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Public perceptions of drinking water pollution and associated health risks in eastern Nepal

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ABSTRACT

Access to clean and safe drinking water remains a major challenge in Nepal in rapidly urbanizing municipalities. This study used a quantitative approach, surveying a sample comprising 69.95% males and 30.05% females aged 25–44 years (67.78%), in Nepal's two easternmost municipalities. Tube wells were the primary drinking water source for 68% of households. Only 25% had tested their water; limited knowledge (58%) was the main barrier, 69% of respondents said that they used filters, distrust and inconvenience hindered wider adoption. Eighty per cent identified perceived pollution sources and 96.63% linked perceived contamination to disease, yet no respondents had participated in awareness programs. Storage practices were inadequate; households relied on earthen pots (43%), bottles (40%), and buckets (16%) with irregular cleaning. Our analysis showed strong linkage between water color, taste, and pollution sources, whereas poor storage and lower-income levels were strong predictors of post-storage discoloration. Seventy-five per cent of households were categorized as very high risk, with diarrhea (35.59%) being the most reported disease, disproportionately affecting children (0–12 years) and the elderly (>60 years) based on the questionnaire. The study shows that there is an urgent need for community-based awareness programs, improved water quality monitoring, and targeted policy interventions aligned with Sustainable Development Goal 6.

Key words: drinking water, public health, water pollution, water storage

HIGHLIGHTS

- This study provides the evaluation of public perceptions, awareness, and behavioral attitudes toward drinking water quality in the rapidly urbanizing municipalities of eastern Nepal.
- While 96.63% of respondents link contaminated water to disease, a gap exists as 100% said that they have never participated in a formal water awareness program, highlighting a massive institutional communication void.
- Regression analysis shows that lower income and education levels are strong predictors of heightened perceived vulnerability and poor domestic water storage practices.
- Despite high perceived risk, wider adoption of Point-of-Use (PoU) filtration is hindered by a 48% distrust in filter efficacy and technical issues like rapid clogging.
- Achieving Sustainable Development Goal 6 (Clean Water and Sanitation) requires shifting from passive municipal reliance toward gender-inclusive, community-based governance and subsidized testing facilities.

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1. INTRODUCTION

Water is a fundamental biotic component sustaining and contributing to the continuation of life on Earth, supporting the cities and industrial prosperity (Khan *et al.* 2020; Joshi *et al.* 2024). However, the stability of this critical resource is uncertain due to climate change, an increase in demand, and polluted water sources (WWAP 2018). The United Nations' outlook to 2050 indicates that the level of urbanization is anticipated to grow from 50 to 69% based on 2009 as a baseline (Abbas *et al.* 2018). Rapid urbanization and population growth increase the water demand (Zubaidi *et al.* 2018; Fenu & Malloci 2020). In developing countries, the water supply systems are inadequate, leading to the discharge of untreated wastewater directly to the freshwater sources (Awoke *et al.* 2016; Zulu *et al.* 2020). Consequently, the deterioration of water quality has become a center of attention because of the detection of hazardous materials in water bodies worldwide (Hasan *et al.* 2019). Sustainable Development Goal (SDG) 6 has been launched to improve water and sanitation, particularly in low- and middle-income countries, where nearly 2 billion people lack access to safe drinking water and this is expected to increase by nearly one-third in 2050 (WWAP 2018). SDG 6 specifically aims to ensure universal access to safe and sustainable water and sanitation by 2030 (Howard 2021).

The safety of public drinking water is facing growing threats as external factors, such as climate change and shifts in land use, increasingly disrupt the stability of water sources (Dunn *et al.* 2012; Pouget *et al.* 2012; Garrote 2017).

In the context of Nepal, these global challenges are magnified by its unique geographical and hydrogeological vulnerability. National statistics show that over 90% of the population has access to basic water supply services, with only approximately one-quarter benefiting from safely managed sources (National Planning Commission 2020). The Terai region is home to approximately 48% of the country's population, which relies heavily on groundwater (Raut *et al.* 2025). However, hydrogeological assessments indicate that this critical aquifer system is under stress. The Terai region of Nepal lies within the Indo-Gangetic Plain, composed of a Holocene alluvial deposit. These shallow, unconfined aquifers are highly permeable, making them significantly vulnerable to vertical percolation of surface contaminants (Khadka *et al.* 2024). The high permeability of the soil profile means that anthropogenic pollutants, specifically agricultural runoff containing nitrates and pesticides, and unmanaged wastewater from septic seepage, rapidly infiltrate the water table (Uprety *et al.* 2020; Hamal *et al.* 2025a). Similarly, the groundwater of the Terai of Nepal contains elevated levels of arsenic and iron (Aryal 2025; Hamal *et al.* 2025b). Households are often settled near the river or rely on shallow tube wells where the water table is accessible but is highly susceptible to microbial and chemical contamination (Nayebare *et al.* 2022). Therefore, physical factors like distance from the river system are a potential exposure to these vulnerabilities. Water management authorities are being compelled to adopt new technologies and develop updated strategies to maintain water quality (Olsen & Shindler 2010; Ho & Michalak 2015). The success of any health intervention largely depends on how seriously the affected community perceives the health threat (Almeida *et al.* 2013). However, noncommunicable diseases often receive minimal focus in public health education due to their gradual onset and delayed symptoms (Kebede *et al.* 2016). This limited public awareness has been linked to higher rates of infection and more severe outcomes (Abuhaloob & Abed 2014). Factors such as individuals' age, gender, physical activity, and body size, as well as environmental conditions like temperature, influence daily water intake levels (Popkin *et al.* 2010).

Knowledge and understanding of water issues in the community are considered essential for solving water-related problems. Knowledge is central to models of water engagement (Dean *et al.* 2016), environmental citizenship (Dobson 2007; Aslin & Lockie 2013), and environmental literacy (NEEF 2015). A major gap in previous research is the failure to connect these scientific facts with how people actually behave. In this

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study, we tried to look at how people make decisions when they lack full information. Without access to lab tests, households rely on sight, smell, and taste to decide if water is safe (de França Doria 2010). These behavioral gaps lead to negative health effects like diarrhea and other waterborne diseases. Children under five and elderly people are likely to be affected by the pathogens introduced through contaminated water sources, as these groups face higher risks due to weaker immune systems (Abuhaloob & Abed 2014). Therefore, this study aims to address the concerns of water governance and public health in the rapidly urbanizing municipalities of eastern Nepal through human dimensions on water quality.

This study aimed to assess the level of public awareness and understanding regarding drinking water quality and its associated health impacts in the study area. By examining community perceptions, knowledge gaps, and attitudes toward safe water practices, the research provides insights into how local knowledge influences water-related behaviors and health outcomes. The findings will help guide targeted awareness campaigns, policy interventions, and community-based strategies to safeguard drinking water quality and protect public health, contributing to the achievement of SDG 6 on clean water and sanitation.

2. MATERIALS

2.1. Study area

As illustrated in the study area map in Figure 1, Kankai and Shivasatakshi municipalities are located on either side of the Kankai River basin of Jhapa district of eastern Nepal. Kankai River lies 26 °40′ to 27 °08′N latitude and 87 °40′ to 88 °10′E longitude. It is a rain-fed perennial river system originating from the Mahabharat range. The climate in the study area is primarily influenced by the summer monsoon, extending from June to September (Silwal *et al.* 2023). Temperatures in the region vary by altitude; in the upper reaches, averages range from 12 to 27 °C, while the lower plains (Terai) experience extremes from 7 °C in winter to over 37 °C during the peak summer months. The regional economy is primarily agrarian with paddy, rice, maize, and other cash crops as major agricultural products. Most of the households rely on a tube well for daily water needs. However, these groundwater sources are increasingly threatened by the vertical percolation of agricultural runoff, unmanaged wastewater, and pressures of rapid urbanization. Seasonal monsoon flooding and proximity to the Kankai River further stress existing water systems and health risks in these areas. The intersection of these environmental and socioeconomic conditions with diverse demographics makes this area critical for studying household-level vulnerabilities related to water quality, awareness and behavior in rapidly urbanizing regions.

2.2. Sampling design and data collection procedures

To evaluate public awareness and perceptions regarding drinking water quality and health impacts, a structured questionnaire survey was conducted in Kankai and Shivasatakshi municipalities of Jhapa district from March to June 2023. A stratified systematic sampling method was used to ensure impartial representation and address potential selection bias (Acharya *et al.* 2013). This technique was selected due to its capacity to cover each household with an equal chance of inclusion, thereby enhancing the reliability and generalizability of the results (Etikan *et al.* 2016). A total of 416 households were surveyed through face-to-face interviews. This approach was selected to maximize clarity and minimize nonresponse rates for quantitative items (Bryman 2016). Interviews were conducted with the head of the household or a knowledgeable adult member. Prior to the survey, verbal informed consent was obtained, and geographic coordinates (GPS locations) were recorded to verify the spatial distribution of the sample.

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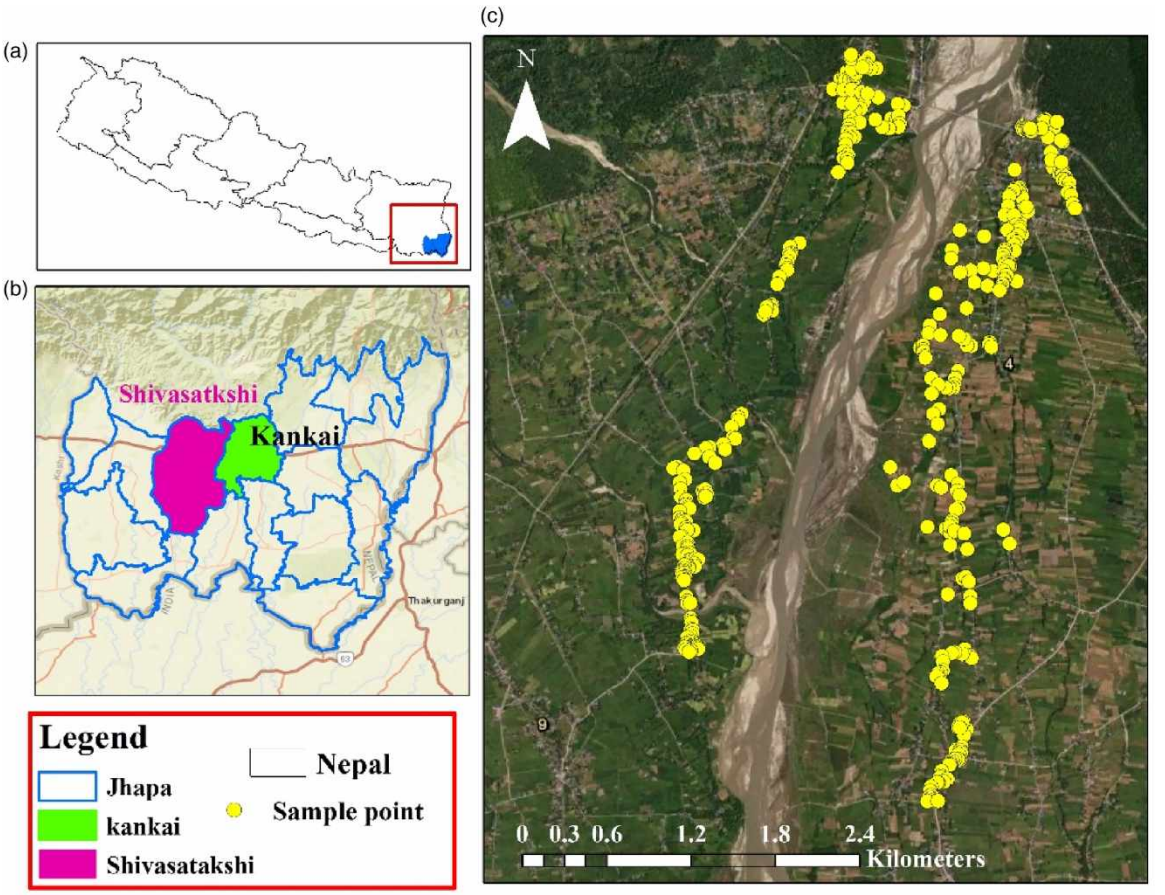

Fig. 1 | Location of the study areas: Kankai and Shivasatakshi, Jhapa, Nepal.

2.3. Questionnaire design

We adopted a descriptive cross-sectional quantitative design to assess household-level water quality perceptions and behaviors. The research instrument was adapted from the validated framework of Afroz *et al.* (2016). The survey was structured into three distinct sections: The first section gathered sociodemographic information (gender, age, education level, occupation, and household income) from respondents. The second section focused on evaluating the participants' understanding of water pollution. The third section assessed their awareness, knowledge, attitudes, and practices related to water contamination and its health effects. Perception intensity was quantified using a Likert scale (ranging from 1 = strongly disagree to 5 = strongly agree). This methodology is effective for capturing empirical population behavior and interpreting relationships between variables at a specific point in time.

2.4. Specification of the model

To evaluate the influence of demographic and socioeconomic factors on individuals' risk perception of water pollution (POWP), a multiple regression analysis was conducted using the following regression model:

$$\mathrm{POWP} = \alpha + \beta_1 \mathrm{Gen}_1 + \beta_2 \mathrm{Age}_2 + \beta_3 \mathrm{Edu}_3 + \beta_4 \mathrm{Inc}_4 + \beta_5 \mathrm{Knw}_5 + \beta_6 \mathrm{Awn}_6 + \beta_7 \mathrm{Wpb}_7 + \varepsilon \quad (1)$$

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Following the approach of Afroz *et al.* (2016), the POWP index was treated as a continuous variable for the multiple regression analysis. While inherently ordinal, previous literature suggests that 5-point Likert scales with sufficient sample sizes ($n = 416$) can be analyzed using parametric methods without significant bias (Norman 2010). The definitions and coding for each variable used in the model are summarized in Table 1.

2.5. Data analysis

We entered all the questionnaire survey data in MS Excel and prepared descriptive summaries using the pivot table function (Clark 2020). Similarly, we grouped the respondents into five age categories: <15, 15–24, 25–44, 45–64, and 65+ years (WHO 1982). The education level of the respondents was categorized into illiterate, primary, and secondary or above. Housing and location types were categorized by structure type (cemented, CGI, or thatched) and residential proximity to the Kankai River (>0.5–1.5, 2–4, and >4 km). The questionnaire was translated into Nepali by the interviewers. Generally, males are the head of the family in Nepal (Adhikari *et al.* 2018); hence, most of the respondents involved in this sampling were males (males = 291, females = 125). Statistical analyses were performed using Excel, OriginPro 2025 (version 10.2), IBM SPSS Statistics 25.0, and R software (version 4.4.0).

3. RESULTS

3.1. Sociodemographic characteristics

The sociodemographic characteristics of the 416 respondents are detailed in Table 2. The sample was predominantly male (69.95%), while females accounted for 30.05%. The age of respondents ranged from 15 to above 65

Table 1 | Description of variables used in the regression in the study area.

Variable	Description of the variable	Category
Gender	Male, female	1 = male 0 = female
Age	The respondent's age	1 = 15–24 2 = 25–44 3 = 45–64 4 = >65
Education	The education level of the respondents	1 = illiterate 2 = primary 3 = secondary or above
Income	Monthly income level of households	1 = <10,000 NRs. 2 = 10,000–20,000 NRs. 3 = 20,001–40,000 NRs. 4 = 40,001–60,000 NRs. 5 = >60,000 NRs.
POWP	Referring to the perception of people about how water pollution has affected them	Five-point Likert scale[a]
AWN	Awareness about water pollution	Five-point Likert scale[a]
KNW	Knowledge regarding water pollution	Five-point Likert scale[a]
ATT	Attitudes toward the pollution of water	Five-point Likert scale[a]

[a]Where 1 represents 'strongly disagree' and 5 represents 'strongly agree'.

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Table 2 | Sociodemographic profile of the respondents.

Variable	Description of the variable	Frequency	%
Gender	Male	291	69.95
	Female	125	30.05
Age group	15–24	33	7.93
	25–44	282	67.78
	45–64	96	23.07
	>65	5	1.22
Education	Illiterate	75	18.02
	Primary	207	49.75
	Secondary or above	134	32.23
Occupation	Agriculture	296	71.15
	Business	99	23.79
	Service	21	5.06
Income	<10,000 NRs.	75	18.02
	10,000–20,000 NRs.	129	31.09
	20,001–40,000 NRs.	178	42.75
	40,001–60,000 NRs.	14	3.34
	>60,001 NRs	20	4.8

years, with the 25- to 44-year age group comprising the highest proportion (67.78%). Respondents aged 15–24 years represented 7.93%, 45–64 years comprised 23.07%, and individuals aged above 65 years accounted for only 1.22% of the total sample. Regarding educational status, 18.02% of participants were illiterate, 49.75% had attained education up to the primary level, and 32.23% had completed secondary education or higher level of education. The economic profile indicates that the majority of households subsist on low- to middle-income levels; 42.75% reported monthly earnings between NRs 20,001 and 40,000. Higher-income households (above 60,001 NRs) were the minority, representing 4.8% of the total sample. Agriculture serves as the primary occupation for 71.15% of the respondents, showing the agrarian nature of the Kankai and Shivasatakshi municipalities.

3.2. Drinking water accessibility

Our study showed that the majority of respondents (68%) reported using tube-well water as their primary source of drinking water, whereas only 32% had access to tap water. A chi-square-based cross-tabulation analysis showed a statistically significant, moderately strong association between drinking water source and occupational category (Cramer's $V = 0.24$, $p = 0.001$). Specifically, 74% of agricultural workers, 51% of business owners, and 43% of service workers reported depending on tube-well water. Spatial proximity to the Kankai also showed a significant association with drinking water source, showing a moderately weak but significant relationship (Cramer's $V = 0.24$, $p = 0.02$). Tube-well dependency was highest among households living within 0.5–1.5 km from the river (78%), followed by those living over 4 km away (71%) and those within 2–4 km range (56%), as illustrated in Figure 2. Furthermore, family size showed a statistically significant but weak positive relationship with access to tap water (Cramer's $V = 0.14$, $p = 0.01$). Access to tap water decreased as household size increased: 49% of families with 1–3 members had access, compared with 31% of families with 4–6 members, and only 25% of families with more than seven members.

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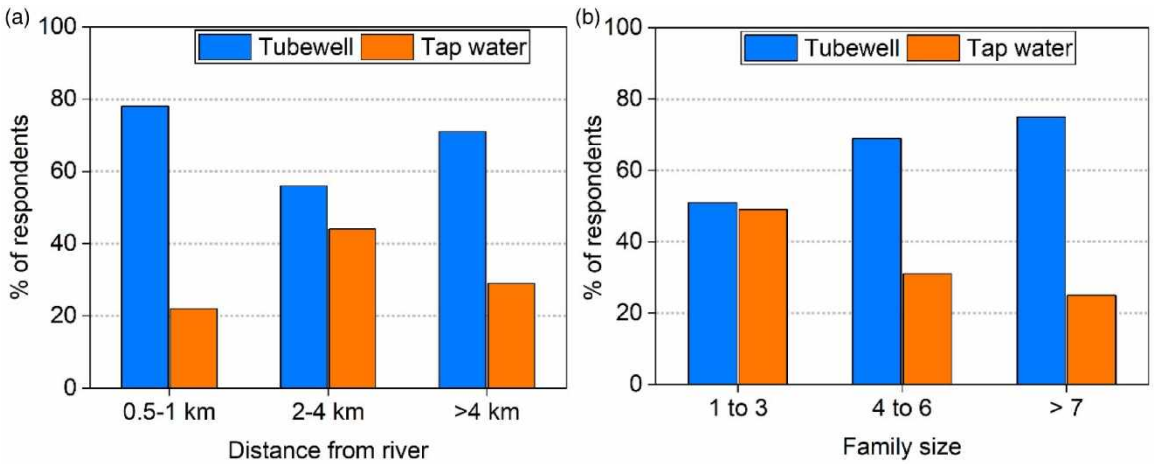

Fig. 2 | The percentage of respondents and their source of drinking water: (a) the distance from the river and (b) family size.

3.3. Household water storage practices

As illustrated in Figure 3, 43% of respondents utilized traditional earthen pots, followed by plastic bottles (40%) and buckets (16%) for primary storage. Beyond the type of vessel, we identified significant vulnerabilities in domestic hygiene. Most households did not use separate utensils for withdrawing water, a practice that facilitates direct microbial transfer. Furthermore, essential sanitary measures such as handwashing before handling drinking water were frequently neglected, particularly among children.

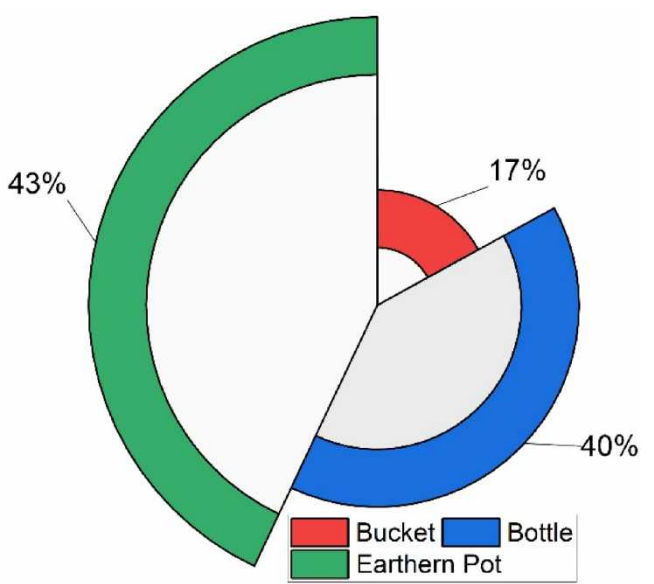

Fig. 3 | Household practices related to drinking water storage in the study area.

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3.4. Household water quality testing and treatment behaviors

Out of the surveyed households, only 25% reported ever having their water tested. Among the 94 respondents who had not tested their water, the primary reason was a lack of knowledge about where or how to get it tested (58%), followed by the perception that testing is too expensive (22%) and dependent on municipal authorities for ensuring water safety (20%), as shown in Table 3. Regarding point-of-use (PoU) treatment, 69% of respondents utilized a domestic water filter. However, the remaining households showed a fundamental distrust in filter efficacy (48%) and cited technical inconveniences, such as rapid clogging(32%), as a reason for nonadoption.

3.5. Household perception and awareness of water pollution

To assess household-level perceptions related to water pollution, a set of structured questions was utilized, as illustrated in Table 4. The results showed that 80% are well-informed regarding the sources of water pollution. Furthermore, 94.5% respondents accepted that water pollution poses significant health risks, while 96.63% recognized that contaminated water is a primary vector for disease transmission. Despite this high level of perceived risk and awareness, none of the respondents reported attending any educational or awareness programs concerning the health impacts of water pollution within their local communities.

3.6. Sources of information about water pollution

Respondents were asked about their information on water pollution. As illustrated in Figure 4, media and communal networks are the primary conduits of information regarding water pollution; 37.5% reported obtaining such information from newspapers, while 21.5% from the community as their main source. Television was

Table 3 | Proportional distribution of household water testing and filtration behaviors.

Behavioral indicator	Reason	Percentage
Water testing participation (n = 100)	Yes	25
	No	75
Primary barrier to testing (n = 94)	Lack of procedural knowledge	58
	Economic constraints (too expensive)	22
	Reliance on municipal authorities	20
Point-of-use filter adoption	Yes	69
	No	31
Primary barrier to filtration (n = 31)	Distrust in filter efficacy	48
	Maintenance issues (gets dirty quickly)	32
	Technical inconvenience	20

Table 4 | Household perception on water pollution.

Items	Yes (%)	No (%)
Are you aware of the causes of water pollution?	80	20
Do you believe that polluted water is harmful to health?	94.5	5.5
Do you think that polluted water can transmit disease?	96.63	3.37
Have you attended awareness programs on the health impact of polluted water?	0	100

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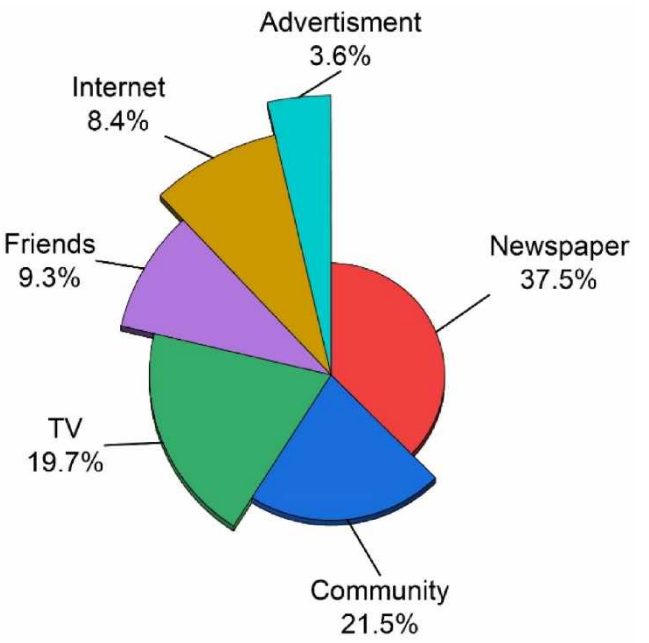

Fig. 4 | Source of information about water pollution.

identified by 19.7% of participants, 9.3% gained knowledge from their friends, 8.4% from the Internet, and 3.6% through advertisements.

3.7. Perceived sources of water contamination

The survey results reveal a strong community consensus regarding the anthropogenic pressures on local water resources. As illustrated in Figure 5, agricultural effluents were identified as the primary contributor to water pollution, cited by 30.04% of respondents. This was followed closely by cremation residues (28.87%) and septic tank seepage (24.74%). Additionally, construction activities were recognized as a pollution source by 16.35% of the surveyed households.

3.8. Perception of waterborne diseases

Respondents were asked to rank the five specific diseases caused by water pollution in the study area, as illustrated in Figure 6. Diarrhea was identified as the most prevalent health outcome, affecting 35.59% of households, followed by skin conditions at 26.68%. Dental issues (tooth-related problems) and jaundice were reported by 20.67% and 13.95% of the participants, respectively. In contrast, a significantly smaller proportion of the sample (3.12%) associated kidney problems with water contamination. Notably, the perception of these health risks varied significantly across the study locations ($\chi^2 = 126.76$, df = 4, $p < 0.0001$), suggesting that local environmental factors or varying levels of health awareness influence how households identify water-related health outcomes.

3.9. Vulnerable age groups to diarrhea disease

We assessed the perceived susceptibility to diarrhea across different age cohorts, as illustrated in Figure 7. The findings show that children (0–12 years) and elderly (over 60 years) groups, typically characterized by weaker

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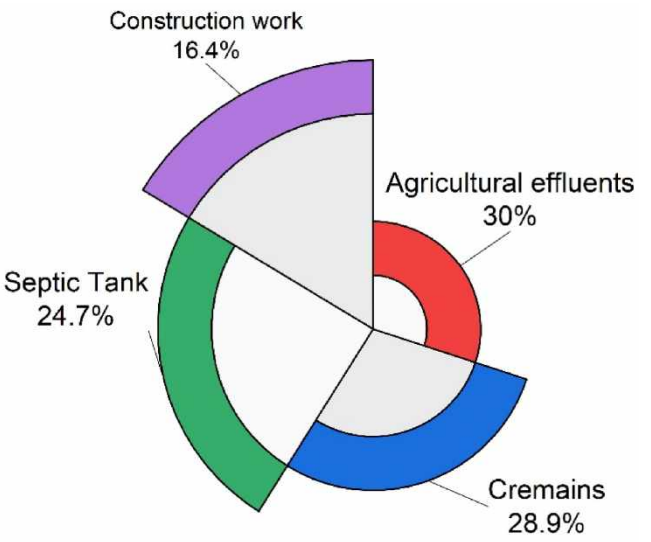

Fig. 5 | Proportional representation of perceived water pollution sources based on household surveys.

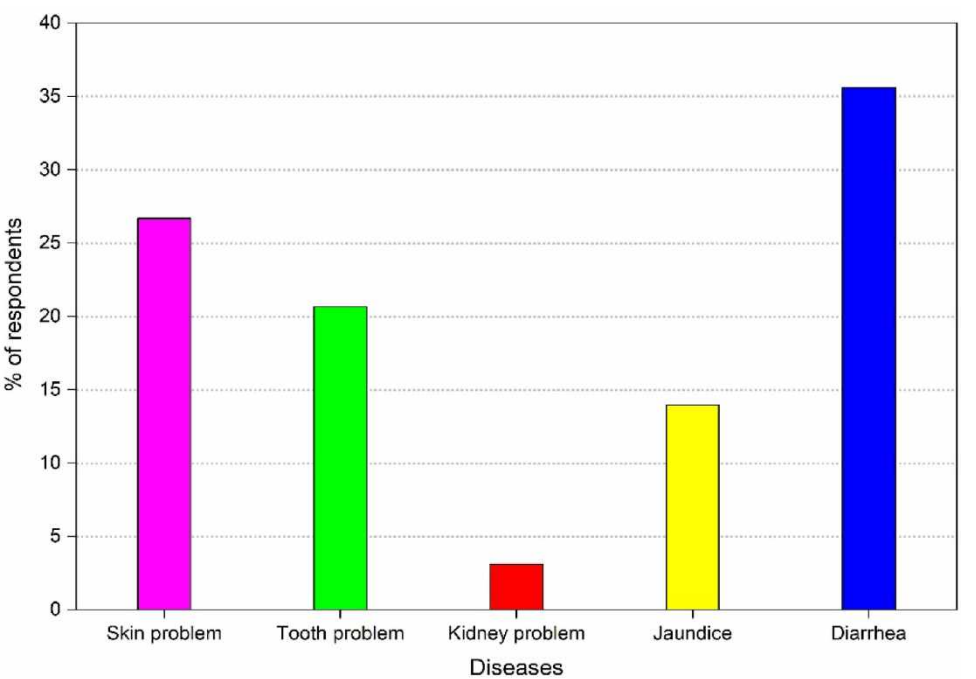

Fig. 6 | Distribution of perceived waterborne health outcomes among survey households.

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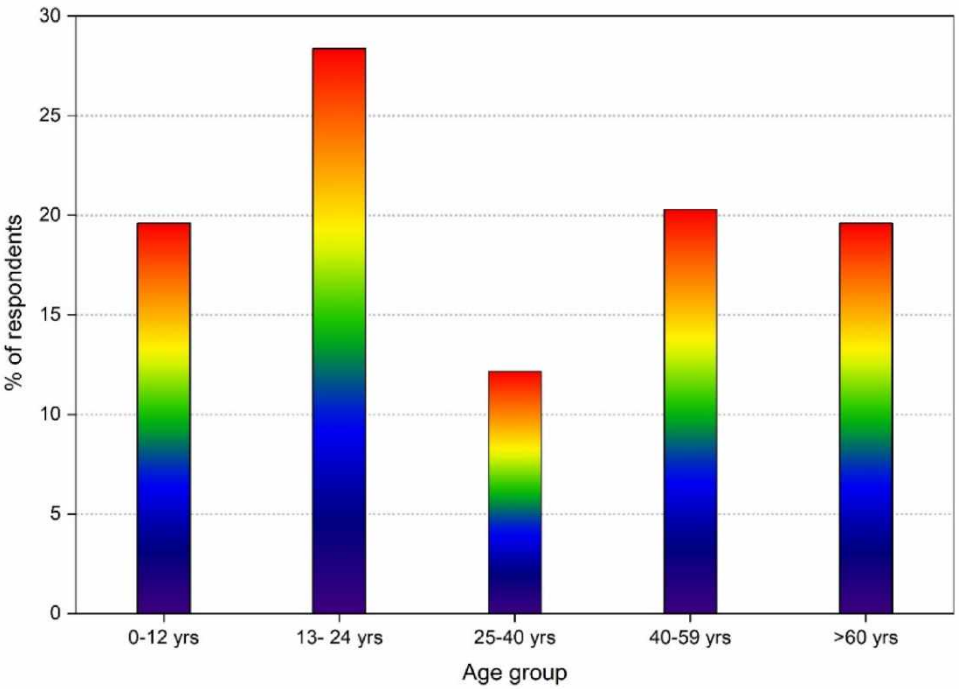

Fig. 7 | Perception of age-based vulnerability to diarrhea disease among households.

immune systems, were reported as affected by 19.59% of respondents. The highest level of perceived vulnerability was between the 13–24 age group (28.37%), followed by 20.29% of the 40–50 age group. In contrast, 12.16% of those aged 25–40 were less affected.

3.10. Statistical association between water quality indicators and perceived pollution

A series of Chi-square tests of independence was conducted to assess the relationships among water color, taste, pollution sources, and changes in color after storage. The results demonstrated a highly significant association between initial water color and poststorage discoloration ($\chi^2 = 412.0$, df = 1, $p < 0.001$), suggesting that water initially perceived as discolored (yellow) is statistically more likely to undergo further aesthetic degradation during storage. Furthermore, a significant relationship was established between perceived pollution sources and poststorage color instability ($\chi^2 = 12.23$, df = 3, $p = 0.006$). This suggests that respondents who identified septic tanks and cremation residues as primary contaminants also reported the highest levels of water color instability over time. Additionally, the correlation between perceived taste and water color was highly significant ($\chi^2 = 290$, df = 3, $p < 0.0001$), indicating that sensory perceptions of water quality in the study area are multidimensional and strongly interlinked.

3.11. Factors influencing risk POWP

In this study, we hypothesized that demographic and socioeconomic variables have different significant effects on the household risk POWP. Based on the regression model shown in Equation (1), the results in Table 5 indicate that the value of the adjusted R^2 was 0.68, suggesting that approximately 68% of the disparity

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Table 5 | Factors influencing risk perception of water pollution.

Coefficient	Estimate	Std. error	*t*-Value	Pr(>|*t*|)	*p*-Value
(Intercept)	2.03	0.41	4.95	0.0001	***
Gender					
Male	3.95	0.06	2.48	0.013	*
Female	3.45	0.1	−3.17	0.001	***
Age					
15–24	4.2	0.16	2.56	0.016	*
25–44	3.15	0.34	9.07	0.0001	***
45–64	1.54	0.58	2.61	0.01	**
> 65	3.54	0.52	6.72	0.0001	***
Education					
Illiterate	4.3	0.11	4.43	0.0001	***
Primary	2.55	0.88	2.87	0.001	**
Secondary or above	2.54	0.89	2.83	0.001	**
Occupation					
Agriculture	4.1	0.1	3.1	0.001	**
Business	0.57	0.06	9.62	0.0001	***
Service	3.55	0.08	−2.86	0.004	**
Monthly income					
< 10,000	4.2	0.115	3.57	0.0003	***
10,001–20,000	4.32	0.3	14.33	0.0001	***
20,001–40,000	3.6	0.086	−2.21	0.027	*
40,001–60,000	−1.69	0.23	−7.2	0.0001	***
> 60,000	3.3	0.229	−2.14	0.03	*
Water pollution awareness	0.307	0.087	3.53	0.0004	***
Water pollution knowledge	0.254	0.085	2.99	0.002	***
Water pollution behavior	0.369	0.032	4.52	0.0001	***
R^2	0.68				

Note: Significant codes: ***0.001, **0.01, *0.05. *F*-statistic: 11.18, *p*-value: ≤0.0001.

in the POWP can be clarified by this model. The *F*-statistic value (11.18) signifies that the general significance of the model was high at 1%. The coefficients of regression prove the nature and magnitude of the relationship among the variables. Positive coefficients for gender ($\beta = 3.95$, $p = 0.013$) and age groups (15–24: $\beta = 4.2$; 25–44: $\beta = 3.15$; >65: $\beta = 3.54$) indicate that these groups have a higher perception of pollution risks compared with their respective reference baselines. Similarly, the coefficients for education (illiterate: $\beta = 4.3$) and monthly income (<10,000 NRs: $\beta = 4.2$; 10,001–20,000 NRs: $\beta = 4.32$) show a significant positive relationship with POWP, potentially reflecting a heightened sense of vulnerability among lower socioeconomic groups. Furthermore, behavioral predictors including awareness ($\beta = 0.307$), knowledge $\beta = 0.254$), and behavior ($\beta = 0.369$) were all significant at $p < 0.01$, confirming that respondents who are more aware and proactive

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have a greater influence on the risk POWP. These results support the hypothesis that demographic and socioeconomic factors have significantly different effects on risk perception in the urbanizing context of Eastern Nepal.

3.12. Socioeconomic and technical predictors of poststorage water discoloration

A linear regression analysis was performed to evaluate the predictive influence of storage methods and monthly income on the frequency of reported color changes in stored drinking water. The model demonstrated statistical significance ($F = 13.08$, $p < 0.001$), indicating that these socioeconomic and technical variables are significant drivers of perceived water quality degradation. Storage methods exhibited a positive and significant effect ($\beta = 0.107$, $p < 0.001$), suggesting that less protective containers, such as buckets and traditional earthen pots, are statistically more likely to be associated with aesthetic color shifts. Conversely, monthly income showed a negative and statistically significant relationship with color change ($\beta = -0.043$, $p = 0.016$). As shown in Figure 8, households in the highest income category reported the lowest frequency of discoloration, particularly when utilizing bottles and buckets, whereas low-income households utilizing earthen pots experienced the highest rates of perceived quality loss (42.4%). These results suggest that higher income may provide a protective effect, likely through access to improved storage infrastructure or superior water handling practices.

3.13. Classification of perceived behavioral vulnerability

Household-level vulnerability to water pollution was evaluated based on perceived indicators focusing on poststorage color change with awareness about water pollution (AWN) and attitudes toward the pollution of water

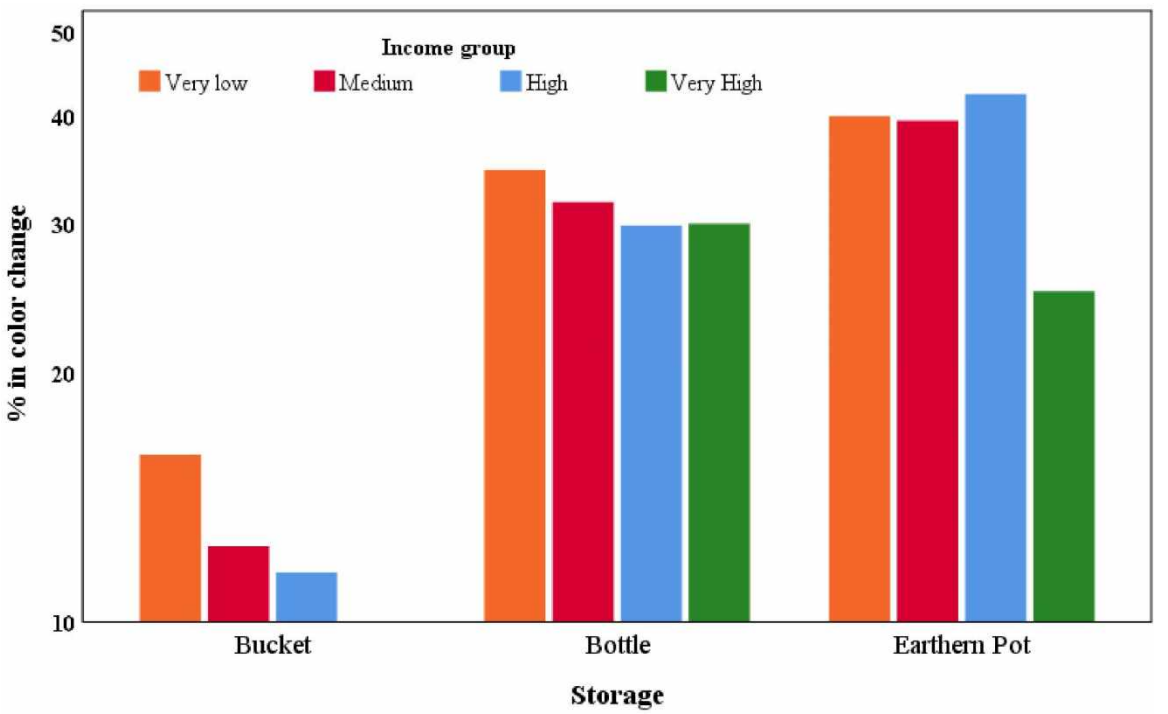

Fig. 8 | Interactive effect of household income levels and storage vessel types on perceived poststorage water discoloration.

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(ATT). Households reporting visible color change, combined with low awareness and negative attitudes, were assigned higher scores and categorized into three risk levels: low, high, and very high. As illustrated in Figure 9, a majority (75%) of households fell into the 'very high perceived vulnerability' category. An additional 20% were classified as high risk, showing moderate behavioral vulnerability, while only 5% were classified as the low-risk category, demonstrating both improved perceived water quality and awareness. This classification reflects behavioral susceptibility and dissatisfaction with aesthetic water quality rather than empirically measured toxicological risk. The association between poststorage color changes, AWN, and ATT was found to be statistically significant ($\chi^2 = 330.37$, df = 2, $p < 0.0001$), which shows a lack of confidence in water safety regardless of objective chemical status.

Disclaimer: *This risk classification is based on perceived indicators and self-reported behaviors, not on microbiological or chemical laboratory analysis*.

3.14. Conceptual framework of household water quality challenges

The integrated findings of this study, encompassing the economic, physical, and mental impacts of water quality issues, are synthesized in Figure 10. This conceptual framework illustrates how household-level exposure characterized by aesthetic degradation and a lack of technical awareness drives specific coping strategies, such as the use of traditional storage vessels and a passive reliance on municipal authorities. The model highlights that the resulting challenges, including medical expenditures and institutional distrust, are disproportionately

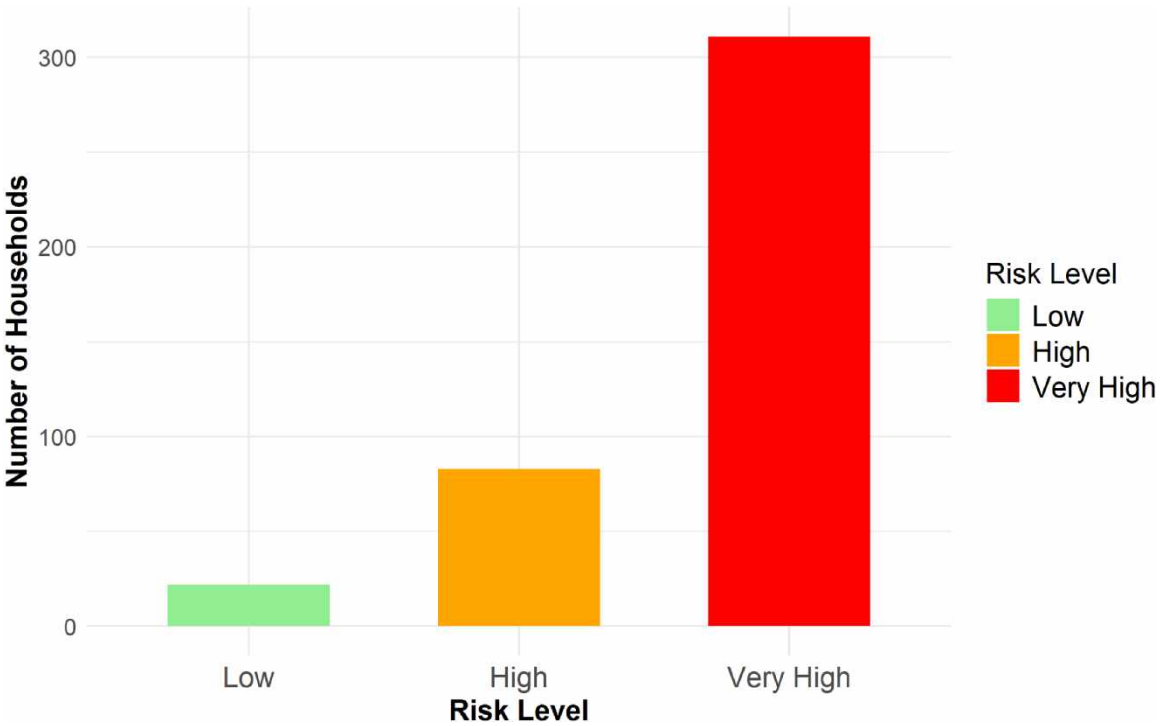

Fig. 9 | Proportional distribution of households by perceived vulnerability to water pollution.

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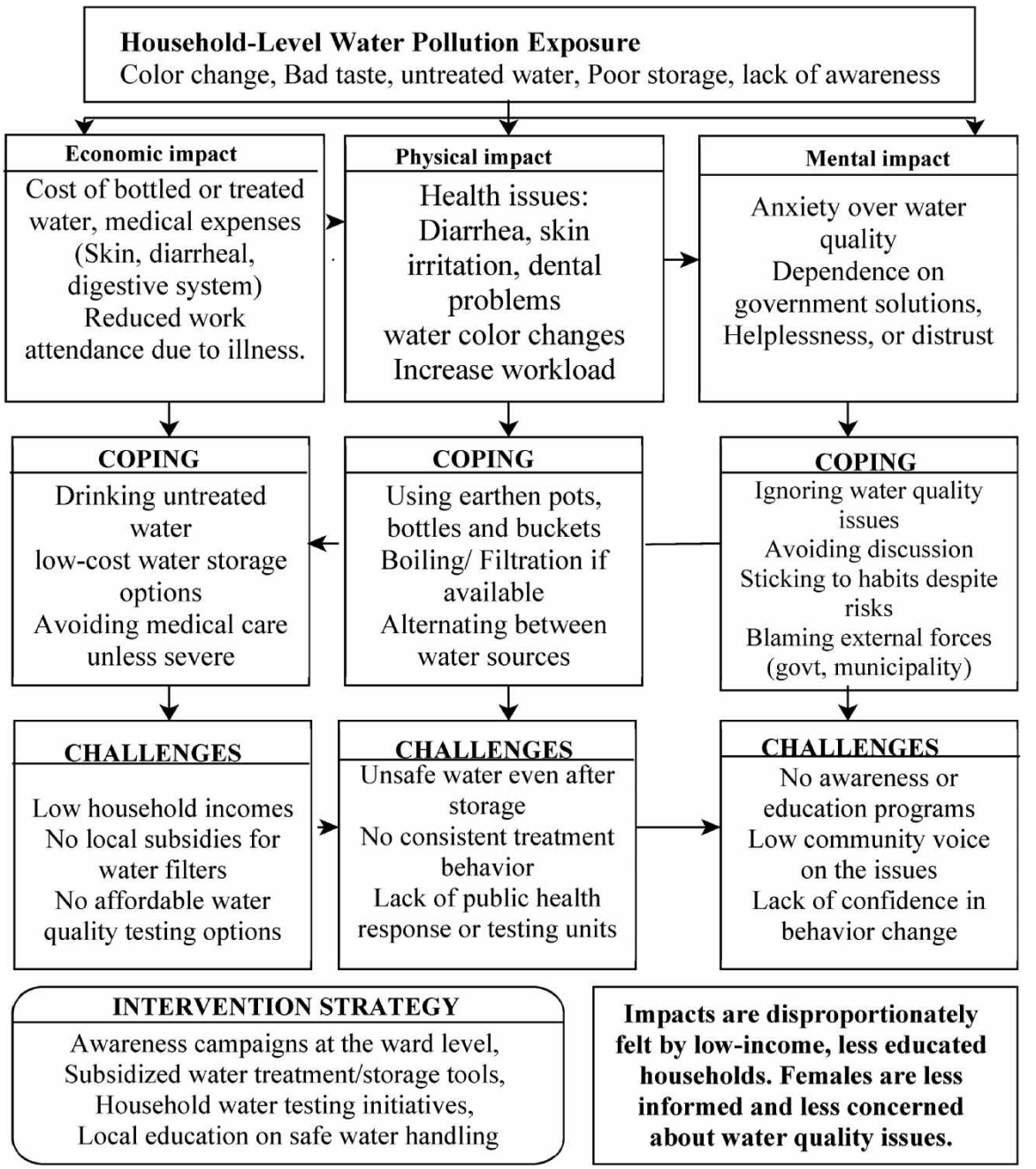

Fig. 10 | Conceptual framework illustrating the multidimensional impacts, household coping mechanisms, and proposed intervention strategies for water quality management in the study area.

experienced by low-income and less-educated households. To break this cycle of vulnerability, a multitiered intervention strategy is proposed, focusing on ward-level awareness and subsidized PoU technologies to bridge the gap between perceived and actual water safety.

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4. DISCUSSION

Local communities in Kankai and Shivasatakshi identify agricultural effluents, cremation, septic tanks, and construction as primary drivers of water contamination. Anthropogenic activities linked to water contamination cause severe public health risks to local communities (Hisam *et al.* 2014; Ishaque *et al.* 2023). While Nepal expanded basic water supply to over 90% of the population, safely managed water declined from 24% in 2000 to 19% recently (Sharma *et al.* 2021). This decline is prominent in the Terai region, where hydrogeological vulnerabilities link with rapid urbanization. Our results showed that dependence on shallow tube wells indicates physical accessibility has outpaced safety assurance. This leaves households vulnerable to visible and invisible contaminants in porous alluvial aquifers. Risk perception in the study area is not uniformly distributed but stratified by gender, education, and income. Regression analysis showed that education and income are positive predictors of water pollution awareness. Education consistently helps create environmental awareness (Maruapula *et al.* 2023). Males aged 25–44 and those above 65 with higher education levels show significantly higher perceptions of pollution risks. Conversely, individuals aged 15–24 show limited awareness due to minimal involvement in water-related issues. Respondents with middle to high incomes (20,001–40,000 and above 60,000 NRs) paradoxically showed lower levels of specific understanding. The capacity to act on health risks is constrained by resource availability. Higher education and income are associated with more informed perceptions of water quality (Borawska 2017). Awareness strategies increase public engagement with environmental concerns (Anderson *et al.* 2007; Tarannum *et al.* 2018; Maliki *et al.* 2021).

Our findings show a gender disparity in perceived vulnerability. Females were less informed about water quality parameters due to lower social interaction and specific concerns. Study data show that newspapers (37.5%) and community meetings (21.5%) are the primary information sources. In rural Nepal, women are the primary gatekeepers of household hygiene and water storage. Excluding them from information channels creates technical risks for household water safety. Gendered access to information remains a critical barrier to environmental health governance (Gevera *et al.* 2022). Correlation between awareness and behavior is heavily influenced by these information sources (Benameur *et al.* 2022). While traditional media remains dominant, social media offers a promising avenue for reaching a diverse audience (Gevera *et al.* 2022). Strategic awareness should combine mass media like television and radio with localized community engagement (Qamar *et al.* 2022). Locals often ignore invisible risks unless water manifests aesthetic degradation like reddish-brown iron oxidation. In the absence of technical verification, people rely on sight, smell, and taste to judge safety (de França Doria 2010). In the hydrogeological context of the Terai, this heuristic is potentially fatal. Permeable Holocene alluvial aquifers facilitate the rapid infiltration of invisible pathogens from septic tanks (Hamal *et al.* 2025a). Cremation and agricultural effluents intersect directly with shallow unconfined aquifers feeding tube wells. Consequently, clear water may contain arsenic or pathogens while turbid water might be biologically fit (Smith 2001; Hamal *et al.* 2025b). By relying on visual quality, 75% of households were classified as 'very high risk'. Their reliance on vision renders them defenseless against invisible chemical and biological threats. Sensory reliance exacerbates negligence in hygienic practices during drinking water storage. Most respondents failed to use separate utensils or maintain regular cleaning routines. Lack of awareness about basic sanitation increases the risk of waterborne diseases (Ahmed & Shafique 2019). Earthen pots, bottles, and buckets are poorly cleaned in lower-income households. A study in Nepal's hilly regions found 63% of samples degraded in microbial quality during storage (Daniel *et al.* 2020). Globally, half the population depends on home storage and uses improvised containers that increase contamination risk (Berihun *et al.* 2023). Our regression model confirms that

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lower-income households use unsafe storage and report higher discoloration. Poverty remains a structural barrier to mitigating health risks. A major gap exists in public understanding of water safety governance. Only 25% of respondents conducted water tests, yet 20% cited a reliance on municipal authorities. Under the Water Supply Management Board Act (2006) and the Local Government Operation Act (2017) of Nepal, the mandate is devolved to local boards. The UWSSP Design Guidelines (2021) place the burden of maintenance on Local Water Users and Sanitation Committees (WUSCs). Respondents have not internalized this policy shift and still expect central-level service. Passive reliance in the Terai contrasts with the hilly regions of Nepal. In the Seti Khola watershed, 88% of schemes were managed through informal community structures (Pokhrel & Rijal 2025). Terai households perceive an abundance of groundwater and lack these adaptive social structures. Residents in the Terai lack the collective action seen in hilly regions, leaving them doubly exposed to risks. This creates a psychological barrier to adopting PoU treatments. Households believing the government must provide water are less likely to invest in filters or boiling.

Diarrhea (35.6%) was the most reported waterborne disease in the study area. Children (0–12 years) and the elderly (>60 years) bear the highest perceived burden. This age-specific vulnerability aligns with global consensus on immune system susceptibility (Abuhaloob & Abed 2014; UNICEF 2023). Across Nepal, lack of sanitation and open defecation contribute to diarrheal prevalence (UNICEF & WHO 2023). Poor water quality was also linked by respondents to kidney, nervous, and digestive system issues. While awareness was high (80%), none of the respondents had attended formal awareness programs. Those with favorable perceptions of water quality exhibited greater confidence in their drinking sources. These insights align with studies highlighting gaps in awareness and reliance on external authorities. The vulnerability classification in this study is based on perceived indicators and self-reported behaviors. It is not based on microbiological or chemical laboratory analysis. A 'very high perceived vulnerability' classification reflects behavioral vulnerability, poor storage, and negative attitudes. Future research must prioritize comparative analysis with laboratory-tested indices to measure the 'perception-reality' gap. Water insecurity in eastern Nepal is constructed through social, behavioral, and institutional deficits. Interventions must go beyond infrastructure to address the human dimension of water quality. This requires gender-targeted campaigns and subsidies for household-level testing. Specific policy efforts must reframe water safety as a shared responsibility. Aligning public perception with legal frameworks can bridge the gap between water access and security (Aryal 2024).

4.1. Policy recommendation

Based on the findings of this study, a multidimensional policy approach is required to bridge the gap between perceived and actual water security in the Kankai and Shivasatakshi municipalities. Municipal health departments must prioritize information dissemination through established channels such as newspapers and community networks to bridge the existing awareness gap. Local governments should mandate regular, ward-level workshops and formal training sessions on groundwater protection and postcollection hygiene, particularly as 100% of respondents currently lack exposure to official outreach programs. To mitigate physical contamination risks, the state should implement subsidies or micro-credit schemes for high-quality, closed-lid storage containers, addressing the aesthetic degradation and microbial vulnerabilities observed in households utilizing traditional earthen pots. Furthermore, policies must focus on enhancing technical literacy and providing localized maintenance support for filtration systems to overcome the 48% distrust in filter efficacy reported by nonusers. Establishing low-cost water testing centers within ward offices is essential to empower the 58% of households currently unaware of testing procedures, facilitating a transition from sensory-based judgment to objective verification. Finally, water governance strategies must be strictly gender-inclusive, specifically targeting

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women as the primary household water managers to ensure that hygiene education translates into effective and sustainable domestic practice.

5. CONCLUSION

This study highlights the major gap in societal awareness in public perceptions and knowledge of drinking water safety and pollution in Eastern Nepal. It also shows people rely on organoleptic cues rather than scientific testing, 43% utilizing potentially unsafe earthen pots. This vulnerability is exacerbated by dependence, where communities passively await government intervention rather than adopting household-level interventions. Our findings show the urgent need for enhanced water quality monitoring, evidence-based policymaking, and expanded public awareness through mass media which is closely related to SDG 6. We concluded an urgent call for the strong involvement of local government in pollution detection and developing infrastructure in testing facilities. However, our study was limited due to its dependence on cross-sectional survey data and the underrepresentation of regional differences. Future research should focus on microbiological and chemical testing with perception surveys to validate the gap between perceived risk and biological reality. Participation of local authorities in research and intervention planning is important in safeguarding public health and promoting sustainable water resource management across Nepal.

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AUTHOR CONTRIBUTIONS

AD contributed to conceptualization, data collection, analysis, data interpretation, and mapping and writing of the original manuscript. MPA was responsible for reviewing and editing. GPP was involved in conceptualization, reviewing, cosupervision, writing, analysis, editing, and correspondence. All authors have read and approved the final version of the manuscript.

ETHICS APPROVAL

Questionnaires were asked, taking the consent from the respondent at the time of the survey.

CONSENT TO PARTICIPATE

All authors listed in the manuscript have agreed to the authorship and have read and approved the manuscript.

CONSENT FOR PUBLICATION

All authors listed in the manuscript have provided consent for submission and subsequent publication of the manuscript.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCES

Abbas, N., Wasimi, S., Al-Ansari, N. & Sultana, N. (2018) Water resources problems of Iraq: climate change adaptation and mitigation, *Journal of Environmental Hydrology*, *26* (6), 1–11. https://www.diva-portal.org/smash/get/diva2:1206419/FULLTEXT01.pdf.

Abuhaloob, L. & Abed, Y. (2014) Knowledge and public perception of dental fluorosis in children living in Palestine, *Journal of Oral Hygiene and Health*, *2* (3), 133. https://doi.org/10.4172/2332-0702.1000133.

Acharya, A. S., Prakash, A., Saxena, P. & Nigam, A. (2013) Sampling: why and how of it, *Indian Journal of Medical Specialties*, *4* (2), 330–333. https://doi.org/10.7713/ijms.2013.0032.

Adhikari, J. N., Bhattarai, B. P. & Thapa, T. B. (2018) Human-wild mammal conflict in a human-dominated midhill landscape: a case study from Panchase area in Chitwan Annapurna Landscape, Nepal, *Journal of Institute of Science and Technology*, *23* (1), 30–38. https://doi.org/10.3126/jist.v23i1.22158.

Afroz, R., Banna, H., Masud, M. M., Akhtar, R. & Yahaya, S. R. (2016) Households' perception of water pollution and its economic impact on human health in Malaysia, *Desalination and Water Treatment*, *57* (1), 115–123. https://doi.org/10.1080/19443994.2015.1006822.

Ahmed, A. & Shafique, I. (2019) Perception of households in regards to water pollution: empirical evidence from Pakistan, *Environmental Science and Pollution Research*, *26*, 8543–8551. https://doi.org/10.1007/s11356-019-04273-4.

Al-Maliki, L. A., Farhan, S. L., Jasim, I. A., Al-Mamoori, S. K. & Al-Ansari, N. (2021) Perceptions about water pollution among university students: a case study from Iraq, *Cogent Engineering*, *8* (1), 1895473. https://doi.org/10.1080/23311916.2021.1895473.

Almeida, M. E. L. D., Teixeira, A. K. M., Alencar, C. H., Paiva, S. M. & Abreu, M. H. N. G. D. (2013) Agreement between parents and adolescents on dental fluorosis: a population-based study, *Brazilian oral research*, *27*, 91–96. https://doi.org/10.1590/S1806-83242013005000004.

Anderson, B. A., Romani, J. H., Phillips, H., Wentzel, M. & Tlabela, K. (2007) Exploring environmental perceptions, behaviors, and awareness: water and water pollution in South Africa, *Population and Environment*, *28* (3), 133–161. https://doi.org/10.1007/s11111-007-0038-5.

Aryal, M. (2024) An analysis of drinking water quality parameters to achieve sustainable development goals in rural and urban areas of Besisahar, *Lamjung, Nepal, World Water Policy*, *10* (1), 297–323. https://doi.org/10.1002/wwp2.12073.

Aryal, M. (2025) Groundwater arsenic contamination in Nepal, *World Water Policy*, *11*, 871–888. https://doi.org/10.1002/wwp2.70008.

Aslin, H. J. & Lockie, S. (2013) Citizenship, engagement and the environment. In: Aslin, Heather J., and Lockie, Stewart, (eds.) Engaged Environmental Citizenship. Darwin, Australia: Charles Darwin University Press, pp. 1–18.

Awoke, A., Beyene, A., Kloos, H., Goethals, P. L. & Triest, L. (2016) River water pollution status and water policy scenario in Ethiopia: raising awareness for better implementation in developing countries, *Environmental Management*, *58* (4), 694–706. https:// doi.org/10.1007/s00267-016-0734-y.

Benameur, T., Benameur, N., Saidi, N., Tartag, S., Sayad, H. & Agouni, A. (2022) Predicting factors of public awareness and perception about the quality, safety of drinking water, and pollution incidents, *Environmental Monitoring and Assessment*, *194* (1), 22. https://doi.org/10.1007/s10661-021-09557-2.

Berihun, G., Abebe, M., Hassen, S., Gizeyatu, A., Berhanu, L., Teshome, D., Walle, Z., Desye, B., Sewunet, B. & Keleb, A. (2023) Drinking water contamination potential and associated factors among households with under-five children in rural areas of Dessie Zuria District, Northeast Ethiopia, *Frontiers in Public Health*, *11*, 1199314. https://doi.org/10.3389/fpubh.2023.1199314.

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Borawska, A. (2017) The role of public awareness campaigns in sustainable development, *Economic and Environmental Studies*, *17* (4 (44)), 865–877. https://doi.org/10.25167/ees.2017.44.14.

Bryman, A. (2016) *Social Research Methods*. Oxford: Oxford University Press.

Clark, D. (2020) Data analysis with pivot tables and charts. In: *Beginning Microsoft Power BI: A Practical Guide to Self-Service Data Analytics*. Berkeley, CA: Apress, pp. 277–304. https://doi.org/10.1007/978-1-4842-5620-6_11.

Daniel, D., Diener, A., van De Vossenberg, J., Bhatta, M. & Marks, S. J. (2020) Assessing drinking water quality at the point of collection and within household storage containers in the hilly rural areas of mid and far-western Nepal, *International Journal of Environmental Research and Public Health*, *17* (7), 2172. https://doi.org/10.3390/ijerph17072172.

Dean, A. J., Lindsay, J., Fielding, K. S. & Smith, L. D. (2016) Fostering water sensitive citizenship–Community profiles of engagement in water-related issues, *Environmental Science & Policy*, *55*, 238–247. http://dx.doi.org/10.1016/j.envsci.2015.10.016.

de França Doria, M. (2010) Factors influencing public perception of drinking water quality, *Water Policy*, *12* (1), 1–19. https://doi.org/10.2166/wp.2009.051.

Dobson, A. (2007) Environmental citizenship: towards sustainable development, *Sustainable Development*, *15* (5), 276–285. https://doi.org/10.1002/sd.344.

Dunn, S. M., Brown, I., Sample, J. & Post, H. (2012) Relationships between climate, water resources, land use, and diffuse pollution, and the significance of uncertainty in climate change, *Journal of Hydrology*, *434*, 19–35. https://doi.org/10.1016/j.jhydrol.2012.02.039.

Etikan, I., Musa, S. A. & Alkassim, R. S. (2016) Comparison of convenience sampling and purposive sampling, *American Journal of Theoretical and Applied Statistics*, *5* (1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11.

Fenu, G. & Malloci, F. M. (2020) DSS LANDS: a decision support system for agriculture in Sardinia, *High-tech and Innovation Journal*, *1* (3), 129–135. https://doi.org/10.28991/HIJ-2020-01-03-05.

Garrote, L. (2017) Managing water resources to adapt to climate change: facing uncertainty and scarcity in a changing context, *Water Resources Management*, *31* (10), 2951–2963. https://doi.org/10.1007/s11269-017-1714-6.

Gevera, P. K., Dowling, K., Gikuma-Njuru, P. & Mouri, H. (2022) Public knowledge and perception of drinking water quality and its health implications: an example from the Makueni County, South-Eastern Kenya, *International Journal of Environmental Research and Public Health*, *19* (8), 4530. https://doi.org/10.3390/ijerph19084530.

Hamal, S., Pant, B., Bist, R. & Adhikari, B. (2025a) Escherichia coli contamination in shallow groundwater and associated health risks: a case from Bedkot Municipality of a Terai Region, Nepal, *Journal of Materials and Environmental Science*, *16* (9), 1731. 1740, 13-8.

Hamal, S., Bist, R., Pant, B. & Adhikari, B. (2025b) Water quality index and human health risk assessment for heavy metals in groundwater of Bedkot Municipality, Kanchanpur, Nepal: a cross-sectional study, *EQA-International Journal of Environmental Quality*, *69*, 73–86.

Hasan, M. K., Shahriar, A. & Jim, K. U. (2019) Water pollution in Bangladesh and its impact on public health, *Heliyon*, *5* (8), e02145. https://doi.org/10.1016/j.heliyon.2019.e02145.

Hisam, A., Rahman, M. U., Kadir, E., Tariq, N. A. & Masood, S. (2014) Microbiological contamination in water filtration plants in Islamabad, *Journal of College of Physicians and Surgeons Pakistan*, *24* (5), 345–350. https://jcpsp.pk/archive/2014/May2014/12.pdf.

Ho, J. C. & Michalak, A. M. (2015) Challenges in tracking harmful algal blooms: a synthesis of evidence from Lake Erie, *Journal of Great Lakes Research*, *41* (2), 317–325. https://doi.org/10.1016/j.jglr.2015.01.001.

Howard, G. (2021) The future of water and sanitation: global challenges and the need for greater ambition, *AQUA – Water Infrastructure, Ecosystems and Society*, *70* (4), 438–448. https://doi.org/10.2166/aqua.2021.127.

Ishaque, W., Mukhtar, M. & Tanvir, R. (2023) Pakistan's water resource management: ensuring water security for sustainable development, *Frontiers in Environmental Science*, *11*, 1096747. https://doi.org/10.3389/fenvs.2023.1096747.

Joshi, T. R., Awasthi, M. P., Joshi, J., Pant, R. R., Bist, H. S. & Thagunna, G. S. (2024) Perception-based assessment of the water supply system in Bhimdatta Municipality, Sudurpashchim Province, Nepal, *Journal of Engineering Technology and Planning*, *5* (1), 114–131. https://doi.org/10.3126/joetp.v5i1.69730.

Kebede, A., Retta, N., Abuye, C. & Malde, M. K. (2016) Community knowledge, attitude, and practices (KAP) on fluorosis and its mitigation in endemic areas of Ethiopia, *African Journal of Food, Agriculture, Nutrition and Development*, *16* (1), 10711–10722. https://doi.org/10.18697/ajfand.73.15480.

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Khadka, G., Dhungana, S., Acharya, M., Sah, R. B. & Paudyal, K. R. (2024) Hydrogeological assessment of groundwater resources in Khutti Khola Watershed, Siraha District, Eastern Nepal, *Journal of Nepal Hydrogeological Association*, *1* (1), 79–93. https://doi.org/10.3126/jnha.v1i1.78224.

Khan, U., Haque, M. I. & Khan, A. M. (2020) Environmental sustainability awareness in the Kingdom of Saudi Arabia, *The Journal of Asian Finance, Economics and Business*, *7* (9), 687–695. https://doi.org/10.13106/jafeb.2020.vol7.no9.687.

Maruapula, K., Yessoufou, K. Y. & Modley, L. S. (2023) Community perceptions, participation, and satisfaction with existing Water Resource Management Plans: a case study of a polluted water system in South Africa, *AQUA – Water Infrastructure, Ecosystems and Society*, *72* (8), 1373–1385. https://doi.org/10.2166/aqua.2023.208.

National Environmental Education Foundation (NEEF). (2015) *Environmental Literacy in the United States: An Agenda for Leadership in the 21st Century*. Washington, DC: NEEF.

National Planning Commission (2020) *National Review of Sustainable Development Goals*. Kathmandu, Nepal: National Planning Commission.

Nayebare, J. G., Owor, M. M., Kulabako, R. & Taylor, R. G. (2022) Faecal contamination pathways of shallow groundwater in low-income urban areas: implications for water resource planning and management, *Water Practice & Technology*, *17* (1), 285–296. https://doi.org/10.2166/wpt.2021.110.

Norman, G. (2010) Likert scales, levels of measurement and the 'laws' of statistics, *Advances in Health Sciences Education*, *15* (5), 625–632. https://doi.org/10.1007/s10459-010-9222-y.

Olsen, C. S. & Shindler, B. A. (2010) Trust, acceptance, and citizen–agency interactions after large fires: influences on planning processes, *International Journal of Wildland Fire*, *19* (1), 137–147. https://doi.org/10.1071/WF08168.

Pokhrel, G. & Rijal, M. L. (2025) Governance of spring-dependent community water supply schemes in Seti Khola Watershed, Nepal, *Water Supply*, *25* (11), 1498–1514. https://doi.org/10.2166/ws.2025.091.

Popkin, B. M., D'Anci, K. E. & Rosenberg, I. H. (2010) Water, hydration, and health, *Nutrition Reviews*, *68* (8), 439–458. https://doi.org/10.1111/j.1753-4887.2010.00304.x.

Pouget, L., Escaler, I., Guiu, R., McEnnis, S. & Versini, P. A. (2012) Global Change adaptation in water resources management: the Water Change project, *Science of the Total Environment*, *440*, 186–193. https://doi.org/10.1016/j.scitotenv.2012.07.036.

Qamar, K., Nchasi, G., Mirha, H. T., Siddiqui, J. A., Jahangir, K., Shaeen, S. K., Islam, Z. & Essar, M. Y. (2022) Water sanitation problem in Pakistan: a review on disease prevalence, strategies for treatment and prevention, *Annals of Medicine and Surgery*, *82*, 104709. https://doi.org/10.1016/j.amsu.2022.104709.

Raut, A. D., Raut, A. S., Mahato, S., Rahman, A. U., Ansari, M. S. & Sah, S. K. (2025) Groundwater crisis in Terai region of Nepal, *International Journal for Research in Applied Science and Engineering Technology (IJRASET)*, *13* (I), 1339–1348. https://doi.org/10.22214/ijraset.2025.73595.

Sharma, S., Baidya, M., Poudel, P., Panthi, S. R., Pote-Shrestha, R. R., Ghimire, A. & Pradhan, S. P. (2021) Drinking water status in Nepal: an overview in the context of climate change, *Journal of Water, Sanitation and Hygiene for Development*, *11* (6), 859–866. https://doi.org/10.2166/washdev.2021.045.

Silwal, C. B., Nepal, M., Pathak, D., Karkee, B., Dahal, K. & Acharya, S. (2023) Groundwater potential zonation in the Siwalik of the Kankai River Basin, Eastern Nepal, *Water Supply*, *23* (6), 2332–2348. https://doi.org/10.2166/ws.2023.137.

Smith, M. K. (2001) Microbial contamination and removal from drinking water in the Terai region of Nepal. Doctoral dissertation. Massachusetts: Massachusetts Institute of Technology.

Tarannum, F., Kansal, A. & Sharma, P. (2018) Understanding public perception, knowledge and behaviour for water quality management of the river Yamuna in India, *Water Policy*, *20* (2), 266–281. https://doi.org/10.2166/wp.2018.134.

UNICEF (2023) *United Nations Children's Fund, The Climate-Changed Child: A Children's Climate Risk Index Supplement*. New York: UNICEF. November 20.

UNICEF and WHO (2023) *Progress on Household Drinking Water, Sanitation and Hygiene 2000–2022: Special Focus on Gender*. New York: United Nations Children's Fund (UNICEF) and World Health Organization (WHO).

Uprety, S., Dangol, B., Nakarmi, P., Dhakal, I., Sherchan, S. P., Shisler, J. L. & Nguyen, T. H. (2020) Assessment of microbial risks by characterization of Escherichia coli presence to analyze the public health risks from poor water quality in Nepal, *International Journal of Hygiene and Environmental Health*, *226*, 113484. https://doi.org/10.1016/j.ijheh.2020.113484.

World Health Organization (1982) *Provisional guidelines on standard international age classification*. New York: United Nations. Available at: https://unstats.un.org/unsd/publication/seriesm/seriesm_74e.pdf.

WWAP (United Nations World Water Assessment Programme)/UN-Water (2018) *The United Nations World Water Development Report 2018: Nature-Based Solutions for Water*. Paris: UNESCO.

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Zubaidi, S. L., Dooley, J., Alkhaddar, R. M., Abdellatif, M., Al-Bugharbee, H. & Ortega-Martorell, S. (2018) A novel approach for predicting monthly water demand bycombining singular spectrum analysis with neural networks, *Journal of Hydrology*, *561*, 136–145. https://doi.org/10.1016/j.jhydrol.2018.03.047.

Zulu, K., Singh, R. P. & Shaba, F. A. (2020) Environmental and economic analysis of selected pavement preservation treatments, *Civil Engineering Journal*, *6* (2), 210–224. http://dx.doi.org/10.28991/cej-2020-03091465.

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