

Perspective

Water Does Not Negotiate: Hydrologic Legitimacy and the Institutional Future of Rural and Regional Development

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ABSTRACT: Rural and regional development is often framed as an economic or service-delivery challenge, whereas water is treated as infrastructure or compliance. That separation is analytically convenient but operationally false. Hydrologic regime reality and water quality dynamics are non-negotiable physical constraints that quietly determine what rural communities can credibly promise, finance, permit, and defend over time. At the same time, many rural water systems and watershed programs operate within institutional arrangements that were not designed for slow hydrologic lags, cross-boundary pollutant legacies, or the legitimacy demands created by uneven exposure to risk. This perspective, therefore, suggests that rural development should be recentered on water governance: the coupled system of hydrologic processes, water-quality legacies, and organizational capabilities that together produce reliability, safety, and trust. Recent primary research is synthesized showing that (1) legacy nutrients and ecosystem memory create multi-decade time lags that can invalidate short political or funding cycles, (2) rural and small system compliance and exposure burdens remain structurally unequal, and (3) adaptive governance capacity depends on institutional fit, partnerships, and policy and planning choices that are themselves socially patterned. A practical agenda for scholars and practitioners is proposed: build hydrologic legitimacy by aligning project claims with hydrologic time, making governance fit explicit across scales, and treating organizational change capacity as core water and rural development infrastructure. The resulting framework provides decision-makers with operational guidance for aligning development claims, governance structures, and investments with hydrologic constraints that ultimately determine long-term feasibility and trust. Rather than presenting new empirical results, this Perspective synthesizes evidence from hydrology, water quality, governance, and organizational change to conceptually reframe rural and regional development around hydrologic legitimacy as a governing constraint.

Keywords: Rural development; Socio-hydrology; Legacy nutrients; Drinking water compliance; Organizational change; Hydrologic legitimacy; Adaptive governance; Water system resilience



1. Introduction: Rural Development Is a Hydrological Legitimacy Problem

Rural development discussions most often center on jobs, roads, broadband, and clinics, with water and sanitation treated as a technical backdrop. However, in many places, the binding constraint on development is not the absence of a plan; it is the inability to sustain credible water services, safe water quality, and adequate water quantity over time. When a town cannot reliably deliver drinking water, maintain wastewater compliance, or defend its watershed from accumulating contamination, every downstream promise becomes fragile [1]. In practice, water becomes the hidden arbiter of what is financeable, insurable, and politically defensible.

Water functions as a governing constraint for both urban and rural development; however, rural systems face heightened legitimacy risk because they typically operate with fewer institutional redundancies, more limited fiscal capacity, and narrower technical staffing, amplifying the consequences of hydrologic misalignment. Because hydrologic processes operate at watershed and aquifer scales, water governance in rural areas is inherently regional, linking upstream land use decisions, downstream infrastructure costs, and cross-jurisdictional development outcomes. Recent national analyses underline why this is not a marginal issue. In the United States, households face a geographically clustered, socially unequal water crisis, characterized by incomplete plumbing and regulatory noncompliance, with rural and disadvantaged communities bearing disproportionate burdens [2]. Recent work shows that disparities in drinking water quality indicators persist across contaminants and violation measures, with especially acute disparities for some demographic groups and smaller systems [3,4]. Studies focused on compliance similarly show inequities in health-based violations and limitations in regulatory assessment frameworks that do not explicitly incorporate equity [5]. These patterns matter for rural development because they shape legitimacy. If residents experience water risk as persistent, uneven, and poorly explained, trust erodes, and opposition to new projects rises. In other words, the perceived fairness and competence of water governance are pivotal factors that can influence the social license required for the construction or modification of infrastructure or systems.

A second driver is physical time. Watersheds do not reset on election cycles. Nutrient legacies and storage in soils, groundwater, and sediments can create long lags between management actions and observable improvements, and those lags can be significant enough to make honest success narratives difficult to sustain [6–9]. In lakes, internal loading and sediment feedback can produce recovery times measured in decades, even after external loading declines, posing a direct challenge to short-term performance reporting [10,11]. When organizations promise rapid water-quality benefits that hydrology cannot deliver, the eventual gap is not merely a scientific error. It is a legitimacy failure that can poison future collaboration.

This perspective challenges the assumption that rural and regional development can be planned independently of hydrologic regimes. In this framing, hydrologic regimes and persistent inequalities in water quality are not peripheral considerations, but governing conditions that ultimately determine what rural communities can credibly promise, finance, and sustain over time. Drawing on recent primary research across socio-hydrology, water quality, drinking water compliance, and organizational change, it synthesizes evidence showing that legacy effects, hydrologic time lags, and institutional misfit routinely undermine development claims framed around short-term performance. The outcome is a reframing of rural development as a problem of hydrologic legitimacy, arguing that institutions that promise outcomes water systems cannot deliver ultimately erode trust, equity, and long-term viability. This reframing is especially timely as increasing water scarcity, aging infrastructure, and unequal exposure to water quality risk are making the consequences of misaligned development promises more visible and more consequential for rural communities. This Perspective does not present new empirical analyses or quantify causal impacts; rather, it synthesizes recent evidence to articulate transferable principles whose implementation and outcomes

will necessarily depend on local hydrologic conditions, institutional arrangements, and regulatory contexts. This paper presents a synthesis-based perspective, asserting that hydrologic legitimacy serves as a critical framework for reconciling rural and regional development claims with hydrologic realities amidst escalating challenges related to water access, reliability, and equity. It also emphasizes the need for further empirical, policy, and practice-oriented research, rather than simply presenting a standalone empirical demonstration.

2. The Hydrologic Constraints Rural Development Keeps Misreading

Hydrologic systems impose constraints that are simultaneously technical and political because they structure who bears risk, when benefits arrive, and what evidence is credible. Socio-hydrologists have argued for years that water resources policy outcomes are co-produced by human decisions and hydrologic response, including feedbacks that can generate unintended consequences and path dependence [12]. That framing is especially relevant for rural regions, where land-use change, resource extraction, agricultural intensification, and infrastructure disinvestment can have long-lasting impacts on water quality [1,6]. Indeed, what often appears to be an emergent water-quality failure is often a delayed expression of past choices.

Legacy effects are the clearest example. Modeling work shows that time lags in watershed response can be large enough that interventions may not produce measurable load reductions for years or decades, even when implementation is real and sustained [8]. For example, in the case of phosphorus, watershed-scale models demonstrate that historic accumulation can continue to degrade water quality over long horizons and complicate policy expectations built on short-term mass-balance logic [9,13]. In lentic systems, mechanistic modeling indicates that internal feedbacks can delay attainment of phosphorus criteria, with median lag times of decades across many lakes [10]. Empirical and modeling studies in eutrophic lakes further show ecosystem memory, in which sediment nutrient interactions prolong recovery, meaning the system effectively remembers prior loading and resists rapid change [11]. These are not academic nuances. They directly affect how rural communities should structure commitments, grants, and accountability.

The practical implication is inconvenient: rural development programs that treat water quality improvements as quick wins often design reputational failure into the project. A more honest approach is to commit to trajectories rather than endpoints, with explicit hydrologic timelines and monitoring designs that can detect early directional change even when full recovery is slow. That is not a call for lower ambition. It is a call for hydrologically defensible ambition. However, there is also a scaling problem. Hydrological processes cross jurisdictional boundaries, but governance often does not. Research on institutional fit emphasizes that misalignment between ecological scales and institutional structures can undermine sustainability, and recent regional work quantifies aspects of vertical fit as a measurable governance challenge rather than a vague concept [14]. In rural contexts, this misfit is common: upstream land use decisions drive downstream treatment costs and health risks, while funding and authority remain fragmented. The result is predictable conflict over who should pay, who should change behavior, and who gets to define acceptable risk. Although the severity of water stress is shaped by climate regime and level of development, legitimacy outcomes arise from interactions among hydrologic stressors, legacy conditions, institutional fit, and historical investment patterns rather than from climate or development status alone.

3. Water Quality and Drinking Water Systems as a Legitimacy Arena

Rural water problems are not only about piping infrastructure. Rural water challenges are about whether institutions can demonstrate competence and fairness under constraints. The empirical literature increasingly indicates that water hardship and water quality burdens are shaped by place and power. At the national scale, Mueller and Gasteyer [2] documented an unequal household water crisis, showing that incomplete plumbing and water quality challenges cluster socially and regionally. Follow-up work expanded the evidence base across multiple drinking water quality indicators and found systematic

disparities associated with demographic composition and system characteristics, including size [4]. Regarding compliance, Allaire and Acquah [5] showed disparities in health-based violations and argued that standard regulatory practices can fail to detect or address equity dimensions central to real-world harm. Collectively, these studies imply that rural development efforts that ignore water equity are not just incomplete; they are likely to misidentify the authentic sources of resistance and distrust.

Legitimacy is therefore shaped not only by outcomes such as compliance or water quality metrics, but also by decision-making processes, including transparency, participation, consistency, and perceived fairness in how water-related decisions are made and implemented. Empirical research in community water management shows that perceptions of procedural justice strongly influence acceptance of scarcity policies, even when the technical case is strong [15]. This relationship matters for rural drinking water and watershed projects because many interventions require behavioral change, rate increases, consolidation, or new enforcement. If communities perceive decisions as imposed, opaque, or biased, technical excellence will not save the program [16]. Conversely, effective procedural mechanisms can foster sustained cooperation, even in the face of significant challenges. On this basis, it is essential to identify the focal point: hydrologic legitimacy. Here, hydrologic legitimacy is defined as the earned belief that institutions are telling the truth about water constraints, distributing burdens fairly, and building durable capability rather than short-term optics. That belief is not generated by messaging but rather the repeated alignment of claims, measurements, and lived outcomes.

4. Organizational Change Capacity Is Water Infrastructure

A rural water system's most limiting asset is often not treatment capacity. It is organizational capacity: the ability for agency organizations (institutions) to plan, partner, finance, comply, adapt, and learn. Thus, the organizational capacity for change and reinvention is where rural development and organizational change scholarship [17] should meet hydrology more explicitly. One line of evidence comes from partnerships and consolidation. Primary research examining how agencies view partnerships in small water systems shows that partnership formation is motivated by practical capacity constraints and the need to access technical, managerial, and financial resources, but also that incentives and barriers are institutional rather than purely technical [18]. Stated plainly, the path to reliability is frequently organizational restructuring, not just capital replacement. Rural development policy often funds hardware while under-resourcing governance and capacity-building, even though the latter can determine whether the hardware delivers outcomes.

Another line of evidence concerns what resilience actually requires. An extensive empirical assessment of policy and planning for drinking water resilience across 100 US cities demonstrated that resilience is partly a function of municipal policy and planning choices, and that these choices vary systematically across communities and institutions [19]. Although this study primarily focused on urban environments, its fundamental contribution is equally relevant to rural areas, where resilience is cultivated through the interplay of planning and governance frameworks and engineering components. For rural communities, the planning framework is often thin because staff capacity is thin, revenue bases are narrow, and turnover is high. Ultimately, treating organizational change capacity as infrastructure means investing in governance routines, decision protocols, data systems, and partnership mechanisms as seriously as pumps and tanks.

Adaptive governance research reinforces the point. An extensive study of irrigation communities examined how combinations of institutional design principles and contextual factors shape successful governance outcomes, showing that institutional effectiveness is contingent on social and biophysical context [20]. The lesson for rural development is that there is no universal governance template. What matters is whether institutions fit their hydrologic and social contexts and can adapt their rules as conditions change. This adaptive capability is where hydrology can strengthen organizational change practice. Hydrologists and water quality scientists are trained to think in terms of lags, storage, thresholds, and

uncertainty. Those concepts map directly onto organizational change challenges: delayed feedback, hidden stockpiling, nonlinear responses, and the tendency for systems to appear stable until they do not. Rural development programs that embed this systems logic into governance, reporting, and public communication will reduce legitimacy risk and increase the probability of durable buy-in [16].

5. A Research and Practical Agenda for Water-Centered Rural Development

If rural development is to be more than a sequence of funded projects, it requires a coherent operating model that aligns institutional goals and timelines with hydrologic realities, including water availability limits, water-quality constraints, watershed response times, and legacy effects that shape when and how improvements can occur. In this context, six actionable strategies are described (below) that provide clear guidance for the implementation of the development program. While six strategies are presented, they are not intended to be pursued uniformly or simultaneously. Under limited budgets, prioritization should be guided by four considerations: urgency, defined by irreversible hydrologic risk or compliance exposure; dependency, where some strategies (e.g., hydrologic timelines and governance fit) are prerequisites for others; equity risk, where delayed action exacerbates disproportionate harm; and leverage, where modest institutional investments unlock durable system-wide benefits. In practice, strategies that reduce legitimacy risk early, such as aligning development claims with hydrologic time and making governance fit explicit across scales, often yield the greatest return by preventing overcommitment, misallocation, and subsequent project failure.

1. Hydrologic timelines should be required for development claims. If a project asserts water-quality improvement, it should specify the expected lag structure, meaning the anticipated time distribution between management action and observable system response, and the dominant mechanisms of delay, such as nutrient storage in soils, groundwater, or sediments, internal loading in lakes, or slow biogeochemical turnover documented in legacy and recovery research [8–11]. Delineating hydrologic regimes does not imply lengthy written caveats; it enables accountability to be designed around what hydrology can credibly demonstrate in early phases, including directional change in loads or concentrations, reduced variance or system instability, measurable shifts in intermediate process indicators (e.g., source contributions or internal cycling rates), or demonstrable slowing of degradation prior to full recovery.
2. Hydrologic legitimacy must be measured, not just compliance. Although the United States and European Union regulatory frameworks define clear indices and thresholds for determining whether water-quality laws are met, compliance alone cannot capture how risks, recovery timelines, and burdens are distributed or perceived by affected communities. Studies documenting disparities in drinking water quality and violations underscore the need for a legitimacy lens, particularly in rural and small-system contexts [2,4,5]. Rural programs should track distributional indicators and incorporate community-defined acceptability thresholds, because perceived injustice is a predictable failure mode.
3. Operationalizing procedural justice must be a design requirement. Substantial empirical literature demonstrates that perceptions of fairness, transparency, and voice strongly shape acceptance of water scarcity and allocation policies, independent of technical merit [15]. These findings are transferable to rural water governance, where distrust often arises not only from outcomes but also from unclear decision pathways, limited disclosure, and ambiguous accountability. Accordingly, development proposals should explicitly specify who participates in decisions, how authority is exercised, what information is disclosed, and how disputes or appeals are handled. Identifying governance structures is not ancillary documentation; it is a risk-management practice that addresses a well-documented source of institutional failure.
4. Governance must fit explicitly and measurably across scales. Making fit operational requires mapping hydrologic boundaries (e.g., watersheds, aquifers, source-water areas) against institutional authority

boundaries (e.g., utilities, municipalities, regulators) to identify where responsibilities for risk generation, mitigation, and financing diverge. Empirical work on vertical fit demonstrates that misalignment can be treated as a measurable condition rather than an abstract concern, including indicators such as cost shifting between upstream and downstream actors, monitoring blind spots created by jurisdictional fragmentation, or enforcement gaps tied to scale mismatch [14]. Rural development proposals should explicitly document these alignments or misalignments and specify how coordination, shared authority, or compensatory mechanisms will be used to manage them.

5. Organizational capacity building must be treated as fundable infrastructure. Empirical research in small and rural water systems shows that reliability often hinges on institutional arrangements rather than capital assets alone, including access to skilled operators, shared technical services, data and reporting systems, and governance routines that persist beyond individual tenures [18,19]. Funding programs can operationalize this by supporting regional operator pools, shared compliance and monitoring services, inter-utility partnerships, governance modernization, and succession planning alongside physical upgrades. Without such investments, rural systems frequently remain dependent on episodic heroics, or periods of performance sustained by individual dedication, informal workarounds, or crisis response rather than durable institutional capacity, which are fragile, inequitable, and prone to failure when personnel changes or stressors compound.
6. Truth-first narratives must be embedded so that projects survive hydrologic time lags. In water-quality systems, these lags commonly include multi-year to multi-decadal delays between land-management change and observable stream or lake response due to nutrient storage in soils, groundwater, and sediments, as well as delayed ecological recovery driven by internal loading and ecosystem memory [8–11]. Projects frequently fail not because interventions are ineffective, but because funding, reporting, and political cycles reward short-term claims that hydrology cannot substantiate. Removing the incentive to oversell requires aligning performance metrics and public communication with hydrologically defensible signals of progress, such as directional change, reduced variability, or slowed degradation, rather than premature endpoint promises. Where hydrologic response is expected to extend beyond the formal funding window, projects should also include provisions for post-award monitoring or follow-up evaluation to assess progress against hydrologically realistic timelines rather than administrative endpoints. When institutions consistently communicate uncertainty, tradeoffs, and realistic timelines using these indicators, they can accumulate credibility that persists through setbacks, whereas credibility erosion is a predictable outcome when time lags are minimized or obscured. This argument addresses systemic incentive structures rather than attributing responsibility to individual institutions.

These strategies collectively argue for a shift from project delivery toward system stewardship grounded in hydrologic reality, institutional behavior, and lived risk. Water-centered rural development succeeds only when time lags, governance fit, and capacity constraints are explicitly treated as design variables rather than minimized or ignored because they complicate planning, reporting, or political narratives. Evidence from hydrologic time-lag and legacy nutrient research, drinking water compliance and equity studies, and governance and procedural justice analyses shows that ignoring these dimensions does not accelerate outcomes; instead, it results in delayed recovery, repeated noncompliance, and declining institutional trust. Accordingly, empirical evidence suggests that the credibility of rural development institutions is shaped less by the scale of investment and more by their demonstrated ability to align commitments with hydrologic constraints, recovery timelines, governance capacity, and equitable risk distribution, as documented across water quality, compliance, and institutional performance studies [2,4,5,8–11,14–16].

6. Conclusions

Empirical evidence from hydrologic time-lag and legacy nutrient studies, drinking water compliance and equity research, and governance and organizational capacity analyses demonstrates that rural and regional development processes systematically underperform when water is treated as a supporting utility

rather than as a governing constraint, leading to delayed recovery, repeated regulatory failure, cost escalation, and erosion of institutional trust. The research base from recent years alone is sufficient to justify a pivot: legacy nutrients and ecosystem memory produce multi-decadal lags; drinking water burdens are unequal and legitimacy-sensitive; and resilience depends on policy, planning, institutional fit, and partnership structures as much as on engineering. Progress will not be defined by expanded rhetoric about resilience alone, but by measurable alignment between hydrologic constraints, institutional capacity, and the claims embedded in rural development policies and investments. Rural and regional revitalization will depend on a more disciplined integration of hydrologic and water-quality science into development practice and institutional decision-making, alongside organizational change processes, so that established scientific knowledge is consistently reflected in planning, funding, and governance over time. If rural development practice adopts hydrologic legitimacy as a core objective, it will change what institutions choose to measure, fund, and promise, even though the underlying hydrologic science and regulatory reporting requirements are already well established. That shift may feel provocative in policy and planning contexts accustomed to short-term performance narratives, but it reflects well-established scientific and empirical evidence regarding hydrologic limits, time lags, and institutional behavior.

Statement of the Use of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this manuscript, the author used ChatGPT to assist in identifying some relevant literature and Grammarly to support grammar, clarity, and flow. After using these tools, the author reviewed and edited the content and takes full responsibility for the published article.

Author Contributions

J.A.H. conceived the study and developed the conceptual and theoretical framework. He conducted the literature review and performed all the syntheses. He drafted the entire article, led all revisions, and approved the final version for submission. The author assumes full responsibility for the accuracy, integrity, and originality of the work.

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Declaration of Competing Interest

The author declares that there are no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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