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WATER INSECURITY AND HOUSEHOLD FOOD INSECURITY IN SINDH: ASSESSING ECONOMIC VULNERABILITY AND COPING STRATEGIES

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Abstract

This study examines the relationship between household water insecurity and food insecurity in selected districts of Sindh, Pakistan, with particular attention to economic vulnerability and coping strategies. The study uses a cross-sectional analytical framework based on a structured household questionnaire covering water insecurity, economic vulnerability, coping strategies, and food insecurity. The analytical dataset comprises 427 complete household records from Tharparkar, Thatta, Hyderabad, and Karachi. Descriptive statistics, internal consistency analysis, correlation analysis, multivariable regression, and bootstrap-based mediation analysis were conducted. Water insecurity was positively associated with economic vulnerability, coping strategies, and household food insecurity. Economic vulnerability and coping strategies were also positively associated with food insecurity, while indirect associations through these mechanisms were statistically distinguishable from zero. The findings support an integrated interpretation of water and food insecurity in which water-related stress is associated not only with resource access but also with household economic pressure and coping responses. The study contributes Sindh-specific evidence to the growing literature on water and food insecurity as interconnected household-level challenges.

INTRODUCTION

Water insecurity extends beyond physical scarcity to include unreliable supply, inadequate quantity, difficult access, affordability constraints, and the social and economic burdens households face in securing water. The Household Water Insecurity Experiences (HWISE) framework advanced this perspective by measuring water insecurity through household experiences rather than infrastructure or aggregate availability alone (Young et al., 2019). This distinction matters in low- and middle-income settings, where nominal access to water may coexist with unreliable or unaffordable household supply (Jepson et al., 2017; Rosinger & Young, 2020).

Food insecurity similarly reflects more than the physical availability of food. Households require sufficient economic and livelihood resources to obtain adequate and acceptable food, making

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purchasing power and vulnerability to shocks central to food access (Sen, 1981). Persistent food-price pressures can further constrain this access, particularly among households with limited economic resources (FAO et al., 2025). Water and food insecurity therefore share an important household-level dimension: both depend on the resources available to meet basic needs.

Growing evidence shows these insecurities are closely connected. Using data from 6,691 households across 27 sites in 21 low- and middle-income countries, Brewis et al. (2020) found that greater household water insecurity was associated with greater food insecurity. Miller et al. (2021) similarly identify water security as an important enabling condition for nutrition because water supports food preparation, hygiene, health, livelihoods, and food production. Water insecurity may consequently affect food security not only through physical water constraints but also through expenditure, lost time, livelihood disruption, and changes in household consumption.

Households also actively respond to water-related stress. Common responses include purchasing water, using alternative or distant sources, storing water, borrowing resources, reducing expenditure, and modifying food consumption (Venkataramanan et al., 2020). Recent multi-site evidence further shows that coping responses vary considerably across settings and should be examined in relation to their frequency and household consequences (Collins et al., 2024). Coping is therefore not necessarily an indicator of successful adaptation; some responses may protect immediate water access while transferring costs to food consumption or other household needs.

In Pakistan, pressures related to household purchasing power and economic conditions can further shape households' ability to secure essential goods and services, including food and water (State Bank of Pakistan [SBP], 2025). These relationships are particularly relevant in Pakistan, where water availability, agriculture, livelihoods, and household welfare are closely interconnected. Pakistan's Economic Survey 2024–25 documents substantial rainfall variability and changes in canal-head withdrawals, including reduced withdrawals in Sindh during both Kharif 2024 and Rabi 2024- 25 (Ministry of Finance, 2025). The Sindh Water Policy likewise identifies water scarcity, dependence on the Indus system, deteriorating water quality, climate-related drought and flood risks, population growth, and increasing urban demand as interconnected challenges (Government of Sindh, 2023). Water insecurity in Sindh is consequently relevant not only to domestic water access but also to livelihoods and household economic security.

Evidence from Pakistan reinforces this concern. Research in Southern Punjab has linked water insecurity with household routines, livelihood constraints, nutrition, and gendered burdens (Ahmed et al., 2021). More recent evidence reports a positive relationship between household water and food insecurity and shows that socioeconomic disadvantage is associated with both outcomes (Ahmed et al., 2024). Urban evidence from Karachi further demonstrates how unreliable supply can push low-income households toward more costly alternative sources, highlighting the role of affordability and unequal access alongside physical availability (Khan & Arshad, 2022). These studies establish the relevance of the water–food relationship in Pakistan but provide limited evidence on how economic vulnerability and coping strategies jointly connect water insecurity with food insecurity in Sindh.

Sindh provides a particularly important context because water-related vulnerability differs across locations. Tharparkar represents an arid environment with substantial livelihood exposure to water constraints; Thatta combines coastal and riverine pressures; Hyderabad represents a mixed urban–rural setting; and Karachi presents a large metropolitan context characterized by irregular supply and reliance on alternative sources. This variation offers an opportunity to examine water insecurity as a household experience across

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contrasting socioeconomic and geographic environments, rather than as a uniform provincial condition.

The present study examines the relationship between household water insecurity and food insecurity in selected districts of Sindh, with economic vulnerability and coping strategies positioned as intervening mechanisms. Specifically, the study assesses whether greater water insecurity is associated with greater economic vulnerability, whether these pressures are reflected in household coping responses, and whether these pathways are associated with food insecurity. By integrating experience-based water insecurity with economic and coping measures, the study extends existing water–food research from documenting coexistence toward examining the household processes through which water-related stress may be reflected in food-security outcomes.

2. Literature Review

2.1 Water insecurity as a household experience

Water insecurity is increasingly understood as a multidimensional household condition involving inadequate quantity, unreliable supply, difficult access, affordability, and the burdens of obtaining and managing water. The HWISE framework advanced this experience-based perspective by measuring household water access, adequacy, reliability, and related consequences across low- and middle-income settings (Young et al., 2019). These measures matter because a formal water source does not necessarily ensure adequate or reliable household access; experience-based indicators can therefore capture dimensions that conventional infrastructure measures may miss (Jepson et al., 2017; Young et al., 2021).

Water insecurity can also generate social and emotional burdens, particularly where responsibility for securing and managing water is unequally distributed within households and communities (Sultana, 2011; Wutich & Ragsdale, 2008). Evidence from Ethiopia further links water insecurity to psychosocial distress, particularly among women, who often bear greater responsibility for household water management (Stevenson et al., 2012). More broadly, evidence indicates that household water insecurity is associated with poorer mental health, demonstrating that its effects extend beyond physical access (Kimutai et al., 2023).

These challenges are particularly relevant in Pakistan, where gaps in water, sanitation, and hygiene services continue to affect household wellbeing and access to basic services (UNICEF Pakistan, 2025). Research in Southern Punjab found that water insecurity affected household routines, women's workloads, livelihoods, and nutritional conditions (Ahmed et al., 2021), while evidence from Karachi shows that unreliable supply and socioeconomic inequality can push disadvantaged households toward costly alternative water sources (Khan & Arshad, 2022). Thus, water insecurity reflects both exposure to water-related stress and the resources available to manage it.

Households respond through purchasing water, using distant sources, storing supplies, borrowing, and modifying expenditure or consumption (Achore et al., 2020; Venkataramanan et al., 2020). Such responses may relieve immediate shortages but impose additional financial and social costs. This makes household coping an important link between water insecurity, economic vulnerability, and food security in Sindh.

2.2 Water insecurity and food security

The relationship between water and food security is grounded in the water–food nexus, which recognizes that water is essential for food production, preparation, hygiene, and livelihood activities. Consequently, pressures on water systems can directly and indirectly affect household food security (Hoff, 2011). This interdependence is particularly important in South Asia, where agriculture and rural livelihoods remain strongly dependent on water resources and where water and food policies

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cannot be considered effectively in isolation (Rasul, 2014; D'Odorico et al., 2018).

At the household level, water insecurity can affect food security through higher expenditure, lost productive time, livelihood disruption, and constraints on food preparation. These pressures can reduce resources available to obtain adequate food (Miller et al., 2021). Evidence from 6,691 households across 27 sites in 21 low- and middle-income countries found that greater water insecurity was significantly associated with food insecurity, including concerns about food availability and reductions in food quantity and quality (Brewis et al., 2020). Experience-based measurement matters because it captures household consequences that conventional indicators of physical water access may overlook (Young, 2021).

Evidence from Pakistan also supports this relationship. Research in Southern Punjab found that water insecurity was associated with household food insecurity and that socioeconomic disadvantage increased vulnerability to both conditions (Ahmed et al., 2024). Earlier evidence from the same broader region linked water insecurity with livelihood disruption, nutritional conditions, and household burdens (Ahmed et al., 2021).

However, limited attention has focused on the economic pathway through which water insecurity may translate into food insecurity, particularly the role of household coping responses in Sindh. This study addresses this gap by examining economic vulnerability and coping strategies as intervening mechanisms linking water insecurity with household food insecurity.

2.3 Economic vulnerability and household coping

Economic vulnerability provides an important link between water insecurity and food insecurity. The Sustainable Livelihoods Framework explains vulnerability through exposure to shocks, available livelihood assets, and households' capacity to respond (DFID, 1999). From this perspective, water insecurity can increase expenditure, reduce productive time, disrupt livelihoods, and divert scarce resources from other essential needs. Sen's entitlement approach similarly emphasizes that food insecurity may result from reduced household command over resources rather than from inadequate food availability alone (Sen, 1981).

Coping strategies are therefore central to understanding household responses to water-related stress. Common strategies include purchasing or collecting water from alternative sources, storing supplies, borrowing, changing routines, and modifying food consumption or household expenditure (Venkataramanan et al., 2020). Evidence also shows that low-income households often carry a disproportionate coping burden because their responses tend to be more labor-intensive and costly (Majuru et al., 2016).

A qualitative synthesis further found that water-insecurity coping can affect household savings, livelihoods, health, and psychosocial well-being, potentially deepening economic disadvantage among poorer households (Achore et al., 2020). More recent evidence from 11 global sites identified 19 distinct coping strategies and emphasized the importance of measuring their prevalence, frequency, and severity (Collins et al., 2024).

Coping should therefore not be interpreted as automatic success. Purchasing water may resolve an immediate shortage while reducing money available for food, whereas borrowing may protect short-term consumption while creating future financial pressure. Evidence from Pakistan likewise indicates that greater reliance on coping strategies during economic crises is associated with higher household food insecurity (Anwar et al., 2024). Thus, coping may function simultaneously as a response to water insecurity and a pathway through which household vulnerability intensifies, supporting its inclusion as an intervening mechanism between water insecurity, economic vulnerability, and food insecurity in Sindh.

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2.4 Research gap

Existing research establishes a strong relationship between water and food insecurity, but important gaps remain. International evidence largely comes from cross-country or multi-site studies, while Pakistan-specific research is concentrated in Southern Punjab and selected urban settings. Moreover, existing studies commonly emphasize nutrition, health, or WASH outcomes, with less attention to economic vulnerability as a pathway linking water insecurity to food insecurity. Coping strategies are also often documented descriptively rather than examined as measurable intervening mechanisms (Venkataramanan et al., 2020; Collins et al., 2024).

Evidence from Sindh remains particularly limited despite substantial variation in its water and livelihood contexts, ranging from arid Tharparkar and coastal Thatta to urban Hyderabad and metropolitan Karachi. This study addresses this gap by providing an integrated household-level assessment of water insecurity, economic vulnerability, coping strategies, and food insecurity within a single analytical framework.

2.5 Theoretical and conceptual framework

This study integrates the Sustainable Livelihoods Framework, water-food nexus, and Entitlement Approach. The Sustainable Livelihoods Framework explains how households respond to environmental stress using available livelihood resources (DFID, 1999), while the water–food nexus highlights the interdependence of water, food, livelihoods, and household welfare (Hoff, 2011; D'Odorico et al., 2018). The Entitlement Approach further emphasizes that food security depends on households' ability to command resources and obtain food, not simply on food availability (Sen, 1981). Accordingly, the study proposes the following conceptual model in Figure 1

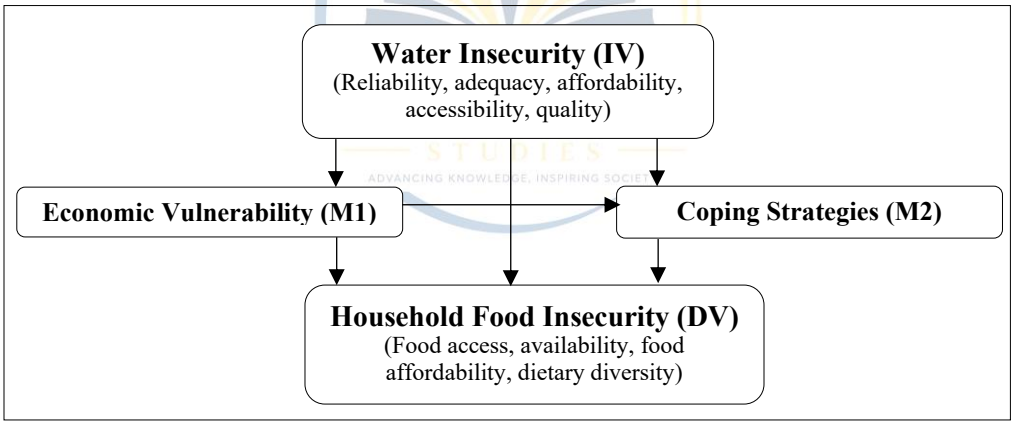


Figure 1: Conceptual Framework

The conceptual framework proposes that water insecurity is associated with household food insecurity both directly and through economic and coping pathways. Water insecurity may increase economic vulnerability, which may shape coping responses, while economic vulnerability and coping strategies may in turn be associated with food insecurity. The framework therefore specifies both direct and sequential indirect pathways linking water insecurity to food insecurity. Water insecurity is measured through 12 items, economic vulnerability through five, coping strategies through six, and food insecurity through eight. These pathways represent theoretically informed statistical associations; given the cross-sectional design, they do not establish temporal or causal relationships.

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3. Methods and Materials

3.1 Study design

The study adopts a quantitative cross-sectional design covering households in four purposively selected districts of Sindh: Tharparkar, Thatta, Hyderabad, and Karachi. The districts were selected to capture contrasting geographic, socioeconomic, and water-service conditions rather than to represent all districts of Sindh statistically. Karachi represents a metropolitan setting, Hyderabad a mixed urban–rural context, Thatta a coastal/riverine environment, and Tharparkar an arid and highly water-constrained setting. According to the 2023 Population and Housing Census, the four districts contain 3,439,220 households in Karachi, 448,479 in Hyderabad, 327,677 in Tharparkar, and 206,281 in Thatta (Pakistan Bureau of Statistics [PBS], 2023).

The sample size was determined at a 95% confidence level with a 5% margin of error, assuming a 50% population proportion, producing a minimum sample of 384 households. After allowing for 10% non-response, the required sample was approximately 427 households. The final sample comprised 427 households, allocated proportionately by district household population: 332 from Karachi, 43 from Hyderabad, 32 from Tharparkar, and 20 from Thatta. This proportional allocation ensured that the sample reflected the relative household distribution of the selected districts.

3.2 Measurement

The study measured water insecurity, economic vulnerability, coping strategies, and household food insecurity, alongside key household and socioeconomic characteristics. Water insecurity was assessed using 12 experience-based items referring to the previous four weeks, scored from 0 (Never) to 4 (Always), and adapted from the HWISE approach (Young et al., 2019). Economic vulnerability comprised five items addressing water-related expenditure, reduced household resources, earning capacity, and livelihood disruption, rated from 1 (Strongly disagree) to 5 (Strongly agree). Coping strategies were assessed using six items covering alternative water sources, water storage, expenditure reduction, food-purchasing changes, and borrowing or assistance, scored from 0 (Never) to 4 (Very often).

Household food insecurity was assessed using eight experience-based items addressing food-related worry, dietary restriction, reduced food intake, skipped meals, and hunger. The items followed the Household Food Insecurity Access Scale (HFIAS) framework, which uses an experience-based approach to assessing household food-access conditions (Coates et al., 2007; Knueppel et al., 2010). Responses were scored from 0 (Never) to 3 (Often).

Mean scores were calculated for each construct, with higher scores indicating greater water insecurity, economic vulnerability, coping use, or food insecurity. Household characteristics included district, residence, respondent and household-head characteristics, household size, presence of children under five years, education, occupation, and monthly household income.

3.3 Data Collection

Data were collected through in-person household interviews conducted by the researcher and trained enumerators. Before the main survey, the researcher pilot-tested the questionnaire with 40 households (10% of the target sample) to assess clarity, response consistency, and field applicability. Based on the pilot, the researcher made necessary wording and procedural adjustments before the main survey. The researcher then supervised the trained enumerators throughout the fieldwork to ensure consistent administration, respondent eligibility, and accurate recording of responses. After completing the pilot phase, the researcher administered the finalized questionnaire to the 427 sampled households through face-to-face interviews.

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3.4 Statistical analysis

Descriptive statistics summarized household characteristics and construct scores. Internal consistency was assessed using Cronbach's alpha, followed by Pearson correlation analysis to examine bivariate associations among the four principal constructs.

Ordinary least squares (OLS) regression was used to estimate associations among water insecurity, economic vulnerability, coping strategies, and food insecurity. Indirect associations were assessed using bootstrap mediation analysis with 5,000 resamples, estimating pathways through economic vulnerability, coping strategies, and their sequential combination. Given the cross-sectional design, these effects are interpreted as statistical mediation patterns consistent with the conceptual framework rather than as evidence of temporal or causal mediation.

3.5 Ethical Considerations

Participation was voluntary, and respondents were informed about the study before providing informed consent. Respondents could decline to answer or withdraw from the interview at any stage. The study maintained confidentiality and anonymity throughout data collection and analysis, and reported no personally identifying information. The collected information was used solely for academic research and presented in aggregate form to protect participants' privacy.

4. Results

The analytical dataset comprises 427 complete household records. Karachi dominates the sample because district allocation follows its substantially larger household population. Overall, 83.8% of households are urban, and 16.2% are rural. Respondents are 53.9% male and 46.1% female, while 82.9% of households have a male household head. The mean respondent age is 38.5 years, and the mean household size is 5.39 persons.

Nearly half of the households report monthly incomes below PKR 50,000, while 17.8% fall in the highest income category (≥ PKR 100,000). Educational attainment is concentrated at the secondary/higher-secondary level (44.7%), followed by graduate-level education or above (26.0%). The occupational profile is primarily concentrated in private employment, business/self-employment, and daily wage labor. These characteristics provide important socioeconomic context for interpreting household exposure to water-related economic pressures and coping responses.

Table 1. Household characteristics

Characteristic	Category	n	%
Location	Urban	358	83.8
	Rural	69	16.2
Gender	Male	230	53.9
	Female	197	46.1
Household-head gender	Male	354	82.9
	Female	73	17.1
Head education	No formal education	51	11.9
	Primary	74	17.3
	Secondary/higher secondary	191	44.7
	Graduate or above	111	26.0
Monthly income	< PKR 25,000	92	21.5
	PKR 25,000–49,999	124	29.0
	PKR 50,000–99,999	135	31.6
	≥ PKR 100,000	76	17.8

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All four study constructs demonstrated good internal consistency, with Cronbach's alpha ranging from .845 to .947 (Table 2). Mean scores were 2.95 (SD = 0.56) for economic vulnerability, 2.58 (SD = 0.65) for water insecurity, 2.34 (SD = 0.62) for coping strategies, and 1.93 (SD = 0.65) for food insecurity. The reliability coefficients indicate strong internal consistency within each construct. These results support the internal consistency of the measurement scales used in the analysis, although reliability alone does not establish construct validity.

At the item level, water-related difficulties were most prominent for inadequate drinking water and interruptions in household supply. Economic vulnerability was particularly reflected in additional expenditure on obtaining water, while purchasing water from alternative sources was the most prominent coping response. Among food-insecurity items, concern about food availability and reduced food quantity were among the most frequently reported experiences.

Table 2. Descriptive statistics and internal consistency

Construct	Items	Mean	SD	Cronbach's α
Water insecurity	12	2.58	0.65	.947
Economic vulnerability	5	2.95	0.56	.845
Coping strategies	6	2.34	0.62	.869
Food insecurity	8	1.93	0.65	.919

Construct scores varied across the four study districts (Table 3). Tharparkar recorded the highest levels of water insecurity and food insecurity, while Thatta showed the highest economic-vulnerability score. Hyderabad had the lowest mean scores across all four constructs. Karachi showed intermediate levels overall, although its large sample contribution means that its estimates substantially influence the pooled sample results.

The descriptive results indicate variation in construct scores across the four districts; however, interpret these differences cautiously because district sample sizes are unequal and no formal test of between-district differences is reported.

Table 3. Mean construct scores by district

District	n	Water insecurity	Economic vulnerability	Coping strategies	Food insecurity
Hyderabad	43	2.06	2.52	2.07	1.54
Karachi	332	2.58	2.94	2.34	1.93
Tharparkar	32	3.02	3.31	2.65	2.34
Thatta	20	2.89	3.33	2.44	2.11

Pearson correlations showed positive and statistically significant associations among all four principal constructs (Table 4). Water insecurity was moderately associated with economic vulnerability ($r = .518$, $p < .001$), coping strategies ($r = .521$, $p < .001$), and food insecurity ($r = .572$, $p < .001$). The strongest association was between economic vulnerability and coping strategies ($r = .642$, $p < .001$).

Overall, the correlation pattern aligns with the proposed conceptual framework: higher water insecurity is associated with greater economic vulnerability, more frequent coping responses, and greater food insecurity. These bivariate

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associations provide the basis for the subsequent multivariable and indirect-effect analyses. However, given the cross-sectional design, interpret them as associations rather than causal relationships.

Table 4. Pearson correlations among study constructs

Variable	1	2	3	4
1. Water insecurity	1.000			
2. Economic vulnerability	.518***	1.000		
3. Coping strategies	.521***	.642***	1.000	
4. Food insecurity	.572***	.525***	.568***	1.000

***p < .001.

Regression analyses showed positive associations among water insecurity, economic vulnerability, coping strategies, and food insecurity (Table 5). Water insecurity was positively associated with economic vulnerability (B = 0.397, p < .001) and coping strategies (B = 0.351, p < .001), while economic vulnerability was also positively associated with coping strategies (B = 0.335, p < .001). In the food-insecurity model, water insecurity (B = 0.307), economic vulnerability (B = 0.250), and coping strategies (B = 0.322) were all positively associated with food insecurity (all p < .001). The model explained 48.4% of the variance in food insecurity.

Table 5. Regression and mediation results

Model/path	B	R^2	p
Water insecurity → economic vulnerability	0.397	.309	< .001
Water insecurity → coping strategies	0.351	.357	< .001
Economic vulnerability → coping strategies	0.335	.357	< .001
Water insecurity → food insecurity	0.307	.484	< .001
Economic vulnerability → food insecurity	0.250	.484	< .001
Coping strategies → food insecurity	0.322	.484	< .001

Bootstrap analysis identified significant indirect associations through economic vulnerability (B = 0.115, 95% CI [0.069, 0.167]) and coping strategies (B = 0.112, 95% CI [0.069, 0.161]). The sequential indirect pathway through economic vulnerability and coping strategies was also significant (B = 0.049, 95% CI [0.029, 0.072]), with a combined indirect effect of B = 0.275 (95% CI [0.216, 0.337]). A positive direct association between water insecurity and food insecurity remained after accounting for the intervening variables.

Overall, the findings are consistent with a statistical partial mediation pattern, with indirect associations operating through economic vulnerability and coping strategies alongside a remaining direct association between water insecurity and food insecurity. Given the cross-sectional design, these findings should not be interpreted as evidence of temporal or causal mediation.

5. Discussion

The findings indicate that household water insecurity is closely connected with economic vulnerability and food insecurity, suggesting that water-related stress extends beyond physical access to affect household welfare. The positive associations across the four constructs align with international evidence linking household water

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insecurity with food insecurity (Brewis et al., 2020) and research identifying water security as an important enabling condition for nutrition (Miller et al., 2021).

Economic vulnerability adds an important dimension to this relationship. Water insecurity may require households to devote additional financial resources, time, or livelihood capacity to securing adequate water, potentially reducing resources available for other essential needs. This interpretation aligns with the Sustainable Livelihoods perspective and evidence that water insecurity can impose economic and livelihood burdens on households (Venkataramanan et al., 2020).

Coping strategies further clarify this relationship. Previous research documents responses such as purchasing water, using alternative sources, storing water, borrowing, and changing household consumption (Venkataramanan et al., 2020; Collins et al., 2024). The present findings suggest that coping is associated not only with water insecurity but also with economic vulnerability and food insecurity. Thus, coping may address immediate water needs while simultaneously placing additional pressure on household resources.

The district variation further highlights the importance of local context. Higher levels of water and food insecurity in Tharparkar and the relatively high economic vulnerability observed in Thatta indicate differences across geographic and livelihood settings. At the same time, the Karachi findings demonstrate that water insecurity is not exclusively a rural or arid-area concern. Evidence from Karachi similarly shows how unreliable supply and unequal access can increase reliance on costly alternative sources (Khan & Arshad, 2022).

The findings also extend existing evidence from Pakistan. Previous research in Southern Punjab has linked water insecurity with household labor, livelihoods, nutrition, and food insecurity (Ahmed et al., 2021; Ahmed et al., 2024). This study extends that evidence to Sindh by examining water insecurity, economic vulnerability, coping strategies, and food insecurity within a single analytical framework. The results therefore support viewing water insecurity as a broader household welfare issue rather than solely a WASH concern. The cross-sectional design does not establish temporal or causal relationships, and unmeasured socioeconomic and household factors may contribute to the observed associations. From a policy perspective, the results suggest that improving physical water supply alone may not fully address household vulnerability. Water interventions should also consider affordability, reliability, equitable access, and the economic costs of coping. Integrating water management with food-security, social-protection, and livelihood policies may therefore provide a more comprehensive response to household vulnerability in Sindh.

6. Policy Implications

The findings suggest addressing household water security as both a water-service and economic-protection issue. Water interventions should therefore consider reliability, affordability, water-related expenditure, and equitable access alongside physical supply.

Three priorities emerge. First, household-level water indicators should complement infrastructure measures to identify affordability and reliability burdens. Second, link vulnerable households with social protection and livelihood support to reduce the risk that water-related costs constrain food expenditure. Third, urban and rural policies should reflect their different contexts, including the cost of alternative water sources in cities and the links between domestic water, agriculture, livestock, and livelihoods in rural areas.

An integrated approach aligns with evidence linking water security to food security and nutrition (Young, 2021; Miller et al., 2021). Strengthening household-level monitoring through existing survey systems could also improve identification of water-related vulnerability and support more targeted policy responses.

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7. Conclusion

This study examined the relationship between household water insecurity and food insecurity in selected districts of Sindh, with particular attention to economic vulnerability and coping strategies. The findings show consistent positive associations among water insecurity, economic vulnerability, coping responses, and food insecurity. These results highlight the importance of understanding water insecurity as a broader household-welfare issue, not solely a matter of physical water access. The study contributes by integrating economic vulnerability and coping into the water–food security relationship, highlighting how household capacity to manage water-related pressures may shape food-security outcomes. For Sindh, effective responses therefore require attention to reliable and affordable water access alongside household livelihoods and economic resilience.

8. Limitations and Future Research

Several limitations should be considered. First, the cross-sectional design limits the ability to establish temporal or causal relationships among water insecurity, economic vulnerability, coping strategies, and food insecurity. Second, the unequal district sample sizes, particularly for Thatta and Tharparkar, require caution when interpreting district-level differences. Third, the study uses adapted experience-based measures rather than the complete HWISE or HFIAS instruments, limiting direct comparability with studies using the original scales. Future research should employ probability-based samples across a wider range of Sindh districts, incorporate seasonal and longitudinal data, and examine gender, water expenditure, livelihood impacts, and food consumption in greater depth. Such research would strengthen evidence on the pathways linking water insecurity with household food security.

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