Access to Safe Drinking Water through Rural Water Supply Schemes: Evidence from District Muzaffargarh (Pakistan)

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Abstract

Access to adequate and safe drinking water is a basic human right, and its provision is the collective responsibility of governments, organizations, and communities. Improving the access and quality of safe water for drinking, domestic consumption, personal hygiene, and certain other situations has always been among the top priority goals of the government of Pakistan. The prime objectives are understanding access to safe drinking water through rural water supply schemes (RWSS) and its socio-economic status. Health impacts on the rural communities of district Muzaffargarh, this evaluative study approached fifteen rural water supply schemes. The primary data were collected from community members who were water consumers of rural water supply schemes (RWSS) and community-based organizations (CBOs) who manage the operation and maintenance of rural water supply schemes (RWSS). The study's findings indicated a significant association between safe drinking water and the social, economic, and health status of local community members who have the facility of rural water supply schemes. The findings also revealed that the water supply schemes have more sustainable and long functionality periods, where local community members are intensively involved in their operation and maintenance.

Keywords: Safe Drinking Water, Water Supply Schemes, Operation and Maintenance of Safe Drinking Water**.**

Introduction

Safe drinking water, improved sanitation, and hygiene are the basic human rights and necessities for individuals, groups, and communities globally. Yet, millions worldwide lack access to this basic necessity, leading to severe health, economic, and social consequences (Khalid et al., 2024). Much of this earth's water is salty and unsuitable for drinking. The remaining available water on earth is available in the glaciers, ice caps, and underground accordingly (Afzal et al., 2023). From the beginning of human civilization, the arrangement of food and water was learned gradually, and human learned the process of fetching underground water for their drinking and agricultural needs.

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The river and underground water have been used for drinking and various purification methods for a long time. Several existing monuments and available records highlighted that humans took various purification methods to remove contamination and ensure safe drinking water (Barbieri et al., 2023).

The provision of safe drinking water is among the most pressing global issues, and to deal with this multilayered factor, the United Nations takes it on the priority agenda in the form of sustainable development goals (Afzal et al., 2022). Goals 6 and 6.1 from the United Nations sustainable development goals focus on the provision, safety, and equitability of drinking water for the whole of humanity (Adkins et al., 2021). The prime objectives of this goal are to ensure the affordable availability of safe drinking water, reduce waterborne diseases and pandemics, and ensure dignity, gender equality, proper hygiene, and healthy living, among others. To ensure the target of sustainable development goal, intensive efforts are made by individuals, organizations, and governments worldwide. As a result, in 2022, more than 6 billion individuals will have access to the basic need of safe drinking water within their premises or at a distance of 250 meters (Lestari et al., 2023).

Unfortunately, 2.2 billion people are still waiting for this basic human need near their homes and contamination-free. Among them, about 1.5 billion individuals have safe drinking water within 30 minutes' distance, which brings a lot of difficulties, especially for women and children. Almost 296 million individuals worldwide still use unprotected drinking water due to their socio-economic and geographical conditions, and about 115 million individuals collected unsafe surface water from rivers, lakes, and ponds (Adimalla et al., 2020). Various facilities and services regarding safe drinking water and improved sanitation exist worldwide, especially in poor and developing countries. This difference is more visible (Xiuping et al., 2023).

Rural Water Supply System (RWSS) in Punjab, Pakistan

Punjab Pakistan's rural water supply system has provided safe drinking water to rural communities for a long time. Different departments, such as the public health engineering department, local government and community development department, municipal corporations, Pakistan Power and Works department, private organizations (national and international), and communities, are largely associated with providing and managing safe drinking water. The prime execution department of the water supply system is the public health engineering department, which is also responsible for operation, maintenance, and sustainability with the help of local community-based organizations.

The public health engineering department has been responsible for the execution of rural water supply schemes since 1961, and the prime focuses on the province's brackish and water scarcity areas. Since then, PHED has established twenty-eight hundred rural water supply schemes to provide safe drinking water to the rural communities of the Punjab province (Afzal et al., 2022). With time, governments established various policies according to the needs of time and geographical situations for effective, safe drinking water, such as the Social Action Plan 1992, that comprehensively enhances the provision, safety, and adequacy of clean drinking water and sanitation. The involvement of local communities and their representatives ensures sustainability and low-cost facilities for the inhabitants (Kumar et al., 2023).

The rural communities of Punjab province of Pakistan have always understood that providing clean and safe drinking water is the responsibility of the government rather than the communities. This created a complication regarding the sustainability and cost-effectiveness of managing the rural drinking water supply schemes. This notion has been changed for the first time in Pakistan's

history. Asian Development Bank (ADB), with the support of rural communities, has converted this task into reality through its "Punjab Community Water Supply & Sanitation Project," which works with the marginalized rural communities in the Punjab Province (Ahmed et al., 2022).
Muzaffargarh is an important city in South Punjab, and the quality of underground water in District Muzaffargarh is not satisfactory as per the guidelines of WHO, especially after the August 2010 flood; as a result of this flood; vast devastation has occurred due to stagnant water of flood the underground water quality has been affected badly. District Muzaffargarh has three water zones: brackish, Sweet, and contaminated. Currently, a burning issue is an arsenic issue. Muzaffargarh is an industrial area with approximately 50 industrial units, and the underground water quality is low daily without wastewater treatment. The remedy exists only with the legislation regarding drinking water. There is a dire need to understand access to safe drinking water and rural water supply schemes.

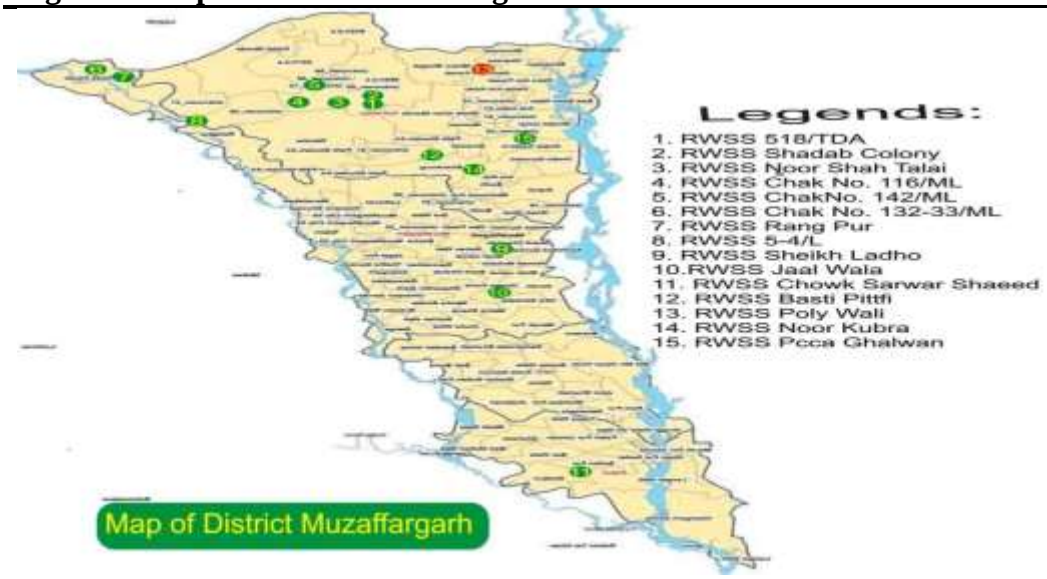
Study Objectives

- To assess the Socio-demographic background and available safe drinking water facilities in district Muzaffargarh's rural communities.
- To understand the impacts of rural water supply schemes on the social, economic, and physical conditions of the community members living in the rural areas of district Muzaffargarh.
- To check the impacts of safe drinking water and community members' health status in district Muzaffargarh.

Research Methodology

This study was conducted in the Muzaffargarh district, and the study's universe was the rural drinking water supply schemes, beneficiary communities, and Community-Based Organizations (CBOs). The respondents were approached by applying simple random sampling techniques, and a sample of fifteen rural drinking water supply schemes was selected randomly. Out of the selected rural water supply schemes, primary data were collected from three Community-Based Organizations (CBOs) members, and seven community members were approached. A total of ten respondents were selected from each selected rural drinking water supply scheme (10 members from each CBO and ten from each community); thus, the study's total respondents were 150.

Figure 1: Map of district Muzaffargarh



Source: Urban Unit Punjab.

The data were collected through structured questionnaires which have several sections regarding provision of safe drinking water, quality of safe drinking water, utilization and satisfaction level among others. Pre-testing was done to check the validity and reliability of the research instrument and necessary improvements were made according to the pre-testing findings. The collected data proceed through SPSS 21 and the findings presented in the form of descriptive as well as advance statistical analysis.

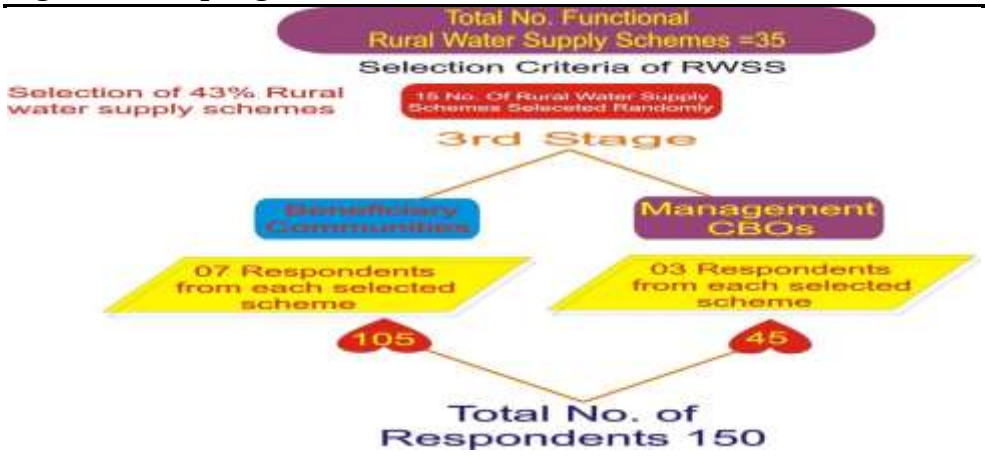
$P=F/N \times 100$

Where, F=Frequency

N=Total frequency

P=Percentage

Figure 1: Sampling flow chart



Results and Discussion

Total participants approached for this study were 150 from the 15 selected rural water supply schemes of district Muzaffargarh. The descriptive results obtained are given below in the form of numbers and percentages for understanding of existing socio-demographic situations.

Table 1: Demographic Characteristics of the Participants

	Category	Frequency	Percentage
Participants Occupation	Agriculture	46	31%
	Labour	48	32%
	Business	23	15%
	Private Service	21	14%
	Govt. Service	11	7%
	Others	1	1%
	Total	**150**	**100%**
Monthly Income (Rs)	0 – 6000	50	33%
	6000 – 15000	72	48%
	15000 – above	28	19%
	Total	**150**	**100%**
Participants Education Level	Literate	80	53%
	Illiterate	70	47%
	Total	**150**	**100%**
Availability of safe drinking water	Yes	97	65%
	No	53	35%
	Total	**150**	**100%**

Findings from table 1 show that (31%) respondents belong to the occupation of agriculture, laborers are (32%), businessmen are (15%), private servants are (14%), Government servants are (7%) and (1%) respondents fall in other categories of occupation. This table also depicts that most of the respondents belong to the occupation of labor. Out of total (33%) respondents are below Rs. 6000, and between Rs 6000 to 15000 is (48%) and (19%) respondents have the income above to Rs 15000. This table also depicts that most of the respondents ' income level is between Rs 6000 to 15000. There are (53%) respondents are literate and (47%) are not literate. This table also depicts that most of the respondents are literate. Where respondents were educated they have sufficient knowledge regarding water and other health & hygiene issues. The findings indicated that there are (65%) respondents who agree to the availability of water for their use and (35%) respondents who do not agree to the availability of water according to their need. This table depicts that the majority of the respondents are satisfied with the availability of water.

Table 2: Existing conditions of safe drinking water in district Muzaffargarh

Factors	Category	Frequency	Percentage
Executing agency of RWSS	PHED	109	73%
	NGO	0	0%
	TMA	21	14%
	PCWSS	20	13%
	Total	**150**	**100%**
Distance of water before RWSS.	½ Km	79	53%
	1 Km	47	31%
	2 Km	10	7%
	Not Applicable	14	9%
	Total	**150**	**100%**
Time saved due to execution of RWSS	One Hour	88	59%
	Two Hours	37	25%
	Three Hours	8	5%
	Four or more hours	4	3%
	Not Applicable	13	9%
	Total	**150**	**100%**
Water quality provided through RWSS	Good	114	76%
	Fair	33	22%
	Poor	3	2%
	Total	**150**	**100%**

Table 2 indicates that (73%) rural water supply schemes were executed by PHED, rural water supply schemes that were implemented by TMA are (14%) and PCWSS has implemented (13%) schemes only. This table also shows that most of the rural water supply schemes have been implemented by the public health engineering department. The findings indicated that (53%) respondents have to get water at the distance of ½ KM, (31%) 1 KM, (7%) 2 KM and (9%) are no response due to the sweetness of underground water. This table also depicts that most of the respondent area is brackish therefore; people have to go to fetch water outside their houses at the distance of ½ KM. The results also indicated that (59%) respondents save their time one hour due water supply schemes, (25%) respondents that save their time two hours, respondents that save their times three hours are (5%), the respondent that save their time more than three hours are (3%) and (9%) respondents fall in not applicable due to sweet underground water. This table also depicts that most of the respondents save one hour after the installation of rural water supply schemes. Results indicated that (76%) Good quality of water is being supplied, (22%) is fair quality and 2% Poor quality of water is being supplied to the respondents. This table also depicts that most of the respondents said that the good quality of water is being supplied to them.

Table 3: Social, economic and health impacts of RWSS

Factors	Category	Frequency	Percentage
Duration of RWSS	One Year	5	3%
	Two Years	13	9%
	Three Years	35	23%
	More than Three Years	97	65%
	Total	**150**	**100%**
Major health issues before RWSS	Hepatitis	35	23%
	Abdominal Diseases (Typhoid, Cholera, Diarrhea)	107	71%
	Any Other disease	8	6%
	Total	**150**	**100%**
Reduction in health expenses	Yes	145	97%
	No	5	3%
	Total	**150**	**100%**
Socio-economic improvement	Yes	86	57%
	Somewhat	48	32%
	No	16	11%
	Total	**150**	**100%**
Challenges / Problems of RWSS	Recovery Problem	27	18%
	Power failure	68	45%
	Water theft	2	1%
	Leakages Problem	10	7%
	Any Other	6	4%
	WAPDA issues	37	25%
	Total	**150**	**100%**

Table 3 describes that (3%) Schemes have been operating since one year, (9%) Two Years, (23%) Three years and (65%) schemes are running from more than three years. Results show that (23%) respondents are suffering from hepatitis, (71%) intra abdominal diseases and (6%) respondents are suffering from different diseases. This table also depicts that the most of the respondents are suffering intra abdominal diseases. This table also depicts that most of the water supply schemes are running from more than three years. The findings describe that the health expenses of respondents has been reduced (97%) due to water supply schemes and (3%) health expenses of the respondents did not reduce. This table also depicts that most of the health expenses of the respondents have been reduced. Table 3 describes that according to (57%) respondents there is socio-economic improvement in their village after the installation of water supply schemes, according to (32%) somewhat and according to (11%) there is no progress in socio-economic in the villages. Table 3 also shows that (18%) respondents facing the recovery problem, according to (45%) Power failure, according to (1%) water theft, Leakages problem are (7%), any other problem are (4%) and according to (25%) of respondents both Recovery Problem and Power failure. This table also depicts that the most of the problems are both Recovery Problem and Power failure.

Hypothesis Testing Analysis

H1, Association between quality of water being supplied and reduction of water borne diseases assessed through Chi Square and the calculated value is 44.908 > than the critical value 12.59159, reject the null hypothesis and conclude that quality of water and diseases are not independent. They are related statistically, the relationship between two variables shows that the community was satisfied with the quality of drinking water, which controlled the water borne diseases. The observed values such as the level of significance are 0.05, degree of freedom is 6, and critical value 12.59159 and Chi Square calculated value is 44.908.

Table 4: Association between quality of water being supply and reduction of water borne diseases

Quality of water being supplied	Reduction in water borne diseases due to RWSS				Total
	10%	20%	30%	40% or more	
Good	16	21	36	41	114
Fair	0	0	0	33	33
Poor	0	0	0	3	3
Total	**16**	**21**	**36**	**77**	**150**

H2, Association between community involvement and duration of functionality of rural water supply schemes. Calculated value is 24.0224 > than the critical value 7.815, reject the null hypothesis and conclude that the involvement of community in designing and planning and duration of operating the scheme are not independent. They are statistically inter-dependent. The relationship between community involvement and sustainability of the project shows that community participated projects are sustainable whereas low community participated projects are not sustainable. Observed degree of freedom is 3, level of significance is 0.05, critical value is 7.815 and Chi-Square calculated value is 24.0224

Table 5: Association between community involvement and duration of functionality of rural water supply scheme

Community involvement	How much long scheme is being functional				Total
	One year	Two Years	Three years	Three or more	
Yes	5	13	35	63	116
No	0	0	0	34	34
Total	**5**	**13**	**35**	**97**	**150**

Discussion

The present research was conducted to explore the impacts of drinking water supply schemes on rural people's health. The study's basic assumption was that good quality drinking water positively affects human health. The present study consisted of all the rural drinking water supply schemes, beneficiary communities, and Community-Based Organizations (CBOs) of district Muzaffargarh's rural drinking water supply schemes. A sample of 150 respondents of the beneficiaries from 15 rural drinking water supply schemes was selected through random sampling. All respondents were contacted individually, and data was collected through a comprehensive questionnaire. All the

respondents were beneficiaries of rural drinking water supply schemes and knew the drinking water supply schemes.

The descriptive result shows that the majority of the respondents, 130%, belong to agriculture and 32% to the labor profession. Most of the 53% of respondents were literate. In the villages of respondents where rural water supply schemes were installed, 79%groundwater was brackish, and sweet groundwater was 8% only. Most of the communities needed help with clean drinking water before the installation of the schemes. The study concluded that community members improved their health and hygiene education after installing drinking water supply schemes. According to the survey results, 51% of respondent's waterborne diseases have been controlled by more than 40% after the installation of water supply schemes. Of the respondents, health expenses were reduced by 97%.

Through statistical analysis, researchers try to check the validity and reliability of data. The results indicated that all the observed values are significant at 0.000 to 0.004, indicating the strong association among study variables and their impacts. The study's hypothesis was also tested through advanced statistical analysis, and the results regarding H1 stated that there is an association between the quality of water being supplied and the reduction of waterborne diseases assessed through Chi-Square, and the calculated value is 44.908 > than the critical value 12.59159. The observed values, such as the significance level, are 0.05, the degree of freedom is 6, the critical value is 12.59159, and the Chi-Square calculated value is 44.908.

Similarly, the findings regarding H2 prove a strong association between community involvement and the duration of the functionality of rural water supply schemes. The calculated value is 24.0224 > than the critical value of 7.815. The observed degree of freedom is 3, the significance level is 0.05, the critical value is 7.815, and the Chi-Square calculated value is 24.0224. Furthermore, the result of the study shows that most of the communities also faced problems regarding the operation and maintenance of the water supply schemes. Most respondents suggested that the Government arrange alternate power supply and backup support mechanisms.

Conclusion

Based on the analysis of the collected data of the 150 respondents from 15 rural drinking water supply schemes of district Muzaffargarh, it is concluded that communities were facing problems, especially regarding the provision of continuous safe drinking water, contamination of water issues, timings of water supply, water tariff by the community-based organization, collection of water bills and WAPDA issues among others, as findings of this study also supported by various researchers and studies such as Coffman et al. (2021), Butu et al. (2022) and Zhao et al. (2022). The research also highlighted the need for safe drinking water and its association with individual and family health.

Findings indicated that waterborne diseases were reduced after the installation of water supply schemes, and almost half of health expenses were reduced regarding waterborne diseases. Installing a water supply system significantly impacted the lives of children and women, the most affected proportion of the population. Women enjoy better experiences regarding their health and hygiene. The overall quality of water being supplied through these schemes was rated as good, and communities saved their time, especially the relief to the women because it was their responsibility to fetch water before the installation of water supply schemes, the matter already highlighted by Toolabi et al. (2021), Riddell et al. (2021) and Wang et al. (2022).

Recommendations / Suggestions

- Need assessment is necessary for the sustainable functionality of rural water supply schemes in rural Punjab, and for this purpose, local communities should initiate projects.
- Government departments like Public Health Engineering, Local Governments, and TMAs should develop mechanisms for collecting electric bills on the pattern of WAPDA. Users may install a water meter to do this.
- Government institutions and NGOs should arrange training programs for CBOs capacity building, awareness-raising campaigns, etc.

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