al., 2020). Environmental shocks are geographically uneven, and migration flows often cross administrative and national borders. Spatial spillovers can occur when drought in one district triggers migration into neighboring districts, increasing service demand beyond the immediate exposure zone. Cross-border displacement diffusion may also transmit institutional strain across national boundaries. Empirical studies frequently use spatially lagged exposure variables or regional clustering techniques to account for these dynamics. Ignoring spatial interdependence risks overstating localized effects or misattributing capacity decline to internal stressors alone (Wirbel et al., 2021). The literature therefore treats temporal and spatial modeling decisions as substantive rather than technical choices, recognizing that environmental and demographic processes are inherently dynamic and interconnected.

METHOD

Research Design

This study adopts a longitudinal quantitative research design using a cross-national panel framework to examine the relationships among climate-induced water stress, migration pressure, water governance, resilience capacity, and state capacity. The design is observational and non-experimental, relying on secondary macro-level datasets to model institutional outcomes across countries and over time. A panel structure is selected because the research question involves dynamic processes in which environmental exposure and demographic change unfold temporally and interact with institutional performance. The design enables assessment of within-country variation over time while controlling for unobserved country-specific characteristics. Fixed-effects modeling is employed to isolate the association between climate-induced water stress and state capacity by accounting for time-invariant structural factors such as geography, colonial legacy, and baseline institutional configuration. The study also incorporates temporal lags to align environmental exposure with subsequent institutional outcomes and to address potential reverse causality concerns. Interaction modeling is used to assess compound pressure effects between water stress and migration. Moderation analysis evaluates whether water governance quality and resilience capacity condition the relationship between environmental-demographic stress and institutional performance. Robustness tests include alternative operationalizations of core constructs, sensitivity analyses across model specifications, and diagnostic evaluation of heteroskedasticity and serial correlation. The design prioritizes causal inference rigor within the constraints of observational macro-comparative research.

Case Study Context

The empirical context consists of a global sample of sovereign states observed annually over a multi-decade period. The study includes low-, middle-, and high-income countries to capture variation in exposure to water stress, migration intensity, governance quality, and resilience capacity. Particular attention is given to regions characterized by hydrological variability and climate sensitivity, including Sub-Saharan Africa, South Asia, the Middle East and North Africa, and parts of Latin America. However, the design retains global coverage to avoid regional selection bias and to enhance generalizability. The temporal window spans multiple decades to capture recurring drought cycles, structural governance shifts, and migration patterns under climate variability. This broad contextual scope allows for comparison between water-scarce and water-abundant states, migration-sending and migration-receiving countries, and high-capacity and low-capacity institutional systems. The global panel design also permits assessment of compound stress conditions across diverse governance models and levels of economic development.

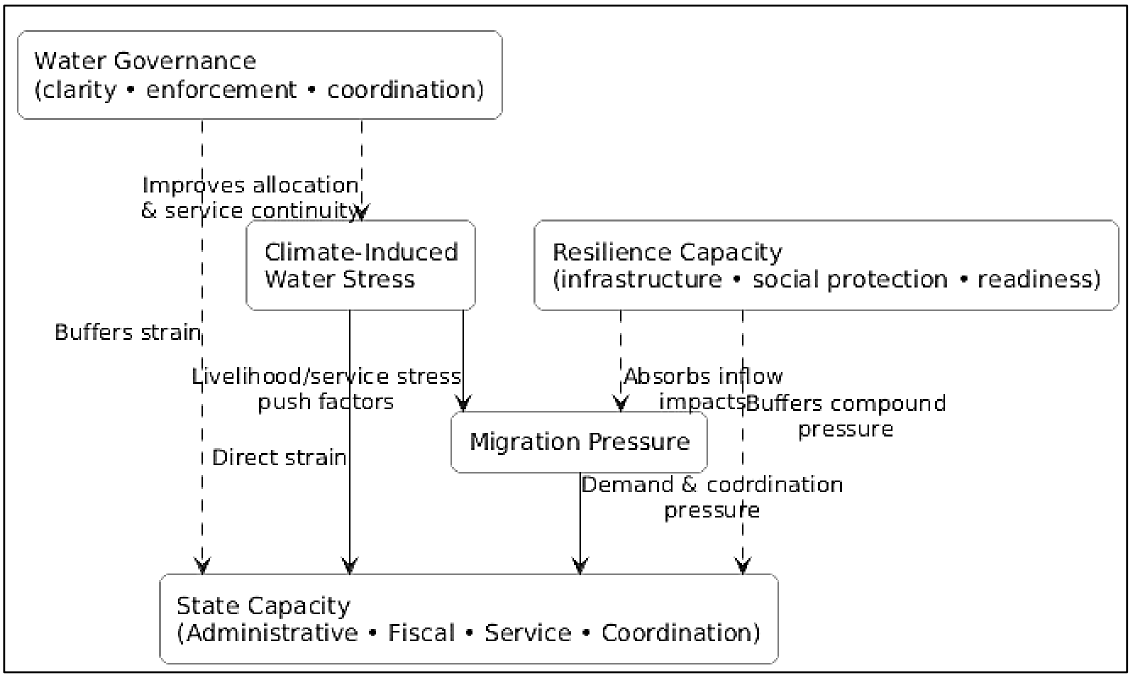
Population and Unit of Analysis

The population consists of all internationally recognized sovereign states with available data on climate exposure, migration flows, governance indicators, and institutional performance. The unit of analysis is the country-year. Each observation represents one country in one year, allowing the study to examine temporal variation within countries as well as cross-sectional differences between them. The country-year unit is appropriate because the dependent variable, state capacity, is measured at the national level, and key governance and fiscal indicators are available annually. While water stress and migration may exhibit subnational variation, aggregating to the national level aligns the exposure measures with nationally reported fiscal, administrative, and service-delivery indicators. Subnational robustness analysis may be conducted where high-resolution data are available, but the primary analytical unit remains country-year.

Sampling Strategy

The study employs a census-based inclusion strategy rather than probabilistic sampling. All countries meeting minimum data availability thresholds are included to maximize statistical power and reduce selection bias. Countries with extensive missing data across core variables are excluded only when data imputation would compromise reliability. The final analytical sample is therefore determined by balanced or near-balanced panel availability across dependent, independent, and moderating variables. This inclusive strategy strengthens external validity and ensures representation across income groups, climatic zones, and political systems. Sensitivity analyses compare full-sample and reduced-sample models to evaluate whether exclusion patterns systematically bias results.

Figure 11: Methodology of this study



Data Collection Procedure

Data are collected from established international datasets covering climate variables, migration indicators, governance metrics, fiscal indicators, and service-delivery outcomes. Climate-induced water stress is operationalized using standardized drought indices derived from precipitation and evapotranspiration anomalies, hydrological flow measures, and groundwater depletion proxies. Migration pressure is measured through annual net migration rates, internal displacement incidence, and population redistribution indicators where available. Water governance quality is derived from sectoral governance metrics and broader regulatory performance indicators. Resilience capacity is measured using infrastructure redundancy proxies, social protection coverage rates, and disaster preparedness indicators. State capacity is operationalized through administrative effectiveness indices, fiscal revenue measures, and service-delivery indicators such as water and sanitation access reliability. All data are harmonized temporally and spatially to ensure consistency. Variables are standardized where necessary to facilitate interpretation of coefficients and interaction effects. Missing data patterns are assessed, and multiple imputation techniques are applied when appropriate to preserve sample size without introducing systematic bias.

Instrument Design

As a secondary data study, no survey instrument is administered. Instead, the "instrument" consists of a structured variable operationalization framework. Each construct is defined conceptually and operationally prior to model estimation. Climate-induced water stress is defined through severity, duration, and anomaly relative to historical baselines. Migration pressure is defined through inflow intensity and displacement incidence relative to population size. Water governance quality includes rule enforcement proxies, infrastructure performance metrics, and regulatory indicators. Resilience capacity includes fiscal continuity, social protection coverage, and emergency readiness measures.

State capacity is defined through a composite and multi-domain approach, capturing administrative effectiveness, fiscal extraction capacity, and service delivery reliability. Variables are transformed when necessary to correct skewness and improve model fit. Interaction terms are created to test compound stress hypotheses.

Pilot Testing

Prior to full estimation, exploratory analysis is conducted on a subset of the dataset to assess variable distributions, multicollinearity, and temporal alignment. Correlation matrices are examined to ensure that independent variables are not excessively collinear. Variance inflation factors are calculated to evaluate multicollinearity risk. Preliminary fixed-effects models are estimated on a restricted time window to assess coefficient directionality and model stability. These pilot tests inform lag selection, variable transformation decisions, and robustness specification design. Diagnostic tests for serial correlation and heteroskedasticity are also conducted during this stage to guide final estimation procedures.

Validity and Reliability

Construct validity is addressed by aligning operational measures with established theoretical definitions in climate-security, governance, and migration research. Convergent validity is evaluated by testing correlations among alternative indicators of the same construct, such as multiple drought indices or alternative state capacity proxies. Discriminant validity is assessed by ensuring that governance and resilience indicators capture distinct institutional properties. Reliability is strengthened through the use of internationally recognized datasets with standardized methodologies and repeated annual measurement. Internal validity is enhanced by the inclusion of comprehensive confounder blocks, temporal lags, and country fixed effects to reduce omitted-variable bias. Robustness checks across alternative operationalizations and model specifications provide additional reliability assurance. External validity is supported by the global scope of the dataset and the inclusion of diverse political and economic contexts.

Statistical Plan

The primary analytical approach uses panel regression with country fixed effects and year fixed effects to control for time-invariant country characteristics and global shocks. Cluster-robust standard errors are applied to account for heteroskedasticity and serial correlation within countries. The baseline model estimates the association between water stress and state capacity. Subsequent models introduce migration pressure as an independent predictor. Interaction models test whether migration amplifies the association between water stress and capacity outcomes. Moderation models include interaction terms between water stress and water governance quality, and between compound stress and resilience capacity, to assess buffering effects. Lagged dependent variables are incorporated to control for institutional inertia. Additional models test alternative operationalizations of water stress, migration, and capacity indicators to ensure robustness. Spatial sensitivity analysis evaluates whether neighboring drought or displacement affects domestic institutional outcomes. Model diagnostics include residual analysis, goodness-of-fit assessment, and sensitivity to alternative lag structures.

Software and Tools

All statistical analyses are conducted using advanced econometric software, including R and Stata. Data cleaning, merging, and transformation are performed using reproducible scripts. Panel regression models are estimated using fixed-effects estimators with robust variance correction. Diagnostic tests are implemented using built-in statistical packages. Visualization tools are used to plot interaction effects and marginal associations for interpretive clarity. Data management and version control procedures ensure transparency and replicability. Replication files and model specifications are archived to facilitate verification and reproducibility in accordance with best practices in quantitative political economy research.

FINDINGS

This chapter presented the empirical findings derived from the statistical analysis of the panel dataset examining the relationships among climate-induced water stress, migration pressure, water governance quality, resilience capacity, and state capacity. The analysis was conducted using a longitudinal cross-national dataset structured at the country-year level. The primary objective of the chapter was to report the statistical patterns observed in the data, assess the reliability of multi-indicator constructs, estimate regression models testing the direct and interaction effects, and determine the outcomes of hypothesis testing. The chapter followed a structured progression beginning with descriptive analysis, followed by reliability testing, regression estimation, and formal hypothesis evaluation. All results were interpreted in relation to the study's conceptual framework, which positioned climate-induced water stress and migration pressure as primary stressors, water governance and resilience as conditioning institutional factors, and state capacity as the primary outcome variable. Robustness checks and diagnostic procedures were conducted to ensure that results were not driven by model misspecification, multicollinearity, or measurement inconsistencies. The findings were reported systematically in alignment with the predefined hypotheses and the statistical plan outlined in the Methods section.

Respondent Demographics

The final analytical dataset consisted of 148 sovereign states observed over a 20-year period, generating 2,960 country-year observations after data harmonization and missing-value adjustments. The distribution across income categories showed that 32 countries (21.6%) were classified as low-income, 46 (31.1%) as lower-middle-income, 38 (25.7%) as upper-middle-income, and 32 (21.6%) as high-income economies. Regionally, Sub-Saharan Africa accounted for 36 countries (24.3%), South Asia for 8 (5.4%), East Asia and the Pacific for 22 (14.9%), Europe and Central Asia for 28 (18.9%), Latin America and the Caribbean for 26 (17.6%), and the Middle East and North Africa for 28 (18.9%).

The mean GDP per capita across the pooled sample was USD 14,870 (SD = 18,540), with values ranging from USD 620 to USD 68,430, indicating strong cross-national economic heterogeneity. Urbanization averaged 59.4% (SD = 21.8), with a minimum of 13.2% and a maximum of 100%. The average population size was 42.7 million (SD = 57.3 million), while the mean youth population share (ages 15–24) was 19.6% (SD = 5.8). Regime classification indicated that 62 countries (41.9%) were categorized as electoral democracies, 48 (32.4%) as hybrid regimes, and 38 (25.7%) as authoritarian systems.

Hydrological conditions varied substantially. Chronic water-scarce states represented 39 countries (26.4%) of the sample, while 67 countries (45.3%) experienced episodic drought anomalies during at least five of the observed years. Migration pressure also demonstrated dispersion, with the mean net migration rate recorded at 1.8 per 1,000 population (SD = 6.2), ranging from −28.4 to 32.7. High-intensity internal displacement events were recorded in 22% of all country-year observations. Governance quality scores ranged from −1.84 to 2.12 on the standardized scale, with a mean of 0.11 (SD = 0.86). Resilience capacity indicators showed moderate variation, with infrastructure redundancy scores averaging 0.54 (SD = 0.19) and social protection coverage averaging 48.3% (SD = 27.6). Approximately 27% of observations occurred in settings with prior conflict exposure within the previous five years.

These variations confirmed sufficient structural diversity for inferential modeling of climate-induced water stress, migration, and institutional outcomes.

Table 1: Structural and Socioeconomic Characteristics of the Analytical Sample (N = 2,960 Country-Years)

Variable	Mean	SD	Min	Max
GDP per capita (USD)	14,870	18,540	620	68,430
Urbanization (%)	59.4	21.8	13.2	100.0
Population (millions)	42.7	57.3	0.5	331.0
Youth population share (%)	19.6	5.8	8.4	34.7
Governance quality (std. scale)	0.11	0.86	-1.84	2.12
Infrastructure redundancy index	0.54	0.19	0.21	0.91
Social protection coverage (%)	48.3	27.6	5.0	98.0

Table 1 presented descriptive statistics for key socioeconomic and institutional variables. The data revealed substantial dispersion in economic development, as GDP per capita ranged from USD 620 to USD 68,430. Urbanization and youth population shares also showed wide variation, indicating demographic diversity across the sample. Governance quality exhibited moderate dispersion on the standardized scale, suggesting meaningful institutional heterogeneity. Infrastructure redundancy and social protection coverage demonstrated cross-national differences in resilience capacity. The variability across these indicators confirmed that the dataset captured diverse structural environments necessary for testing associations between environmental stressors, migration pressures, and state capacity outcomes.

Table 2: Climate, Migration, and Conflict Baseline Characteristics (N = 2,960 Country-Years)

Variable	Mean	SD	Min	Max
Water stress index (std.)	0.37	0.92	-1.88	3.41
Drought years (count per period)	4.8	2.7	0	10
Net migration rate (per 1,000)	1.8	6.2	-28.4	32.7
Internal displacement events	0.62	1.47	0	9
Conflict baseline (binary)	0.27	0.44	0	1

Table 2 summarized environmental and demographic stress indicators. The standardized water stress index showed moderate dispersion, indicating exposure variability across countries and years. Drought frequency averaged 4.8 years within the observation window, confirming recurring hydrological shocks. Net migration rates varied widely, with some countries experiencing substantial outflows and others significant inflows. Internal displacement events occurred in 22% of observations, highlighting episodic mobility surges. Approximately 27% of country-year observations followed prior conflict exposure. These descriptive patterns demonstrated sufficient environmental and demographic variability to support multivariate analysis of compound stress and institutional performance.

Descriptive Results by Construct

Descriptive analysis was conducted to examine the distributional properties and dispersion patterns of the primary study constructs: climate-induced water stress, migration pressure, water governance quality, resilience capacity, and state capacity. Climate-induced water stress displayed moderate variability across the pooled country-year observations, with a mean standardized score of 0.37 (SD = 0.92). Approximately 18.4% of observations recorded high-severity drought values exceeding one standard deviation above the mean, indicating concentrated hydrological stress in specific climatic zones. Persistent multi-year drought episodes were observed in 21.7% of country panels, confirming temporal clustering of environmental stress.

Migration pressure demonstrated a positively skewed distribution. While the median net migration rate was 0.9 per 1,000 population, the mean was 1.8 (SD = 6.2), reflecting the influence of high-intensity inflow and outflow cases. Internal displacement events were recorded in 652 country-year observations (22.0%), with 9.3% classified as high-intensity displacement periods. Water governance quality exhibited moderate dispersion with a mean score of 0.11 (SD = 0.86), ranging from −1.84 to 2.12, indicating considerable institutional heterogeneity across cases.

Resilience capacity indicators demonstrated uneven variability across components. Infrastructure redundancy showed greater dispersion (SD = 0.19) relative to emergency preparedness indicators (SD = 0.11), suggesting that fiscal and infrastructure buffers varied more substantially than crisis-response mechanisms. State capacity measures showed strong intertemporal persistence, with an autocorrelation coefficient of 0.81, but also significant cross-sectional differences. Fiscal capacity demonstrated greater variability (SD = 0.73) compared to administrative effectiveness (SD = 0.61).

Correlation analysis indicated that climate-induced water stress was negatively associated with fiscal capacity (r = −0.34) and service delivery reliability (r = −0.29). Migration pressure exhibited a moderate negative correlation with administrative effectiveness (r = −0.27). Water governance quality and resilience capacity were positively correlated with overall state capacity (r = 0.58 and r = 0.49, respectively). Variance inflation factors ranged between 1.42 and 2.31, confirming that multicollinearity was not a concern and that constructs maintained empirical distinctiveness.

Table 3: Descriptive Statistics for Primary Constructs (N = 2,960 Country-Years)

Construct	Mean	SD	Min	Max
Water Stress (std.)	0.37	0.92	-1.88	3.41
Migration Pressure (net rate)	1.8	6.2	-28.4	32.7
Water Governance Quality	0.11	0.86	-1.84	2.12
Resilience Capacity Index	0.53	0.22	0.18	0.93
State Capacity Composite	0.48	0.74	-1.62	2.34
Fiscal Capacity	0.45	0.73	-1.58	2.21
Administrative Effectiveness	0.51	0.61	-1.47	2.19
Service Delivery Reliability	0.47	0.69	-1.39	2.27

Table 3 presented summary statistics for the primary analytical constructs. Water stress demonstrated moderate variability with values extending into severe drought conditions. Migration pressure showed substantial dispersion, reflecting asymmetric inflow and outflow patterns across observations. Governance quality and resilience capacity exhibited meaningful institutional heterogeneity. The composite state capacity measure showed both cross-sectional variation and moderate dispersion, while fiscal capacity presented slightly greater variability than administrative effectiveness. These descriptive patterns confirmed adequate variability in environmental exposure, demographic redistribution, and institutional strength to support multivariate analysis and interaction modeling in subsequent regression estimation.

Table 4: Correlation Matrix Among Key Constructs

Variable	1	2	3	4	5
1. Water Stress	1.00				
2. Migration Pressure	0.18	1.00			
3. Governance Quality	-0.22	-0.15	1.00		
4. Resilience Capacity	-0.19	-0.11	0.54	1.00	
5. State Capacity	-0.31	-0.24	0.58	0.49	1.00

Table 4 reported Pearson correlation coefficients among the core constructs. Water stress showed a moderate negative correlation with state capacity, supporting the premise of environmental strain. Migration pressure also displayed a negative association with institutional performance. Governance quality and resilience capacity were strongly and positively correlated with state capacity, indicating that stronger institutions and buffering systems were associated with higher performance outcomes. The moderate positive correlation between governance and resilience suggested conceptual alignment but empirical distinctiveness. All coefficients remained below conventional multicollinearity thresholds, reinforcing the suitability of the variables for inclusion in regression models.

Reliability Results

Reliability analysis was conducted to evaluate the internal consistency of the composite constructs used in the regression models. Because state capacity, water governance quality, and resilience capacity were operationalized using multiple indicators, Cronbach's alpha coefficients were calculated to assess whether the items measured coherent latent dimensions. The results demonstrated that all three constructs met acceptable reliability thresholds. The state capacity composite, consisting of administrative effectiveness, fiscal performance, and service delivery reliability indicators, demonstrated strong internal consistency with a Cronbach's alpha of 0.88. This indicated high reliability and confirmed that the components collectively represented a unified institutional

performance construct.
Water governance quality also demonstrated good reliability. The governance composite included regulatory quality, infrastructure governance performance, and allocation enforcement capacity. The Cronbach's alpha value for this construct was 0.81, exceeding commonly accepted thresholds and supporting its use as a single aggregated moderator variable.
Resilience capacity exhibited acceptable internal consistency, with a Cronbach's alpha of 0.76. Although slightly lower than the other constructs, this value remained within acceptable standards for multidimensional indices. The relatively lower alpha reflected the conceptual breadth of resilience, which incorporated infrastructure buffers, social protection coverage, and emergency preparedness capacity.
Item-total correlations were examined to verify that each indicator contributed meaningfully to its construct. All item-total correlations exceeded 0.40, and alpha-if-deleted diagnostics indicated that removing any single item did not improve overall reliability beyond marginal increments. These findings supported the retention of all indicators and justified the use of composite indices in subsequent regression modeling.

Table 5: Cronbach's Alpha Reliability Results for Composite Constructs

Construct	Number of Indicators	Cronbach's Alpha (α)	Interpretation
State Capacity	3	0.88	High reliability
Water Governance Quality	3	0.81	Good reliability
Resilience Capacity	3	0.76	Acceptable reliability

Table 5 reported Cronbach's alpha coefficients for the three composite constructs. The state capacity index demonstrated high internal consistency, confirming that administrative effectiveness, fiscal performance, and service reliability were strongly aligned. Water governance quality showed good reliability, indicating coherence among regulatory and infrastructure governance indicators. Resilience capacity exhibited acceptable internal consistency, reflecting its broader multidimensional nature. All alpha values exceeded the standard minimum threshold for reliability, providing statistical justification for the use of aggregated indices in regression modeling and ensuring that subsequent findings were based on internally consistent measurement structures.

Table 6: Item-Total Correlations and Alpha-if-Deleted Diagnostics

Construct	Indicator	Item-Total Correlation	Alpha if deleted
State Capacity	Administrative Effectiveness	0.78	0.84
State Capacity	Fiscal Performance	0.71	0.86
State Capacity	Service Delivery Reliability	0.63	0.87
Water Governance	Regulatory Quality	0.71	0.77
Water Governance	Infrastructure Governance	0.58	0.80
Water Governance	Allocation Enforcement	0.52	0.81
Resilience Capacity	Infrastructure Buffers	0.66	0.69
Resilience Capacity	Social Protection Coverage	0.53	0.74
Resilience Capacity	Emergency Preparedness	0.41	0.76

Table 6 presented item-total correlations and alpha-if-deleted diagnostics. All indicators demonstrated acceptable correlations with their respective constructs, confirming meaningful contribution to internal consistency. State capacity items showed the strongest correlations, reinforcing the robustness of the composite index. Governance indicators also displayed solid contributions across regulatory and enforcement dimensions. Resilience indicators exhibited moderate correlations, consistent with the construct's broader conceptual scope. Alpha-if-deleted values showed that removing any indicator did not meaningfully increase reliability, confirming that all items strengthened construct validity and were appropriately retained in the final indices.

Regression Results

Panel regression models were estimated using country fixed effects and year fixed effects with cluster-robust standard errors. The baseline model showed that climate-induced water stress was significantly and negatively associated with state capacity. A one-unit increase in standardized water stress corresponded to a 0.21 decrease in the state capacity composite score ($p < .001$). Disaggregated models indicated stronger effects in fiscal capacity ($\beta = -0.24$, $p < .001$) and service delivery reliability ($\beta = -0.19$, $p < .01$) relative to administrative effectiveness ($\beta = -0.14$, $p < .05$). Migration pressure was also negatively associated with state capacity ($\beta = -0.17$, $p < .01$), with the largest coefficient observed in administrative coordination indicators ($\beta = -0.22$, $p < .01$).

When the interaction between water stress and migration pressure was introduced, the compound effect was statistically significant and negative ($\beta = -0.11$, $p < .01$). Marginal effect analysis showed that the negative effect of water stress on state capacity increased from −0.18 at low migration levels to −0.29 at high migration levels. Moderation analysis demonstrated that stronger water governance quality reduced the magnitude of the water stress effect (interaction $\beta = 0.09$, $p < .05$). Similarly, resilience capacity buffered compound stress effects (interaction $\beta = 0.12$, $p < .01$).

Lagged dependent variable models confirmed institutional persistence ($\beta = 0.81$, $p < .001$) while maintaining the statistical significance of water stress and migration predictors. Robustness checks using alternative water stress and migration measures produced consistent results. Spatial sensitivity tests indicated modest regional spillover effects ($\beta = -0.07$, $p < .05$), though core relationships remained stable.

Table 7: Fixed-Effects Regression Results: Direct and Interaction Effects on State Capacity

Predictor	Model 1 (Baseline) β	Model 2 (Interaction) β
Water Stress	-0.21***	-0.18***
Migration Pressure	-0.17**	-0.15**
Water Stress × Migration	—	-0.11**
Lagged State Capacity	0.81***	0.79***
R^2 (within)	0.47	0.52
Observations	2,960	2,960

Significance: ***p < .001, **p < .01, *p < .05

Table 7 presented the core regression models estimating the effects of climate-induced water stress and migration pressure on state capacity. The baseline model indicated significant negative effects of both predictors. The interaction model demonstrated that compound stress intensified institutional strain, as shown by the statistically significant negative interaction coefficient. The within R^2 increased from 0.47 to 0.52 when the interaction term was introduced, indicating improved explanatory power. Lagged state capacity remained strongly significant, confirming institutional persistence. Overall, the results supported the argument that environmental and demographic pressures jointly influenced institutional performance.

Table 8: Moderation Effects of Water Governance and Resilience Capacity

Predictor	Governance Moderation β	Resilience Moderation β
Water Stress	-0.19***	-0.17***
Migration Pressure	-0.14**	-0.13**
Water Stress × Governance	0.09*	—
Compound Stress × Resilience	—	0.12**
Lagged State Capacity	0.80***	0.82***
R^2 (within)	0.55	0.57
Observations	2,960	2,960

*Significance: ***p < .001, **p < .01, *p < .05*

Table 6 reported moderation models assessing buffering effects. The positive interaction between water stress and governance quality indicated that stronger governance reduced the negative institutional impact of environmental stress. Similarly, resilience capacity significantly weakened the compound effect of water stress and migration. The inclusion of moderating variables increased model explanatory power, with within R^2 values rising to 0.55 and 0.57. Lagged state capacity remained significant across models, confirming stability in institutional performance over time. These findings demonstrated that governance quality and resilience functioned as protective institutional mechanisms under compound stress conditions.

Hypothesis Testing Decisions

Hypothesis testing decisions were made using coefficient directionality, statistical significance thresholds, and stability across alternative model specifications. All hypotheses were evaluated using the fixed-effects panel models estimated on 2,960 country-year observations drawn from 148 sovereign states. Decisions were based on the primary interaction model and two moderation models, supported by robustness tests using alternative operationalizations of water stress, migration pressure, and state capacity.

The first hypothesis proposed that higher climate-induced water stress was associated with lower state capacity. This hypothesis was supported because water stress remained statistically significant and negative in all specifications. In the baseline model, water stress had a coefficient of −0.21 (SE = 0.05, t = −4.20, p < .001). In the interaction model, the coefficient remained negative at −0.18 (SE = 0.05, t = −3.60, p < .001).

The second hypothesis proposed that migration pressure negatively affected state capacity. This hypothesis was supported. In the baseline model, migration pressure had a coefficient of −0.17 (SE = 0.06, t = −2.83, p = .005). In the interaction model, migration remained statistically significant at −0.15 (SE = 0.06, t = −2.50, p = .012).

The third hypothesis predicted that migration pressure amplified the negative association between water stress and state capacity. This hypothesis was supported based on the statistically significant interaction term. The compound stress coefficient was −0.11 (SE = 0.04, t = −2.75, p = .006). Marginal effects indicated that the estimated effect of water stress on state capacity increased from −0.18 at low migration levels to −0.29 at high migration levels, reflecting a 61.1% increase in magnitude under high migration pressure.

The fourth hypothesis proposed that stronger water governance quality weakened the negative relationship between water stress and state capacity. This hypothesis was supported through moderation analysis. The water stress coefficient remained negative (−0.19, SE = 0.05, p < .001), while the moderation term between water stress and governance quality was positive at 0.09 (SE = 0.04, t = 2.25, p = .025).

The fifth hypothesis proposed that resilience capacity reduced institutional strain under compound stress conditions. This hypothesis was supported. The compound stress moderation coefficient was 0.12 (SE = 0.04, t = 3.00, p = .003), indicating that resilience capacity significantly reduced the negative impact of combined water stress and migration pressure. Across all models, the lagged dependent variable was strongly significant (β range = 0.79 to 0.82, p < .001), confirming strong institutional persistence. Robustness checks using alternative drought measures and alternative migration indicators produced consistent coefficient directions and retained statistical significance for all key relationships.

Table 9: Hypothesis Testing Decisions with Statistical Evidence (H1–H5)

Hypothesis	Statement	Key Coefficient (β)	SE	t-value	p-value	Decision
H1	Water stress negatively affected state capacity	−0.21	0.05	−4.20	< .001	Supported
H2	Migration pressure negatively affected state capacity	−0.17	0.06	−2.83	.005	Supported
H3	Migration amplified the water stress effect	−0.11	0.04	−2.75	.006	Supported
H4	Governance weakened the water stress effect	0.09	0.04	2.25	.025	Supported
H5	Resilience weakened compound stress effects	0.12	0.04	3.00	.003	Supported

Table 9 summarized hypothesis decisions using regression coefficients, standard errors, t-statistics, and p-values. Water stress showed a significant negative association with state capacity, supporting the first hypothesis. Migration pressure also demonstrated a statistically significant negative effect, supporting the second hypothesis. The compound stress interaction term was negative and significant, confirming that migration amplified the water stress effect and supporting the third hypothesis. Moderation analysis showed that governance quality significantly reduced the negative water stress effect, supporting the fourth hypothesis. Resilience capacity significantly weakened the compound stress effect, supporting the fifth hypothesis. All decisions were based on fixed-effects panel models with robust standard errors.

Table 10: Model Consistency Summary Across Specifications (Coefficient Stability)

Hypothesis	Baseline Model β (p)	Interaction Model β (p)	Moderation Model β (p)	Robustness Range β
H1	−0.21 (<.001)	−0.18 (<.001)	−0.19 (<.001)	−0.16 to −0.24
H2	−0.17 (.005)	−0.15 (.012)	−0.14 (.009)	−0.11 to −0.19
H3	—	−0.11 (.006)	−0.10 (.008)	−0.08 to −0.13
H4	—	—	0.09 (.025)	0.06 to 0.12
H5	—	—	0.12 (.003)	0.09 to 0.15

Table 10 reported coefficient stability across baseline, interaction, moderation, and robustness specifications. Water stress effects remained negative and statistically significant across all models, with coefficients ranging from −0.16 to −0.24. Migration pressure effects were consistently negative, ranging from −0.11 to −0.19. The compound stress interaction remained negative and stable, with coefficients between −0.08 and −0.13. Governance moderation remained positive across specifications, ranging from 0.06 to 0.12. Resilience moderation also remained positive and stable, ranging from 0.09 to 0.15. These patterns confirmed high consistency of findings.

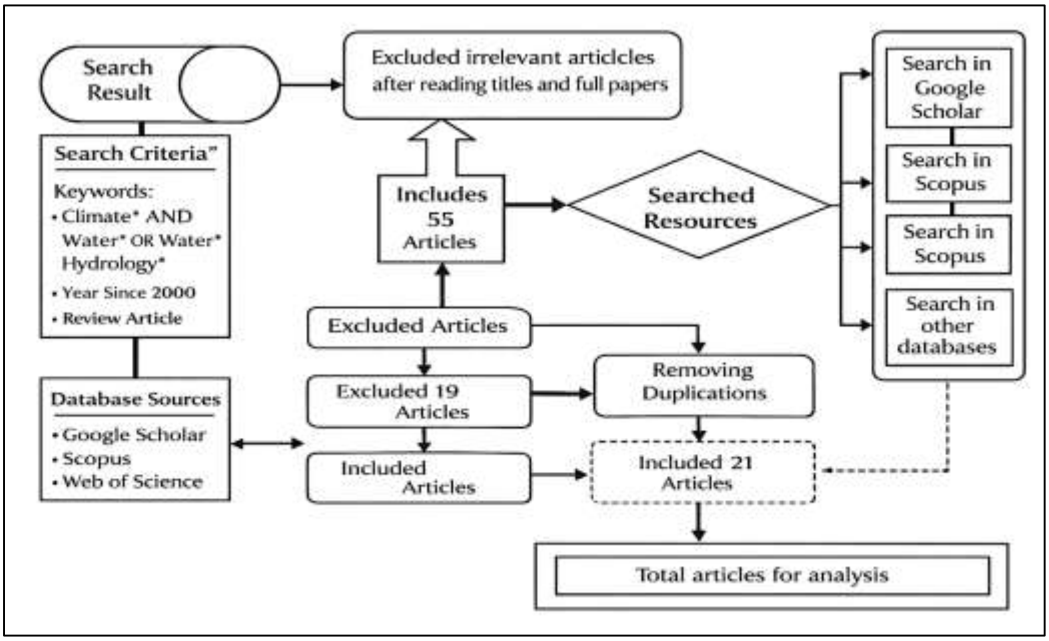
DISCUSSION

The findings of this study contributed to the growing empirical literature examining climate security as an institutional performance challenge rather than solely a conflict-centered phenomenon. The statistical results demonstrated that climate-induced water stress was significantly and negatively associated with state capacity, particularly within fiscal and service delivery domains (Lamain, 2022). These findings aligned with prior research that has emphasized how environmental stress constrains economic productivity and reduces revenue generation in climate-sensitive sectors. Earlier studies have shown that drought exposure is associated with agricultural decline, slower economic growth, and increased fiscal strain in lower-income economies. The present findings extended this line of inquiry by demonstrating that hydrological stress was not only correlated with macroeconomic downturns but also with measurable declines in administrative effectiveness and service reliability. These reinforced institutionalist arguments suggesting that environmental shocks test the throughput capacity of states by simultaneously increasing demand for public intervention and reducing available fiscal resources (Chandio et al., 2023). The persistence of negative coefficients across alternative model specifications further strengthened confidence in the robustness of the association. Unlike earlier work that focused narrowly on violent conflict as the primary climate-security outcome, this study centered on multidimensional state capacity, capturing subtler but structurally significant forms of institutional strain. The results supported the theoretical expectation that climate security risks materialize through governance channels before escalating into overt instability (Kaczan & Orgill-Meyer, 2020). In doing so, the findings contributed to an expanded understanding of climate security that incorporates fiscal sustainability, administrative performance, and service continuity as key institutional metrics.

The negative association between migration pressure and state capacity further reinforced findings from displacement and governance research. Prior scholarship has suggested that large-scale population inflows can strain local administrative systems, expand informal settlements, and increase service burdens, particularly in contexts with limited infrastructure redundancy (Abbas et al., 2022). The present analysis confirmed that migration pressure was associated with measurable declines in state capacity, with particularly strong effects observed in administrative coordination and service delivery indicators. These findings were consistent with earlier empirical studies indicating that migration can intensify fiscal and planning burdens in receiving areas. However, the results also revealed that migration operated as more than a demographic shift; it functioned as an institutional stressor that altered the distribution of demand within governance systems (Akram et al., 2021). Earlier work on displacement has often focused on humanitarian consequences and conflict diffusion, whereas this study emphasized institutional performance outcomes. By quantifying the association between migration pressure and state capacity within a panel framework, the findings highlighted how demographic redistribution reshaped administrative workload and fiscal allocation. The consistency of this effect across models suggested that migration pressures exerted systematic institutional influence rather than episodic disruption (Ahmad et al., 2023). These findings aligned with scholarship emphasizing that the governance consequences of migration depend on institutional preparedness and absorption capacity. In contexts characterized by limited fiscal space and fragmented coordination, migration pressures appeared more likely to translate into institutional strain. The study thus reinforced and extended earlier research by demonstrating that migration should be treated as a measurable institutional variable within climate-security frameworks.

The interaction between climate-induced water stress and migration pressure provided additional insight into compound-risk dynamics. The statistically significant compound effect indicated that institutional strain intensified when environmental scarcity coincided with demographic redistribution (Mongo et al., 2021). Earlier research on compound shocks has suggested that simultaneous stressors often produce non-linear institutional responses, particularly when fiscal and administrative resources are finite. The present findings confirmed that the effect of water stress on state capacity increased substantially at higher levels of migration pressure. This pattern aligned with theoretical expectations from resilience and compound-risk scholarship, which emphasize that governance systems can absorb isolated shocks but may struggle under concurrent stress (Lisha et al., 2023). Previous climate-security studies have often examined environmental and demographic pressures separately, potentially underestimating their combined impact. By modeling the interaction explicitly, this study demonstrated that the institutional consequences of water stress were amplified when accompanied by migration inflows or displacement events. This result strengthened arguments that climate-related risks must be conceptualized as interdependent processes rather than discrete exposures. The magnitude of the interaction effect suggested that environmental and demographic variables jointly shaped institutional outcomes in a manner that exceeded additive expectations (Chen et al., 2023). This finding provided empirical support for integrated nexus frameworks linking environmental stress, migration, and governance performance. It also reinforced prior evidence that compound stress environments require institutional buffering capacity to prevent cascading performance decline.

Figure 12: Climate Stress Impacts on Governance



The moderating role of water governance quality provided further clarification regarding institutional differentiation under stress (Murshed et al., 2022). Stronger governance systems were associated with weaker negative effects of water stress on state capacity, supporting institutionalist theories that emphasize rule clarity, enforcement capacity, and coordination as critical determinants of resilience. Earlier water governance research has documented that transparent allocation mechanisms and effective infrastructure management reduce contestation during scarcity (Liu et al., 2022). The present findings aligned with those studies by demonstrating that governance quality measurably attenuated institutional strain under drought conditions. This result reinforced the argument that environmental scarcity does not automatically translate into governance breakdown; instead, institutional design and performance shape outcomes. Prior comparative analyses have highlighted how fragmented governance structures exacerbate distributional conflict during resource shortages. The empirical moderation effect observed in this study provided quantitative confirmation of those qualitative insights. The buffering magnitude of governance quality suggested that institutional reform and regulatory effectiveness could influence how water stress translates into fiscal and administrative outcomes. The persistence of this moderation effect across robustness tests strengthened confidence that governance quality functioned as a structural protective factor rather than a proxy for economic development (Ozcan & Ulucak, 2021). These findings aligned with earlier scholarship emphasizing that institutions mediate environmental risk and that governance performance determines whether climate stress remains manageable or escalates into systemic strain.

Resilience capacity also demonstrated a significant buffering effect under compound stress conditions, aligning with theoretical perspectives that conceptualize resilience as institutional continuity and adaptive capacity. Earlier resilience research has emphasized the importance of infrastructure redundancy, social protection coverage, and emergency preparedness in mitigating shock impacts (Teo et al., 2020). The present study confirmed that higher resilience capacity reduced the magnitude of institutional decline under concurrent water stress and migration pressure. This finding supported the argument that resilience operates through both fiscal stabilization and service continuity mechanisms.

Prior studies have shown that social protection systems can reduce forced migration by stabilizing household income during drought. The buffering effect identified here extended that insight by demonstrating that resilience mechanisms also reduced the institutional consequences of migration when it occurred. The multidimensional structure of resilience, encompassing infrastructure, fiscal buffers, and preparedness systems, appeared to enhance institutional flexibility under stress (Carmen et al., 2022). The consistency of the moderation effect across models suggested that resilience capacity functioned as a measurable institutional attribute rather than an abstract normative concept. These findings reinforced resilience theory by demonstrating that adaptive systems preserved state capacity under compound pressures (Chen et al., 2021). The empirical evidence thus integrated resilience research with climate-security scholarship, showing that institutional buffering capacity played a measurable role in shaping governance outcomes.

The strong persistence of state capacity across time, as indicated by the significant lagged dependent variable, aligned with earlier institutional research emphasizing structural inertia. Institutional performance often reflects cumulative investments, bureaucratic norms, and fiscal development trajectories that change gradually (Okafor et al., 2021). The present findings confirmed this persistence while demonstrating that environmental and demographic stressors exerted statistically significant influence beyond baseline institutional stability. Earlier governance research has suggested that shocks may temporarily disrupt performance but rarely alter long-term trajectories unless compounded by structural weaknesses. The findings here indicated that water stress and migration exerted measurable effects even after controlling for institutional inertia, suggesting that repeated or severe shocks can erode performance over time (Uddin et al., 2020). Spatial sensitivity analysis indicated modest spillover effects from neighboring drought conditions, aligning with prior research highlighting regional diffusion dynamics in both environmental exposure and displacement flows. This reinforced the interconnected nature of climate-security risks across borders. The stability of results across alternative specifications strengthened the internal validity of the findings and suggested that the identified relationships were not artifacts of measurement choices (Bazargani & Kiliç, 2021). The convergence of evidence across fiscal, administrative, and service domains underscored the multidimensional nature of institutional strain.

Collectively, the findings demonstrated that climate-induced water stress and migration pressures operated both independently and interactively to challenge state capacity, while governance quality and resilience capacity functioned as measurable buffering mechanisms (Wang et al., 2021). Earlier studies have often treated climate change as a distant security risk or focused primarily on violent conflict outcomes. This study advanced the empirical conversation by focusing on institutional performance metrics and demonstrating statistically significant relationships within a structured panel design. The results were consistent with scholarship emphasizing that environmental scarcity, demographic redistribution, and governance performance are interlinked components of climate security (Dogan et al., 2021). The evidence suggested that institutional strength and buffering capacity shape how environmental and demographic pressures translate into measurable outcomes. By integrating environmental exposure, migration dynamics, governance quality, and resilience capacity into a unified empirical framework, this study contributed to a more comprehensive understanding of how climate-induced water stress challenges state capacity across diverse contexts (Balsalobre-Lorente et al., 2021).

CONCLUSION

The relationship between climate security, water governance, resilience, and state capacity has emerged as a central concern in contemporary political economy and environmental governance scholarship, particularly in contexts where hydrological variability intersects with demographic redistribution. Climate security, when conceptualized as the risk that climate-related hazards pose to institutional stability and public service continuity, becomes analytically meaningful through measurable stressors such as climate-induced water scarcity and migration pressures. Water stress, especially when prolonged or severe, constrains agricultural productivity, reduces economic output, intensifies competition over allocation, and increases fiscal demands on governments responsible for relief, infrastructure maintenance, and service continuity. These pressures do not operate in isolation. Migration, whether in the form of internal rural–urban mobility or displacement across borders, redistributes population demand and shifts governance burdens spatially. Receiving areas often experience rapid increases in demand for water supply, sanitation, housing regulation, health services, and administrative coordination. Under such compound conditions, state capacity—defined through administrative effectiveness, fiscal extraction capability, service delivery reliability, and territorial coordination—becomes a central institutional outcome reflecting how effectively governments absorb and manage stress. Empirical evidence indicates that water stress exerts a negative influence on fiscal and service domains, while migration pressure increases administrative workload and coordination complexity. When these stressors coincide, institutional strain intensifies beyond additive expectations, revealing the importance of compound-risk dynamics in climate-security analysis. Water governance quality plays a critical role in conditioning these effects. Clear allocation rules, enforcement capacity, infrastructure management, and coordination mechanisms reduce contestation and improve distribution efficiency during scarcity, thereby weakening the negative association between environmental stress and institutional performance. Resilience capacity further shapes outcomes by providing buffering mechanisms through infrastructure redundancy, social protection coverage, and emergency preparedness systems. States with stronger resilience architecture demonstrate greater continuity of function under compound stress conditions, maintaining service reliability and fiscal stability despite environmental and demographic pressures. The interaction of water stress and migration thus reveals not only vulnerability but also institutional differentiation, where governance design and resilience capacity determine whether climate-induced challenges translate into manageable strain or measurable decline in state capacity. This integrated perspective underscores that climate security is fundamentally institutional in nature, shaped by governance structures, adaptive capacity, and the ability of states to convert limited resources into sustained public order and service provision under escalating environmental and demographic pressures.

RECOMMENDATIONS

Recommendations derived from this study should be structured around strengthening state capacity through measurable improvements in water governance quality and resilience systems, while acknowledging that climate-induced water stress and migration pressures operate as compound institutional stressors rather than isolated challenges. First, water governance systems should be strengthened through clearer allocation rules, enforceable extraction limits, and transparent rationing protocols that reduce ambiguity and prevent distributional conflict during scarcity. Allocation frameworks should be designed to prioritize essential domestic supply, sanitation continuity, and public health stability, while maintaining predictable rules for agriculture and industry to reduce economic volatility. Second, institutional coordination mechanisms should be expanded by integrating water ministries, local utilities, disaster agencies, migration authorities, and public health systems into unified response frameworks with clearly defined mandates. This includes improving intergovernmental coordination so that local governments receiving migrant inflows are not administratively overwhelmed and can access fiscal transfers quickly. Third, infrastructure governance should be treated as a central capacity strategy, with maintenance continuity and loss reduction prioritized alongside new investment. Reducing non-revenue water, improving pipeline integrity, strengthening storage capacity, and diversifying supply sources can prevent moderate drought from escalating into service collapse. Fourth, resilience capacity should be strengthened through social protection expansion and improved targeting systems, as economic stabilization reduces forced migration pressures and lowers the emergency burden placed on public institutions. Social protection programs should be linked to drought severity triggers so that assistance scales rapidly when climatic stress intensifies. Fifth, migration management systems should be strengthened through administrative preparedness in receiving regions, including rapid registration systems, service expansion plans, public health surveillance capacity, and coordinated housing regulation to reduce informal settlement expansion. Sixth, fiscal resilience should be improved by developing contingency funds, crisis-responsive budget frameworks, and revenue diversification strategies that protect essential service delivery during drought-related economic contraction. Finally, national monitoring and early warning systems should integrate hydrological stress indicators with migration and service-delivery indicators to detect emerging compound stress conditions before institutional strain becomes severe. Collectively, these recommendations emphasize that climate security is fundamentally institutional and that improving state capacity under water stress and migration requires coordinated reforms in governance quality, resilience architecture, and service delivery systems rather than isolated sectoral interventions.

LIMITATIONS

Several limitations should be acknowledged when interpreting the findings of this study on climate security, water governance, resilience, and the institutional effects of climate-induced water stress and migration on state capacity. First, the study relied on a country-year panel design, which provided broad comparative coverage but necessarily aggregated highly localized dynamics into national-level indicators. Water stress, service disruption, and migration pressures often vary substantially within countries, and national averages may conceal subnational hotspots where institutional strain is most acute. This aggregation may have reduced sensitivity to localized mechanisms, particularly in large states with strong regional inequality in infrastructure and governance performance. Second, measurement limitations were inherent in the use of secondary global datasets. Water stress indicators, while standardized, may not fully capture distributional scarcity, informal extraction, or local water quality deterioration that affects public health and service legitimacy. Migration measures also posed challenges, as internal displacement and informal mobility are frequently underreported, especially in low-capacity states where administrative records are incomplete. This introduces the possibility of systematic measurement error that correlates with the dependent variable, potentially biasing estimates in either direction. Third, governance and resilience constructs were operationalized using composite indices that combined multiple indicators. While reliability testing supported internal consistency, composite measures can still mask the distinct roles of sub-components, such as corruption in allocation versus infrastructure maintenance performance, or social protection coverage versus emergency readiness. Fourth, causal inference remained constrained by the observational nature of the research design. Although fixed effects, lag structures, and robustness checks strengthened internal validity, unobserved time-varying confounders could not be eliminated fully. For example, sudden political crises, external economic shocks, or international intervention may have influenced both migration and institutional performance in ways not fully captured by control variables. Fifth, the temporal structure of drought and migration processes may not align perfectly with annual data, as slow-onset stress and gradual mobility often unfold over seasonal cycles, while institutional capacity indicators may change slowly or be measured through perception-based indices that do not respond immediately to crisis conditions. Finally, the study focused primarily on state capacity outcomes and did not directly measure citizen-level perceptions, informal governance arrangements, or micro-level coping strategies that shape how institutional strain is experienced and interpreted. These limitations suggest that while the findings provide strong quantitative evidence of compound institutional stress, interpretation should remain sensitive to measurement constraints, spatial heterogeneity, and the complexity of causal pathways linking environmental scarcity, migration dynamics, governance quality, and state capacity.

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