

Women as Agents of Climate Adaptation: Gendered Nature-Based Solutions in Mekong Riverside Communities, Thailand

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Abstract

This study explores women's roles as agents of climate adaptation in riparian communities along the Mekong River in Rattana-wapi District, Nong Khai Province, Thailand. Using a qualitative research design grounded in Feminist Political Ecology, data were generated through semi-structured in-depth interviews with 14 key informants and focus group discussions with 86 community members (total $n = 100$), and analyzed using inductive thematic analysis. The study focuses on how women develop, negotiate, and enact adaptive strategies in response to intensifying hydro climatic disruption, including extreme heat, erratic precipitation, and growing uncertainty in Mekong River flow regimes driven by both climatic variability and upstream and tributary hydropower development. The findings identify four interrelated domains of women's adaptive agency: household-level resource and risk management; stewardship and intergenerational transmission of Traditional Ecological Knowledge; coordination and governance of social networks; and leadership in applied adaptive innovation. Across these domains, women's practices, including local seed conservation, integrated rice–fish cultivation, the use of compost, manure, and mixed cropping, and community-based fisheries governance, align with the core principles of Nature-based Solutions (NbS) and may be understood as grassroots NbS that sustain both livelihoods and ecosystem functions. Yet this adaptation labor remains institutionally unrecognized and structurally undervalued, and women disproportionately absorb the costs of household resilience during climate shocks. The study concludes that climate adaptation policy in transboundary river context should formally recognize, resource, and support women's adaptive roles, moving beyond deficit-oriented vulnerability framings towards gender-responsive governance that treats women's agency as foundation for equitable and sustainable adaptation.

Keywords gendered climate adaptation, nature-based solutions, traditional ecological knowledge, Mekong River Basin

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Introduction

The Mekong River has never been entirely predictable, but communities along its banks built livelihoods around its rhythms. Seasonal floods inundated floodplains, receding waters exposed fertile soils, and fisheries followed the pulse of rising and falling water. This seasonal delivery of water, sediment, and nutrients has underpinned agricultural and fisheries productivity across the Lower Mekong (Oeurng et al., 2016). That rhythmic dependability is now breaking down. Cascade dams on the upper mainstream and its tributaries have altered flow regimes, and unseasonal releases have disrupted fish migration and accentuated periods of low flow and drought (Soukhaphon et al., 2021). These changes coincide with projections of longer and drier dry seasons, shorter and more intense wet seasons, and more frequent floods and droughts across the Lower Mekong (see Oeurng et al., 2016). For households whose livelihoods depend directly on the river, this is not an abstract environmental shift; it is an immediate livelihood crisis, of kind already documented in fishing communities near the Don Sahong Dam (Soukhaphon et al., 2021).

Nong Khai Province, on the Thai–Lao border, illustrates these pressures with particular clarity. Located on the Mekong mainstream downstream of both the Lancang cascade and Lao’s Xayaburi Dam, the province sits at the intersection of hydroclimatic vulnerability and livelihood precarity. More than 50,000 households derive primary income from Mekong-based livelihoods. In Rattanawapi District, the primary field site approximately 78% of farmland is used for flood-recession agriculture, whose productivity depends directly on the river’s seasonal inundation cycle (Nong Khai Provincial Statistical Office, 2022). When that cycle becomes erratic, the consequences are not confined to harvests. Such disruption can undermine household food security, strain community resource governance, and erode the systems of Traditional Ecological Knowledge (TEK) through which generations have read and responded to riverine change. Rattanawapi therefore offers a critical case for examining how riparian communities negotiate hydroclimatic disruption under conditions of structural vulnerability.

These disruptions, however, are not experienced uniformly. A dominant strand of climate policy and development discourse frames women in the Global South primarily as vulnerable to climate change, disadvantaged in resource access, economic opportunity, and decision-making power (Akter et al., 2016; Denton, 2002). This framing captures real inequalities, but it obscures as much as it reveals. Arora-Jonsson (2011) argues that generalizations about women’s vulnerability deflect attention from inequalities in decision-making and risk increasing women’s responsibilities without corresponding or rewards. Drawing on Feminist Political Ecology (FPE) (Rocheleau et al., 1996), subsequent scholarship has therefore foregrounded the power relations that shape women’s differentiated exposure and agency. Empirical work in Southeast Asia lend support to this critique. Studies document women’s informal leadership in household

adaptation, resource management, and peer-based knowledge exchange during climate stress, while also showing that men and local officials retain control over key adaptive decision (Han et al., 2022; Tran et al., 2025). In Thai riparian context, however, the mechanism through which women put adaptive practices into effect at the community level remain empirically underexplored. This study therefore asks not whether women are vulnerable to climate change, which the evidence amply confirms, but how they act as agent of adaptation within systems that simultaneously constrain them and depend upon them

This study examines how women in riparian communities along the Mekong River in Rattana-wapi District, Nong Khai Province, develop, negotiate, and enact climate adaptation strategies across four interrelated domains: household-level resource and risk management; stewardship and intergenerational transmission of TEK; coordination of community social networks; and leadership in applied adaptive innovation. These domains were derived inductively through iterative thematic analysis of in-depth interviews and focus group discussions, rather than being imposed from existing frameworks. The analysis is grounded in feminist political ecology (Rocheleau et al., 1996) and the sustainable livelihoods framework (Scoones, 1998), but the categories themselves reflect participants' own accounts of their adaptive roles.

The argument proceeds in three steps. *First*, women's adaptive strategies in these communities extend beyond reactive coping; In Scoones' (1998) terms, they represent longer-term shifts in livelihood strategies rather than temporary adjustments, and they strengthen socio-ecological resilience over time. *Second*, many of these practices align with the core principles of Natural-based Solutions (NbS) as defined by Cohen-Shacham et al. (2016) and may therefore be understood as grassroot NbS. Grounded in women's TEK, they can enrich formal adaptation framework that have largely been developed elsewhere and in urban settings (Kiss et al., 2022; Olivadese, 2025). *Third*, despite the depth of these contributions, structural barriers constrain women's adaptive capacity and limit their formal recognition in climate governance. These barriers include disproportionate labor and nutritional burdens, exclusion from formal decision-making, and the marginalization of local knowledge in policy (Arora-Jonsson (2011; Bezner Kerr et al., 2022; Han et al., 2022; Tran et al., 2025). Taken together, the findings complicate the representation of women as passive victims of climate change and support the case for gender-responsive governance frameworks in transboundary river contexts that recognizes and resources women's agency as central element of equitable and sustainable adaptation.

Literature

Hydroclimatic Disruption and Livelihood Precarity in the Lower Mekong Basin

The Lower Mekong Basin exemplifies what O'Brien and Leichenko (2000) term "double exposure": a condition in which particular regions, sectors, and social groups are confronted simultaneously by the impacts of climate change and by the consequences of economic globalization. In the Mekong, the second of these pressures is most visible in transnationally financed hydropower development. By early 2019, Laos alone operated 61 hydropower dams, most developed under build-operate-transfer concessions and oriented toward electricity export. China, meanwhile, has completed a cascade of eleven dams on the upper mainstream (Lancang) (Soukhaphon et al., 2021).

Increasingly erratic precipitation and progressive disruption of the seasonal flood pulse – driven jointly by climatic variability and upstream and tributary dam operations – are unsettling the agro-ecological rhythms on which riparian livelihoods depend. The seasonal delivery of water, sediments and nutrients underpins agricultural and fisheries productivity in the Tonle Sap and the Mekong Delta (Oeurng et al., 2016), yet unseasonal dam releases have disrupted fish migration and spawning cues (Soukhaphon et al., 2021), while farmers in the Vietnamese Delta report earlier saline intrusion, intensifying storms and back-to-back droughts and floods that leave little time for recovery (Tran et al., 2025).

Shifting Frameworks: From Vulnerability to Agency

Scholarly approaches to gender and climate adaptation have undergone considerable conceptual revision since the early 2000s. Early contributions foregrounded the structural dimensions of women's vulnerability-poverty, insecure access to land, and exclusion from climate decision-making-while already noting the undervaluation of women's environmental knowledge (Denton, 2002). Much of the subsequent literature, however, has continued to framed women as disproportionately vulnerable and low in adaptative capacity (e.g., Akter et al., 2016), a framing that critics argue risks casting women as passive victims rather than active agents of adaptation (Arora-Jonsson, 2011). Drawing on Feminist Political Ecology (FPE) (Rocheleau et al., 1996), subsequent scholar has challenged this deficit framing by foregrounding power relations that shaped women's differentiated exposure and agency, cautioning against portraying women either as uniformly vulnerable or as inherently virtuous environmental stewards (Arora-Jonsson, 2011).

This reorientation is particularly consequential in the Mekong region, where the feminization of agriculture—driven in part by sustained male out-migration—has repositioned women at the center of everyday livelihood and environmental management (Han et al., 2022).

Yet their agency in adaptation remains largely informal and negotiated: in the Vietnamese Mekong Delta, women sustain household adaptation through diversification and peer network, while husbands, male relatives and local officials continue to control adaptive decision (Tran et al., 2025). Such practices constitute forms of informal leadership that remaining largely invisible to formal adaptation planning (Tran et al., 2025), echoing evidence from South Asia that women's collective management of forest and water is central to community resilience yet under-recognized in policy (Adhikari & Ghimire, 2025).

Traditional Ecological Knowledge and Nature-based Solutions

Two frameworks are particularly relevant to understanding women's adaptive roles in riparian contexts. Traditional Ecological Knowledge (TEK) refers to the cumulative body of knowledge, practices, and beliefs that communities develop and transmit across generations through sustained engagement with their ecosystems (Berkes, 2017). Nature-based Solutions (NbS) are defined by IUCN as "actions to protect, sustainably manage and restore natural and modified ecosystems to address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefit" (Cohen-Shacham et al., 2016, p. xii), and have become increasingly influential in climate and water governance (Olivadese, 2025).

In principle, both frameworks create space for recognizing community-based, place-grounded adaptive practices. NbS scholarship, for instance, emphasizes co-creation with diverse local actors and collaborative governance as conditions for successful implementation (Frantzeskaki, 2019). In practice, however, NbS are frequently implemented through technocratic, top-down knowledge system (Olivadese, 2025). An analysis of 58 urban NbS cases found that citizen participation remains predominantly tokenistic, that the knowledge of non-expert groups often goes unheard, and that even indigenous communities central to an initiative may be excluded from its design (Kiss et al., 2022). Notably, this evidence derives largely from urban and European contexts, and the implications for rural, riparian communities in the Global South remain underexplored. This tension between frameworks' potential and the reality of their implementation is a central problem the present study address.

The Convergence Gap: TEK, NbS, and Gendered Agency

Feminist political ecology critiques suggest why TEK, NbS, and gendered agency are rarely brought together. Climate solutions, including ecological restoration, remain dominate by techno-managerial expertise that privileges Eurocentric science over local and embodied knowledge. Gender integration within these solutions, meanwhile, tends to rely on women-centered, binary framings that essentialize women's vulnerability rather than recognizing their agency (Resurrección, 2024). These critiques are reflected in the literature reviewed here. Studies of gender and climate adaptation in the Mekong region have examined structural vulnerability

or household livelihood strategies (Han et al., 2022; Tran et al., 2025). Conversely, influential NbS scholarship has focused on governance, participation, and design in largely urban and European setting, with little or no attention to gender (Frantzeskaki, 2019; Kiss et al., 2022; Olivadese, 2025). As a result, women's contributions to ecosystem-based adaptation have been documented only in fragments and have rarely been treated as a coherent subject of inquiry.

This gap is particularly pronounced in Thai riparian context. Women's adaptive roles have been documented in the Vietnamese Mekong Delta (Tran et al., 2025) and in Cambodia and Vietnam more broadly (Han et al., 2022). By contrast, empirical attention to how Thai riparian women put adaptive practices into effect, and to the structural conditions that enable or foreclose those practices, remains limited. In particular, existing work has not specified the domains through which women's agency operates at the community level, nor examine how their customary practices align with, and potentially enrich, formal NbS frameworks.

Positioning the Present Study

This study addresses these intersecting gaps by centering the lived experiences of women in the Mekong riparian communities of Nong Khai Province. Rather than positioning women as passive beneficiaries of externally designed adaptation interventions, it treats them as knowledgeable agents whose ecological knowledge, governance roles, and adaptive practices contribute to riverine resilience. Much of this contribution has remained informal and largely invisible to formal adaptation planning (Tran et al., 2025). Following feminist political ecology, however, the study avoids romanticizing women as inherently virtuous environmental stewards (Arora-Jonsson, 2011). It recognizes that women's agency is exercise within and often negotiated against, gendered power relations that shape who controls land, resources, and adaptive decisions (Han et al., 2022; Tran et al., 2025)

Specifically, the study pursues two aims. First, it identifies the domains through which women's adaptive agency operates at the community level. Second, it examines the extent to which their customary, place-based practices align with, and could enrich, formal Nbs frameworks (Cohen-Shacham et al., 2016). By bringing feminist political ecology, TEK scholarship, and NbS frameworks together within a single empirical inquiry, the study responds to call to move beyond essentialized accounts of women's vulnerability toward the recognition of situated, embodied knowledge (Resurrección, 2024). In doing so, it offers a more nuanced account of gendered adaptive agency, attentive not only to what women do, but also to the structural conditions that simultaneously enable and constrain what they able to do.

Research Methodology

Study Site and Research Context

This study was conducted in riparian communities along the Mekong River in Rattanawapi District, Nong Khai Province, within the Lower Mekong Basin. The district is characterized by pronounced hydrological variability, recurrent climate extremes, and a high proportion of flood-recession agricultural land. It was selected as the primary field site because of its high exposure to hydroclimatic disruption and its socio-demographic profile, notably the prevalence of out-migration and household dependence on farming and fisheries.

Research Design

The study adopts a qualitative research design grounded in an interpretivist epistemological orientation and informed by feminist political ecology. This approach suits the study's concern with women's lived experiences, their situated and embodied knowledge, and social processes through which they develop, negotiate, and enact adaptive practices within gendered relations of power. Rather than measuring how adaptation strategies are distributed across a population, the study seeks to understand their meanings, mechanism, and contexts, analytical objectives for which qualitative methods are particularly well suited.

Participant Selection and Sampling

Participant selection combined purposive and stratified random sampling strategy designed to ensure representation across institutional, community, and socially differentiated groups relevant to climate adaptation governance. The total sample comprised 100 participants recruited across three categories.

Institutional representatives were selected purposively on the basis of their formal roles in climate-related governance and resource management. This category comprised two subgroups: experts and policymakers ($n = 4$), including district agricultural officers, Chief Executives of Subdistrict Administrative Organizations (SAOs), and river basin committee representatives; and community leaders ($n = 10$), including village heads, assistant village heads, and local council members occupying formal or semi-formal leadership positions at the subdistrict level.

Community members ($n = 86$) were recruited through stratified random sampling, with strata defined along three axes: age group (older adults aged 60+, working-age adults aged 18–59, and youth aged 15–17); gender identity (women, men, and LGBTQ); and primary livelihood type (fishing-dependent, farming-dependent, and mixed). Within each stratum, participants were randomly selected from household registry lists provided by the relevant SAOs. The deliberate

inclusion of LGBTQ (n = 10) ensured representation of groups whose adaptive experiences are absent from mainstream climate adaptation research.

Data Collection

Data were generated through two complementary qualitative methods, selected for their capacity to capture both institutional perspectives and community-level lived experience and to enable triangulation across participant groups.

In-depth Interviews. Fourteen semi-structured in-depth interviews (IDIs) were conducted with key informants (7 women, 7 men), comprising local government officials and agricultural officers. The interview guide addressed three substantive areas: observed hydroclimatic trends and their consequences for agricultural and livelihood systems; the design, implementation, and gender dimensions of existing climate adaptation policies and programs; and structural barriers constraining the adoption of Nature-based Solutions at the community level. The semi-structured format allowed for systematic comparison across informants while preserving the flexibility to pursue emergent themes.

Focus Group Discussions. Eighty-six community members participated in focus group discussions (FGDs), which used participatory tools including community mapping to elicit collective knowledge on locally grounded adaptation strategies, natural resource governance, and experiences of water and food insecurity. Guiding questions addressed seasonal and hydrological change; women's roles in household and community-level resource management; decision-making about seeds, water, and fishing areas; and changes in livelihood and farming practices made in response to shifting environmental conditions. The group setting was analytically productive in its own right: as it surfaced both shared and contested narratives, revealed social norms governing resource use, and allowed individual accounts to be examined through collective deliberation.

All sessions were conducted in Thai and the Isan dialect between July and September 2025. Interviews lasted 45 to 60 minutes and focus group discussions 60 to 90 minutes. Each session was audio-recorded with participants' informed consent and transcribed verbatim prior to analysis

Data Analysis

Data were analyzed using inductive thematic analysis following the six-phase approaches of Braun and Clarke (2006): familiarizing oneself with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. Consistent with their guidance, the analysis proceeded recursively rather than linearly, with movement back and forth between phases as coding and theme development were refined.

Coding proceeded inductively, without predetermined categories, allowing themes to be developed through close and repeated engagement with the data. Constant comparison across participant groups, namely institutional representatives, community leaders, and community members, was used throughout to identify both convergent and divergent patterns.

The four analytical domains presented in the Findings section, namely household-level resource and risk management, stewardship and intergenerational transmission of TEK, coordination of community social networks, and leadership in applied adaptive innovation, were developed through this inductive process rather than imposed a priori from existing theoretical frameworks.

To enhance the trustworthiness of the analysis, member checking was undertaken with a purposively selected subset of participants ($n = 100$). Emerging interpretations and analytical categories were returned to these for participants for critical review, so that the findings remained accountable to the lived realities from which they were derived.

Ethical Considerations

Fieldwork was conducted in accordance with institutional ethical guidelines. Informed consent was obtained from all participants prior to data collection, and coded identifiers replaced personally identifying information throughout the analysis and reporting process.

Findings

The findings are presented into two analytical sections. The first examines how community members perceive and experience intensifying hydroclimatic disruption. The second analyzes women's roles as agents of adaptation across four interrelated domains: (1) household-level resource and risk management, (2) stewardship and intergenerational transmission of TEK, (3) coordination and governance of social networks, and (4) leadership in applied adaptive innovation. These domains were derived inductively from the data and interpreted through feminist political ecology and the sustainable livelihood framework.

1. Perceptions and Experiences of Intensifying Hydro Climatic Disruption

Participants across all groups expressed a shared awareness of environmental disruption, yet the framing of these perceptions diverged between institutional and community-level accounts. Institutional representatives tended to interpret hydro climatic change through a governance and planning lens, whereas community members, and particularly women, described it as an immediate, embodied, and multidimensional livelihood crisis. This divergence in framing is itself a substantive finding, with direct implications for how adaptation interventions are designed and for whom.

Institutional representatives, including village heads and agricultural officers, drew on long-term observation to characterize current conditions as a breakdown of established agricultural calendars. They contrasted present unpredictability with the relatively stable seasonal patterns of two to three decades ago, emphasizing how this disruption undermines the reliability of Traditional Ecological Knowledge (TEK) as a basis for crop planning and livelihood decisions. As one village leader observed:

"The seasons have changed. In the past, the seasons were very different from each other. Now, there are three seasons in one day. We can no longer tell what time of year it is. This makes it difficult to live and work" (Village Leader No.5, IDI, 22 August 2025).

Community members participating in FGDs framed these changes differently. While they acknowledged agricultural impacts, participants foregrounded the physiological consequences of extreme heat and rapid temperature fluctuation, including illness, fatigue, and reduced capacity for labors, as their most pressing everyday concerns. Women in particular linked climatic instability to diminished physical capacity for both farm work and caregiving, a dimension of vulnerability that institutional accounts did not address. As one participant stated:

"The weather swings. It rains in the evening, and it is hot in the morning. We cannot change our bodies. People get sick, with coughs and colds, because the air changes too fast" (Community Member No.8, FGD, 22 August 2025).

FGD narratives further revealed that off-season rainfall poses acute risks to short-cycle secondary crops such as tomatoes and chili, which are critical for immediate household cash flow and daily subsistence. This concern was largely absent from institutional accounts, which focused on staple rice production and long-term food security planning.

Taken together, these divergent perceptions indicate a gap between how hydro climatic disruption is institutionally understood and how it is materially experienced at the household level. Adaptation policies designed around institutional framings risk overlooking the embodied, labor-intensive, and household-level dimensions of climate stress that women disproportionately absorb. This finding provides the context within which the four domains of women's adaptive agency, analyzed in the following section, should be understood.

2. Women as Agents of Adaptation

Before presenting the four domains of women's adaptive agency, two cross-cutting observations warrant attention. *First*, the findings complicate the prevailing narrative that frames

rural women primarily as passive victims of environmental disruption. The evidence from Rattana-wapi District demonstrates instead that women act as agents of climate adaptation, working at the interface between household survival and community-based resource governance. This is not to suggest that women are unaffected by hydroclimatic disruption. As the following domains show, their agency is exercised under considerable constraint and frequently at personal cost.

Second, the study's intersectional design, which deliberately included LGBTQ+ persons, revealed that participants broadly shared the adaptive strategies documented among women, but reported greater exclusion from formal community decision-making processes. This highlighted their dependence on the informal solidarity networks that women anchor. Gendered adaptive capacity is therefore not uniform. It is differentially shaped by overlapping social identities and structural constraints.

2.1 Household Resource and Risk Management

Women in Rattana-wapi absorb much of the shock that hydroclimatic disruption transmits to the household economy, mediating between declining resource availability and essential subsistence needs. This role operates across two interconnected dimensions: proactive livelihood diversification and reactive consumption smoothing.

Livelihood Diversification. A gendered divergence in economic adaptation was evident across households. Men tended to remain engaged in monoculture, high-risk production systems such as tobacco or single-crop rice, which are acutely vulnerable to climate-induced failure. Women, by contrast, constructed diversified livelihood portfolios that combined agricultural, non-agricultural, and informal income-generating activities, allowing labor and resources to be reallocated quickly when primary income streams were disrupted. In Scoones' (1998) terms, this represents a livelihood strategy in its own right rather than a supplementary activity, spreading risk across sources so that a single shock does not affect all household income at once. Women themselves described these activities not as supplementary but as safety nets to be activated immediately. As one participant stated:

"The rice is gone when the river floods our fields. My husband waits for the water to go down, hoping for help from the government, but I must find another way to get money immediately, selling vegetables from my garden or weaving baskets, so we can buy food that same night" (Community Member No.12, FGD, 22 August 2025).

For women, adaptation was neither deferred nor anticipatory. It was an ongoing, everyday practice driven by immediate responsibility for household survival.

Consumption Smoothing. Beyond income generation, women managed food access and intra-household distribution under conditions of scarcity. During periods of climate stress, they used rationing strategies that prioritized the nutritional needs of children and older family members, often at personal cost. As one participant recounted:

"During the dry months when the garden doesn't produce anything, I add more water to the rice pot to make it last longer. I feed my husband and the children first. I tell them I'm not hungry, even when my stomach hurts, if there's not much left" (Community Member No.8, IDI, 22 August 2025).

This account demonstrates the micro-politics of intra-household resource allocation. Household resilience was not a neutral or collectively shared achievement. It was sustained in part through women's self-deprivation, a dimension that aggregate measures of resilience routinely obscure.

2.2 Stewardship and Intergenerational Transmission of TEK

Women in Rattanawapi acted as custodians of local biodiversity and TEK, in roles that extend beyond agricultural labor to the active management of biological resources. This stewardship underpins one of the community-level practices that align with NbS principles and it operated through two main practices.

Seed Conversation and Exchange. Women were the principal keepers of local rice varieties whose traits are attuned to the Mekong's flood-pulse ecology, including tolerance to drought and periodic submergence that participants contrasted with commercial hybrid varieties. Through the deliberate selection, saving, and circulation of resilient seed across households and generations, women maintained a shared pool of planting material that underpins adaptive capacity in agriculture. Participants describes this practice not as an attachment to tradition but as a deliberate choice to retain varieties suited to local conditions. As one participant explained:

"I save the seeds from the rice that survives the drought. My grandmother taught me which ones are strong. The new seeds from the town die too easily, but our old seeds know how to wait for the rain" (Community Member No.7, FGD, 22 August 2025).

Ethnobotanical Knowledge and Food Security. Women also held detailed knowledge of riverbank ecologies, including the spatial and seasonal distribution of edible wild plants, medicinal herbs, and semi-domesticated species, which functioned as subsistence safety net when cultivation failed. When crops were compromised by heat stress or insufficient, this knowledge allowed women to draw on riparian landscapes as alternative food source, reducing the household's reliance on cultivated production alone. As one participant stated:

"When the garden dries up and the vegetables turn yellow, I go to the river edge. I know which weeds are medicine and food. The river always gives us something to eat if you know where to look" (Community Member No.5, FGD, 22 August 2025).

Women's TEK is therefore appeared neither static nor merely cultural heritage. It functioned as dynamic, practice-based form of environmental knowledge that supported the resilience and redundancy of the local food system under climatic uncertainty.

2.3 Coordination and Governance of Social Networks

A gendered division in resource governance was evident in the study communities. Men predominantly controlled physical infrastructure, including irrigation pumps and canal maintenance, while women exercised authority over the social relationships through which resource use is regulated. This division was not merely descriptive. It indicated that women sustain the relational and normative foundations on which community-based natural resource management depends. Through dense informal networks, women brokered consensus, mediate resource conflicts, and upheld ecological boundaries, functions that formal governance structures neither performed nor recognized.

Conflict Resolution and Water Access. During periods of seasonal water scarcity, access to the Mekong and its tributaries became a potential site of conflict. Women mitigated these tensions through negotiation embedded in everyday social spaces such as markets, temples, communal gathering points, rather than through formal dispute-resolution mechanisms, water access was framed not as individual entitlement but as shared obligation tied to collective survival. As one participant stated:

"We women talk at the well. If one family is taking too much water, we don't argue; we remind them that everyone's children are thirsty. It is about respect, not rules" (Community Member No.15, FGD, 22 August 2025).

This exemplifies a relational form of resource governance in which equitable distribution is maintained through shared social norms, social ties, and reputational accountability rather than administrative procedure. Women thereby turned potentially volatile competition into

negotiated cooperation, sustaining the social basis of community water governance under climatic stress.

Social Norms and the Enforcement of Conservation Zone. Women also played a significant, though largely unrecognized, role in translating formal conservation regulations into everyday practice. Fish Conservation Zones (FCZs), although established through state-led technocratic processes, depend on local compliance for their effectiveness. In Rattanaawapi, women were central to securing that compliance. They monitored fishing practices and addressed transgressions not through formal sanctions but through peer accountability and influence exercised within household. As one participant explained:

"If we see someone's husband casting a net in the sanctuary zone, we do not call the police. We tell his wife. Shame is a stronger fence than any wire we could put up" (Community Member No.15, IDI, 22 August 2025).

These practices constitute a normative conservation order in which ecological rules are sustained through relational authority and collective accountability rather than coercive enforcement. Conservation effectiveness in this context rested less on formal surveillance than on the social infrastructure that women maintained. The findings therefore reframe women's roles in fisheries governance, from passive beneficiaries of conservation interventions to participations whose informal authority is central to their operation.

2.4 Leadership in Applied Adaptive Innovation

Women in Rattanaawapi were at the forefront of an agroecological transition, which complicated accounts that portray rural communities as resistant to change or dependent on externally introduced technologies. Rather than passive adopting outside interventions unchanged, women acted as context-specific innovators whose practices sought to reconcile ecological integrity with livelihood security. This leadership was most evident in two practices they had advanced largely on their own initiative: integrated rice–fish systems and organic soil management.

Integrated Rice–Fish Co-culture. Women were increasingly adopting and managing integrated rice–fish systems. The arrangement is ecologically circular: fish suppress pests and contribute nutrients to the paddy, while flooded rice fields provide aquatic habitat. Participant described the system as reducing their dependence on purchased inputs while generating a dual yield that buffers against both market volatility and climate-induced crop failure. As one participant explained:

"The chemicals differ every year in price, but the fish work for free. They eat the bugs on the rice, and their waste feeds the soil. If the price of rice is low, we still have fish to sell. We are building a farm that feeds itself" (Community Member No.9, FGD, 22 August 2025).

This account reflects women's capacity to translate ecological processes into economically viable production models, reducing household exposure to rising input costs while strengthening the adaptive capacity of the wider agroecosystem.

Organic Soil Management. Women were also leading a shift towards organic soil management to response to declining soil fertility, which participants attributed to erosion and to years of chemical-intensive cultivation. Drawing on close observation of their own fields, women were adopting organic amendments such as compost, manure, and biochar, alongside mixed cropping. Participation described these practices as deliberate responses to degraded land rather than as inherited routines. As one participant stated:

"The soil is tired from the chemicals men used for tobacco. Now, we feed the land with compost so it can hold the water when the rain stops. We are healing the ground, so it does not crack in the heat" (Community Member No.16, FGD, 22 August 2025).

Taken together, these practices position soil health as a collective adaptive resource to be maintained over time rather than an input to be extracted, and they locate women as the principal agents of that reorientation in the study communities.

Discussion

The findings from riparian communities along the Mekong River in Rattanaowapi District, Nong Khai Province, provide offer empirical grounding for three interconnected arguments. *First*, women act as active agents of climate adaptation, not merely as passive victims of environmental disruption. *Second*, many of their adaptive practices are embedded in living systems of Traditional Ecological Knowledge (TEK) and closely align with core principles of Natural-based Solutions (NbS). *Third*, despite the depth of these contributions, structural barriers continue to constrain their formal recognition in climate governance. Each argument is developed in turn in the sections that follow.

Women as Adaptive Agents: Rethinking the Vulnerability Paradigm

The findings reinforce that shift in gender-climate scholarship from portraying women primarily as vulnerable subjects towards recognizing them as active agents of adaptation. Feminist political ecology has long theorized this shift (Arora-Jonsson, 2011; Rocheleau et al.,

1996), yet it remains empirically underexplored in Thai riparian contexts. Early contributions emphasized women's structural marginalization and resource dependence, even as they noted the undervaluation of women's environmental knowledge (Denton, 2002). Much of subsequent literature continued to frame women as disproportionately vulnerable and low in adaptive capacity (e.g. Akter et al., 2016). The findings from Rattana-wapi District complicate this deficit framing. Women are not merely exposed to climatic and hydrological shocks; they are actively recalibrating farming systems, livelihood portfolios, and social norms in response to a river that can no longer be relied upon as predictable seasonal reference.

The recalibration must be situated within what O'Brien and Leichenko (2000) term "double exposure": the simultaneous impact of climate change and economic globalization on particular regions and social groups. In the Lower Mekong, the latter is most visible in transnationally financed hydropower development. Climate variability combine with dam operations is disrupting the seasonal flood pulse on which agriculture, fisheries, and riparian livelihoods depend (Oeurng et al., 2016; Soukhaphon et al., 2021). Against this backdrop, women's strategies extend beyond short-term coping alone. These strategies include livelihood diversification, seed conservation, agroecological innovation, and the governance of social networks. In Scoones' (1998) terms, they represent not merely temporary adjustments to change but longer-term shifts in livelihood strategies, with diversification serving as a means of adaptation rather than of coping alone. This contrasts with evidence from the Vietnamese Mekong Delta, where women's adaptive responses remained largely reactive and focused on immediate survival (Tran et al., 2025). This contrast suggests that locally embeded knowledge may enable more anticipatory forms of adaptation. These patterns are also consistent with the broader feminization of agriculture documented across Southeast Asia, particully in Cambodia, Lao PDR, and Vietnam, where male out-migration has place women at the center of everyday livelihood and environmental management (Han et al., 2022).

The findings also expose the ambivalence of resilience as an analytical category. Scoones (1998) identifies consumption smoothing as a household strategy for cushioning the effects of shocks and stresses, but the Rattana-wapi evidence reveals who bears its costs. During periods of climate stress, women smooth household consumption by extending rice supplies, prioritizing other family members' nutrition, concealing their own hunger. This echoes Agarwal's (1997, p.39) observation that rural women in South Asia often "eat last and least." Agarwal attributes this pattern less to innate altruism than to women limited fallback options and greater dependence on the household. Comparative evidence show that women tend to prioritize feeding their families over themselves during climate-induced food insecurity, at the cast of their own nutrition (Adhikari & Ghimire, 2025; Denton, 2002). Women's self-deprivation in Rattana-wapi therefore reflects not virtue but constrained bargaining positions through which household resilience is effectively subsidized by women's bodies, time, and nutrition. It also

illustrates Arora-Jonsson's (2011) warning that climate responses can increase women's responsibilities without corresponding rewards. Community-level adaptive capacity may thus rest upon gendered sacrifices that risk compounding long-term health disparities. Resilience in this setting, is neither neutral nor collectively shared; it is differentially produced and disproportionately borne by women.

Grassroots Nature-based Solutions Embedded in Traditional Ecological Knowledge

The findings contribute to NbS to TEK scholarship by showing how women's place-based practices in a river basin under compounded climatic and infrastructural pressure align with the core principles of NbS. These practices protect, sustainably manage, and restore modified agro-ecosystems while addressing a societal challenge, namely household food and livelihood security, and generating co-benefit for human well-being and biodiversity (Cohen-Shacham et al., 2016). In this sense, they may be understood as grassroots NbS. This finding is significant because NbS are frequently implemented through technocratic, top-down processes that offer limited scope for integrating local knowledge system (Olivadese, 2025), and because citizen participation in NbS governance remains largely tokenistic (Kiss et al., 2022). The Rattanawapi evidence therefore extends a body of NbS research drawn largely from urban and European settings by documenting community-driven, women-led practices in a rural riparian context of the Lower Mekong.

Women's integrated rice–fish systems illustrate this alignment most clearly. Comparative evidence from Thai farms shows that rice–fish co-culture provides a range of regulating services, including nutrient cycling, biological control of weeds and pests, and support for faunal and microbial diversity. It also reduces reliance on chemical fertilizers and pesticides and generates income from both rice and fish, with total ecosystem service values around one quarter higher than those of rice monoculture (Arunrat & Sereenonchai, 2022). Such integrated aquaculture–agriculture systems are also recognized as adaption options that diversify production and help sustain farm viability under climate change (Bezner Kerr et al., 2022). Women's shift towards compost, manure, and mixed cropping similarly reflects agroecological practices that IPCC associates with lower yield variability under dry conditions, although evidence that organic matter consistently improve soil water properties remains mixed (Bezner Kerr et al., 2022, p.745). In Rattanwapi, women describe these practices as deliberate response to longer dry seasons and increasing erratic rainfall. Their seed conservation practices sustain local varieties valued for drought and flood tolerance. This reflects the IPCC's assessment that landraces are often better adapted to local conditions and harsh environments without external inputs, and that farmer seed systems and diverse agroecosystems maintained through Indigenous and local knowledge offer important adaptation opportunities (Bezner Kerr et al., 2022, p.745, 818).

Central to these practices is their embeddedness in women's TEK. Women's detailed knowledge of local seed varieties, wild edible plants, and riverine micro-ecologies enable them to build layered ecological and social safety nets that neither formal food assistance nor state-led conversation programs currently replicate. During agriculture failure and hydrological shocks, this ethnobotanical expertise turns the surrounding riparian landscape into a reserve subsistence system. Wild foods nonetheless remain under-examined in climate and food-system research, and evidence on their nutritional importance is still limited (Bezner Kerr et al., 2022, p. 758), which underscores the contribution of these findings. Consistent with Berkes et al. (2000), women's TEK emerges there not as static cultural heritage but as a dynamic form of adaptive management, continually updated through observation of changing river. Yes, this knowledge remains marginal in formal planning. The IPCC concludes with high confidence that Indigenous and local knowledge, although an important component of many adaptation strategies, continues to be marginalized in food system, and that greater integration would increase adaptation effectiveness (Bezner Kerr et al., 2022, p. 818). This gap between NbS policy discourse and the situated, embodied knowledge practice by women (Resurrección, 2024) thus represents both an injustice and missed opportunity for effective adaptation.

Informal Governance and the Structural Limits of Recognition

The study's third contribution lies in illuminating women's role in sustaining the social infrastructure of environmental governance, and in revealing the structural barriers that prevent this role from receiving formal recognition. Sneddon and Fox (2006) argue that conventional analyses of Mekong hydro politics privilege the basin and international scale, effectively rendering illegitimate the activities of local resource users who depend on the river for their livelihoods. Even this critical hydro politics, however, does not engage with gender. The findings from Rattanawapi District address this omission by showing that the everyday governance of water and aquatic resources is sustained through women's social networks, relational forms of resource governance, and informal sanctioning practices.

Women's mediation of water access, negotiate irrigation turns, and uphold fish conservation zones (FCZs) through peer accountability and social pressure. These practices partly resemble the design principles that Ostrom's (1990) identified for enduring common-pool resource institutions, notably community-based monitoring and graduated sanctions. Yet they operate through relational, gendered spaces rather than through formal organizations, and are better understood through Cleaver's (2000) notion of institutional bricolage. In this view, resource management institutions are socially embedded, pieced together from existing norms and relationships rather than deliberately designed, and often depart from the formal design principles advocated for robust common-pool resource management. This resonates with evidence from the Vietnamese Mekong Delta, where women's adaptive strategies constitute

forms of informal leadership that remain largely invisible to formal adaptation planning (Tran et al., 2025). In Rattana-wapi, also, women's environmental authority resides in informal domains that state and donor institutions rarely see, even though it is indispensable to the legitimacy and effectiveness of local conservation regimes.

This invisibility has concrete consequences. The Chief Executives of Subdistrict Administrative Organizations (SAOs) and the district officials interviewed in this study acknowledge the effectiveness of women's seed networks and FCZ enforcement. At the same time, they confirmed that neither receives a dedicated budget or institutional mandate. This institutional blindness renders women's adaptive labor economically invisible, limits the potential to scale up effective grassroots NbS, and concentrates the costs of resilience on those least able to bear them. Several mutually reinforcing barriers sustain this outcome. Entrenched gender norms continue to exclude women from formal decision-making (Han et al., 2022; Tran et al., 2025). These norms are compounded by a long-standing policy assumption that informal and traditional institutions are inherently weak and must be replaced by formal arrangement (Cleaver, 2000), and by the persistent marginalization of Indigenous and local knowledge relative to external scientific expertise (Bezner Kerr et al., 2022; Resurrección, 2024). The result is precisely what Arora-Jonsson (2011) cautions against – climate responses that increase women's responsibilities without corresponding recognition or rewards.

Conclusion

This study examined how women in riparian communities along the Mekong River in Rattana-wapi District, Nong Khai Province, develop, negotiate and enact climate adaptation strategies under conditions of intensifying hydroclimatic disruption. The finding show clearly that women are not merely recipients of climate assistance but active agent of community resilience. They build an adaptive infrastructure that operates across ecological, economic, and social domains, yet remains largely invisible to the formal governance frameworks that could support and scale it.

This infrastructure rests on four interconnected pillars. *First*, women buffer household against climate shocks through livelihood diversification and intra-household consumption smoothing, often at the cost of their own nutrition. *Second*, they sustain local agrobiodiversity by conserving seed varieties valued for drought and flood tolerance and by transmitting TEK across generations. *Third*, they govern the informal social networks through which water access is mediated and resource conflicts are resolved where formal institutions are absent or ineffective. *Finally*, they lead agroecological innovations, notably integrated rice-fish systems and the use of compost, manure, and mixed cropping, which align with the core principles of NbS and may be understood as grassroots NbS operating without formal recognition or dedicated institutional support.

Translating these findings into policy requires four concrete shifts. *First*, gender-responsive NbS programing must move beyond rhetorical commitment towards direct, dedicated funding for women's grassroots practices, including seed networks, integrated farming systems, and the enforcement of fish conservation zone (FCZs). The The Chief Executives of SAOs and district officials in this study acknowledge these practices as effective, yet none receives a dedicated budget. *Second*, women's roles in resource monitoring, conflict mediation, and conservation governance should be formally recognized within subdistrict administrative structures. This recognition should complement rather than replace the informal arrangements through which these roles currently operate, since such socially embedded institutions are often more legitimate and effective than externally imposed ones. *Third*, the costs of resilience must be addressed through gender-sensitive social protection and health monitoring systems that identify and mitigate the disproportionate physical and nutritional burdens women absorb during climate shocks, burdens that current adaptation frameworks rarely measure or compensate. *Fourth*, women's TEK should be systematically integrated into formal climate and hydrological monitoring through participatory, citizen-science approaches, bridging the gap between ground-level adaptive knowledge and state-level planning.

Effective climate adaptation in riparian communities cannot be achieved by importing external solutions while overlooking the adaptive systems that already exist. In Rattanawapi, those systems are sustained largely by women. Recognizing, resourcing, and institutionally supporting women's roles in ecological stewardship, livelihood governance, and agroecological innovation is therefore not a matter of gender equity alone. It is a precondition for building resilience that is socially just, ecologically robust, and genuinely responsive to the communities most exposed to hydroclimatic uncertainty in the Mekong.

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References

- Adhikari, A., & Ghimire, S. (2025). Gendered dimensions of climate change impacts: Challenges and adaptive strategies. *Turkish Journal of Agriculture-Food Science and Technology*, 13(5), 1354–1367. <https://doi.org/10.24925/turjaf.v13i5.1354-1367.7481>

- Agarwal, B. (1997). *"Bargaining" and gender relations: Within and beyond the household*. (FCND Discussion Paper No.27). International Food Policy Research Institute.
<https://ageconsearch.umn.edu/record/42661/files/dp27.pdf>
- Akter, S., Krupnik, T. J., Rossi, F., & Khanam, F. (2016). The influence of gender and product design on farmers' preferences for weather-indexed crop insurance. *Global Environmental Change*, 38, 217–229. <https://doi.org/10.1016/j.gloenvcha.2016.03.010>
- Arora-Jonsson, S. (2011). Virtue and vulnerability: Discourses on women, gender and climate change. *Global Environmental Change*, 21(2), 744–751.
<https://doi.org/10.1016/j.gloenvcha.2011.01.005>
- Arunrat, N., & Sereenonchai, S. (2022). Assessing ecosystem services of rice–fish co-culture and rice monoculture in Thailand. *Agronomy*, 12(5), 1241.
<https://doi.org/10.3390/agronomy12051241>
- Berkes, F. (2017). *Sacred ecology*. Routledge. <https://doi.org/10.4324/9780203123843>
- Berkes, F., Colding, J., & Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications*, 10(5), 1251–1262. [https://doi.org/10.1890/1051-0761\(2000\)010\[1251:ROTEKA\]2.0.CO;2](https://doi.org/10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2)
- Bezner Kerr, R., Hasegawa, T., Lasco, R., Bhatt, I., Deryng, D., Farrell, A., Gurney-Smith, H., Ju, H., Lluch-Cota, S., Meza, F., Nelson, G., Neufeldt, H., & Thornton, P. (2022). Food, Fibre, and Other Ecosystem Products. In *Climate change 2022: Impacts, adaptation and vulnerability*. (pp. 713–906). Cambridge University Press. <https://doi.org/10.1017/9781009325844.007>
- Braun, V., & Clarke, V. (2006). Using Thematic analysis in Psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Cleaver, F. (2000). Moral ecological rationality, institutions and the management of common property resources. *Development and Change*, 31(2), 361–383.
<https://doi.org/10.1111/1467-7660.00158>
- Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (Eds.). (2016). *Nature-based solutions to address global societal challenges*. International Union for Conservation of Nature (IUCN).
<https://doi.org/10.2305/IUCN.CH.2016.13.en>
- Denton, F. (2002). Climate change vulnerability, impacts, and adaptation: Why does gender matter? *Gender & Development*, 10(2), 10–20. <https://doi.org/10.1080/13552070215903>
- Frantzeskaki, N. (2019). Seven lessons for planning nature-based solutions in cities. *Environmental Science & Policy*, 93, 101–111. <https://doi.org/10.1016/j.envsci.2018.12.033>
- Han, Y.-C., Pross, C. A., Agarwal, R. A., & Raluca Torre, A. (2022). *The state of gender equality and climate change in ASEAN*. The ASEAN Secretariat Public Outreach and Civil Society Division. <https://asiapacific.unwomen.org/sites/default/files/2022-09/State-of-Gender-Equality-and-Climate-Change-in-ASEAN-2.pdf>
- Kiss, B., Sekulova, F., Hörschelmann, K., Salk, C. F., Takahashi, W., & Wamsler, C. (2022). Citizen participation in the governance of nature-based solutions. *Environmental Policy and Governance*, 32(3), 247–272. <https://doi.org/10.1002/eet.1987>

- Nong Khai Provincial Statistical Office. (2022). *Nong Khai provincial statistics 2022*. Nong Khai Provincial Statistical Office.
- O'Brien, K. L., & Leichenko, R. M. (2000). Double exposure: Assessing the impacts of climate change within the context of economic globalization. *Global Environmental Change*, 10(3), 221–232. [https://doi.org/10.1016/S0959-3780\(00\)00021-2](https://doi.org/10.1016/S0959-3780(00)00021-2)
- Oeurng, C., Cochrane, T. A., Arias, M. E., Shrestha, B., & Piman, T. (2016). Assessment of changes in riverine nitrate in the Sesan, Srepok and Sekong tributaries of the Lower Mekong River Basin. *Journal of Hydrology: Regional Studies*, 8, 95–111. <https://doi.org/10.1016/j.ejrh.2016.07.004>
- Olivadese, M. (2025). Rethinking nature-based solutions: Unintended consequences, ancient wisdom, and the limits of nature. *Land*, 14(6), 1272. <https://doi.org/10.3390/land14061272>
- Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press.
- Resurrección, B. P. (2024). Colonial erasures in gender and climate change solutions. *WIREs Climate Change*, 15(5), e890. <https://doi.org/10.1002/wcc.890>
- Rocheleau, D., Thomas-Slayter, B., & Wangari, E. (Eds.). (1996). *Feminist political ecology: Global issues and local experience*. Routledge.
- Scoones, I. (1998). *Sustainable rural livelihoods: A framework for analysis* (IDS Working Paper 72). Institute of Development Studies. <https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/3390>
- Sneddon, C., & Fox, C. (2006). Rethinking transboundary waters: A critical hydropolitics of the Mekong basin. *Political Geography*, 25(2), 181–202. <https://doi.org/10.1016/j.polgeo.2005.11.002>
- Soukhaphon, A., Baird, I. G., & Hogan, Z. S. (2021). The impacts of hydropower dams in the Mekong River Basin: A review. *Water*, 13(3), 265. <https://doi.org/10.3390/w13030265>
- Tran, T. T., Nguyen, T. T., Ashton, E. C., & Aka, S. M. (2025). Support needs of agrarian women to build household livelihood resilience: A case study of the Mekong River Delta, Vietnam. *Climate*, 13(8), Article 163. <https://doi.org/10.3390/cli13080163>