Assessment of Water Quality and Customer Satisfaction of Water Supply Schemes in District Badin, Sindh, Pakistan

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ABSTRACT: In many developing countries like Pakistan, water availability to drink is a serious public health problem primarily due to poor quality water in combination with its inadequate delivery. The district Badin is situated at the farthest part of Indus River. The study evaluates the water quality and satisfaction on the operated water supply schemes of the district with respect to the five talukas of the said district which includes Badin, Matli, Shaheed Fazil Rahu, Talhar and Tando Bago. A method mix between laboratory analysis of 330 water samples and structured household survey of 234 households along with qualitative data from key informant interviews and focus group discussions were used. The water samples were tested for physical, chemical and microbiological characteristics. Results revealed wide-spread microbiological contamination in all talukas in the form of E.coli and Total coliforms. From the water supply scheme level to the household level, contamination levels were significantly higher, while chemical parameters were mostly within acceptable limits. Badin and Tando Bago were found to be the most polluted, whereas Talhar had relatively good water quality. Survey findings showed a low level of trust and satisfaction with piped water services. Although most households had access to piped water for domestic use, they relied on handpumps, public taps, or bottled water for drinking purposes. Only 10% reported being "very satisfied." Unreliable timing of supply, weak billing practices, and poor household water storage practices were key factors affecting dissatisfaction. The study concludes that technical improvements, institutional strengthening, and improved WMPs are necessary to enhance water services in District Badin.

KEYWORDS: Safe Drinking Water, Service Reliability, Microbial Contamination, Community Satisfaction, Water Security

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Introduction

Water is a critical factor for human existence, public health, and economic development. Its availability and quality are on a decline globally, however. Water used to be considered a free and abundant resource. However, since population growth and the improper management of resources, it is now rare, and it is often polluted (Jianping et al., 2014). Consequently, many people have no access to safe water and suffer from increased risks of waterborne diseases (Parveen et al., 2016). This is the same issue that Pakistan has. Water pollution and water resources protection are still one of the main concerns of the country (Sajjad et al., 2025). The perception of the quality of the drinking water may be influenced by previous experiences, water availability, and environmental conditions more than by laboratory measurements. These perceptions can get confused with actual water quality in regions with water scarcity and challenges such as saltwater intrusion, which can result in mistrust of the public water supply systems (Alaeddine et al., 2017).

From the South Asian region and beyond, it has been found that people's perception of the water quality is not always reflected in its actual tested quality. This disparity affects the access, reliance, and revenue of communities to water. Studies conducted in Indonesia revealed that piped water was of good taste, appearance, and chemical quality. Despite this, the majority of people in several cities (82%, 58% and 66% in Malang, Bogor, and Semarang, respectively) chose to drink bottled water. This indicates that Water Decisions are not necessarily based on quality but on perception. Also, the poor storage conditions of the bottled water were found to be the source of bacteria in bottled water (Zikrina et al., 2024). A similar trend was observed in Islamabad, as 86% of households used public water for non-drinking-related uses, while 54.9% of them used bottled water for drinking. The authors explained that this was due to public distrust in the water supply system, rather than due to the actual quality of the water (Ahmed et al., 2022). The results show that, technically, negative perceptions are not easily overcome, despite the evidence. The public's perception of the quality of the drinking water is correlated with several factors. Sensory attributes of water quality, rather than laboratory tests, are often used to determine water quality. Besides perceived health risks, attitudes towards water treatment chemicals, previous water quality problems, and water supplier confidence have a significant effect on the public's judgment. Perception is influenced by other factors such as the context of the pipe, its dependability in providing service, media information, and interpersonal information. However, the overall perception of the drinking water quality is not only of a technical nature, but also a psychological and social one (Doria, 2010).

Several studies have identified factors that may affect consumers' satisfaction with the water supply scheme. These include reliability of supplies, water pressure, water quality – taste, smell, clarity, distance to water point and clear billing systems. A study in Matara, Sri Lanka revealed that more than 95% of the respondents were happy with the water safety, smell, and clarity. Satisfaction with service delivery was low, however, and primarily due to the poor water pressure. Taste satisfaction and risk perception were also influenced by the location of the consumer (Ellawala & Priyankara, 2016). An Eastern Indian state study revealed that all four factors – timing, appearance, water quantity and pressure – were important for consumer satisfaction. The primary supply disruption factors were pipeline damage, cyclones and reservoir maintenance (Mohanty & Rout, 2024). The satisfaction with rural water points in Woliso District, Ethiopia, was associated with the location of the water points, waiting time for water, guards at the water points, and reliability of water service. The authors suggested that these factors should be taken into consideration when planning future water projects (Mekuriaw & Gurmessa, 2020). A survey of 205 households conducted in rural Nepal in 12 water-user committees revealed dissatisfaction for various reasons in various areas. The major issue in villages was weak institutions. Poor water quality and location were the primary concerns in market centers. In both situations, user satisfaction had an impact on willingness to pay and on willingness to participate in maintenance (Bhandari & Grant, 2007). In addition, trust and a sense of ownership influence the acceptance of water supply schemes in the communities. A more recent study in Karak district, Pakistan supports this finding. It demonstrated that participation of the community in the planning, construction, op, and maintenance by the Community Based Organizations (CBOs) was the primary factor contributing to the success of water schemes in terms of satisfaction and sustainability (Rasool et al., 2024). During the introduction of new water sources, the role of trust is the same. A survey of reclaimed water in the township of Diepsloot, Johannesburg, showed that the general acceptance was high and particularly high among those with a higher level of education.

The authors' findings indicated that there was a need for an awareness-creating trust-building process before the communities could accept new water sources (Thililo et al., 2024). The study was conducted in the southwest of Iran on the conservation behavior of households. It revealed that, in addition to infrastructure and price, social norms, moral values, and habits also influence conservation behavior using an extended theory of planned behavior. Adopting infrastructure alone is not sufficient to alter behavior; the model accounted for up to 54% of the variation in water-saving behavior across the various households (Savari et al., 2022). A study conducted in Nowshera, Pakistan, also explored the willingness to pay for improved drinking water quality, which is a valuable tool in designing public health policies (Arveen et al., 2016). As noted in prior studies, community involvement is a key component of successful and sustainable water delivery programs. Program sustainability can be attributed to community ownership, relevance to real needs, good program management, and financial support. There is a complex relationship between participation and tangible effects on water supply programs' sustainability, which needs to be explored further (UNICEF & WHO, 2021). Access to adequate and reliable water supply is limited for many, particularly in rural areas, and is often of poor quality. The aim of this study is to assess the water quality and community perceptions regarding government water supply schemes in District Badin. In water quality, this study analyzed physical, chemical, and microbial contamination and measured the satisfaction of the water consumers of the piped water supply schemes with regard to the reliability of the water supply and billing system, in particular.

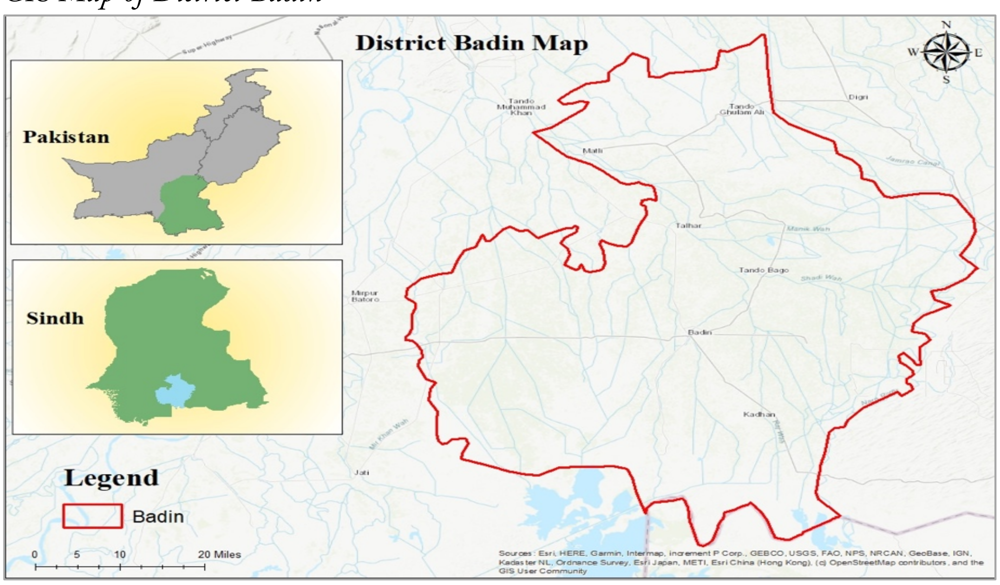
Material and Methods

Study Area

The Badin district is situated in the southern part of the Sindh province, with its boundaries adjacent to the Tando Muhammad Khan, Tharparkar, Mirpurkhas districts, and the Arabian Sea to the south. Badin district is situated in the south of lower Indus plain between 24°13'and 25°12'north latitudes and 68°21'and 69°20'east longitudes. Administratively divided into 5 talukas, out of which two are coastal, Badin, Matli, Golarchi, Shaheed Fazil Rahu, Talhar and Tando Bago. The administrative boundaries of district Badin stretches 6726 square kilometers, with 86% population living in rural areas. Average annual rainfall is around 125 mm. The climate is moist and humid, in summer reaches up to 40 oC, while in winter mercury falls around 8 oC. Despite the fact district Badin is oil and gas rich the district is marginalized and most vulnerable to several natural and human induced hazards. The GIS map of the study area is given in Figure 1, which is generated through ArcGIS software.

Figure 1

GIS Map of District Badin



Study Design

A mixed-methods approach was adopted to meet the objectives of the study. Data were collected through three complementary components: (i) collection and laboratory analysis of water samples, (ii) a structured household survey to record consumer perceptions, and (iii) key informant interviews (KIIs) and focus group discussions (FGDs) to gather supporting qualitative information.

Field Survey and Data Collection Tools

A detailed field survey plan was developed to direct the data collection process and to ensure that the methodology is technically sound and appropriate to the study area. A team of multi-disciplinary researchers experienced in water quality assessment and in community-based social research was used to gather data. The data collection tools used included a household questionnaire and a site observation checklist; these tools were designed to take into account the literacy level of the respondents, their general awareness, and their socio-cultural context in an effort to increase the clarity, validity, and reliability of the respondents' data. Like most surveys, these instruments were first tried out in the field and then modified in response to the findings of the piloting phase.

Sampling Plan

Water Quality Sampling

There were 330 water samples collected, 96 water supply schemes, and 234 household water samples. 2-3 samples were obtained from the water source and storage locations at each scheme, while 4-5 samples were obtained at each household near the scheme, to represent spatial variation in water quality, particularly at the head, middle, and tail of the distribution network. Samples were collected in 1 L polypropylene bottles. To prevent cross-contamination between sampling and analysis in the laboratory, bottles were first washed in deionized water and then autoclaved. Samples were all taken by hand in accordance with a standard procedure to standardize sampling across sites. Samples were collected and then placed in containers with air-proof caps and kept in coolers containing ice to ensure sample integrity in transit to the lab. Untreated samples were used for analysis.

Household Survey

In addition to the Household survey, Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) were also conducted with 234 households that are connected to the Government of Sindh water supply schemes. Five KIIs with key stakeholder and two FGDs were held in the five communities operating and managing their water supply schemes. Structured guides were used for KIIs and FGDs to collect the data for these interviews and discussions. The survey aimed to: (i) gain insight into the perceptions of the quality of water received at the household level, (ii) determine level of satisfaction with scheme performance and service delivery, and (iii) collect information on water storage practices, water supply timing, system operation and maintenance, and payment for water services. To provide representative coverage across the network and to account for variation in services at different points of supply, households were randomly chosen from the head, middle and tail of each scheme. The survey was conducted with a gender balanced enumeration team, which enabled the survey to capture the full spectrum of household experiences and perceptions.

Laboratory Analysis

Water samples were analyzed for the following parameters as shown in Table 1.

Table 1

Water Quality Parameters and Analytical Methods

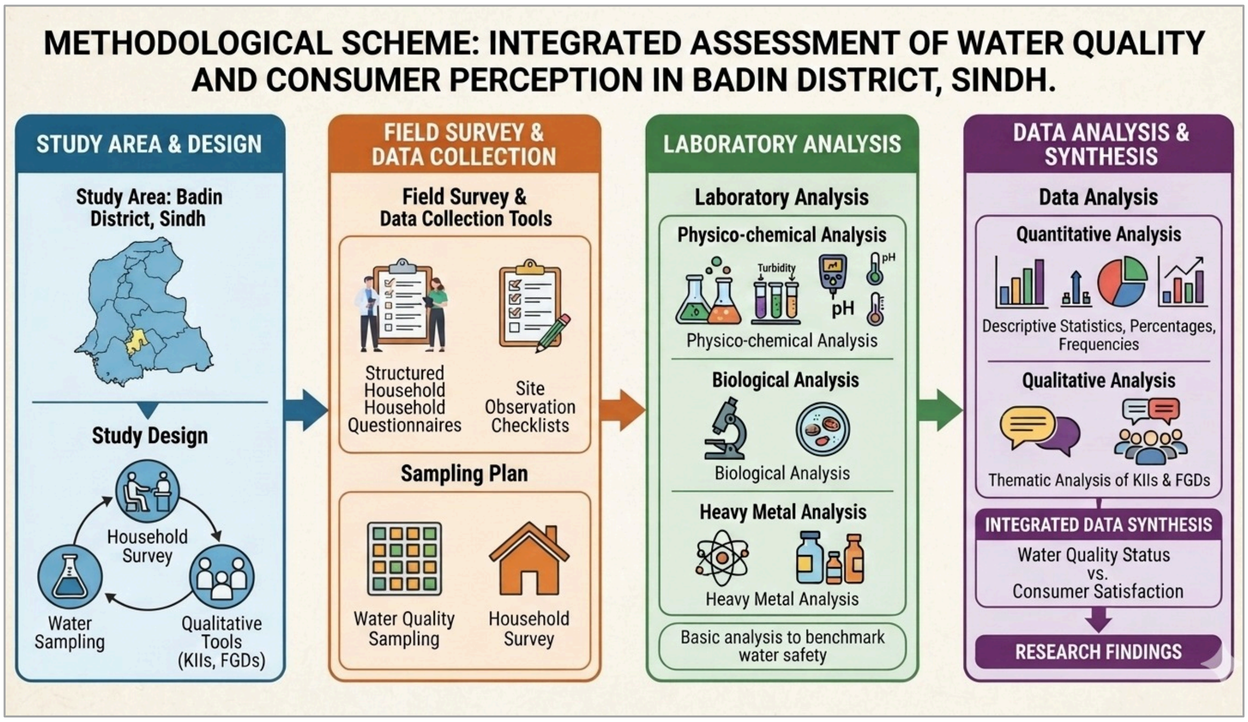
Category	Parameters	Analytical Method / Instrument
Physical and chemical parameters	pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Turbidity	Calibrated electrode probe meter
Microbiological parameters	*E. coli*, Total Coliform bacteria	Plate count method (analyzed in replicate)
Chemical contaminants	Nitrate, Fluoride	Spectrophotometer
Chemical contaminants	Arsenic	Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

Data Analysis

Quantitative data from the water quality tests and household surveys were compiled and analyzed using descriptive statistics, including percentages and frequency distributions, to summarize water quality status and levels of customer satisfaction across talukas, using SPSS and statistical tools. Qualitative data from KIIs and FGDs were used to support and contextualize the quantitative findings, particularly in explaining household water-use behavior and the underlying reasons for satisfaction or dissatisfaction with the water supply schemes. The overall methodological framework is summarized in the scheme in Figure 2, which was prepared using the AI tool.

Figure 2

The methodological framework of the study.



Results and Discussion

Household Water Supply and Drinking Water Sources

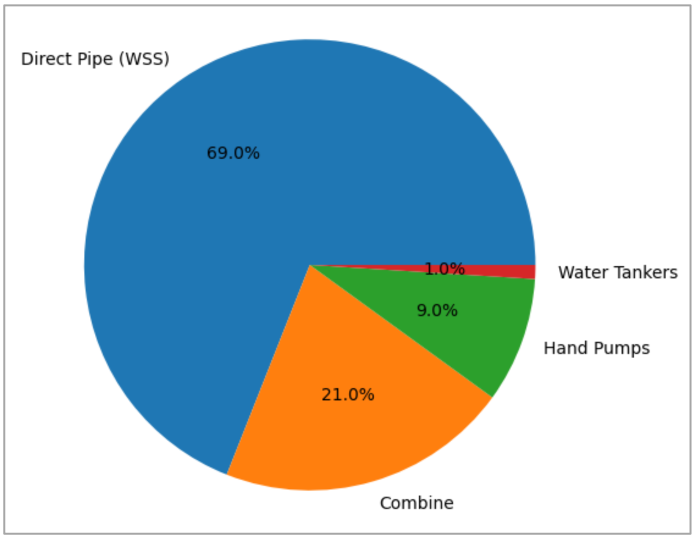
Across the district, households relied on multiple sources for domestic water. Household water sources in District Badin are illustrated in Figure 3. Sixty-nine percent of respondent households were connected directly to the WSS through a direct pipe connection, 21% used a combination of sources including the direct pipe, 9% depended on hand pumps, and 1% relied on water tankers. In the case of drinking water, hand pump (49%) was the primary source, followed by direct pipe water (33%), public taps (9%), and filtered water (9%) in all talukas. This pattern was consistent across the district: even in talukas where piped connections were common, households did not rely on the WSS for drinking purposes. Discussions held during KIIs and FGDs, conducted across the sampled talukas, confirmed that most pipe-connected households use the WSS for domestic tasks only, while drinking water is obtained separately through bottled supply.

"Whoever can afford it purchases the bottled water; only the poor who cannot afford to pay for bottled water use the supplied water for drinking purposes" (FGD – 1 respondent)

This finding suggests that, irrespective of taluka, the population's trust in the piped network for drinking purposes remains low, mirroring similar findings from urban Islamabad, where the majority of households used the public network only for non-drinking purposes despite the network's technical quality (Ahmed et al., 2022).

Figure 3

Household Water Sources for Domestic Use in District Badin

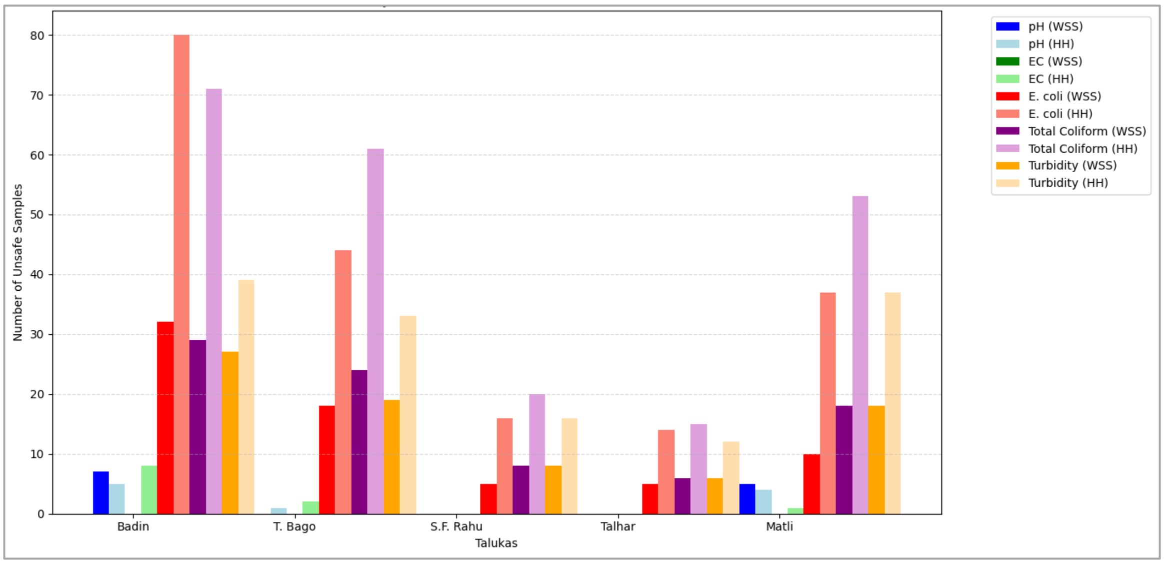


Water Quality Results

Laboratory testing of water samples from both the WSS and connected households showed that all five talukas experienced water quality problems, though the scale and pattern of contamination varied by taluka. Badin taluka recorded the highest number of non-compliant samples in the d. Taluka-wise distribution of non-compliant samples is presented in Figure 3. At the WSS level, 32 samples exceeded limits for *E. coli* and 29 for total coliform, while at the household level this rose sharply to 80 samples for *E. coli* and 71 for total coliform. Turbidity was also a concern, with non-compliant samples rising from 27 at the WSS to 39 at the household level. Badin was the only taluka, along with Matli, where pH exceedances were also recorded at both WSS and household levels. Tando Bago (T. Bago) taluka showed the second-highest contamination levels. E. coli exceedances rose from 18 samples at the WSS to 44 at the household level, and total coliform exceedances rose from 24 to 61. Turbidity exceedances nearly doubled between the WSS (19 samples) and households (33 samples). Matli taluka also showed a clear increase in contamination between the WSS and household level, with E. coli exceedances rising from 10 to 37 samples and total coliform from 18 to 53. Matli was notable for recording the only arsenic exceedance among WSS samples in the entire district (1 sample), alongside pH exceedances at both WSS and household levels. Shaheed Fazil Rahu taluka recorded comparatively lower contamination levels, though the same pattern of deterioration from WSS to household was still evident: *E. coli* exceedances rose from 5 to 16 samples, and total coliform from 8 to 20. No pH, EC, fluoride, or nitrate exceedances were recorded in this taluka. Talhar taluka recorded the lowest overall contamination levels in the district. *E. coli* exceedances increased from 5 samples at the WSS to 14 at the household level, and total coliform from 6 to 15. As in Shaheed Fazil Rahu, no pH, EC, fluoride, or nitrate exceedances were found. Across all five talukas, the same overall pattern held true. Microbiological contamination (*E. coli* and total coliform) was far more prevalent than chemical contamination (pH, EC, fluoride, arsenic, nitrate), and contamination levels consistently increased between the WSS and the household level. This district-wide increase from source to household points to a shared underlying cause, most likely contamination occurring during storage or handling at the household level rather than a problem isolated to any single taluka's infrastructure.

Figure 3

Taluka-wise Distribution of Water Quality non-Compliant Samples (Above Permissible Limits) in Water Supply Schemes (WSS) and Households



Community Perception of Water Supply Efficiency and Performance

Respondents across all five talukas were asked to rate the efficiency of the WSS, defined as its ability to provide a sufficient and reliable volume of water. Community perception of water supply performance is summarized in Figure 4(a–b). District-wide, 26.5% of respondents were not satisfied, 25.5% were somewhat satisfied, 41.2% were partially satisfied, and only 6.8% were fully satisfied. When asked about the overall performance of the scheme, 25.5% expressed dissatisfaction, 23.5% were somewhat satisfied, 41.5% were partially satisfied, and 10% were fully satisfied. These figures are not a reflection of any specific problem in any of the talukas, as the respondents were proportionally selected from all five talukas in the district. In both the efficiency and the performance measures, the reliability of the supply timing was determined as a problem. During FGDs conducted across the sampled talukas, respondents also described the same reason behind both satisfaction and dissatisfaction.

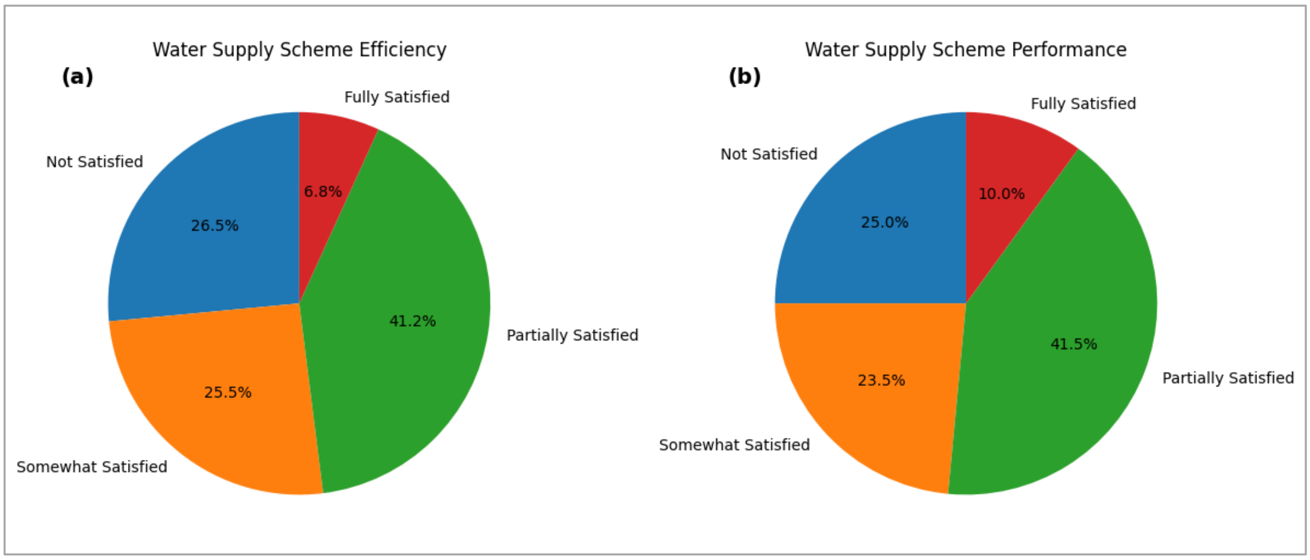
"There is no fixed timing for supply of water, and that totally depends on their mood" (FGD – 1 respondent).

"Supply of water depends on different factors: availability of water and especially availability of electricity" (KII respondents)

This indicates that the timing and predictability of water delivery, rather than the presence or absence of a piped connection, is the key concern for consumers throughout the district. This finding is consistent with studies from Sri Lanka and Ethiopia, where service reliability and timing, rather than water availability alone, were found to be the strongest predictors of consumer satisfaction (Ellawala & Priyankara, 2016; Mekuriaw & Gurmessa, 2020).

Figure 4

Community Perception of Water Supply Performance: (a) Satisfaction with Water Supply Scheme Efficiency; (b) Satisfaction with Water supply Scheme Performance

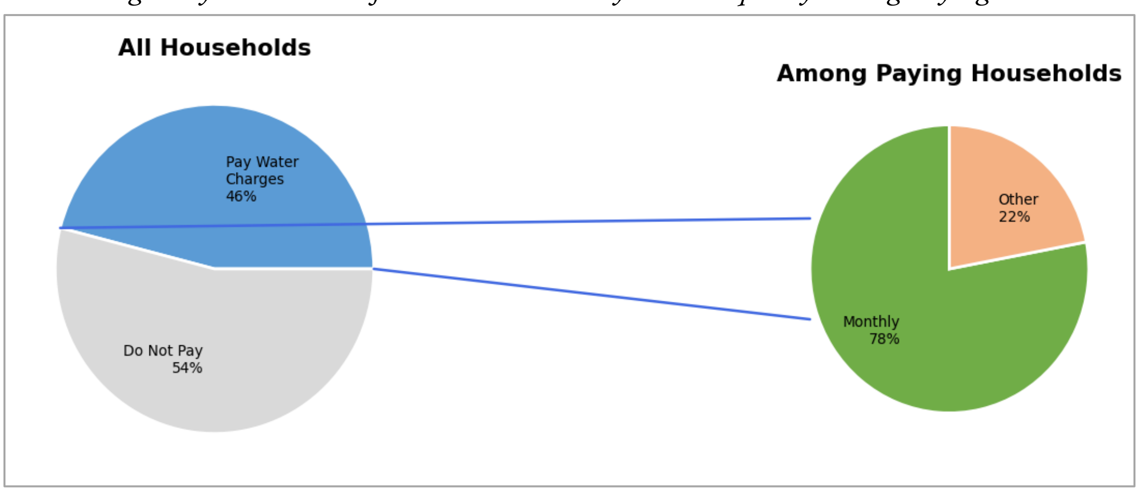


Billing, Payment, and Community Contribution

Payment behavior with respect to water charges across the district was as shown in Figure 5; 46% of respondents indicated that they pay water charges, of which 78% paid monthly. In non-paying households, "bill not received" was the most frequently reported reason, with no formal billing system being the next most common reason. A problem reported more frequently in rural parts of the district compared to the urban centers, such as Badin city. Although the billing system is not well developed, 58% of the respondents in the sampled talukas stated that they contributed to the work of the schemes on a need basis, even if there is no formal system of billing. This discovery implies that this poor performance in bill recovery cannot be attributed to the area alone, but may stem from the limited administrative capacity of the government-operated schemes to integrate these into all five talukas, especially in the more remote rural schemes. The willingness of over half of households to contribute to maintenance despite poor billing indicates community engagement is present throughout the district, even where formal payment systems are not.

Figure 5

Water Charges Payment Status of Households and Payment Frequency among Paying Households in District Badin



Overall District-Wide Community Perception

Taking all five talukas together, only 10% of households connected to a WSS reported being fully satisfied with the service they received, with the majority reporting partial or no satisfaction. Dissatisfaction was linked consistently, across talukas, to unmet supply needs and concerns about water quality. Five water supply schemes across the district were reported to be managed directly by the community with the help of relevant government departments. District-wide, 46% of consumers paid their water bills, with 78% of payers doing so monthly; among the 56% who did not pay, non-receipt of bills and the absence of a billing system were the main reasons given. Separately, 42% of respondents reported contributing to system maintenance whenever required, indicating that low revenue recovery rather than lack of community engagement remains the primary threat to the financial sustainability of the schemes across all talukas.

Conclusion

This study assessed the water quality and household satisfaction associated with Government of Sindh water supply schemes across all five talukas of district Badin, such as Badin, Matli, Shaheed Fazil Rahu, Talhar, and Tando Bago. The findings show that water quality problems and service dissatisfaction are present throughout the district, though their severity differs from taluka to taluka. Laboratory testing of 330 water samples revealed that microbiological contamination was more prevalent than chemical contamination (such as excess pH, fluoride, arsenic, nitrate). In all five talukas, the water quality gets worse after water is collected and is not consistently poor at the water supply scheme (WSS). Water contamination was highest in Badin and Tando Bago talukas, and lowest in Talhar taluka, and was not found to be free from contamination in any taluka. The household survey revealed that even when piped water is being used, residents do not completely trust the water supply for drinking water. WSS is utilized by the households for domestic purposes in the district, while hand pumps, public taps, or bottled water are used for drinking. The overall satisfaction level, based on opinions from the survey completed on the water supply scheme, was poor; only 9.8% of households reported being fully satisfied with the services provided, and supply timing was the most common reason for satisfaction and dissatisfaction. Billing systems were identified as being weak, especially in rural areas, as over half of the households lacked bills and did not pay water charges; this was primarily attributable to the lack of a formal billing system and lack of water bills received. Nonetheless, the majority of households indicated that they would share in the upkeep of the scheme if it were necessary, indicating that there is a level of openness in the community in regard to supporting the scheme even when there is no formal scheme in place. The practices of household water storage also varied widely: more than one-third did not have any storage facility, and rural households used open ponds as their main water storage facility or had no storage option. This is probably one of the factors that leads to contamination from WSS at the household level. The conclusion of the study is that the problems of the government-operated water supply schemes in the district of Badin are not technical in nature. Household satisfaction is low in all talukas; although the problems of microbiological contamination are a public health issue, the problems seem to be more around the timing of supply, weak billing system, and poor storage conditions. Solutions to these problems must be implemented at different technical and institutional levels, but in all five talukas. Future studies could further be conducted in the same manner, but with seasonal water quality monitoring in all talukas to account for variation with changes in rainfall and temperature. The cost-effectiveness of interventions – billing system changes, water quality monitoring, and consumer satisfaction could also be studied. A longitudinal study of households following these interventions would help answer whether there is evidence of increased satisfaction and decreased contamination over time due to greater reliability of services and increased billing transparency.

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