

## Review of impacts of climate changes on the urban water security of Islamabad, Pakistan

Attaullah Shah<sup>1</sup> ✉, Rehmat Karim<sup>2</sup>, Karamat Ali<sup>3</sup>

<sup>1</sup> Karakorum International University, Department of Civil Engineering Technology, University Road, Gilgit, 15100, Baltistan, Pakistan

<sup>2</sup> Karakorum International University, Department of Tourism and Hospitality Management, Gilgit, Baltistan, Pakistan

<sup>3</sup> Karakorum International University, Department of Environmental Sciences, Gilgit, Baltistan, Pakistan

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**Abstract:** The global warming and subsequent climate change has seriously threatened the glaciers of the Hindukush Karakoram Himalaya (HKH) region. These glaciers provide water to more than 60% people of the 11 countries, including Pakistan. The capital city of Pakistan has witnessed unprecedented urbanisation, population increase, development of new townships and associated economic activities. These challenges, together with climate change, have created severe pressure on the water resources of the city. In this mixed mode research, including questionnaire survey of 20 questions was distributed among the residents of the city online through Google Form. The questions were related to the expected impact of climate change on the availability of water, measures for conservation of water etc. About 205 residents from various parts of the city with different demographic backgrounds responded. This was followed by Focus Group Discussions (FDGs) of the experts and the major challenges to the urban water security of Islamabad with special reference to climate change have been assessed. The research has revealed that the water resources of the city are highly unsustainable. The residents have high concerns about the availability and quality of water. The results have shown that there is a number of governance issues in water distribution systems of the city. There are no organized water conservation strategies employed by City Government. The lack of institutional and policy framework has further complicated the situation. Residents seem willing for metering of water for its conservation. Recommendations have been made to municipal authorities for rational water resource management of the city.

**Keywords:** climate change, global warming, Islamabad, urban water

### INTRODUCTION

It is a well-established fact that water is an essential necessity for the life and livelihood of all living things. Ensuring access to clean water and sanitation for everyone is one of the 17 Sustainable Development Goals set by the UN for the period 2015–2030 [OJHA *et al.* 2017]. The latest World Water Development Report of the UN warns about the impacts of climate change on the quality, quantity and availability of drinking water for billions of people [UN 2020]. The water demand at global level is increasing at 1% per year, while about 2.2 bln people don't have access to clean water at present. Meanwhile, 4.2 bln

people (55% of the global population) lack properly managed sanitation systems.

The water resources of Pakistan are mainly fed from Upper Indus Basin (UIB), which provide 44% of water needs to country through a vast network of canals, barrages, weirs and dams [KHAN *et al.* 2015; TAHIR *et al.* 2011]. At the same time 50% or more of the water in UIB is supplied from the melting glaciers in the Hindukush-Karakoram-Himalaya (HKH) region and the sustainability of UIB water system is directly linked with the regular supply of water from these glaciers [ARCHER 2003]. Spatial and temporal variations in glaciers of HKH region have been experienced in the last few decades, showing advance, stable

and retreat status at various locations [SCHERLER *et al.* 2011]. The increase in global temperature and subsequent climate change in the region has also contributed to the retreat of glaciers and formation of new glacial lakes in the Karakoram range [SENESE *et al.* 2018; SHAFIQUE *et al.* 2018]. Similarly, glacial retreat and increase in number and areas of glacial lakes has been observed in Himalayan region [JHA *et al.* 2016; KHADKA *et al.* 2018; PRAKASH, NAGARAJAN 2018].

The relationship between the glacial retreat and ground water resources has not been researched extensively. Rigorous research and coordinated efforts are required to develop various climate models and quantify the variability of water resources due to glacial dynamics [PRAKASH, MOLDEN 2020]. There is a need to analyse the hydroclimatic variables for future planning of the water availability to the millions of people in the basin [KHAN, ADAMS 2019]. The large spread of precipitation during 21<sup>st</sup> century is expected to provide water availability in the range of -15% to +60% of the baseline during 1971–2000, which will require appropriate adaptation measures [LUTZ *et al.* 2016]. The increase in precipitation tends to increase the areas of glacial lakes in the UIB, which will change the patterns of surface water flows and ground water [ASHRAF, HANIF-UR-REHMAN 2019]. On the basis of use of variety of climate prediction techniques under various scenarios, a flood with return period of 10 year or even lower has been projected in future in UIB [KHAN *et al.* 2020a].

In some parts of the KHK regions, like Himalaya basins, the decrease in water to the extent of 40% has been predicted during 2010–2050. These basins are already facing severe water shortages in many parts and the future uncertainty about the water availability can lead to serious droughts in these basins [LI *et al.* 2016]. The spatio-temporal variations of the hydro-meteorological data of the Kankai River Basin in East Nepal Himalaya showed declining trends in the surface water and ground water due to expected increase in the temperature 0.14–0.64°C per decade. The water availability in the basin will be highly variable at the downstream end [SILWAL *et al.* 2020].

The globalisation, urbanisation and increase in global population have created severe pressure on the global water resources. The Global Water Partner (GWP) has defined water security as “Water security, at any level from the household to the global, means that every person has access to enough safe water at affordable cost to lead a clean, healthy and productive life, while ensuring that the natural environment is protected and

enhanced” [GWP 2000]. Various metrics have been employed for assessment of water security such as water stress index (WSI), water resource vulnerability index (WRVI), economic water security index (EWSI) and water poverty [FALKENMARK *et al.* 1989; RASKIN *et al.* 1997; SULLIVAN 2002]. Asian Development Bank introduced the concept of National Water Security Index (NWSI), which incorporated five important dimensions of household, economic, urban & environmental security and resilience to water-related disasters [ADB 2016]. The NWSI of Pakistan when compared with the neighbouring countries of India, Bangladesh, Nepal, Cambodia, Sri Lanka and China indicated that Pakistan shows very vulnerable status in terms of availability of water per capita both in short and long terms. This is shown in Table 1.

To deal with the challenges of water scarcity due to climate changes, timely innovations at the demand and supply sides will be required. At the supply side, construction of small dams and catchment systems may prove more useful, as the construction of large water reservoirs entail many national and international challenges. For increased resilience against water variability, multiple water storage options may be employed. On the demand side, water conservation strategies for drinking and irrigation water will be required. This will involve designing and implementation of more efficient irrigation systems, like sprinkler system, drip irrigation and close conduit system to save the waste of water. At the same time water metering and water rationing can also rationalise the demand of water for irrigation and drinking. The climate water governance issues in Pakistan include river basin and watershed management, agriculture and irrigation management, urban and domestic water issues, floods, droughts and disaster management, groundwater management, and transboundary management [YASIN *et al.* 2020]. Urbanisation and population increase in Pakistan is further threatening the urban water security, while high reliance on ground water is further worsening water availability [SREOSHI *et al.* 2020]. Due to these challenges, it is important to understand the dynamics of urban water related hazards of HKH region including Pakistan [ROMERO-LANKAO, GNATZ 2016]. To build urban water resilience in Pakistan, some important interventions at institutional and governmental level will be required. These may include mapping water sources, assessment of water demand and supply with future projections, developing deeper understanding of recharge zones and their protection, documentation of climate induced

**Table 1.** National Water Security Index (NWSI) of Pakistan as compared to the neighbouring countries

Country	KD1	KD2	KD3	KD4	KD5	Total rating	NWSI
Bangladesh	1	3	1	1	1	7	1
Cambodia	1	1	1	2	1	8	1
Pakistan	1	4	1	1	1	8	1
Nepal	1	3	1	2	3	10	2
Sri Lanka	3	4	1	1	2	11	2
China	3	4	2	2	2	13	2
India	1	3	1	1	2	8	1

Explanations: KD = key dimension; KD1 = household security; KD2 = economic water security; KD3 = urban water security; KD4 = environmental water security; KD5 = resilience; 1 = hazardous, 2 = engaged, 3 = capable, 4 = effective, 5 = model.

Source: ZHANG *et al.* [2021].

water issues in the wake of increased population and urbanisation [SINGH, PANDEY 2020].

Islamabad, the capital of Pakistan, has witnessed high rate of urbanisation and population increase due to enhanced economic activities in the last two decades. The development of new housing townships caused by more incentives for construction industry, has created high pressure on the water availability for the newly developed areas. Hence, the availability of sufficient water and its quality both are becoming the two major challenges [SOHAIL *et al.* 2019]. The current water demand of the city is about 475,000 m<sup>3</sup> per day but only 280,000 m<sup>3</sup> per day are supplied by the municipal sources; the remaining is mostly extracted by the residents through dug wells. The other sources of water include the Khanpur dam and diverted water from the springs located at Saidpur, Shahdara, and Noopur villages. Furthermore, about 180 deep tube wells have been used for extracting ground water in different parts of the city. There are two water treatment plants at Sangjani and Simly dam, having a design capacity of 352,000 m<sup>3</sup> per day [ALI *et al.* 2012].

The high rate of urban sprawl has consumed the open and barren areas of the city and the water recharge processes have been seriously disturbed. Severe water shortages have been reported in the newly developed areas [KHAN *et al.* 2020b; YASMEEN *et al.* 2021]. In the absence of water conservation strategies and laws, the water wastage has been one of the major reasons for water shortages. The water conservation and enforcement of bylaws can preserve the precious water resource and can also reduce the carbon credits to help develop a sustainable approach [ABID *et al.* 2021]. In Pothwar region including the districts of Rawalpindi and Islamabad, the total rainwater potential is about 3.5 mln acre feet (MAF)<sup>1</sup> for rain harvesting, out of which only 0.1 MAF is being utilised with various water harvesting techniques and the rest is leaving the area without benefiting the local communities [AHMED *et al.* 2019]. The perceptions of people of Islamabad about the impacts of climate changes on the availability and quality of water, has shown serious concerns [AHMED, SHAFIQUE 2019; SHABBIR, AHMAD 2016].

The water conservation strategies in the city are mainly based on 3Rs (reduce, reuse, and recycle). To reduce the consumption of water, besides legislation and enforcement, awareness and education of communities is also required. Rain water harvesting (RWH) is one of the commonly used technique for water conservation. It is a method for accumulating and saving rainwater from various elements such as rooftops, surface runoff, and other catchments. Though the precipitation in Islamabad is relatively higher, no organised system and policy has been developed for RWH yet. Among recent developments, the Capital Development Authority (CDA) has proposed to introduce the RWH in the building bylaws. According to this proposal, a 5 marla<sup>2</sup> house will have 200-gallon<sup>3</sup> tank, 400 gallons for 10 marla, 600 gallons for 1 kanal<sup>4</sup> and 800 gallons for 2 kanals plot per house. The proposal has focused on 4 Cs, that is: capturing water from runoff, capturing runoff from local catchments, capturing seasonal flood water, and conserving water through

watershed management. The proposal is not yet approved for implementation as part of the building bylaws. Based on the literature review, it can be deduced that the availability of quality water is becoming a major challenge for the capital of Pakistan in the wake of climate change. This research was motivated by understanding the dynamics of water security in Islamabad under the changing climates through a questionnaire survey and focus group discussion.

## MATERIALS AND METHODS

### STUDY AREAS OF CAPITAL CITY OF ISLAMABAD, PAKISTAN

The capital city of Pakistan was established in 1960's when it was decided to shift the federal capital from Karachi to Islamabad. The area is Potohar Plateau, which remained uninhabited previously with scattered nomadic population of few thousands before the decision of making it capital of the country. The area of the city is 906 km<sup>2</sup> with a population of about 2 mln, according to 2017 census. Most of the residents of the city are working in public and private offices with sizeable business community and small industrial sector. The city contributes 1% of the national GDP and 24% income tax revenue of the country [PBS 2017]. The population of the city is expected to raise to 4.4 mln in next 25 years, with an average growth rate of 5.7%, one of the highest in the region [RASHID *et al.* 2018]. The location map of the city is shown in Figure 1.

### QUESTIONNAIRE SURVEY AND FOCUS GROUP DISCUSSIONS

A questionnaire survey was conducted amongst the residents of Islamabad using Google Form. The survey was comprised of demographic details, the age, sex, location etc. of the respondents. The questionnaire was comprised of 20 questions about the perceptions of the residents of the city about the quality of water, expected impacts of climate changes on the water availability, and their willingness for various conservation strategies. For Focal Group Discussion (FGD), the platform of Institution of Engineers Pakistan Islamabad chapter was used and the standard procedure of structured questions and pre-planned probes was administered in line with KRUEGER and CASEY [2000]. The two-way focus group discussion method was used, in which two groups were used. One group actively discussed the issues and the other groups observed and raised questions. The typical parts of the FGD, included introduction by the moderator, welcoming the participants and requesting them to introduce themselves. This is followed by the opening question, which is normally simple, so that the participants can feel comfortable. The following major questions were asked from panel of 6 experts, from the water resource management, municipal authorities and consumers.

1. Introduction of the delegates by moderator (10 min).
2. Water sustainability and security issues due to climate changes (15 min).
3. The major quality issues of water (15 min).
4. What are the major threats to water security of Islamabad? (15 min).

<sup>1</sup> 1 MAF = 1233.48 m<sup>3</sup>

<sup>1</sup> 1 marla = 25.2929 m<sup>2</sup>.

<sup>1</sup> 1 gallon = 4.546 dm<sup>3</sup>.

<sup>1</sup> 1 kanal = 505.857 m<sup>2</sup>.

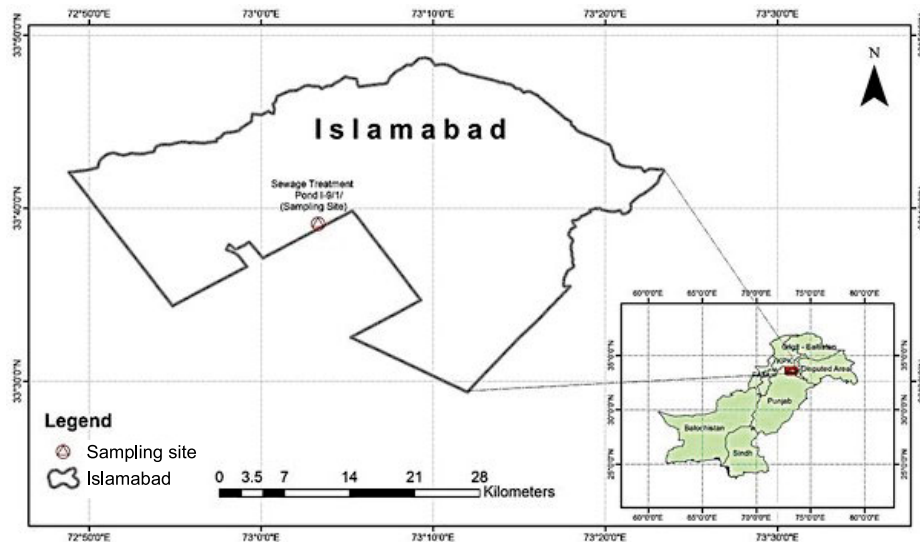


Fig. 1. Location map of Islamabad; source: JAVED *et al.* [2017], modified

5. What are current water conservation strategies and way forward? (15 min).
6. What are the expected climate change impacts on urban water security? (15 min).
7. What are some of the solutions for sustainable urban water security of the city? (15 min).
8. Questions and answers session (20 min).

The FGD was administered online and besides the panel experts, about 50 observers/listeners also participated, which lasted for about 2 h. The secretary of the Institution of Engineers played a moderator role.

## RESULTS AND DISCUSSION

### RESPONSES OF SURVEY

46 people responded to the survey, which included 7% female and 93% male. Majority of the respondents were in the age of 55 or more (52%) followed by the age group of 37–54 year (35%). About 50% of the respondents were living in the city for 6 years or more, showing their good familiarity with the water issues of the city. Majority (91%) were located in the urban areas. The major responses are shown in Figure 2.

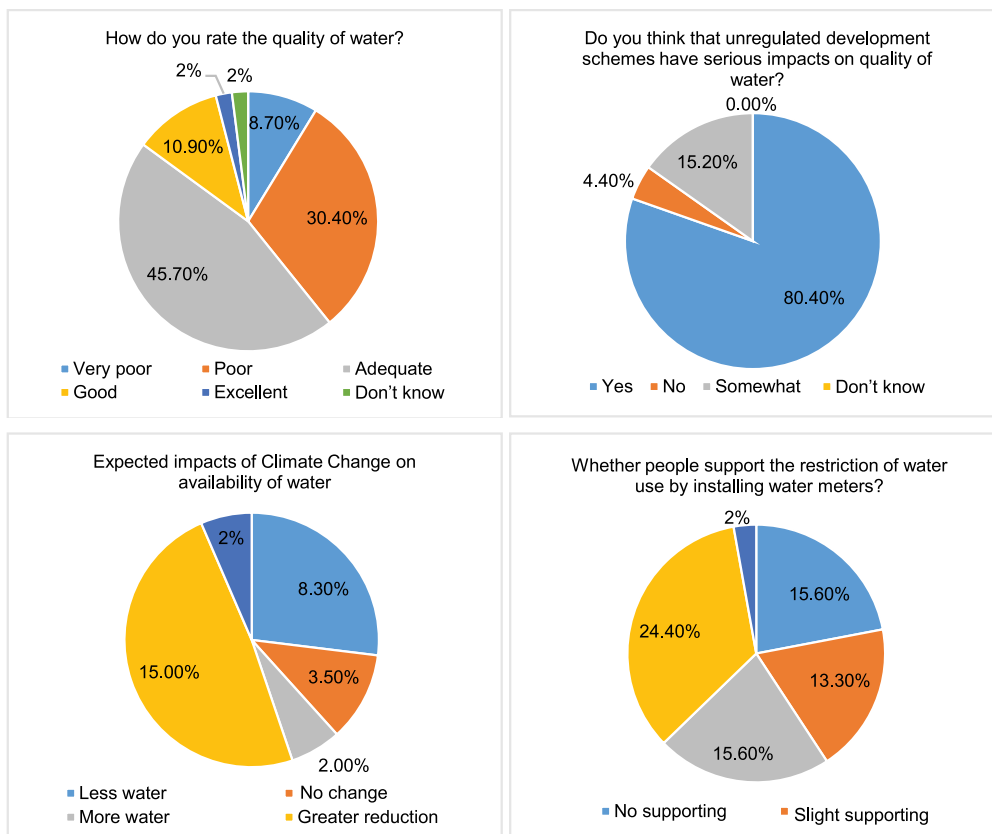


Fig. 2. Major responses of the questionnaire survey ( $n = 46$ ); source: own study

The major findings of the survey are given as follows.

1. The main reasons for the water quantity and quality deterioration as responded by the majority included urbanisation, discharge of septic tanks, urban waste water and deforestation. This was also endorsed by the experts in the FGD.
2. Majority of the people (80%) report that unregulated development schemes and slums have deteriorated the quality of water.
3. 78% of the people think that the climate change will limit amount of water and they show high degree of concerns over it.
4. No organised water conservation strategies have been reported at individual or institutions level.
5. About 54% people recommend that water metering be undertaken for water conservation of the city.
6. People have shown their willingness to reduce consumption of non-drinking water by shortening shower time, washing car less frequently than once a month, reducing watering the lawns etc. Majority of the people (85%) are also willing to reuse the waste water for irrigation and car washing, etc.
7. The people in general believe that increased in population and urbanisation will ultimately lead to severe water shortages, if the existing water resources are not augmented.

## RESULTS OF FOCUS GROUP DISCUSSIONS

The major responses to various questions in the FGD are given as follows:

### Q.1 Sustainability of urban water security of Islamabad

The former member of Engineering of the Municipal Corporation Islamabad (MCI) responded: "There are many structural and administrative issues relating to water supply. MCI has no funding for maintenance since last four years. Replacement and repairs of damaged pipes is a major issue as large amount of water is wasted".

The water scarcity issue is mainly due to lack of funding for repairs and maintenance of the supply pipes, which have been worn out as these were laid in 1970s. The water needs are presently met from Simly dam, Khanpur dam and extraction from ground through 100 tube wells. Shortage is mainly faced in summer due to increase in demand, power outages and extensive leakages. The shortage is also met from supply of water through water tankers. The situation in new residential areas in some cases is worse as the water supply in summer fails and people rely on transported water through water tankers.

Regarding the water management, one of the experts replied: "The water supply authorities having four directorates that are facing funding issues and also they don't have institutional support for enforcement of the relevant laws against abuse of water. The issue is more of management than availability".

The existing storage capacity of the water is not sufficient and a large amount of water is wasted as runoff.

### Q.2 Major quality issues of drinking water supplied by municipal authorities

The water quality issue has been attributed to leaking pipes and poor maintenance. The lack of appropriate treatment facilities also leads to poor quality. The existing water treatment plants installed across the city are also not properly maintained.

### Q.3 Major water security challenges

One of the major issue as pointed out by the expert: "Eight new housing sectors being developed by Capital Development Authority will face severe water shortage if new water resources are not explored. About 100 illegal housing schemes have no water availability plans and they are functioning without legal approval".

The major threats to urban water security include urbanisation, increase in population and unregulated developments. The new housing schemes both legal and illegal pose severe challenges for water security of the city. There seems no short terms solution with the city administration. The burden on ground water is increasing as large volume of water is extracted from ground through 100 tube wells, which is leading to continuous lowering of water table. In the absence of appropriate water recharge mechanism, the ground water is lowering at 5–6 feet<sup>5</sup> per year.

### Q.4 Water conservation strategies

One of the experts responded: "Though Islamabad has high level of precipitation, in the country with average rain fall 1142 mm per year, yet there is no organised water recharge and rain water harvesting system at individual and institutional levels".

The policy of establishing Rain Water Harvesting System (RWHS) by large plots was approved, but could not be implemented due to poor institutional and administrative framework. The litigations by various large consumers, illegal connections by services stations, water wastage in general are some of the major sources of water abuse. The experts stressed over the need to bring stringent water conservation regime through legislation and institutional strengthening, installation of water meters and imposing heavy fines on the individuals and organisations abusing the water.

### Q.5 Impacts of climate changes on the urban water security of Islamabad

One of the experts recalled that "Water crisis was experienced in 1994, due to severe draught and emergency was enforced. This led the Municipal authorities to enforce water rationing".

Majority of the water supply of Islamabad comes from stored water of various dams, hence the climate change will have severe impact on the availability of surface water for storage. The change in the climatic patterns will also disturb the supply patterns of the water. Currently the Simly dam has capacity for supply to 120 days, but in severe draught it goes down to 60–50 days, thereby leading to severe water crisis. The experts opine that the climate change will have severe repercussions for the water supply of the city.

### Q.6 Major recommendations by the FGD for urban water security of Islamabad

1. Three prong strategy (3Es) of education, engineering and enforcement was advocated by the experts. Awareness about the current status of water challenges needs to be created through social media and other media resources. To repair and replace the damaged pipes, funding is required from the Federal Government and diligent enforcement of existing bylaws is required.

<sup>5</sup> 1 foot = 0.3048 m.

2. For ground water recharge, proper check dams, diversion dams, drainage galleries and other appropriate structures may be constructed.
3. Short term, medium term and long term strategies and feasibility for water security of the city may be undertaken.
4. For water conservation, water metering for large consumers was recommended. Similarly, for large plots the policy of rain water harvesting (RWH) may be implemented as an integral part of design and construction. The completion certificate for such facilities may not be issued unless the RWH system is deployed.
5. Policy dialogue involving the ministry of water and power, representatives from business community, industries and chamber of commerce etc. may be undertaken to highlight the issue and formulate appropriate policy tools for water governance.

## CONCLUSIONS

This research was undertaken to assess the urban water security challenges of Islamabad, Pakistan due to climate change on the basis of questionnaire survey and Focus Group Discussions. The following major conclusions are drawn.

Majority of the respondents of the questionnaire survey have shown their concerns about the quality and quantity of water due to urbanisation, increased in population and unregulated development schemes. People have also serious concerns about the impacts of climate change on the availability of water. There are no organised water conservation strategies for rain water harvesting and ground water recharge. The respondents have shown their willingness for reduction in water use and reuse of waste water.

The Focus Group Discussions have revealed serious administrative and state issues in the water supply system of the city. The existing pipelines have exhausted their service life and the lack of funds for repair of maintenance of the pipelines have led to wastage of water.

For improvement of urban water security of Islamabad Pakistan, three prongs strategy including education (awareness), engineering (repair and maintenance) and enforcement (implementation of rules and related laws) is recommended.

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