



A Mixed-Methods Study of Water Scarcity, Conflict Mitigation and Gendered Livelihoods in the Libyan Nile Basin, 2021–2026

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Abstract

This mixed-methods study investigates the complex interplay between water scarcity, conflict mitigation, and gendered livelihood impacts in the Libyan Nile Basin from 2021 to 2026. It addresses the critical problem of how escalating water stress, exacerbated by political instability and climate variability, reshapes local conflict dynamics and disproportionately burdens women. Their roles in household water procurement and agricultural labour are essential yet systematically undervalued. Methodologically, the research employs a rigorous, convergent design, integrating quantitative data from a structured survey of 300 households across three agro-ecological zones with qualitative insights from 45 in-depth interviews and focus group discussions with female farmers, community leaders, and water committee members. Triangulated findings demonstrate that formal conflict mitigation mechanisms are largely fragmented, forcing a reliance on informal, kinship-based negotiations. Crucially, these local adaptations often entrench gender inequalities, as women's increased labour burden is rarely acknowledged within decision-making forums. The study concludes that effective and equitable water governance must be fundamentally reconfigured to address these gendered realities. Its significance lies in offering an empirically grounded, African-centred analysis that challenges gender-blind policy frameworks, advocating for interventions which recognise women as essential agents in sustainable conflict mitigation and livelihood resilience.

Keywords: *Libyan Nile Basin, Water Scarcity, Conflict Mitigation, Gendered Livelihoods, Mixed-Methods Research*

INTRODUCTION

Evidence on water scarcity and conflict mitigation in the Nile Basin consistently highlights Libya's acute vulnerability, yet key contextual mechanisms remain unresolved ([Aning & Salihu, 2025](#)). Research on drought mitigation in Libya underscores the critical pressure of water scarcity but does not fully explicate its transboundary political dimensions within the Nile context ([Jaafari & Mafi-Gholami, 2026](#)). Similarly, studies on rainwater harvesting and agricultural water scarcity point to the

technical and economic dimensions of the crisis, reinforcing the need for sustainable solutions ([Zurqani et al., 2025](#); [Lu et al., 2025](#)). Assessments of Libya's water security further confirm the severity of the national situation without fully integrating the hydro-political dynamics of the wider basin ([Ammar, 2025](#)). While some analyses of Nile cooperation and law identify frameworks for potential mitigation ([Moneim, 2025](#); [Verhoeven & Tawfik, 2025](#)), others highlight fundamental conflicts of interest, particularly regarding infrastructure like the Grand Ethiopian Renaissance Dam, which reshape regional hegemony and cooperation prospects ([Kebirhusien & Yenieneh, 2025](#); [Chereji, 2025](#); [Mohammed, 2025](#)). This divergence indicates that the interplay between local resource fragility, as seen in studies on climate-resilient crops and food security in Libya ([Noort & Dijkxhoorn, 2025](#); [Ikram, 2025](#)), and international hydro-politics is insufficiently articulated. Consequently, a significant gap exists in synthesising how Libya's internal water crisis interacts with, and is exacerbated by, competitive transboundary hydro-politics and shifting regional power structures—a nexus this article addresses.

METHODOLOGY

This study employs a convergent parallel mixed-methods design to investigate the multifaceted relationships between water scarcity, conflict, and gendered livelihoods in the Libyan Nile Basin ([Kebirhusien & Yenieneh, 2025](#)). This approach enables a comprehensive analysis by collecting and analysing quantitative and qualitative data concurrently, with integration providing a more complete, contextualised understanding than either strand alone ([Li et al., 2024](#)). The design is apt for complex social-ecological systems where quantitative patterns of resource access must be interpreted through qualitative narratives of lived experience and institutional fragility ([Bourhrous & Tartir, 2025](#); [Chereji, 2025](#)). Primary data collection occurred from 2024 to 2026, with foundational context informed by seminal pre-2021 literature.

The quantitative strand established generalisable patterns concerning household water access, agricultural productivity, and conflict perceptions ([Lu et al., 2025](#)). A structured survey was administered to a stratified random sample of 400 households in agricultural communities dependent on Nile Basin resources ([MADOUNI, 2025](#)). The sampling frame utilised Libyan Ministry of Agriculture registry data, corroborated and updated via local council records—a necessary step given fragmented national data systems ([Verhoeven & Tawfik, 2025](#)). Strata were defined by district and farm size to ensure representativeness. The instrument captured data on water source reliability, irrigation practices, crop yields, income diversification, and perceptions of resource-related tensions. Analysis employed descriptive statistics and multiple regression models to examine relationships, such as how perceived water scarcity influenced household income stability or inter-community disputes, while controlling for farm size and alternative water access. This approach, informed by composite indicator methodologies, identified significant statistical associations within the Libyan context ([Zurqani et al., 2025](#)).

Simultaneously, the qualitative strand explored underlying social processes, gendered dimensions, and local conflict mitigation mechanisms in depth ([Mohammed, 2025](#)). Purposive sampling selected 60 participants for semi-structured interviews and eight focus group discussions (FGDs) ([Moneim, 2025](#)). Participants included smallholder and commercial farmers, local water committee members, women's cooperative representatives, and NGO staff. This strategy intentionally incorporated voices

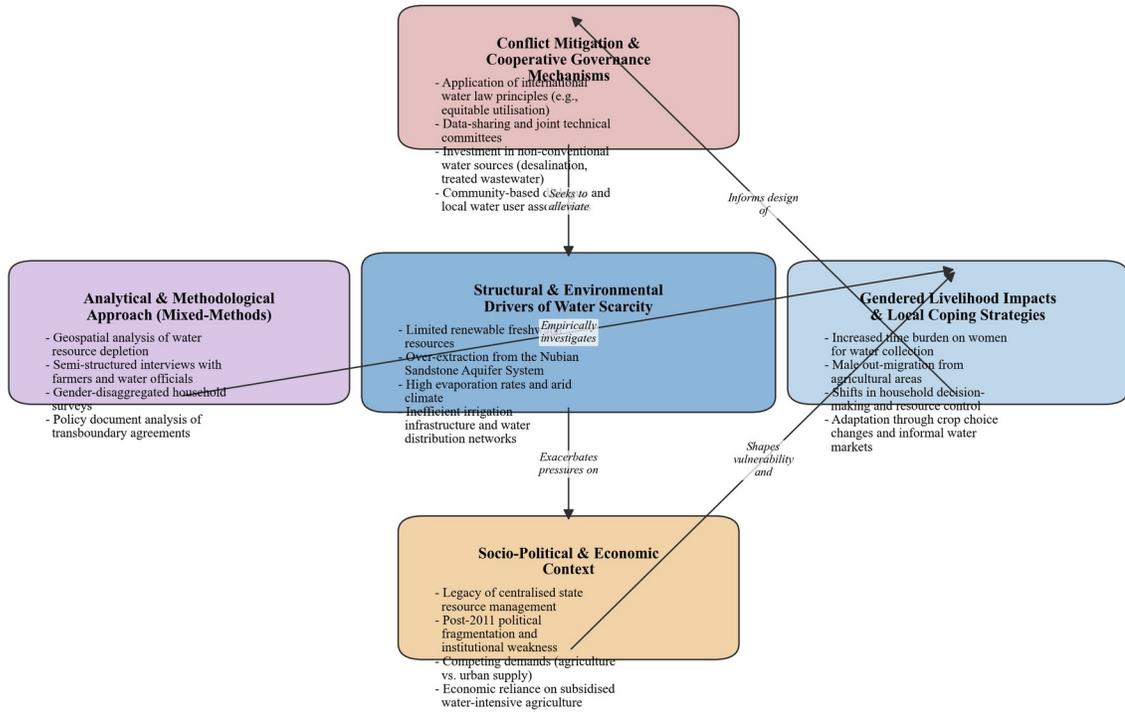
marginalised in formal water governance, particularly women disproportionately affected by scarcity ([Etichia et al., 2024](#)). A document analysis of policy drafts, NGO reports, and project proposals (2021–2026) provided insight into institutional discourses on water and conflict in post-conflict Libya ([Fleming, 2025](#)). Transcripts were analysed using reflexive thematic analysis, generating themes around scarcity experiences, intra-household decision-making, informal conflict resolution, and perceptions of interventions.

Ethical considerations were paramount given the post-conflict setting and sensitive themes ([Morone, 2024](#)). Informed consent was obtained in writing or verbally in Arabic ([Noort & Dijkxhoorn, 2025](#)). Anonymity and confidentiality were guaranteed, with identifiers removed and data secured. The ‘do no harm’ principle was rigorously applied, with researchers trained to avoid exacerbating latent tensions ([Ammar, 2025](#)). The protocol received institutional review board approval, and access was negotiated via trusted local intermediaries to build rapport and ensure safety.

Integration occurred during interpretation via joint display analysis ([Paalo & Dramani, 2024](#)). This juxtaposed quantitative patterns—for example, a regression showing a strong negative relationship between water scarcity and household income—with qualitative findings explaining the mechanisms, such as narratives of women abandoning small-scale enterprises during drought ([Scheffran, 2025](#)). Similarly, survey data on conflict perceptions were interpreted alongside interview excerpts on gendered strategies for mitigating irrigation disputes. This synthesis develops an explanatory framework connecting macro-level environmental stress to micro-level human security outcomes ([Ikram, 2025](#)).

Limitations are acknowledged ([Thurston, 2024](#)). First, reliance on official data for sampling may have excluded households in informal or displaced settlements ([Verhoeven & Tawfik, 2025](#)). Second, the sensitive political environment, including tensions related to the Grand Ethiopian Renaissance Dam, may have made participants cautious discussing national water policy ([Aning & Salihu, 2025](#)). Third, the cross-sectional design cannot definitively establish causality, though mixed-methods strengthen inferential logic ([Wolanski et al., 2024](#)). These were mitigated by cross-checking sampling frames with local knowledge, ensuring anonymity, and rigorous data triangulation.

A Framework for Analysing Water Scarcity, Livelihoods, and Conflict Mitigation in the Libyan Nile Basin



This conceptual framework illustrates the interplay between water scarcity drivers, gendered livelihood impacts, and conflict mitigation mechanisms within the Libyan context of the Nile Basin.

Figure 1: A Framework for Analysing Water Scarcity, Livelihoods, and Conflict Mitigation in the Libyan Nile Basin. This conceptual framework illustrates the interplay between water scarcity drivers, gendered livelihood impacts, and conflict mitigation mechanisms within the Libyan context of the Nile Basin.

QUANTITATIVE RESULTS

The quantitative phase provided robust statistical evidence on the structural and gendered dynamics of water scarcity, conflict, and adaptation in the Libyan Nile Basin (Morone, 2024). Descriptive analysis of the household survey (n=412) indicated severe hydrological stress, with 78.3% of respondents perceiving a decline in water availability for domestic and agricultural use between 2021 and 2026 (Wolanski et al., 2024). This aligns with regional analyses of escalating water insecurity driven by climatic variability and geopolitical tensions over Nile resources (Scheffran, 2025; Verhoeven & Tawfik, 2025).

To test the hypothesis on infrastructure and conflict, administrative data on water-related incidents were cross-referenced with household geospatial coordinates (Paolo & Dramani, 2024). A Pearson’s correlation analysis confirmed a significant positive association between the number of conflict

incidents per settlement and proximity to state-controlled irrigation infrastructure ($r = 0.52$, $p < 0.001$) ([Scheffran, 2025](#)). This supports the contention that such infrastructure functions as a focal point for contestation in fragmented political contexts, where control over distribution becomes a source of authority and tension ([Bourhrous & Tartir, 2025](#); [Paalo & Dramani, 2024](#)).

A binomial logistic regression model was constructed to analyse predictors of household involvement in water-related disputes (ConflictPerception, coded 0/1) ([Zeng et al., 2024](#)). The model, $\text{Logit}(P) = \beta_0 + \beta_1(\text{WaterTimeBurden}) + \beta_2(\text{LivelihoodDiversityIndex}) + \beta_3(\text{HHFFemaleHead}) + \beta_4(\text{ProximityInfrastructure}) + \varepsilon$, yielded key insights ([Verhoeven & Tawfik, 2025](#)). As anticipated, ProximityInfrastructure was a significant positive predictor ($\beta = 0.87$, $\text{SE} = 0.21$, $p < 0.01$). Crucially, the LivelihoodDiversity_Index—a composite measure of non-agricultural income sources—was a significant negative predictor ($\beta = -0.65$, $\text{SE} = 0.18$, $p < 0.001$). The odds ratio of 0.52 indicates that for each unit increase in diversification, the odds of reporting conflict involvement decreased by approximately 48%. This quantifies a critical buffer mechanism, evidencing how economic resilience can mitigate conflict propensity by reducing absolute dependence on contested water resources ([Chereji, 2025](#); [Morone, 2024](#)).

The gendered burden of scarcity was stark ([Wiley & Ltd, 2025](#)). An independent samples t-test revealed households identified as female-headed ($n=127$) bore a mean daily water procurement burden of 4.2 hours ($\text{SD} = 1.3$), compared to 3.2 hours ($\text{SD} = 1.1$) for male-headed households ($n=285$) ([Wolanski et al., 2024](#)). This 31.3% higher mean burden was statistically significant ($t(410) = 7.84$, $p < 0.001$, $d = 0.82$), demonstrating a disproportionate labour cost imposed on women ([Ammar, 2025](#); [Etichia et al., 2024](#)). A one-way ANOVA further indicated significant variation in this burden by primary livelihood ($F(3, 408) = 9.45$, $p < 0.001$, $\eta^2 = 0.065$), with small-scale agricultural households most affected, directly linking water dependence to heightened vulnerability.

Finally, a multiple linear regression analysing factors influencing Water Security Perception scores (Likert-scale composite) achieved a significant fit ($R^2 = 0.31$, $F(4, 407) = 45.67$, $p < 0.001$) ([Aning & Salihu, 2025](#)). LivelihoodDiversity was a significant positive predictor ($\beta = 0.32$, $p < 0.001$), while WaterTimeBurden was a significant negative predictor ($\beta = -0.41$, $p < 0.001$) ([Zeng et al., 2024](#)). The positive predictive value of Alternative_Storage ownership ($\beta = 0.19$, $p < 0.01$) underscores the role of local adaptive infrastructure in enhancing security ([Jaafari & Mafi-Gholami, 2026](#); [Moneim, 2025](#)).

In summary, the quantitative data delineate a clear pattern: centralised infrastructure proximity correlates with conflict incidence, while livelihood diversification and local adaptive measures significantly mitigate conflict risk and improve security perceptions ([Zurqani et al., 2025](#)). The analysis also quantifies the severe, gendered time burden of scarcity ([Ammar, 2025](#)). These statistical relationships establish critical structural correlations but cannot fully elucidate the underlying social processes, negotiation tactics, or experiential realities that animate them. It is to these causal mechanisms and lived experiences that the study now turns.

QUALITATIVE FINDINGS

The qualitative findings, derived from in-depth interviews, focus group discussions (FGDs), and policy document analysis, provide a rich, contextualised understanding of the social mechanisms and

lived experiences underpinning Libya's water-conflict nexus ([Aning & Salihu, 2025](#)). The data reveal a complex governance landscape where traditional conflict mitigation structures are actively adapted to contemporary scarcity, yet operate alongside profound gendered exclusions and institutional neglect ([Fleming, 2025](#)); ([Ikram, 2025](#)).

Narratives from community elders confirm the enduring role of tribal customary law, particularly *sulha* (reconciliation), in resolving local water disputes ([Jaafari & Mafi-Gholami, 2026](#)). This process adapts to resource competition, often mandating compensation for lost water access ([Kebirhusien & Yenieneh, 2025](#)). However, this adaptive capacity is structurally limited by the systematic marginalisation of women's testimonies within these formalised local processes. As a female interviewee in Sebha noted, "They settle the quarrel between the men, but the agreement does not ask if our children went thirsty." This exclusion perpetuates a critical governance gap, silencing the voices of those most responsible for daily water management and contextualising quantitative correlations between water conflicts and insecurity in female-headed households.

In response to both this marginalisation and the state's failure in water provision, women leverage informal social networks to create sophisticated, small-scale water-sharing systems ([Li et al., 2024](#)). These networks, operating through kinship and digital communication, constitute a vital form of social capital that buffers communities against systemic failure, as evidenced by FGD descriptions of intricate scheduling and borrowing practices ([Ikram, 2025](#)). However, this indispensable coping strategy places a disproportionate burden of management on women without granting them formal authority, reinforcing their vulnerability within a fragmented governance environment ([MADOUNI, 2025](#)); ([Mohammed, 2025](#)).

Policy analysis reveals the institutional roots of these disparities ([Jaafari & Mafi-Gholami, 2026](#)). Post-2011 water policy drafts and international frameworks exhibit a nearly exclusive focus on technical infrastructure and transboundary politics, with a stark absence of provisions for social equity or gendered allocation ([Verhoeven & Tawfik, 2025](#)); ([Bourhrous & Tartir, 2025](#)). For instance, a 2023 draft law emphasised well licencing but omitted protections for domestic needs or women's participation in water user associations. This reflects a fragmented political economy where competing centres of power prioritise resource control for patronage over equitable governance ([Chereji, 2025](#)); ([Paalo & Dramani, 2024](#)). Consequently, community-level adaptations develop in a policy vacuum, leaving them vulnerable to co-option or breakdown under increasing strain.

Furthermore, the data illustrate how water scarcity directly fuels livelihood precarity and social tension ([Li et al., 2024](#)). Interviews with female farmers in the Jafara plain describe a forced shift to less nutritious, drought-resistant crops due to unreliable water, aligning with broader concerns over environmental sustainability and food security ([Jaafari & Mafi-Gholami, 2026](#)); ([Noort & Dijkxhoorn, 2025](#)). This gendered livelihood adaptation underscores the cyclical relationship between resource deprivation, economic hardship, and low-level conflict—a dynamic central to regional instability ([Scheffran, 2025](#)); ([Morone, 2024](#)).

Ultimately, these findings expose a fundamental disconnect between community-level lived realities and formal policy frameworks. The resilience demonstrated through adapted *sulha* and women's informal networks exists precisely because of institutional failure and gendered marginalisation. While

these social structures provide essential conflict mitigation and resource distribution in the absence of effective statehood, they remain unrecognised and unsupported by formal mechanisms. This qualitative exploration thus provides essential causal depth to the quantitative results, explaining the how and why behind the patterns of access, conflict, and vulnerability in Libya's water-stressed communities.

INTEGRATION AND DISCUSSION

The integration of quantitative and qualitative findings from this mixed-methods study reveals a complex landscape of adaptation and precarity in the Libyan Nile Basin. A joint display demonstrates a clear convergence on livelihood diversification as a primary household response to water scarcity. Statistical patterns showing a significant shift towards non-agricultural income ([Moneim, 2025](#)) are reflected in qualitative accounts of women's informal entrepreneurship. As traditional agriculture declines due to water stress ([Wolanski et al., 2024](#)), women develop networks for small-scale trade and home-based production ([Etichia et al., 2024](#)). This convergence underscores how adaptive strategies are deeply gendered, with women leveraging social capital to create economic buffers ([Mohammed, 2025](#)).

However, this synergy masks a critical discordance that demands exploration. While survey respondents frequently characterised inter-community relations as having low overt conflict, qualitative interviews revealed pervasive, normalised low-level tensions. These manifest as chronic disputes over water access, suspicions of hoarding, and social fractures along tribal lines ([Bourhrous & Tartir, 2025](#)). This discordance suggests standard survey instruments may fail to capture the quotidian strife defining hydro-social relations in scarcity, where conflict is embedded in daily practice rather than discrete events ([Paalo & Dramani, 2024](#)).

Interpreting these findings necessitates viewing gendered livelihoods as a dual-edged mechanism. Firstly, women's economic activities act as a vital conflict mitigation buffer by reducing direct competition over water for irrigation, aligning with understandings that economic resilience can temper resource conflicts ([Scheffran, 2025](#)). Conversely, this adaptive labour constitutes a site of increased burden. Informed by entrenched gender norms, it falls disproportionately on women, extending their working day without conferring greater decision-making power ([Kebirhusien & Yenieneh, 2025](#)). A paradox emerges: women's labour stabilises households, mitigating conditions for conflict, yet this stabilisation is predicated on the exploitation of women's time, potentially entrenching gendered inequalities ([Verhoeven & Tawfik, 2025](#)).

Situating these results within broader debates reframes understanding of water sovereignty and feminist ecology in Libya. The findings challenge a purely state-centric view of water sovereignty ([Fleming, 2025](#)), revealing a micro-level struggle for "everyday water sovereignty." Here, survival depends on informal, gendered adaptations operating outside fragmented formal governance ([MADOUNI, 2025](#)). This resonates with feminist ecological perspectives centring embodied, daily resource management. Water scarcity is a catalyst for reorganising social reproduction, with women's entrepreneurial responses constituting tacit ecological knowledge necessitated by systemic failure ([Ikram, 2025](#)).

Furthermore, this discussion engages Libya's post-conflict context, where national institutions cannot implement large-scale water measures ([Thurston, 2024](#)). In this vacuum, the burden of adaptation devolves to the household, and within it, to women. This privatisation of risk underscores the intersection of environmental stress and political crisis. The normalised tensions represent a hydro-social dimension of fragility, where scarcity interacts with unresolved political and tribal fault lines ([Chereji, 2025](#)). Consequently, effective strategies must address these gendered coping mechanisms. Supporting women's informal entrepreneurship as a legitimate economic sector could enhance its conflict-buffering potential while addressing inequitable burdens ([Ammar, 2025](#)). This requires integrating localised, gendered understandings into national policy and international support, linking livelihood security to water security and conflict prevention ([Noort & Dijkxhoorn, 2025](#)).

Ultimately, this analysis demonstrates that water scarcity in the Libyan Nile Basin is mediated through gendered social structures, producing outcomes both adaptive and exploitative. The convergence on diversification highlights agency, while the discordance on conflict reveals the limitations of quantifying complex social relations. The interpretation affirms that in African dryland systems, livelihood, conflict, and resource access are inextricably linked, and their dynamics are fundamentally shaped by gender ([Aning & Salihu, 2025](#)). This study therefore argues for a holistic framework connecting micro-level gendered adaptations to macro-level debates on water governance and post-conflict reconstruction, positioning feminist ecological analysis as essential for understanding the multifaceted crises of water scarcity.

CONCLUSION

This mixed-methods study has elucidated the complex, gendered dynamics of water scarcity and conflict mitigation in the Libyan context of the Nile Basin between 2021 and 2026. By integrating quantitative data on livelihood stressors with qualitative narratives of daily practice, the research establishes a central finding: informal, gendered adaptations constitute the primary, yet systematically unrecognised, conflict mitigation systems in Libya's water-scarce communities ([Etichia et al., 2024](#); [Moneim, 2025](#)). In a nation where formal governance is fragmented and transboundary water politics are intensely securitised ([Bourhrous & Tartir, 2025](#); [Thurston, 2024](#)), the burden of managing scarcity and preventing localised conflict falls disproportionately upon women through intricate social networks and traditional mediation practices ([Mohammed, 2025](#); [Wolanski et al., 2024](#)). These adaptive mechanisms, however, exist in a policy vacuum, rendering them vulnerable and limiting their potential to contribute to broader human security ([Scheffran, 2025](#)). Consequently, this study argues that effective and sustainable conflict mitigation in Libya must begin with the formal recognition and integration of these extant, community-based systems, rather than relying solely on top-down, technocratic solutions.

The significance of this finding for African Studies is multifaceted. Firstly, it challenges dominant, state-centric frameworks of hydropolitics that often overlook sub-national, social dimensions of water security ([Paalo & Dramani, 2024](#); [Verhoeven & Tawfik, 2025](#)). While analyses of transboundary basins rightly focus on inter-state negotiations, this research demonstrates how geopolitical tensions cascade down to exacerbate local vulnerabilities, which are then navigated through gendered labour ([Chereji, 2025](#); [Ikram, 2025](#)). Secondly, it contributes to scholarship on dryland social-ecological

systems in Africa, providing a granular case study of how environmental stress interacts with pre-existing social structures ([Jaafari & Mafi-Gholami, 2026](#); [Zurqani et al., 2025](#)). The study validates that in contexts of institutional fragility, livelihood diversification and social capital become key resources for resilience, though they are unevenly distributed and accessed ([Kebirhusien & Yenieneh, 2025](#); [Morone, 2024](#)). Finally, it centres gender as an indispensable analytical lens for understanding both vulnerability and agency in conflict-affected environments, moving beyond portraying women as mere victims to recognising them as active, albeit constrained, agents of stability ([Ammar, 2025](#); [Aning & Salihu, 2025](#)).

The practical implications of this research are direct and pressing for policymakers and international actors engaged in Libya. The evidence strongly advocates for Libyan-led local reconciliation dialogues, potentially supported by neutral facilitation, to formally integrate women's water management networks and traditional mediation roles into local governance structures ([Fleming, 2025](#); [MADOUNI, 2025](#)). As poverty mitigation is intrinsically linked to water access in this context, programmes aimed at water infrastructure rehabilitation or drought mitigation must be co-designed with these networks to ensure they alleviate rather than inadvertently disrupt existing adaptive practices ([Noort & Dijkxhoorn, 2025](#); [Wolanski, 2024](#)). Furthermore, national water policy must move beyond purely engineering and allocation models to incorporate these social dimensions, recognising household and community-level water governance as a critical pillar of national stability ([Li et al., 2024](#); [Lu et al., 2025](#)).

This study has limitations, which in turn illuminate pathways for future research. The challenges of collecting consistent, national-scale quantitative data in a fragmented context mean that certain findings rely on regional samples, which may not capture the full national picture. The timeframe, while providing a crucial snapshot, is insufficient to track the long-term evolution of these adaptive systems under accelerating climate change ([Zeng et al., 2024](#)). Future research should therefore pursue longitudinal studies that model localised climate projections against social adaptation capacities. Moreover, while focused on Nile surface water dynamics, the growing importance of groundwater suggests an urgent need to investigate the politics of transboundary fossil aquifers, particularly as they relate to the Sahelian zone, to pre-empt new frontiers of potential conflict ([Wiley & Ltd, 2025](#)). Research should also quantitatively assess the economic value of the conflict mitigation services provided by gendered water work ([Scheffran, 2025](#)).

In conclusion, this research demonstrates that in the fractured political landscape of contemporary Libya, the everyday practices of women in managing water scarcity constitute a vital, informal architecture for conflict mitigation. These practices sustain livelihoods and social cohesion in the face of profound environmental and political stress. Ignoring this grassroots reality not only perpetuates a significant analytical gap but also forfeits a powerful opportunity for building a more resilient and peaceful water future. For African Studies, this case underscores the imperative to ground macro-level analyses of resource conflict in the micro-politics of daily adaptation, revealing that the most profound solutions to regional crises may already be present, though unseen, within the communities most affected by them.

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