

# Diagnosing the Gap Between Latent and Realized Adaptive Capacity: A Policy Capacity Extension of the IPCC Contextual Vulnerability Framework

Mercedes Asamani

[mnasaman@mtu.edu](mailto:mnasaman@mtu.edu)

Michigan Technological University

Chelsea Schelly

University of Wisconsin–Madison

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## Research Article

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# Abstract

When climate vulnerability assessments identify a region's vulnerabilities but ignore whether the institutions responsible for responding can act, they produce findings without pathways. This paper is situated within this challenge and attempts to close this gap. It argues that the policy capacity framework which assesses institutional competence across analytical, operational, and political dimensions at the individual, organizational, and systemic levels—is not a supplement to the IPCC contextual vulnerability framework but a theoretically grounded operationalization of its most underdeveloped yet critical component: adaptive capacity. The adaptive capacity scholarship in CVA studies acknowledge that environmental, socio-economic and political conditions are central to whether a system is vulnerable to climate impacts, but they do not provide the diagnostic categories to assess how capable institutions are of addressing vulnerabilities or where their capacity is constrained. Findings show that analytical capacity is constrained not by absent expertise but by the absence of any mechanism translating co-located research into planning intelligence, and operational capacity is the binding constraint. Political capacity fails in an unexpected configuration: tribal nations and community organizations are engaged as co-equal partners, yet adaptation commitments do not survive competing planning priorities, inverting the standard expectation of procedural exclusion. Cross-tier triangulation reveals an underlying framing divergence that renders these deficits coherent rather than incidental. Institutional assets should count as adaptive capacity only where a translation mechanism is demonstrated.

## 1.0 Introduction

Climate change is having enormous impacts on socio-ecological systems across the globe (IPCC, 2022; Meier et al., 2024). Significant effects result from changes in the frequency and intensity of extreme climatic events as well as in the unpredictability of weather patterns (Thornton et al., 2014). Climate-related hazards arise from the interplay between the changing physical characteristics of the climate system and the evolving exposure and susceptibility of socio-ecological systems (Oppenheimer et al., 2015). The IPCC (2022) defines climate vulnerability as the propensity or predisposition to be adversely affected. Thus, vulnerability is the degree to which a system is susceptible to or unable to cope with the adverse effects of climate change, including climate variability and extremes (Pachauri et al., 2014).

The US has seen a significant increase in climate-induced disasters over the last decade, costing the country billions of dollars and aggravating existing systemic vulnerabilities (Shi & Moser, 2021). Climate risks and vulnerabilities are widely and unevenly distributed across the United States, with existing inequalities further exacerbating vulnerabilities to the impacts of climate change (Lewis et al., 2023). With the acceleration of climate risk, vulnerability is becoming an important concept in climate change studies and to the IPCC considering its significance in informing adaptation strategies (Le et al., 2020). Understanding vulnerability is crucial because it links the effects of climate change to the potential and priorities for adaptation and informs policy interventions (Rossati, 2016; Zarafshani et al., 2016; Malone & Engle, 2011).

Climate vulnerability studies in recent decades have gained popularity and birthed two research ideologies reflected in reports of the Intergovernmental Panel on Climate Change (IPCC): one focusing on biophysical conditions to support adaptation to physical shock and stressors and the other focusing on the intersection between physical stressors or biophysical conditions and socioeconomic drivers (Bedeke, 2023; Guillaumont & Simonet, 2011; Adger, 2006). The former, i.e., outcome-oriented approaches, is risk-hazard centered and focused on assessing climate vulnerability triggered by climatic stressors or drivers such as droughts, storms, extreme precipitation events, etc. (Guillaumont & Simonet, 2011; Brooks et.al., 2005). This approach views vulnerability as an endpoint that represents the total of the anticipated effects of climate change on systems or a collection of exposure units (Turner II et al., 2003; Brook, 2003; van den Berg & Keenan, 2015). The limitations of the former ideology, i.e., outcome-oriented assessments, on accounting for the full extent of climate vulnerability and failure to capture the complexities of human-environment problems as questioned by scholars in the social sciences led to the development of the latter, i.e., contextual-oriented assessments, to account for both biophysical and socioeconomic drivers of climate vulnerability (Smith & Diedrich, 2024; O'Brien et.al., 2007; Kelly & Adger, 2000; Adger, 2006). Within the social science approaches, vulnerability is recognized as a state of well-being and is not the same for different populations living under different environmental conditions or faced with complex interactions of social norms, political institutions, resource endowments, technologies, and inequalities (Adger, 1999; Smith & Diedrich, 2024). Thus, studies that sit at the intersection of both biophysical and socioeconomic drivers of climate vulnerability seek to address these limitations, provide a holistic approach to vulnerability studies, and prevent the potential of maladaptive responses (Smith & Diedrich, 2024; Berkhout et.al., 2014).

Over the past decade, several climate vulnerability frameworks and methodologies have emerged that sit at the intersection of the two main ideologies, capturing interactions across biophysical and socioeconomic conditions. Dominant among these frameworks is the IPCC's third (TAR, 2001) and fourth assessment report (AR4, 2007) (Smith & Diedrich, 2024). The IPCC TAR/AR4 framework defines vulnerability as a function of exposure, sensitivity, and adaptive capacity. Exposure is hazard-centered and focuses on climatic stressors like drought, extreme precipitation events, storms, etc. and how exposed systems are to these climate variations; sensitivity is the degree to which systems are affected either adversely or beneficially; with adaptive capacity being the ability of systems to adjust to climate change (IPCC, 2001; 2007).

Despite the growing body of climate vulnerability research in both developed and developing countries, including studies in rural and low-income regions in the United States (Junod et al., 2024; Greene, 2018; Lewis et al., 2023), important gaps remain in understanding whether the institutions responsible for translating vulnerability knowledge into adaptation action possess the competence to do so, particularly in remote rural areas. This gap is not external to the IPCC TAR/AR4 framework often used in these studies; it lies within the adaptive capacity component itself. Adaptive capacity in adaptive conventional CVA scholarship has been narrowly operationalized through general structural characteristics such as resource availability, human capital, ecological conditions, and institutional responses as central determinants of climate vulnerability (Engle, 2011; Gupta et al., 2010; Adger et al., 2009). These studies

often focusing on how these characteristics determine vulnerability by moderating exposure and sensitivity, produce findings that describe vulnerability accurately but do not specify the institutional capacity or competence to address these vulnerabilities or guide governance responses to it.

Building on Asamani and Schelly (2025), we ask: *What climate vulnerabilities characterize Michigan's Western Upper Peninsula, and how do policy capacity conditions reflect the WUPPDR's capacity to address them?* The paper makes three contributions: it provides vulnerability assessment with diagnostic categories capable of specifying where institutional capacity is constrained; it extends this analysis to a remote rural setting underrepresented in the literature; and it makes visible an equity dimension conventional assessments miss, in which governance failure rather than resource scarcity alone determines who receives effective adaptation.

## **2.0 Adaptive Capacity and its Operationalization**

### **2.1 The IPCC TAR/AR4 Framework and The Limitations of the Adaptive Capacity Component**

The IPCC TAR/AR4 vulnerability framework (Fig. 2.1) is the most operationalized framework, especially in context-oriented climate vulnerability or climate adaptation studies (Smith & Diedrich, 2024). According to this framework, vulnerability is a function of exposure, sensitivity, and adaptive capacity (IPCC, 2001; 2007). The IPCC (2001) defines exposure as the nature or degree to which a system is exposed to shocks and stressors, sensitivity as the degree to which a system is affected by exposure to shocks and stressors (IPCC, 2007), and adaptive capacity as the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damage, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007). The definitions encompass both the biophysical assets of a system and the social, institutional, and political conditions that enable or constrain adjustment.

The components of the IPCC TAR/AR4 vulnerability framework have been operationalized in several vulnerability studies to draw empirical conclusions. Exposure has been operationalized in climate vulnerability studies as climatic stressors or drivers resulting in pressures which may cause state changes or impacts on human and natural systems (Bedeke 2023; Foden et.al., 2019; Estoque et.al., 2023). Examples include extreme precipitation critical infrastructure, people and buildings in flood prone areas or areas with climatic stressors, rising temperatures, drought, extreme heat, rising sea levels, flooding, storm, natural hazards such as earthquakes (Foden et.al., 2019; Estoque et.al., 2020; Estoque et.al., 2023). While exposure describes factors that are external to the species, sensitivity describes intrinsic attributes that are recognized to moderate and/or exacerbate the impact of those pressures on a system's response or vulnerability (Estoque et.al., 2023; Estoque et.al., 2020; Foden et.al., 2019). Examples of the operationalization of sensitivity in climate vulnerability studies include assessment of physical or environmental impact or damage to property and critical infrastructure, loss of lives due to climatic stressors, how population characteristics influence vulnerability, change in crop yield as a result

of changing temperature, damages and interruptions caused by stressors, strong dependency on agricultural income, absence of flood-resistant housing, reduced erosion protection, deforestation, wetland degradation, the degree to which different social groupings experience hazards or risks, vulnerability of critical infrastructure including health systems, etc. (Estoque et.al., 2023; Foden et.al., 2019). Adaptive capacity also describes a system's ability to adjust to climate impacts often highlighting structural characteristics across physical, environmental, socio-economic and political features (Estoque et.al., 2020; Estoque, et.al, 2023; Engle, 2011). Examples include lack of financial resources, lack of protected areas, lack of wetland management capacity, lack of protected forest areas, lack of urban planning, governance interventions, level of education or ecological knowledge and skills, access to technology (Estoque, et.al., 2023; Engle, 2011)

Adaptive capacity in climate vulnerability assessment (CVA) scholarship, while recognizing government interventions, availability of economic resources, technology, and levels of education as critical determinants of a system or region's vulnerability, focuses less on the capacity or competence of specific or authorized government institutions to support adaptation and enhance (Engle, 2011; Foden et.al., 2019). The adaptive capacity scholarship in CVA studies acknowledges that environmental, socio-economic, and political conditions are central determinants of a region's vulnerability to climate impacts but does not provide diagnostic categories to assess how capable institutions are of addressing vulnerabilities or where their capacity is constrained. The result is vulnerability assessments that identify and simply describe what a region faces and what resources nominally exist but cannot specify whether the organizations responsible for adaptation possess the competence to address vulnerabilities effectively. The policy capacity framework (Wu et.al., 2015) directly addresses this diagnostic gap: by organizing institutional competence across analytical, operational, and political dimensions, thereby providing the systematic vocabulary necessary to assess the institutional dimension of adaptive capacity empirically, moving the CVA scholarship from merely describing general structural constraints to climate adaptation to specifying precisely the competence or capacity of institutions or agencies to support adaptation.

## **2.2. Existing Institutional Approaches**

Scholars have increasingly recognised this narrow operationalization and limitation. Engle (2011) argues that adaptive capacity must be understood as a dynamic, multilevel property that encompasses not only the latent potential of a system to adapt but also the realized ability of actors to mobilize that potential through governance processes. This is a distinction this paper seeks to make and diagnose as its organizing question by extending the IPCC contextual vulnerability framework.

Wellstead and Stedman (2015) argue that many climate vulnerability assessments treat policy and governance as exogenous to the vulnerability system—as background conditions rather than as constitutive dimensions of adaptive capacity itself. This treatment produces assessments that accurately describe what a region is exposed to and sensitive toward but systematically understate the governance barriers that prevent effective response. The result is a set of vulnerability findings that

cannot be acted upon because the analysis has not interrogated whether the institutions responsible for action are equipped to respond.

Most directly, Gupta et al. (2010) developed an adaptive capacity wheel (ACW) explicitly as a method for assessing institutional characteristics necessary for adaptation. They include variety, learning capacity, room for autonomous change, leadership, availability of resources, and fair governance, as central determinants of whether a system can translate potential into action. The ACW is a widely applied tool for institutional adaptive capacity assessment.

These interventions establish that governance is constitutive of adaptive capacity rather than incidental to it. They differ, however, in what they supply. Engle offers a conceptual distinction—latent versus realized—without an instrument for locating where realization fails. Wellstead and Stedman identify policy capacity as a promising corrective without operationalizing it into an assessment procedure or applying it empirically within a vulnerability assessment. Gupta et al. supply a full instrument, but one calibrated to a different question. This paper occupies the space between these three interventions. It operationalizes Engle's latent-realized distinction into an assessment instrument capable of locating where realization fails; it executes Wellstead and Stedman's proposal by developing policy capacity into a coding architecture and applying it within a contextual vulnerability assessment; and it addresses a unit of analysis the adaptive capacity wheel does not reach, assessing not whether a governance regime enables societal adaptive capacity but whether a designated organization holds the competences required to act.

## **2.3. What Policy Capacity Adds: The Policy Capacity Framework as an Operationalization of Adaptive Capacity**

From a governance perspective, most scholars define policy capacity as the ability of governments to make intelligent choices (Painter & Pierre, 2005), to scan the environment and set strategic directions (Howlett & Lindquist, 2004), to weigh and assess the implications of policy alternatives (Bakvis, 2000), and to make appropriate use of knowledge in policymaking (Parsons, 2004). Some scholars have often limited and restricted the definitions of policy capacity, focusing solely on the availability or calibre of particular skills, such as policy advising, to influence decision-making. For instance, policy capacity is defined by Painter and Pierre (2005) as the ability to marshal the necessary resources to make intelligent collective choices, in particular to set strategic directions, for the allocation of scarce resources to public ends. Others have maintained this comparatively limited focus while incorporating additional resources and skills, such as those related to gathering and applying policy-relevant knowledge, the capacity to formulate options, the application of both qualitative and quantitative research methods to policy issues, the efficient use of communications, and stakeholder management techniques (Howlett, 2009).

Wu et.al., (2015), in filling this gap, introduced a framework for analyzing policy capacity and defined policy capacity as the set of skills and resources—or competences and capabilities—necessary to perform policy functions. This definition, comprising three sets of skills and competences and three levels of resources and capabilities, is sufficiently broad to encompass all the aspects of policy capacity.

Following Moore's (1995) analysis, their framework categorizes policy capacity across three types of competences: analytical (the ability to gather, process, and use information for policymaking), operational (the ability to implement and manage policy processes), and political (the ability to build support, negotiate, and sustain policy commitments). These competences are assessed at three levels: individual (the skills and knowledge of policy workers), organizational (the resources and structures of government agencies), and systemic (the broader governance environment, including public trust and legitimacy).

The three policy capacity competences map directly onto the governance or institutional dimension of adaptive capacity and address the limitations of this component of the IPCC TAR/AR4 framework as theorized in the CVA literature (Engle, 2011; Estoque et.al., 2020; Estoque et.al., 2023). Analytical capacity corresponds to the information and knowledge resources that Smit and Wandel (2006) identify as foundational to adaptive capacity: without the ability to collect, process, and act on vulnerability data, institutions cannot make informed adaptation decisions. Operational capacity corresponds to the resource mobilization and implementation dimensions of adaptive capacity that Adger et al. (2005) and Engle (2011) emphasize. Political capacity corresponds to the legitimacy, coalition-building, and sustained commitment dimensions that Gupta et al. (2010) include in their adaptive capacity wheel. This correspondence suggests that policy capacity is not merely complementary to the adaptive capacity component of the IPCC CVA framework; it is a systematic operationalization of adaptive capacity's governance or institutional dimension.

Policy capacity and the adaptive capacity wheel are not competing answers to the same question. They differ in unit of analysis, and the difference determines what each can diagnose. The ACW assesses whether an institutional regime enables the adaptive capacity of a society. Its unit is the governance arrangement in aggregate, and its dimensions—variety, learning, leadership, fair governance—are properties of a system of rules and relationships. This is appropriate for asking whether a national or sectoral governance regime supports adaptation. It is less suited to asking whether a particular organization can execute particular functions, because its categories do not decompose into organizational competences. This distinction matters for adaptation practice.

An ACW assessment of the Western Upper Peninsula would return a regime-level judgment about learning capacity and fair governance. A policy capacity assessment returns an organizational assessment about which competences WUPPDR holds, which it lacks, and at what point in the chain from knowledge to action the failure occurs. The latter is what a regional planning authority can act upon, because it identifies deficits attributable to identifiable institutional arrangements rather than to diffuse governance quality. This paper's contribution relative to Wellstead and Stedman (2015) is correspondingly specific. They argued that policy capacity is relevant to climate adaptation decision-making; they did not operationalize it into an assessment instrument, apply it within a vulnerability assessment, or generate empirical findings from it. This paper does all three, producing a seventeen-code architecture (Table 1) applied to a documentary record, and reporting what that application reveals.

Table 1 presents the integrated conceptual framework combining the IPCC contextual vulnerability framework with the policy capacity framework as an operationalization of adaptive capacity’s institutional dimension. The table specifies the three IPCC CVA components—exposure, sensitivity, and adaptive capacity—their constituent dimensions, and the extension of the adaptive capacity component through the three organizational-level competences of the policy capacity framework.

Table 1

The IPCC Contextual Vulnerability Framework Extended Through the Policy Capacity Framework:  
Integrated Conceptual Framework

| IPCC TAR/AR4<br>CVA Component                                                                         | Dimension                                  | Description                                                                                                                                                                                                                                                                                                                                      |
|-------------------------------------------------------------------------------------------------------|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EXPOSURE                                                                                              |                                            |                                                                                                                                                                                                                                                                                                                                                  |
| Exposure                                                                                              | Climate Stressors                          | The presence and degree of climate-related stressors to which the region is subject, including temperature variability, changes in precipitation patterns, lake-effect snowfall, and shifting seasonal dynamics driven by Lake Superior's hydrological properties.                                                                               |
|                                                                                                       | Extreme and Compound Events                | The occurrence of extreme weather events and compound hazards, where multiple stressors interact to amplify impacts. Includes flooding, severe storms, and cascading events in which one hazard triggers or intensifies another across interconnected systems.                                                                                   |
| SENSITIVITY                                                                                           |                                            |                                                                                                                                                                                                                                                                                                                                                  |
| Sensitivity                                                                                           | Socioeconomic Susceptibility               | The degree to which socioeconomic conditions predispose the region to harm from climate stressors. Includes household income levels, energy burden rates, poverty, food insecurity, demographic aging, and dependence on climate-sensitive economic sectors such as health, forestry, mining, and tourism.                                       |
|                                                                                                       | Infrastructure Susceptibility              | The degree to which aging or inadequate infrastructure amplifies exposure to climate impacts. Includes the condition and redundancy of transportation, energy, water, and communications infrastructure, with particular attention to geographic isolation and rural service gaps.                                                               |
|                                                                                                       | Intersectional and Compounding Sensitivity | The interaction effects among multiple sensitivity factors that together produce vulnerability pathways more severe than any single factor alone. High energy costs, an aging population, low health service density, and economic precarity compound one another, creating cascading susceptibilities that cross-cutting analysis must capture. |
| Adaptive Capacity: Conventional CVA Dimensions as recognized in the IPCC framework and CVA literature |                                            |                                                                                                                                                                                                                                                                                                                                                  |
| Adaptive Capacity                                                                                     | Policy Responses and Legislation           | The existence of formal policy instruments, legislation, and planning mandates that authorize and direct adaptation action.                                                                                                                                                                                                                      |
|                                                                                                       | Resource Availability and Distribution     | The availability of financial and technical resources to support adaptation. Includes federal and state adaptation funding streams, grant mechanisms, and equity dimensions of resource allocation.                                                                                                                                              |
|                                                                                                       | Human Capital                              | The skills, technical expertise, and knowledge assets available to support adaptation planning and implementation.                                                                                                                                                                                                                               |

| IPCC TAR/AR4<br>CVA Component                                       | Dimension                             | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------------------------------------------------------------|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Policy Capacity Framework Extension</b>                          |                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Adaptive Capacity: Policy Capacity Extension (Organizational Level) | Analytical Capacity (Codes: AC1–AC5)  | The organizational ability to gather, process, and use climate and vulnerability information for planning and decision-making. Encompasses access to technical expertise and climate science (AC1); institutionalized data systems and GIS infrastructure (AC2); systematic vulnerability monitoring protocols (AC3); an evidence-based planning culture (AC4); and the constraints that limit these capabilities in practice (AC5). In remote rural planning organizations, analytical capacity is frequently constrained by the research-practice gap: the absence of institutional mechanisms to translate available scientific knowledge into actionable planning intelligence.                                                                                                                      |
|                                                                     | Operational Capacity (Codes: OC1–OC6) | The organizational ability to implement, manage, and coordinate climate adaptation programs and activities. Encompasses funding stability and the resource base for sustained planning (OC1); dedicated staffing for adaptation functions (OC2); program implementation ability (OC3); inter-agency coordination mechanisms (OC4); performance tracking systems for adaptation activities (OC5); and the operational constraints that limit these functions (OC6). In remote rural contexts, operational capacity is characteristically shaped by what Carson and Wellstead (2015) term “government with a cast of dozens”: generalist staff simultaneously managing multiple planning mandates without dedicated adaptation resources.                                                                  |
|                                                                     | Political Capacity (Codes: PC1–PC6)   | The organizational ability to build stakeholder support, sustain adaptation commitments across political cycles, and engage affected communities in governance processes. Encompasses institutional authority and planning mandate (PC1); formal stakeholder engagement mechanisms (PC2); access to state and federal decision-makers (PC3); network position and inter-institutional relationships (PC4); inclusion of tribal nations and marginalized communities as co-equal participants (PC5); and the political constraints affecting commitment durability (PC6). Political capacity is the dimension through which justice concerns are most directly embedded in institutional adaptive capacity: failure at PC5 and PC6 constitutes both a governance gap and a recognitional justice deficit. |

## 2.4 Why the Policy Capacity Lens Advances the IPCC Framework

Climate vulnerability assessment scholarship has converged over the past two decades on contextual approaches that situate biophysical exposure within socioeconomic conditions, with the IPCC's TAR/AR4 formulation of vulnerability as a function of exposure, sensitivity, and adaptive capacity emerging as the dominant framework (IPCC, 2001; 2007; Adger, 2006; O'Brien et al., 2007; Smith &

Diedrich, 2024). Of these three components, however, adaptive capacity remains the least developed analytically. Conventional operationalizations proxy it through general structural characteristics such as resource availability, human capital, ecological conditions, and the nominal presence of institutional arrangements (Engle, 2011; Gupta et al., 2010; Brooks et al., 2005).

These proxies establish whether the conditions for adaptation nominally exist; they do not establish whether the institutions formally charged with adaptation possess the competence to act. The consequence is a body of assessments that describe vulnerability accurately but produce findings without pathways. Where an assessment cannot specify whether the responsible authority holds the analytical, operational, and political competence to translate vulnerability knowledge into adaptation action, its recommendations rest on an untested assumption of institutional readiness. This limitation is most consequential in remote rural regions, where planning authorities frequently operate with constrained staffing, budgets, and data infrastructure (Carson & Wellstead, 2015).

The IPCC contextual vulnerability framework operationalizes vulnerability as  $V = f(E, S, AC)$ , where  $E$  is exposure,  $S$  is sensitivity, and  $AC$  is adaptive capacity. Conventional CVA practice treats  $AC$  primarily as a socioeconomic property: the financial, human, and technological resources available to a system. The policy capacity framework reframes  $AC$ 's institutional dimension across two axes: the type of governance competence required (analytical, operational, political) and the scale at which that competence must be present (individual, organizational, systemic). For this study, the focus is on the organizational level in assessing the policy capacity of the WUPPDR.

Three implications follow. First, the policy capacity framework enables CVAs to produce findings that are directly actionable for governance reform: rather than recommending "increase adaptive capacity," an integrated assessment can specify that the WUP needs a formalized MTU–WUPPDR data-sharing agreement. Second, the framework enables cross-case comparison of institutional adaptive capacity across different remote rural regional planning organizations, testing whether the constraints identified in WUPPDR are idiosyncratic or structural. Third, and most importantly for justice scholarship, the framework makes visible a crucial equity mechanism that conventional CVA misses: when institutional adaptive capacity fails at the organizational levels, the communities bearing the greatest exposure and sensitivity are also those least likely to see effective adaptation action, and this distributional pattern is a product of governance failure, not merely resource scarcity.

## 3.0 Materials and Methods

### 3.1 Case Selection

Michigan's Western Upper Peninsula (WUP) is selected as the sub-unit of analysis for the vulnerability assessment because it represents a critical case (Flyvbjerg, 2006; Yin, 2018) for studying the intersection of rural climate and energy vulnerability, and policy capacity. The WUP's geographical isolation, extreme weather exposure, aging infrastructure, high energy costs, and limited institutional

resources create conditions where the interplay between biophysical and socioeconomic vulnerabilities and governance capacity is particularly pronounced. These features are shared by many remote, rural, and resource-dependent communities globally, including parts of Appalachia, northern Maine, rural Alaska, and remote communities in Australia and Canada (Carson & Wellstead, 2015), providing grounds for analytical generalizability.

Michigan's Western Upper Peninsula, consisting of the counties of Baraga, Gogebic, Houghton, Iron, Keweenaw, and Ontonagon, is characterized by its proximity to Lake Superior, rugged terrain, dense forests, and sparse population (Tiwari et.al., 2023; Ketola et.al., 2025). The Western Upper Peninsula Planning and Development Region (WUPPDR) is a federally designated Economic Development District (EDD) and regional planning organization serving the six-county WUP region, established under the Public Works and Economic Development Act and funded primarily by the U.S. Economic Development Administration (WUPPDR, n.d). As the primary regional planning and coordination body, WUPPDR's core planning functions center on its Comprehensive Economic Development Strategy (CEDS), focusing on economic development and includes recreation, housing, hazard planning, and transportation (Lu & Carter, 2023; Mayer, 2017). WUPPDR is selected as the institutional unit of analysis for three reasons: it is the organizational actor most directly responsible for translating vulnerability knowledge into adaptation planning at the regional scale; it exemplifies the governance conditions that Carson and Wellstead (2015) identify as characteristic of remote rural jurisdictions or sparsely populated regions; and focusing on WUPPDR enables a clearly bounded, methodologically rigorous assessment of institutional adaptive capacity that can be compared across other regional planning organizations in analogous governance contexts.

## **3.2 Research Design**

This chapter employs a two-phase qualitative methodology that reflects the two-component structure of the research question. The two phases are analytically distinct on purpose but theoretically integrated through the IPCC TAR/AR4 framework: Phase 1 establishes what climate vulnerabilities WUP faces and covers the contextual vulnerability assessment, i.e., the biophysical and socioeconomic dimensions of vulnerability for the six-county WUP region through a systematic literature review. Phase 2 assesses whether the primary governance actor responsible for translating that knowledge into action possesses the institutional capacity to do so by employing a directed qualitative content analysis of the WUPPDR's primary organizational documents, using the policy capacity framework as the analytical coding schema. Together, they produce findings that neither phase could generate alone.

## **3.3 Phase 1: PRISMA-Compliant Systematic Review—Search Strategy and Document Selection**

Phase 1 employs a systematic review following PRISMA 2020 reporting guidelines (Page et al., 2021) to identify, screen, and synthesize documents relevant to climate vulnerability in Michigan's Western Upper Peninsula. The PRISMA 2020 framework does not restrict inclusion to peer-reviewed literature; it requires transparent and reproducible search and selection procedures regardless of source type. Consistent

with this, the systematic review incorporates peer-reviewed scholarship, grey literature, government and institutional reports, and regionally focused academic publications and media reports, applying the same structured screening protocol across all source types. This approach is methodologically appropriate here: the chapter's vulnerability assessment requires a comprehensive, auditable synthesis of existing evidence on the WUP's biophysical and socioeconomic conditions, and the most relevant evidence base for a remote rural region beyond academic or peer-reviewed publications includes government agency reports, regional planning documents, and institutional publications that do not appear in academic databases but carry substantial empirical and policy authority. The systematic review ensures that vulnerability findings are grounded in the full available body of relevant evidence rather than an unsystematic selection, with transparent procedures enabling the reader to assess the completeness and basis of the review. It is important to note that the PRISMA protocol governs the identification, screening, and selection of evidence for the vulnerability assessment (Phase 1); Phase 2's institutional assessment draws on WUPPDR's primary organizational documents retrieved through targeted collection, which is reported separately below.

The search was conducted across five sources in three tiers as referenced in Table 3. Two academic databases were searched: Google Scholar and the Michigan Digital Commons. The Michigan Digital Commons was searched as a second source because it archives regionally focused academic scholarship that does not always appear in broader databases, including theses, working papers, and applied research produced by Michigan Technological University and other Michigan institutions that specifically address the WUP region. Government and institutional report repositories constituted the third source, targeting NOAA, the EPA, the Michigan Department of Environment Great Lakes and Energy (EGLE), Michigan.gov, Census Reporter, Great Lakes Integrated Sciences and Assessment (GLISA), National Weather Service, and Data USA and Michigan Technological University's Regional Climate Resilience Center. The Google search engine was the fourth source used in reaching regional media reports and online publications from news portals like Rural Insights, Keweenaw Reports, Upper Michigan Source, Detroit Free Press, and other online publications. The WUPPDR's website was the fifth source used to gather data for the organization's adaptive capacity using the policy capacity framework.

Tier 1 comprised peer-reviewed scholarly publications and academic publications retrieved from Google Scholar and the Michigan Digital Commons that specifically address the WUP region. Tier 1 sources provide the primary scientific and scholarly foundation for the analysis. Tier 2 comprised government and institutional reports from agencies and regional organizations with direct mandates relevant to the WUP's climate conditions and governance landscape. Tier 3 comprised local media reports and community-level documents, including local news coverage of climate-related events, community organization publications, and publicly available materials from local government bodies in the six-county WUP region. These sources primarily serve to triangulate and contextualize patterns identified through Tier 1 and Tier 2 sources, providing locally embedded perspectives on vulnerability conditions and community-level responses that may not be fully captured in academic or governmental documentation.

Boolean operators were used to construct search strings that captured relevant literature, thereby minimizing irrelevant results. Search terms were applied consistently across all sources using Boolean combinations: (“Michigan” OR “Michigan’s Western Upper Peninsula” OR “Great Lakes Region” OR “Western Upper Peninsula” OR “Upper Peninsula Michigan”) AND (“climate” OR “vulnerability” OR “adaptation” OR “resilience” OR “energy” OR “infrastructure” OR “hazards” OR “Climate Hazards” OR “floods” OR “socioeconomic vulnerabilities” OR “adaptation planning” OR “Demographic Information” OR “WUPPDR”). Searches were conducted between May 2024 and May 2026. Details on the PRISMA flow diagram can be found in Appendix B and the summary of literature search, Appendix B.

For the second part of the analysis, WUPPDR’s own primary organizational documents, including its Comprehensive Economic Development Strategy (CEDS) report, the Regional Prosperity Plan, meeting minutes, and other publicly available organizational communications, were assembled separately through direct retrieval from WUPPDR’s website. These documents (n = 65) are not indexed in searchable academic or governmental databases and therefore were not identified through the systematic review search protocol. Their retrieval followed a targeted organizational document collection procedure appropriate to the institutional case study component of the study. Within the tiered corpus, they are classified as institutional documents in Tier 2.

### **3.4 Phase 2: Directed Qualitative Content Analysis**

Phase 2 employs directed qualitative content analysis (Selvi, 2019; Mayring, 2014; Hsieh & Shannon, 2005) to assess WUPPDR’s institutional adaptive capacity. The designation of this phase as “directed” is methodologically precise: the policy capacity framework (Wu et.al., 2015; Wellstead & Stedman, 2015) provides the priori coding schema, with the three policy capacity competences—analytical, operational, and political—and their associated indicator codes (AC1–AC5; OC1–OC6; PC1–PC6) derived directly from the framework before the first coding round. This is analytically distinct from Phase 1’s systematic review, in which content analysis is used to synthesize evidence about a phenomenon (WUP’s climate vulnerability) reported across documents. In Phase 2, the documents themselves, WUPPDR’s own primary organizational records, are the objects of analysis: the analysis examines what those documents reveal about WUPPDR as an institution, not what they report about regional conditions.

The coding scheme was developed in two stages. In the first stage, the primary coding categories were derived deductively from the IPCC TAR/AR4 framework. The three components of the IPCC contextual vulnerability framework: exposure, sensitivity, and adaptive capacity, served as the primary categories for Phase 1 of this analysis. With regard to the second phase of the analysis, the three policy capacity competences: analytical, operational, and political were used.

For the institutional competence dimension specifically, the named indicator codes presented in Table 1 were derived from the policy capacity framework’s three competence types at the organizational level: AC1 (access to expertise), AC2 (data infrastructure), AC3 (data practices), AC4 (evidence-based planning culture), and AC5 (analytical constraints) for analytical capacity; OC1 (resource availability), OC2 (staffing capacity), OC3 (implementation ability), OC4 (coordination), OC5 (accountability systems), and

OC6 (operational constraints) for operational capacity; and PC1 (institutional authority), PC2 (stakeholder engagement), PC3 (access to decision-makers), PC4 (network position), PC5 (inclusion of marginalized groups), and PC6 (political constraints) for political capacity.

For the exposure, sensitivity, and adaptive capacity dimensions, coding proceeded simultaneously across all three tiers. Within each primary category, subcodes were allowed to emerge inductively from the data during the first coding round. For example, within exposure, the compounding and cascading nature of WUP hazards emerged inductively from the pattern of co-occurring hazard references across documents, it was not predetermined by the IPCC framework, which treats exposure categories separately. Similarly, within sensitivity, the compounding relationship between energy costs, aging population, and low health service density emerged inductively as a recurring cross-document pattern rather than as a framework-specified subcode. These inductively derived subcodes were recorded in analytical memos during the first round and formalized into the coding scheme before the second round.

The second coding round served three purposes: checking consistency of code application across documents, incorporating the inductively identified subcodes from the first round, and conducting cross-tier triangulation. Where all three tiers converged on a pattern—for example, the characterization of energy costs as significantly above state and national averages—the finding is reported as corroborated. Where WUPPDR's characterizations diverged from Tier 1 scholarship or Tier 3 community sources, the divergence was treated as an analytically significant finding. For the institutional adaptive capacity assessment, the second round cross-checked institutional capacity findings from WUPPDR's organizational documents (Tier 2) against supplementary observations in other Tier 2 and 3 describing WUPPDR's governance context and partner relationships, and against Tier 1 scholarly literature on rural planning capacity constraints.

## **4.0 Results**

### **4.1 Vulnerability Profile of Michigan's Western Upper Peninsula**

#### **Exposure**

The Great Lakes, and Lake Superior in particular, emerged as the primary driver of the WUP's climate exposure. The hydrological properties of Lake Superior shape the region's weather patterns, driving lake-effect snowfall, extreme precipitation events, temperature variability, and coastal hazards including flooding and erosion. The Father's Day Flood of 2018, which caused catastrophic damage in Houghton County, illustrates the severity of extreme precipitation events in the region and the vulnerability of aging infrastructure to climate-related hazards. The data consistently showed that the WUP's exposure is not limited to single hazard types but involves compound and cascading risks where one climate stressor amplifies the effects of others. Common hazards identified in the analysis included long winters, heavy snowfall, heavy rainfall, intense storms, rising temperatures, flooding, and shoreline erosion.

## **Sensitivity**

Sensitivity analysis revealed socioeconomic conditions that make the region susceptible to climate impacts. Key sensitivity factors included: challenged energy systems with high electricity prices significantly above state and national averages; the region's rurality and geographical isolation limiting access to services; aging infrastructure vulnerable to extreme weather; an aging population thereby increasing susceptibility to extreme weather conditions; low health service density limiting healthcare access during climate-related emergencies; food insecurity linked to limited agricultural capacity and supply chain vulnerabilities; and economic dependence on climate-sensitive sectors. These sensitivity factors do not operate in isolation; they compound one another, creating cascading vulnerability pathways.

Over the years, extractive industries like mining have also left the region with remnants of environmental degradation and impacts on health. While these socio-economic conditions predispose the region to climate stressors, the consequence of the region's exposure on critical infrastructure and economic activities also makes the region vulnerable. The impact of extreme weather events on businesses in the region has also accounted for revenue loss of millions of dollars with forty-three (43) businesses in Gogebic and Ontonagon counties reportedly losing a combined revenue of 3.1 million dollars as a result of extreme weather events in the region. Hunting and fishing activities, including inadequate production of phytoplankton, and local tourism activities are also impacted by the extreme weather events thereby impacting the local economy.

### **Adaptive Capacity: Conventional Dimension**

Socioeconomic conditions significantly constrain the WUP's adaptive capacity. Inadequate and aging infrastructure limited financial resources, and insufficient funding support for disaster or adaptation planning were observed across data sources clearly articulated in the sections above. Results from a local survey also indicated that local government representatives from the Upper Peninsula were less likely to discuss issues of unmet needs among their residents as compared to their Lower Peninsula counterparts. Low household incomes and high energy costs limit individual and household-level adaptive capacity, reducing the financial buffers that allow residents to invest in weatherization, relocate from flood-prone areas, or manage climate-related health costs. The analysis also identified important adaptive capacity assets. The presence of Michigan Technological University provides a concentration of scientific and technical human capital unusual in a remote rural region. Community organizations, local agencies, and emerging partnerships between tribal nations, academia, and regional planning bodies represent social capital assets that can be mobilized in support of adaptation efforts.

## **4.2 WUPPDR's Analytical Capacity**

WUPPDR's analytical capacity is partially developed and constrained by a significant research-practice gap. Evidence coded across AC1, AC2, and AC4 in the data confirms that WUPPDR references partnerships with Michigan Technological University and acknowledges the DOE-funded Regional

Climate Resilience Center as a knowledge resource, and that some planning language draws on regional climate projections. However, AC3 and AC5 codes reveal the limits of these assets: WUPPDR's own documents contain no systematic protocol through which academic vulnerability findings are regularly synthesized into planning priorities or adaptation investment decisions, no internal data collection systems dedicated to tracking local vulnerability indicators over time, and explicit acknowledgements of gaps in localized climate impact data. The translation of MTU's research outputs into actionable policy intelligence remains informal and episodic rather than institutionalized.

## **4.3 WUPPDR's Operational Capacity**

WUPPDR's operational capacity is significantly constrained across OC1, OC2, OC4, and OC6. OC2 codes reveal a small staff that must simultaneously manage economic development planning, transportation planning, housing programs, environmental resilience, grant administration, and community development without dedicated climate adaptation personnel, precisely the "government with a cast of dozens" that Carson and Wellstead (2015) identify as a structural constraint on policy capacity in remote rural jurisdictions. OC1 codes reveal heavy dependence on federal EDA grants and project-specific funding, with limited base funding for ongoing planning functions. OC4 codes document that inter-agency coordination for adaptation planning, while present through informal relationships, is ad hoc rather than formalized. OC5 codes find no dedicated performance tracking for climate adaptation activities, and OC6 codes confirm chronically underfunded infrastructure maintenance.

## **4.4 WUPPDR's Political Capacity**

WUPPDR's political capacity is mixed across the PC codes. PC1 codes confirm that WUPPDR holds formal planning authority as the federally designated regional planning organization. PC3 codes document engagement with EGLE and EDA on resilience and hazard mitigation grant activities. PC4 and PC5 showed evidence of engagement with academic institutions like the Michigan Technological University, local partners and tribal nations including the Keweenaw Bay Indian Community and the Lac Vieux Desert Band of Lake Superior Chippewa. Other local partners include organizations under the Chambers of Commerce and Convention and Visitors Bureaus (CVBs), Community Development partners, Economic and Business Development organizations, other state planning agencies, educational institutions, and foundations. These local partners are engaged as co-equal governance partners in WUPPDR's adaptation planning activities. However, PC6 codes predominate: WUPPDR's own planning documents reveal that competing priorities are framed with greater planning urgency than climate adaptation. The Father's Day Flood of 2018 created a policy window that elevated political attention to climate hazards, with adaptation commitments from this window institutionalized into WUPPDR's core planning priorities including the development of rural hazard resilience tools (RHRT) with local partners.

## **5.0 Discussion: Institutional Capacity as an Equity Dimension**

The most significant contribution of this study's integrated framework lies in its treatment of adaptive capacity. By operationalizing adaptive capacity through the policy capacity framework (Wu et.al., 2015), the analysis moves beyond the conventional CVA practice of assessing adaptive capacity primarily through structural proxies. The findings reveal that the WUP's adaptive capacity deficit is not merely a function of limited financial resources, as conventional CVA might suggest, but is compounded by systematic governance constraints within WUPPDR that would prevent effective adaptation action even if socioeconomic resources were substantially improved. The WUP case illustrates the distinction Engle (2011) draws between latent and realized adaptive capacity vividly: the region possesses meaningful adaptive assets in the form of MTU's research capacity, tribal governance institutions, and community organizations, yet these assets are not effectively translated into adaptation action because WUPPDR lacks the analytical infrastructure, operational capacity, and political conditions necessary to mobilize them.

The connection between adaptive capacity and justice operates through this governance gap in ways that conventional CVAs miss. When WUPPDR's institutional adaptive capacity is constrained, the communities most exposed and sensitive to climate impacts, who are disproportionately low-income, elderly, geographically isolated, and socially marginalized, are also the communities least likely to see effective adaptation action. WUPPDR lacks the analytical capacity to document their specific vulnerabilities systematically, the operational capacity to direct adaptation resources toward their needs reliably, and the political capacity to sustain their participation in planning processes over time. The analysis showed the inclusion of various local stakeholders in regional planning adds a procedural and recognitional justice dimension: the communities most affected by WUPPDR's governance failures seem represented in the processes through which WUPPDR makes adaptive governance decisions amid existing constraints.

This paper has advanced the argument that climate vulnerability assessment requires a theoretically complete treatment of adaptive capacity, one that moves beyond the conventional measurements of vulnerability in climate vulnerability studies, but the institutional and governance conditions that determine whether a system's adaptive potential is ever realized. The policy capacity framework provides the systematic diagnostic categories; analytical, operational, and political competences at individual, organizational, and systemic levels (for this study, the organizational level), necessary to assess those conditions empirically. This integration represents a theoretically grounded extension of the IPCC TAR/AR4 framework, not an addition from outside it. Where adaptive capacity scholarship has long recognized the importance of institutions, policy capacity scholarship provides the vocabulary to assess those institutions in ways that produce governance-oriented, actionable recommendations.

## 6.0 Conclusion

The empirical findings demonstrate that the WUP faces compound vulnerabilities driven by Lake Superior's climatic influence, the socioeconomic conditions of a remote post-extraction rural region, and systematic governance constraints within WUPPDR across the analytical, operational, and political

dimensions of institutional adaptive capacity. WUPPDR's limited in-house climate analytics, its small and multi-tasked staff, its grant-dependent and short-horizon funding structure, and the need for a sustained and well-resourced engagement of partners in adaptation planning together constitute a governance gap that is analytically distinct from, and compounding of, the region's biophysical and socioeconomic vulnerabilities. Recommendations are organized according to the three policy capacity dimensions: investment in systematic vulnerability data collection and institutionalized MTU–WUPPDR data-sharing agreements (analytical capacity); creation of a dedicated regional climate adaptation coordinator position and multi-year funding commitments (operational capacity); and structured engagement with tribal nations as co-equal governance partners and targeted outreach to low-income and elderly residents (political capacity).

These findings are transferable to other remote, rural, resource-dependent regions whose primary regional planning organizations face analogous governance conditions, including regions in Appalachia, rural Alaska, northern Maine, and remote areas of Australia and Canada. The pattern identified in the WUPPDR case, meaningful socioeconomic and knowledge assets coexisting with systematic governance constraints that prevent their effective deployment toward adaptation, is consistent with Carson and Wellstead's (2015) findings in remote Australia and Wellstead and Stedman's (2015) findings in Canada, suggesting that governance-based constraints on adaptive capacity are a structural feature of remote rural regional planning organizations rather than a WUPPDR-specific pathology.

## **Declarations**

## **Author Contribution**

Author M.A wrote the main manuscript, developed the research, and reviewed and Author C.S supervised, and reviewed.

## **Data Availability**

All data supporting the findings of this study are available within the paper and its Supplementary Information.

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Table 3

Table 3 is not available with this version

Figures

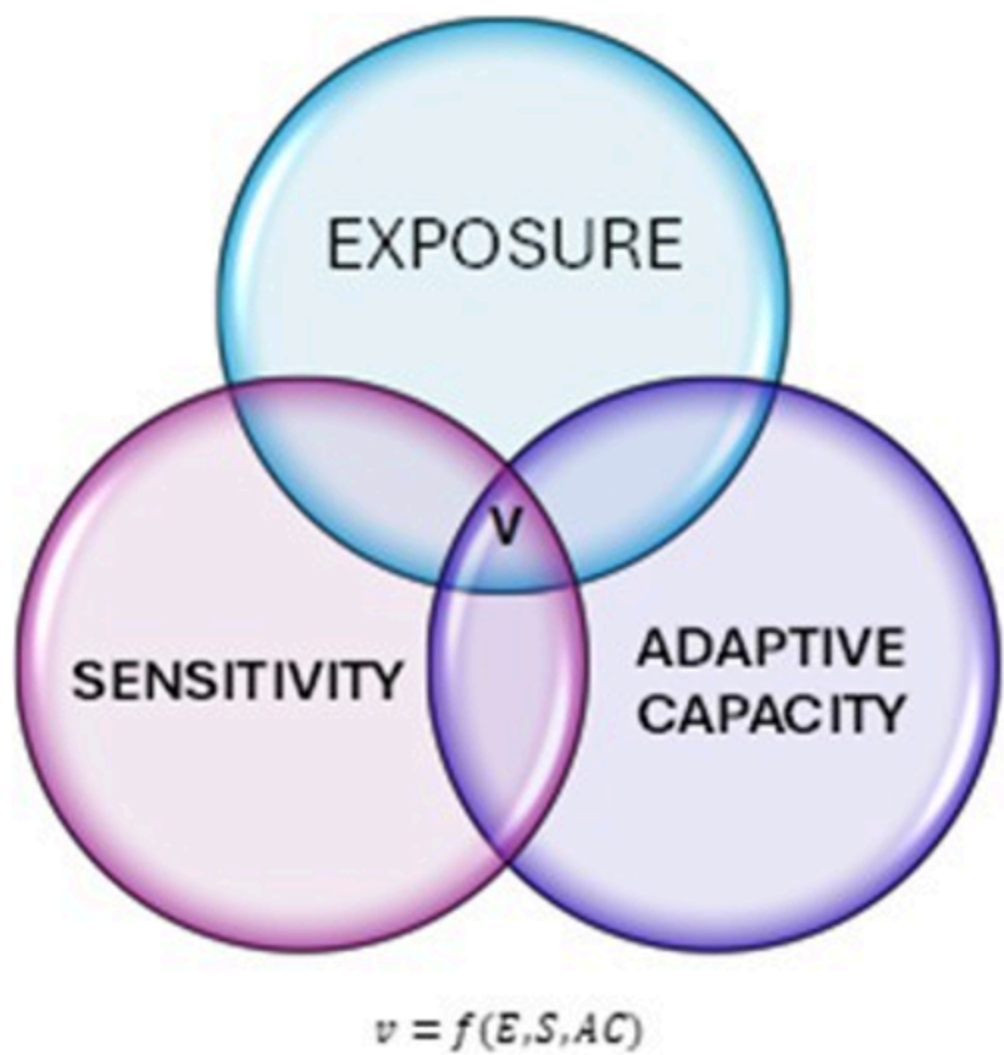


Figure 1

Figure 2.1: TAR/AR4 CVA Framework

## Supplementary Files

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