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Efficient Strategy to Remove Potable Water Scarcity in Lahore

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Water is life" is not only a phrase but also a reality which ensure human survival. This study provides an important tool to analyze different water management strategies that can be helpful in saving available water resources in an efficient way. Consultation with the public and officials of Water and Sanitation Agency (WASA), Lahore Development Authority (LDA), and Water & Power Development Authority (WAPDA) made this easier to understand the acceptability of the explored strategies in Lahore. A sample size of 400population was observed a supportive method to draw favorable results from the collected primary data. It is estimated that Lahore and its outskirts receive highest rainfall which contributes 40% to the annual groundwater recharge but the water table is still depleting gradually. Thisresearchprovidesnecessaryinformationregardingtheconservation of ground water. The correlations method was applied to check the significance of the variables. The findings proposed that authorities must communicate awareness among general public regarding importance of water or should start programs for water management. The other way of correlating strategies implemented in other similar countries led us towards billing and taxing as the topmost strategy to be implemented in our case study. A total of 66% targeted population was willing to make this strategy implemented through government support. Although other strategies like flash flooding, water recycling, rainwater harvesting, and equitable access to water all the time were following the acceptance as 60%, 61%, and 62% respectively. Finally, imposition of strict laws on water usage leads toward water saving for a sustainable future.

Keywords: Water recycling, Direct Potable Reuse (DPR), Scarcity, Rainfall harvesting

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Author's Contribution
Dr. Ijaz Ahmad was responsible for the overall guidance of other authors and the monitoring of the data. Muhammad Sajid Iqbal was responsible for data analysis, Noor ul Huda Naveed was responsible for data compilation and Muhammad Junaid Iqbal was responsible for data collection. Muhammad Sajid Iqbal and Noor ul Huda have compiled this Research Paper.

Conflict of interest
There exists no conflict of interest in publishing this manuscript in IJIST.

Project details. NIL

Introduction

This fact is proved that with the increase in urbanization the demand for fundamental amenities like potable water is increased. The recent migration trends of masses toward developed cities in search of basic needs of life are very common around the world. It is the main reason of extensive urbanization [1]. The rapid urbanization and the population growth have increased the demands of fresh water to manage various tasks from domestic to industrial scales [2]. The increase in demand has put an intolerable liability on the natural water reserves. Correspondingly, the rapid changes that had been seen in the climate are also the major factors in the scarcity of water in different cities. In this situation, the strategies for water management can be a progressive step towards preserving this natural resource for the challenges that the future beholds. The enhanced cycle of various human activities like agriculture, urbanization, and industrialization have put huge pressure on available reservoirs of fresh water [3]. The recent study on the assessment of adoption of rainwater harvesting system in residential building in Lahore is also supporting one of the best strategies for management. Various countries faced this challenge and implemented different strategies and approaches to cope with this. The major issues seen in South Africa are the extraordinary level of poverty and inequality (water services problems), higher need of already stressed water capitals through the developing economy, annual rainfall which has been recorded is lesser time, fast-flowing rivers and huge underground reservoirs, exacerbation of scanty rainfall by high levels of evaporation, consumption of half of the available resources, abandoned growth in population and decrease of water resources, low level of social flexibility, the amount of water per capita, unmanageable use of water resources, unaware and uneducated population, and poor technological capability[4].In India, the challenges faced during portable water management are to access of the general public to adequate safe water, institutional challenges, service provision, over-extraction of groundwater, increasing monetary crisis, absence of affected people involvement, and inadequate transparency[5]. The policies implemented to overcome these challenges are to develop and to manage these resources, to promote river basin organization, to guarantee integrated water resource management, to support groundwater governance, to scale community-based tanks rejuvenation, to endorse public-private partnership, and to set up and strengthen water regulatory authorities [6]. Sri Lanka is also falling on the line of those countries which faced water management challenges [7]. The main challenges are ejection of the private sector participation, the feeble institutional arrangement, the contamination of water resources from urban, industrial, and agricultural wastes, and soil erosion of water by mismanagement of land-use [7]. The strategies adopted by the Siri Lankans are the institutional arrangements in the water sector, the planned water policies and laws, maintainable water resources management, water transfer competence, construction of new hydraulic infrastructure, and the availability of more water storage through dams [7]. In Lahore, the main challenges identified are in accessible safe water, institutional challenge, and undiversified service provision, over-extraction of groundwater, growing financial crunch, lack of advanced technology, and lack of awareness to manage portable water.[8]. The solutions derived in the light of the above countries are to apply taxing/billing over high usage, institutional arrangements in the water sector, to improve our technological capacity, try alternate models (Intern-Basin Transfer Approach, Auto-flush system), incentive-based voluntary programs, water conservation measures (groundwater recharge), and rainwater capture[9]. Amendments concerning potable water management in building regulations are a very important tool to support policy measures taken by the authorities. We are living in the modern era but still, people of our far furlong, as well as urban dwellings are in a state of water shortage. Thus, intentionally or unintentionally people are forced to drink either unhygienic water, bottled, or tap water. Communities have been facing deficiencies of potable water supply due to the rapid growth of population and development patterns[10]. At the same time Pakistan is struggling to

manage natural hazards for survival from nastiest catastrophic conditions which may occur in future. [11]

Pakistan lacks in reliable statistics due to the unavailability of safe and sufficient drinking water. Pipe water in Pakistan is contaminated either because of leakages with all sorts of bacteria or geological conditions and insufficient purification. The process of recovering drinking water from wastewater to enhance the sustainability and reliability of water supplies is called Direct Potable Reuse (DPR). This process can support the supply side. A dominant question in the planning and engineering sector is to determine how can communities continue to grow and flourish while meeting the water resource needs and providing a high quality of life to future generations? Access to adequate water supplies for municipal, industrial, and agricultural uses are important factors among these needs.

Many regions around the world face freshwater shortages due to poor management of the increasing population and development burdens. This research aims to bridge this gap through assessment of different water management strategies in Lahore.

Methodology

The methodology involves the widespread review of relevant literature and collection of primary data through interviews with relevant stakeholders. Literature review convinced and pushed for the initiation of research which was majorly supported by research articles from peer-reviewed journals. A good number of research articles/reports regarding water management strategies, mostly published in high evaluated journals, were reviewed for comprehension of different strategies adopted by countries for the removal of water scarcity. This helped in identifying the research gap and the study domain to be tapped. Primary data were collected through interviews from two sets of respondents: (I) concerned officials of WAPDA, WASA, and LDA, (ii) residents from a sampled household. As many as 8 officials were interviewed to take the viewpoint of WASA and LDA for management strategies. This is a total number of officials whose work domain is related to the scope of this research. Interviews done with concerned officials helped in understanding the motivation behind introducing water management strategies in the case study. Institutional, legislative, and operational issues concerning the introduction and implementation of the most suitable strategies were also documented through these interviews. Snowball sampling technique was used to approach the officials.

So, after reviewing literature about the challenges and strategies faced by different countries, we determined the main role of the study, based on that aim we formulated different objectives to meet our demands. After the formulation of objectives, the next important step was to define the scope of the study. We determined our target population and also the type of research to be carried out. We defined the scope to limit our study to meet the main purpose of the research.

Interviews with selected residents were conducted to consider their views on the implementation of analyzed strategies and to explore factors affecting the adaptability of the strategies. It was a daunting task to identify and select the residents for interviews who would have some knowledge and awareness about the water management strategies. The scope of the study could have been very extensive due to the large sample size if all populations would have been considered for sample size. Therefore, to calculate the sample size of residents, a discussion was held with WAPDA, WASA, and LDA officials to devise a plan for data collection. The plan included9 official towns/zones created by authority and to collect 45 interviews from each zone.

Thus, a total of 400households came into calculations by Solvin's formula of sample size with a 95% confidence level. The population is projected till 2020 by the following formula

$$\mathbf{Pt=P_0*(1+r/100)^t}$$

The population was calculated as 12540846.Out of these 400, a total of 352 interviews were conducted successfully, and the remaining 48 couldn't be conducted due to the non-

cooperation of respondents. Either the residents felt reluctant to respond or the houses were locked. The collected data are further processed by the chi-square test, t-test, and regression analysis on SPSS to draw the best results. After applying these analyses, the best method was a correlation to support the defined variables and study.

Case Study.

Lahore with a population of 11.13 million people is termed as the administrative, educational, business, political, and recreational hub of the province Punjab located in the sub-tropical, semi-arid region[12].The water table in Lahore has been observed depleting the freshwater layer and dropping data rate of 2 ft per annum[13].Lahore receives average rainfall as 575 mm annually, and changing from 300 mm to1200 mm[14].The monsoon period is from July to August which is the hottest spell of the year with most water demand. It is estimated that Lahore has the highest rainfall which contributes 40% of the annual groundwater recharge. Water channel include canal passing through the center, and Ravi River passing adjacent to the boundary. Hence due to rainwater harvesting, canal, and the river, it can be formulated for the varying ideas to adopt water management strategies. The most important is to make people aware of changing their water usage pattern and to contribute to recharging the underground water table. Lahore is the second-most populous city of the country with the population increasing at a frightening rate, correspondingly have an increasing water demand[15].The study site is mapped in Figure 1.

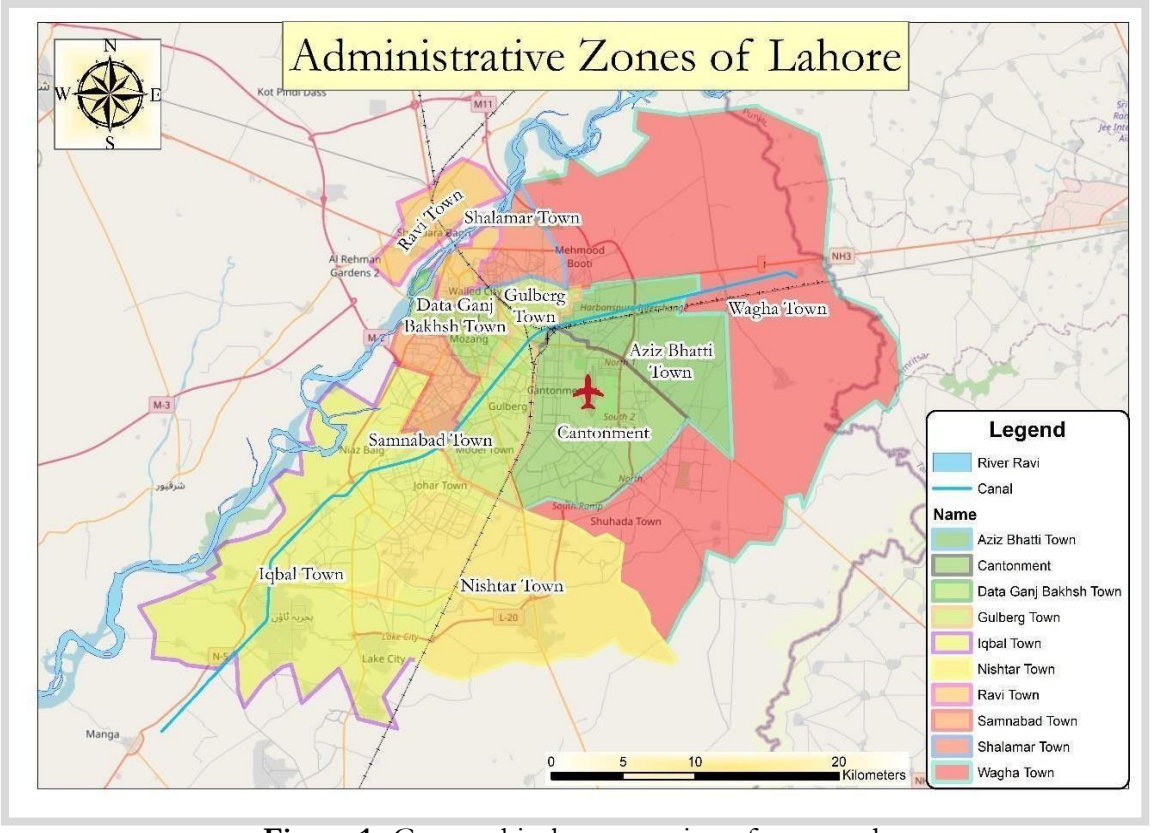

Figure 1: Geographical presentation of case study

Results

The main purpose of taking interview of officials of relevant authorities was to make them involved in introducing the best possible strategies for potable water management in our case study. These strategies were discussed with them through a checklist of strategies derived in the light of literature of different countries. As LDA officials were already doing the practice of groundwater recharging through the amended building regulations 2014. Therefore, their main focus was to get the public involved in this process and they were keen to implement these

strategies with the collaboration of other authorities like WAPDA and WASA in Lahore. Likewise WASA, the WAPDA officials also focused to get the public response and to make them aware of the water management strategies and were in progress to use such models through rules and regulations.

The viewpoint of Residents

The basic aim behind getting the response was to get their viewpoint for supporting or rejecting the potable water management strategies coded into the questionnaire. Therefore, in the future, this research might be helpful to the officials for defining policies for these strategies.

Socio-economic information of the residents

The main purpose of adding this question was to get an idea of what is the comparative usage of water between bigger and smaller families. In our case study, household size contained1 to 3 which is 22%, 4 to 6 is 46% and more than 6 was 32%.

In our case study, most of the families were literate and knew how to use water effectively. Awareness programs could easily be delivered for the follow up of water management strategies in Lahore. People were observed keenly to attend such events and to provide their feedback positively. The demographic information and literacy rate are mentioned in Figures 2 and 3. Figure 4 is showing water consumption at various levels in the city boundary.

Demographic Information

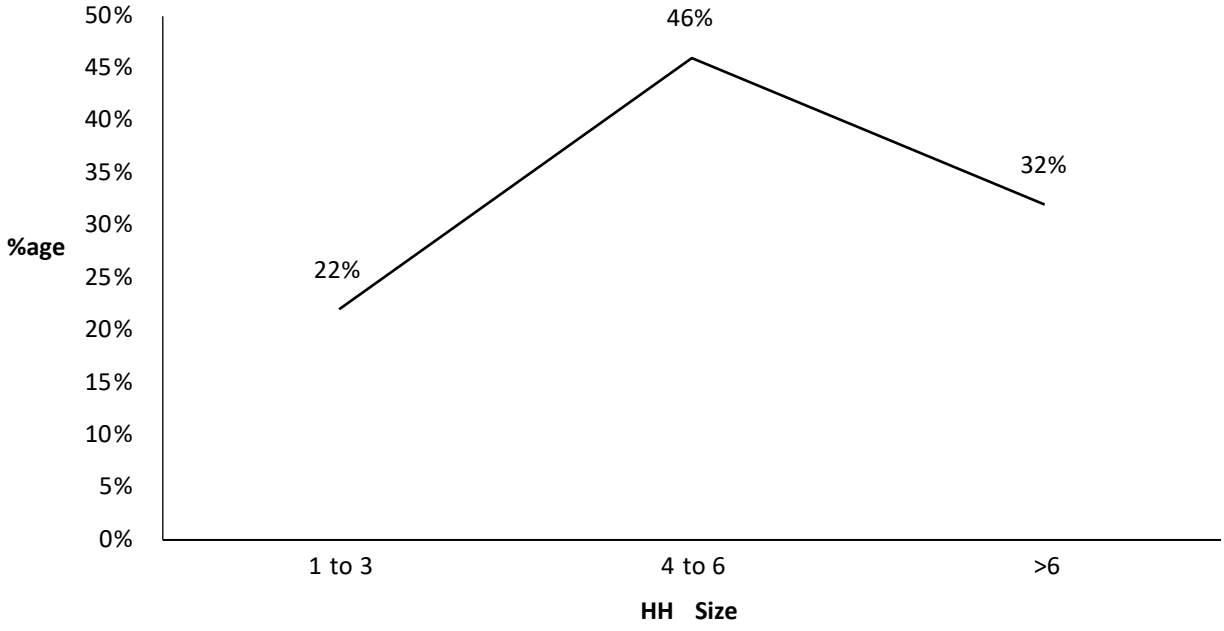

Figure 2: Demographic information of respondents

Table 1reveals that the general public response agreeing upon "Accessibility towards instructions given by authority for water management" as the most effective among the five correlated strategies. The public acceptability towards this strategy is 67% of the targeted population. The same strategy is dependent on others like the involvement of the public in helping the authorities to implement strategies as 69% of the total. Accordingly, work needs to be done on all the strategies to get the required results as per the public desire.

Table 2 elaborates the correlation between the public acceptability of the extracted strategieswhichrecognizesaccessibilitytowardsbilling/taxingtobeexecutedimmediatelyin line with other strategies. The public response towards this strategy is 66% of the sample. The public willingness towards flash flooding is 60%, reusing the water as 61%, for rainwater harvesting 61%, for recycling the water as 64%, and for equitable access for water as 62%. The analysis is based on preliminary studies and can be revised with future studies.

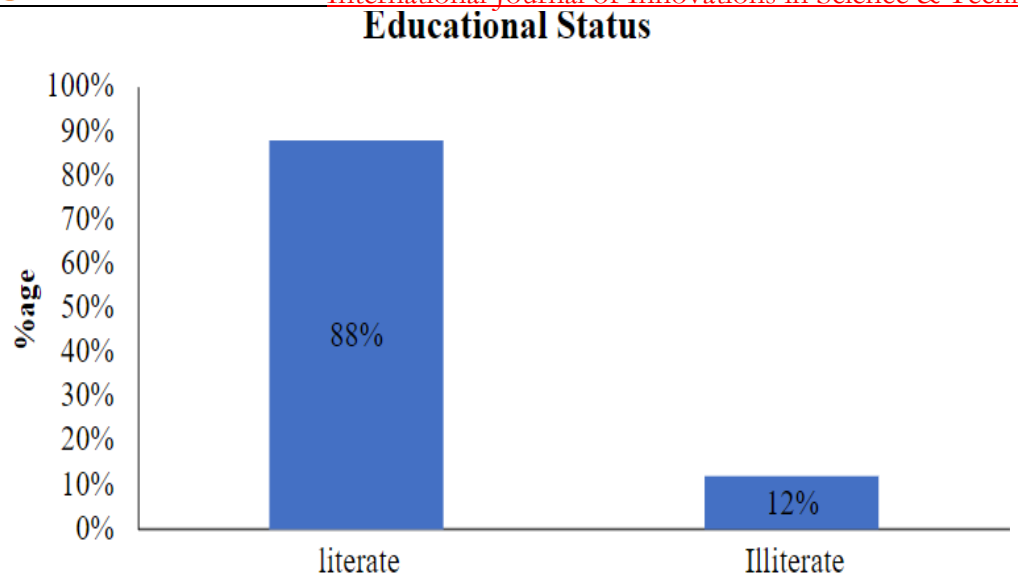

Figure 3: Literacy rate in the study site

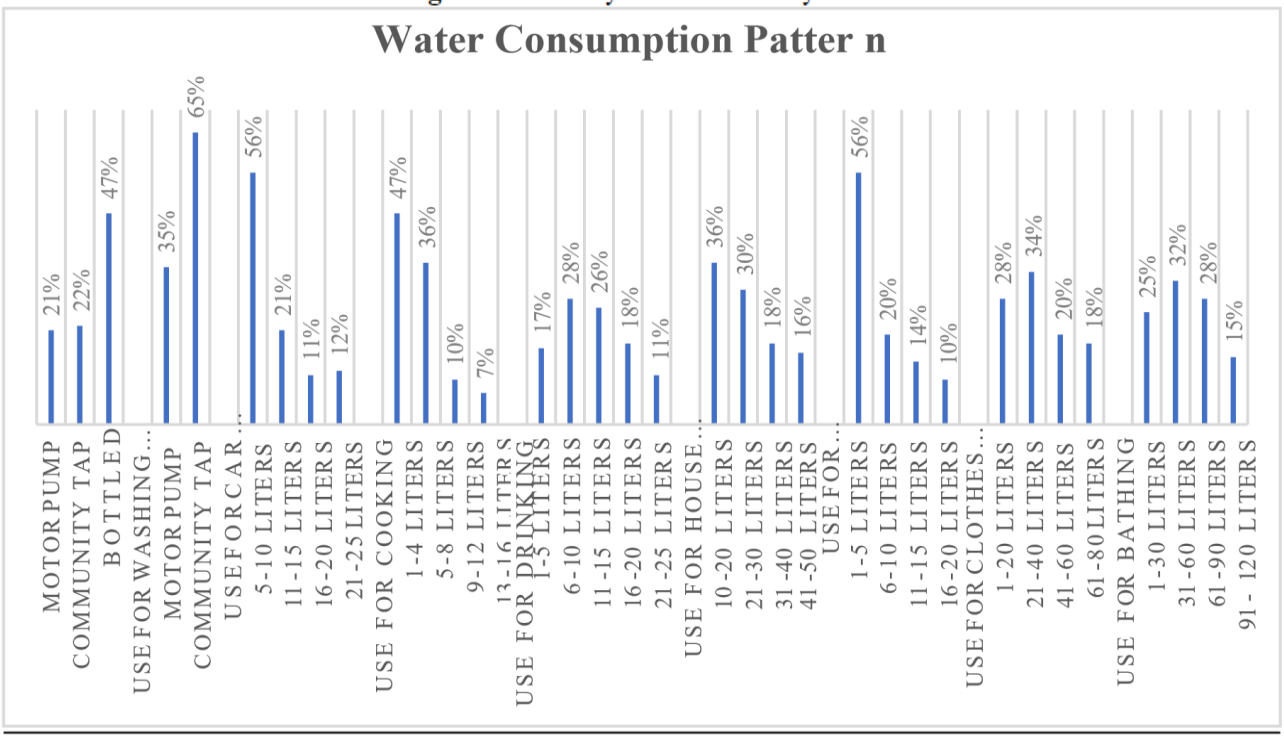

Figure 4: Water Consumption Pattern of residents

Table 1:Awareness Status of the Residents

Correlations

		1.Involvement in supporting the govt for strategies	2.Acceptability towards accessibility of water all the time	3.Acceptability towards instructions by govt for water management	4.Acceptability towards awareness through social media	5.Acceptability towards events on awareness of water management
1.Involvement in supporting the govt for water management	Pearson Correlation	1	.543**	.571**	.412**	.408**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	352	352	352	352	352
2.Acceptability towards accessibility of water all the time	Pearson Correlation	.543**	1	.684**	.549**	.583**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	352	352	352	352	352
3.Acceptability towards Instruction given by authority for water management	Pearson Correlation	.571**	.684**	1	.616**	.675**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	352	352	352	352	352
4.Acceptability towards awareness through social media	Pearson Correlation	.412**	.549**	.616**	1	.766**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	352	352	352	352	352
5.Acceptability towards events arranged by govt on awareness of water management	Pearson Correlation	.408**	.583**	.675**	.766**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	352	352	352	352	352

**. Correlation is significant at the 0.01 level (2-tailed).

Table 2: Correlation status of water management strategies by residents

Correlations

		1.Acceptability towards billing or taxing	2.Acceptability towards flash flooding	3.Acceptability towards reusing the water	4.Acceptability towards rain water harvesting	5.Acceptability towards availability of water is all the time	6.Acceptability towards recycling the polluted water
1.Acceptability towards billing or taxing	Pearson Correlation	1	.791**	.792**	.769**	.785**	.607**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	352	352	352	352	352	352
2.Acceptability towards flash flooding	Pearson Correlation	.791**	1	.729**	.717**	.698**	.544**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	352	352	352	352	352	352
3.Acceptability towards reusing the water	Pearson Correlation	.792**	.729**	1	.685**	.689**	.681**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	352	352	352	352	352	352
4.Acceptability towards rain water harvesting	Pearson Correlation	.769**	.717**	.685**	1	.727**	.498**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	352	352	352	352	352	352
5.Acceptability towards availability of water is all the time	Pearson Correlation	.785**	.698**	.689**	.727**	1	.538**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	352	352	352	352	352	352
6.Acceptability towards recycling the polluted water	Pearson Correlation	.607**	.544**	.681**	.498**	.538**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	352	352	352	352	352	352

**. Correlation is significant at the 0.01 level (2-tailed).

Discussion

As the levels and quality of groundwater in Lahore is being dejected at a very fast rate, therefore it is projected that the aquifer will not be used in near future. Therefore, there is a dreadful requirement for considering the undercurrents and aspects accountable for this worthless condition. After the analysis of interview data based on previous studies regarding potable water management problems in the case study, we can draw some direction for the strategies. In the first table, one of the most important strategies resulted is the instructions from the government authorities to the public for water management strategies. These instructions can be given through events or seminars and social media campaigns. This will help in altering the attitude of people to take some initial steps to think for alternative options for aquifer recharge and contribute towards saving it from vanishing.

Other strategy accepted after public response and supporting views of officials is the billing and taxing mechanism for the water usage in the household. The billing system can be effective in reducing the household water wastage. At the present stages, authorities should make policies for the implementation of suggested strategies in the case study with the instructions of the government for water management. In later stages, groundwater levels monitoring is required for sustainable management of this resource, public awareness is required through different seminars for potable water use and reuse, with the collaboration of advanced technological facilities authorities. With the ongoing situation of nature, there is very important to save even tiny drops of rainwater for replacing the extraction of groundwater. Lahore receive 575 mm rainfall annually, rainfall water harvesting mechanism should be adopted to save this reserve.

Pakistan was once a water-stressed country has now become a water-scarce country. A study was conducted to prioritize the strategies required to fill the gap for potable water management. The findings of the study in form of government authorities to give public access towards instructions for water management as well as water recycling, rainwater harvesting and execute billing or taxing on a priority basis for public well-being. These strategies must be in line with all other strategies like flash flooding, and equitable access to water all the time for its effective implementation. These methods will be the best tools to save water for other fields of agriculture and biodiversity. The present data results beautifully in the above precious strategies but with the ongoing situation of nature, strategies can be altered with further studies.

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Questionnaire

	Title: "Novel Strategies to Meet Potable Water Scarcity in Lahore"	**Researchers:** Mohammad Junaid Iqbal Muhammad Sajid Iqbal Noor ul Huda **In Supervision of:** Dr.Ijaz Ahmad

Purpose: This interview schedule is prepared for taking inputs of public pertinent to water management in context of Lahore. It is, however, ensured that this schedule and the findings obtained through it will be solely used for educational purposes.

Name of Interviewer_____ Name of the Respondent_____

Date: _____

Sr. No.	Question	Response		
1	What is the number of households?			
2	What is the household size?			
3	What is your educational status?			
4	What is the occupation of head of household?			
5	What is the total number of earning members?			
6	What type of water do you use for drinking?			
7	What type of water do you use for washing or bathing purpose			
8	11. Does it need to engage events/Programs on water saving in your area? _____	Yes	No	Indifferent
9	12. Do want to get any information through social media about water management?	Yes	No	Indifferent
10	13. Do want to get any instructions about water saving through concerned authority of your area?	Yes	No	Indifferent
11	Is the provision of water billing and taxing on water usage is manageable for you?	Yes	No	Indifferent

12	Does rainwater harvesting need implementation in your house?	Yes	No	Indifferent
13	Will you use the strategy of flash flooding to save water?	Yes	No	Indifferent
14	Will you feel easy to reuse the water in your house?	Yes	No	Indifferent
15	Will you use the strategy of recycling the polluted water in your house?	Yes	No	Indifferent
16	Do want to get equitable access to water all the time in your area?	Yes	No	Indifferent
17	Will you cooperate authorities to impose strategies in your area?	Yes	No	Indifferent

Suggestions	Regarding the best strategies to be implement in Lahore

The End