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Urban Governance and Water Conservation: Action Coherence by the Judicial Water Commission in Lahore

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Abstract

This study attempts to highlight the efforts made by the Judicial Water Commission (JWC) to combat the water crisis in Lahore, striking the knell of existential peril to urban sustainability owing to incessant aquifer depletion and continuous groundwater contamination. The inefficient urban governance model, unable to deter the burgeoning water issue in the provincial capital, paved the way for the inception of the JWC. Aligned with the Qualitative Methodology for data collection and analysis, while structured by the Social-Ecological Systems (SES) Framework, this research unearths the results that Lahore, despite the unprecedented intervention of the JWC, is on the brink of catastrophe of water scarcity and requires unwavering popular support in the water conversation drive. *Ergo*, to deter this mounting danger, this paper recommends the overhauling and expansion of the policy framework of JWC with the inculcation of water conservation strategies for domestic, agricultural, industrial, commercial, and planning entities.

Key Words: Aquifers Depletion, Groundwater Contamination, JWC, Surface Water, Treatment Plants

Introduction

The Non-traditional security threat of the extreme water crisis has now gained a pendulous and ominous momentum in Lahore, posing an existential threat to urban sustainability. The externalities caused by expanded industrialisation and depletion of groundwater by rapid urbanisation have pushed Lahore into the abyss of unfathomable peril. The incessant practice of untreated waste discharge into the groundwater and unabated extraction from the aquifers have almost dragged the city into a precipice of ecological collapse, a harbinger of the corollaries of ineffective governance and unsustainable practices. In addition to human activities, Lahore's water issue is also a product of climate change. The desiccated Ravi River, limited rainfall spells and increased temperatures of the city have turned the objective of maintaining hydrological equilibrium into a Sisyphean task. Lahore, in the face of declining aquifers and mounting groundwater contamination, is rushing to a water Armageddon marked by inefficient urban governance. Resultantly, in the absence of effective environmental governance, the Judicial Water Commission was propelled to appear on the scene as the *Deus Ex Machina*, ascending the leadership role of defeating the menace of the water crisis in the provincial capital (Basharat, 2016; JWC, 2020). To put the spanner into the wheel of incessant groundwater contamination and aquifer depletion, the Judicial Water Commission introduced unprecedented sustainable water conservation strategies in the form of aquifer charges, surface water usage, rainwater harvesting systems, wastewater treatment plants, ablution water tanks, and water recycling systems (Muzaffar, et. al., 2023; Thompson, 2015).

However, groundwater conservation in Lahore, in the future, is a very tough challenge. *Ipso facto*, in this perilously serious landscape, the JWC needs to incorporate water water-saving strategies of the Netherlands (Rotterdam), Denmark (Copenhagen), and Australia into its policy framework. Finally, the unwavering popular support for the Judicial Water Commission is a *sine qua non* for an effective water-saving drive in Lahore (Deines et al., 2019).

Literature Review

Ali et al., (2018) argue that industrialization and population expansion have contributed to aquifer depletion and groundwater contamination in Lahore, a city witnessing the boom of urbanization. (Basharat, 2016) ascribes incessant extraction and untreated wastewater discharge as chief contributors

to the degradation of groundwater resources in the provincial capital, tossing the public health sector into the abyss of unprecedented crisis. (Farooqi et al., 2007) draw serious attention to potential public health challenges, sprouting out of public exposure to contaminated groundwater in Lahore.

(Wycisk et al., 2003) Shed light on successful water conservation strategies under practice in Denmark and the Netherlands, introducing rainwater harvesting, wastewater recycling, and aquifer recharge strategies to mitigate water crises. (Thompson, 2015) suggests that these strategies of Denmark and the Netherlands can serve as a blueprint for Lahore in the water conservation drive. (JWC, 2020) presents the noval strategies introduced by the Judicial Water Commission for water conservation like ablution water tanks, rainwater harvesting, water recycling systems and cleaning the Lahore Branch Canal. (Carlson et al., 2011) argue that public participation and stakeholder engagement are crucial for the success of water conservation initiatives, whereas (Svetina et al., 2024) focus on the need for technological interventions, such as GIS-based monitoring systems, to enhance regulatory oversight for water conservation.

Research Methodology

The Philosophical minaret of the Post-Positivist Approach guided the navigation of this study, providing the foundation for understanding the hydrological, environmental, administrative, and demographic dimensions of the water crisis in Lahore. To shed light on the unprecedented Case Study of water conservation strategies in Lahore steered by the Judicial Water Commission, the research employs the Exploratory Research Design. Adhered to the Qualitative Method for data collection and analysis, the path of the whole research was illuminated and guided by the Social-Ecological Systems (SES) Framework in seven steps.

The role played by the JWC, as the buttress against the depleting aquifers and groundwater contamination, forms ‘The Focal SES’, the first step of this SES Framework. In the second SES step, the study of the ‘Subsystems and Components’ was specifically focused on and divided into Resource System (RS), Resource Units (RU), Governance System (GS), and Actors (A). In this stage, the data extracted from the reviews of hydrogeological surveys and ethnographic observations was further analysed by the prisms of Stakeholder Mapping, and Trend Analysis, unearthing the relationship among governance policies, industrial behaviours, and resource sustainability. (Muzaffar, et. al., 2024). Examining ‘Interactions’ in the third step, sheds light on the contours of water-saving policy interventions by the JWC, with adherence to data collection and analysis tools of survey and Content Analysis respectively. Installation of wastewater treatment plants in over 200 industries and water conservation through initiatives such as the construction of ablution water tanks, water recycling systems, rainwater harvesting systems, etc. mark the positive ‘Outcomes’ of the role played by the JWC, the fourth step in the SES Framework.

In the fifth step ‘Cross-Scale and Cross-Level Linkages’, a comparative review of national, and regional policies uncovered the gaps in current water conservation policies of the JWC, necessitating incorporation of the advanced strategies from water saving models of the Netherlands, Denmark, and Australia. In the sixth step, ‘Contextual Factors’, the researchers examined external factors related to the water crisis in Lahore like climate change, the Indus Water Treaty, and rapid urbanization by extracting information from primary sources (interviews) and secondary sources (like archival reviews) to analyze their systemic impact. Finally, in the seventh step, ‘Iterate and Adapt’, the Triangulation Strategy was used to synthesize the findings and ensure validity, presenting actionable recommendations.

The Looming NTS threat of water crisis in Lahore

The availability of clean water in the Lahore District is now becoming an iridescent dream. In the 1980s and 1990s, before massive urbanization and industrialization in the inhabited areas of the provincial capital, groundwater was quite drinkable, with hardly any culture of using mineral water and water treatment plants. However, due to unprecedented urbanization, spiralling population, and huge

industrialization, the groundwater levels of Lahore are now not only depleting speedily but also being contaminated swiftly, presenting handwriting on the wall for urban sustainability.

Groundwater contamination in Lahore

The following details show a dismal situation of groundwater contamination in Lahore:

Microbiological indicators

Massive urbanization, faulty environmental policymaking, haphazard spatial planning, and underdeveloped culture have propelled unprecedented seepage of untreated sewage into the aquifers, thereby causing microbiological contamination of the groundwater in Lahore.

According to a study conducted in the year 2018, 40% of water samples taken in Lahore could not meet the WHO standards of bacteriological quality, showing widespread contamination of groundwater with pathogens that spread dreaded diseases such as Cholera, Typhoid, Hepatitis A, Hepatitis E, and Diarrhea (Ahmed et al., 2018). Another study corroborates the detection of coliform bacteria in water samples taken from random tube wells and tap water in Lahore. Similarly, a hydrogeological survey established that 100% of samples from shallow depths (approximately between the depths of 120–150 feet) tested positive for bacterial contamination, while deeper wells (ranging between 400–700 feet) remained free of such pollutants (Ahmad et al, 2012). Likewise, *Escherichia coli* (E. coli), being the gold standard for detecting fecal contamination in drinking water, has tested positive in most of the groundwater samples of Lahore (Edberg et al, 2000). An investigation of water quality conducted near the Charrar Drain showed alarming readings of Total Coliform levels ranging from 7.8 to 11.0 MPN/100ml and fecal coliform levels between 4.5 and 7.8 MPN/100ml, indicating the direct wastewater discharge into the groundwater (Anwar & Gaffar, 2018; Yates, 2007).

Chemical indicators

Home to over a thousand industries (Ghaffar & Iqbal, 2020), bounded by agricultural peripheries of Kasur, Nakanna and Sheikhupura (Farooq et al., 2007), and generator of over 3000 tonnes of solid waste daily (Akhtar et al., 2014; Ahmed et al., 2012) Lahore is finding it hard to deaccelerate the unstoppable trend of chemical contamination of groundwater. Approximately, due to the oxidative dissolution of arsenic-containing minerals exacerbated by irrigational practices and alkaline topsoils (Ali et al., 2018; Podgorski et., 2017), more than 1.5 million people of Lahore are at the peril of arsenic poisoning, resulting in cardiovascular diseases, skin lesions and cancer (Farooqi et al., 2007). The arsenic readings of hotspots in Lahore exceed the WHO permissible limit of 10 µg/L (Podgorski et al., 2017; Aram et al., 2021). Due to the contamination of groundwater by anthropogenic sources, Fluorosis (skeletal and dental) is ubiquitous among populations consuming water with fluoride concentrations (Younas et al., 2019; Abbas, et al., 2015 ;). A study establishes that due to industrial wastes, over 30% of water samples in Lahore contain heavy metals (Ghaffar & Iqbal, 2020). Long-term exposure to groundwater contaminations of heavy metals like Lead(exceeding 15 µg/L) and Chromium is also adding to kidney damage, anaemia, and neurological impairments in the populace of Lahore (Ghaffar & Iqbal, 2020). What's more, carcinogenic risk, neurological disorders, and respiratory issues are sprawling in Lahore owing to excessive contamination of groundwater by industrial discharges and municipal water chlorination mechanisms (Méndez et al., 2004). The overuse of fertilizers and direct sewage injection into groundwater are the chief causes of Nitrate contamination in Lahore (Farooqi et al., 2007), exceeding 10 mg/L in drinking water, exposing infants to Methemoglobinemia (blue baby syndrome). Pollutants such as dichlorodiphenyltrichloroethane (DDT) and trichlorophenol are also contaminating the groundwater in Lahore incessantly.

Physical indicators

The Physical indicators of the groundwater of Lahore, as seen in Table 1, are also betokening impending NTS threat of water contamination. Turbidity of groundwater in Lahore is high due to limited filtration systems. TDS and hardness, because of salinity, are very high. Conductivity, caused by industrial wastes, is also a matter of great concern in Lahore owing to the high range.

Table 1
Physical Indicators of Lahore's Groundwater Quality

Indicator	WHO Standard	Reading Range of groundwater in Lahore	Range
Turbidity	≤ 5 NTU	1.8 to 6.5 NTU	High
Colour and odour	Colourless and odourless	Varied but mostly colourless and odourless.	Normal
pH	6.5 to 8.5	6.5 to 8.6	Normal
Total Dissolved Solids (TDS)	≤ 1000 mg/L	300 to 1500 mg/L	Very High
Conductivity	>1400 µS/cm is a concern	800 to 2300 µS/cm	High
Hardness	>200 mg/L is hard	150 to 500 mg/L	Very High(Adimalla & Qian, 2019
Temperature	No specific limit	18°C to 28°C	Normal (Vansteenbergen & Oliemans, 2002)

Source: (Raza et al., 2017; Ali et al., 2018; Podgorski et al., 2017; Ahmad et al., 2021)

An overview of groundwater depletion in Lahore

The groundwater of Lahore has declined significantly over the years (Basharat, 2016), with drinkable water now available at a depth of at least 800 feet.

The water table in central Lahore fell below 40 meters in 2017 and is further predicted to drop below 70 meters by 2050 (Shafqat, 2017). Over the past eight years, Lahore has experienced a 5.66% reduction in groundwater levels. By 2030, Lahore is predicted to confront a snowballed NTS threat of water crisis. The main reasons for depleting groundwater in Lahore are mentioned in the Table 2 mentioned below:

Table 2
Causes of Groundwater Depletion in Lahore

Reason for groundwater depletion	Details
Urbanization: Over-extraction by wells due to population growth	Rapid population growth and urbanization have increased water demand. Installation of large-diameter recharge wells has resulted in groundwater depletion by 16.45% to 39.24%. The popular water demand in Lahore exceeds 1.4 billion litres per day, with over 80% extracted from groundwater sources. The water extraction rate per year is 1.6 billion cubic meters.
Use of electric motors by domestic and commercial users for pumping water	Today, around 500,000 electric motors operate in Lahore for the extraction of large volumes of groundwater daily.
Inefficient agricultural irrigation	Traditional irrigation practices in the peripheral areas of Lahore have led to high groundwater consumption and wastage.
Service stations	Over 1,200 vehicle service stations operate in Lahore in the areas of Lahore Cantonment, Walton Cantonment, WASA, DHA, and other places for pumping groundwater for washing cars.
Reduced natural recharge	Lahore receives an average annual rainfall of 649 mm. However, Urban impervious surfaces like roads and buildings have limited rainwater infiltration and aquifer recharge.
Watering streets and parks	Public areas consume approximately 10 million litres of groundwater daily for street cleaning and parks.
Overuse in houses	Domestic usage accounts for over 50% of Lahore's groundwater extraction, with high wastage in households.
Commercial usage	Commercial buildings and businesses consume groundwater without efficient water conservation practices.
Industrial overuse	Industries consume significant groundwater, accounting for over 30% of the total water usage.
Lack of effective regulations	Weak policies allow unregulated and excessive groundwater extraction. In addition, the water bills are very low in Lahore.

Source: (J.W.C, 2020)

Judicial Water Commission's role in conserving groundwater in Lahore

The Judicial Water Commission was constituted by the Lahore High Court in 2019 vide the Writ Petition No. 227807/2018 titled ' Haroon Farooq Vs Government of the Punjab'. Mr Justice (Rtd) Ali Akbar Qureshi was appointed as the Chairman of this Commission to combat the burgeoned challenge of the water crisis in Lahore (LHC, 2019). Whereas, Mr Syed Kamal Ali Haider, a devoted practitioner of law, became the Focal Person of the JWC with a great vision in his eyes to contribute generously to human security in Lahore. As seen in Figure 1, a team consisting of EDP, Industries, Auqaf, Cooperatives, PHA, LCB, WCB, DHA, Irrigation, LG&CDD, Dolphins, and MCL was incepted by the Chairman JWC to lead the water conservation drive in Lahore (JWC, 2020)

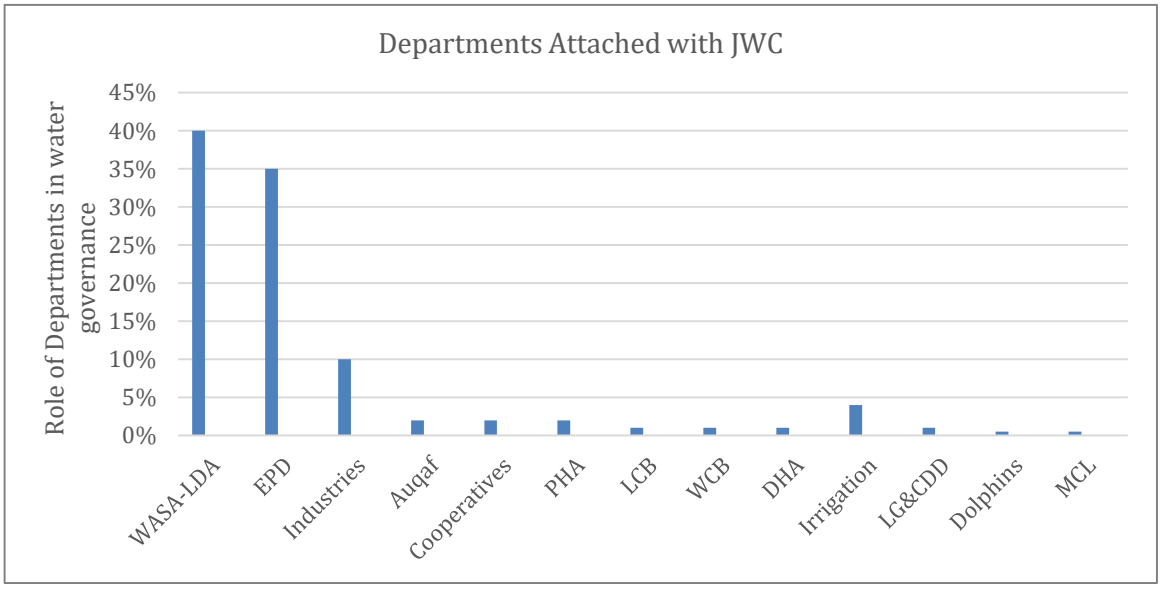

Figure 1 Departments Allied with JWC, Source: (JWC, 2020)

Initiatives taken by the JWC for water conservation in Lahore

To save the incessant depletion of water resources in Lahore, the Judicial Water Commission, under the leadership of its Chairman Mr. Justice (Rtd) Ali Akbar Qureshi, as seen in Table 3, took the following measures:

An unprecedented strategy to re-use ablution water for horticulture

The JWC introduced an unprecedented strategy to construct reservoirs in all the mosques of Lahore, saving the ablution water to be reused for horticultural and cleanliness purposes. This is an outstanding strategy to reduce the burden on aquifers, discouraging the continuous extraction of groundwater through tube wells by the horticultural authorities. The construction of a water reservoir in Nimra Mosque in Johar Town laid the first brick of the foundation of this advanced strategy in Lahore. Following this successful experiment, 186 ablution water tanks have been constructed in various areas under the jurisdictions of LDA, PHA, DHA, and Cooperative Housing Societies. Despite being confronted with financial constraints, Ablution water tanks have been successfully made in the following mosques: Jamia Masjid Khalid, Jamia Masjid Mazhar-ul-uloom and Imam Bargah Nishtar Colony in the Walton Cantonment area, saving up to 9,000 gallons of groundwater daily. Moreover, water Tanks at Jamia Masjid Askari-III, V, and VIII in Lahore Cantt are saving up to 28,000 gallons of groundwater in a day. On JWC's direction, the DHA has constructed water reservoirs in forty-nine mosques, saving 12,300 gallons/day. The Auqaf Department has completed a huge project of a water reservoir at the shrine of Ali Hajveri (famous as Daata Sahib), saving up to one lakh gallons/ day (JWC, 2020).

The creative mechanism of Water Recycling Systems in service stations

Lahore is home to over five hundred Service Stations that had been continuously misusing the huge volume of groundwater in the city until the intervention of the JWC**.** According to a study by the JWC, one service station consumes water equal to a hundred domestic users (a single car wash consumes approximately 400 litres). To stop this wastage of groundwater, the JWC spearheaded a campaign to install water-recycling systems in the service stations, catching the used water and processing it to be used up to seven times. This policy intervention by the JWC resulted in the sealing of 194 service stations in Lahore temporarily to ensure compliance with this initiative. Now approximately, 370 service stations in the jurisdiction of Lahore have successfully installed water-recycling systems, thanks to excellent efforts by WASA, LCB, DHA, and WCB.

The policy intervention for reusing treated water

On the direction of the JWC, international companies like the US Denim and Coca-Cola Pvt Ltd are treating wastewater amounting to approximately 7.2 million litres. This treated water is fit to be reused for horticultural drives and the cleanliness of roads. Therefore, the Judicial Water Commission, directed PHA, and LWMC (Lahore Waste Management Company) to reuse this treated water for their operational purposes, thereby discouraging the incessant extraction of groundwater for these tasks.

Table 3
Duties assigned by JWC to Departments

Department	Responsibilities assigned by JWC
Water And Sanitation Agency	Installation of ablution water reuse tanks, car wash recycling systems and monitoring wastewater treatment plants.
Irrigation Department	Restoration and maintenance of Lahore branch canal water channels.
Auqaf Department	Implementation of ablution water reuse projects at religious shrines.
Industry Department	Monitoring industrial compliance with wastewater treatment directives.
Environmental Protection Department	To install effluent treatment plants.
Registrar Co-operative Department	Ensuring cooperative housing societies adhere to aquifer charge collection policies and water conservation.
Park And Horticultural Authority	Utilizing treated and recycled water for horticultural activities.
Lahore Cantonment Board	Construction of ablution water tanks in mosques, transitioning to canal water for horticulture and installing water recycling plants at service stations.
Walton Cantonment Board	Same as for the Lahore Cantonment Board.
Defence Housing Authority	Same as for the Lahore Cantonment Board.
Dolphin Force	Challans on violations of JWC's directives.
LGCDD	To implement city-wide water conservation initiatives, including rainwater harvesting projects.
Metropolitan Corporation, Lahore	Supporting the Judicial Water Commission's directives to repurpose treated wastewater for road cleaning and park irrigation, reducing wastage of clean water.

Source: (J.W.C, 2020)

The Canal Restoration Project for Surface Water Usage

To decrease extraction from the groundwater, the JWC, successfully reopened seventeen out of twenty-four irrigation channels of the Lahore Branch Canal that had been blocked for over three decades. This canal restoration project has allowed institutions of FC College, Model Town Park, Lawrence Garden, Race Course Park, Mental Hospital, Quaid E Azam Campus of Punjab University, Aitchison College, Jallo Park and Governor House to utilize surface water for irrigation purposes, saving lacs of gallons of clean water with reduced dependence on the aquifers. In compliance with the directive of JWC, the WCB has reduced its dependence on aquifer water, now primarily relying on canal water and water ablution tanks for horticultural and floricultural purposes, saving over 53,000 gallons of water daily(JWC,2020)

Project for desilting the Lahore Branch Canal

The Lahore Branch Canal, due to its role in supplying millions of gallons of surface water to eleven locations in Lahore, is of massive importance for irrigational purposes in in the city. However,

the capacity of this canal was greatly reduced due to accumulated silts, sewerage, and filth for years. Because of the intervention of the JWC, the Lahore Branch Canal was cleaned unprecedentedly. The whole canal, from Jallo Point to Thokar Niaz Baig, was de-silted and cleaned, with the permanent closing of sewerage inlets that were contaminating the water of this canal. Resultantly, the water of the canal was purified enough to be used for irrigation or horticultural use in Lahore. Now, due to this policy implementation by the Irrigation Department, approximately 27.125 cusecs of water, equivalent to 1.75 crore gallons, is being saved daily(JWC, 2020).

Construction of Lawrence Road Rainwater Harvesting Project

To combat groundwater depletion, the JWC, in collaboration with WASA, started the Lawrence Road Rainwater Harvesting Project in Lahore. This project envisions the construction of an underground reservoir over 13,000 square feet, which is capable of storing up to 15 lac gallons of rainwater in Lahore. This project has great benefits. Firstly, by substituting harvested rainwater for horticultural and urban cleaning, the project will significantly reduce groundwater extraction. Secondly, with the help of this project, there will be prevention of urban floods and water accumulation on the nearby roads, ensuring smooth traffic flow and convenience for the public. Thirdly, these projects promote the sustainable use of water resources and the enhancement of urban greenery.

Installation of water metres

Out of 700,000 water connections in Lahore installed by WASA, only 31,000 have operational water metres. The absence of water meters in such huge quantities is adding to unbridled wastage of groundwater by the users, water theft and many illegal water connections. The lack of proper metering has restrained the revenue generation on aquifer usage, making it very difficult to develop a critical infrastructure for ensuring clean water in the city. JWC's decision to install water metres against all connections will cope with the issues of less revenue generation and astronomical waste of Water Resources.

The policy of aquifer Charges on housing Societies:

The JWC, for the first time in the history of Lahore, introduced the policy of collection of aquifer charges from private housing societies, commercial units, and service stations, restraining these entities from wasting clean water. This initiative has resulted in the collection of rupees sixty-two crore from various private and public housing societies. Industries and factories owe Rs. 171,071,835, while big hotels and government departments contribute to an overall collection of Rs. 547,380,262. Therefore, the JWC has directed WASA, LCB, WCB, and DHA to collect these outstanding amounts from the defaulters. More than 130 big industries are now paying aquifer charges for the consumption of groundwater. The total savings from aquifer charges and improved conservation measures amount to 23.85 million gallons daily.

Punitive Measures against Wasting Water:

To deter the misuse of water, the Dolphin Force, in collaboration with WASA, has been directed by the JWC to issue challans to the persons involved in washing vehicles and cleaning pavements and roads unnecessarily. The Dolphin Force has issued over seven thousand challans, shaping a public perception that water is a precious resource, not to be squandered.

Development of alternate water sources

On the direction of JWC, a PC-I for the "Lahore Water and Wastewater Management Project" was designed in 2019. The cost of this AIIB (Asian Infrastructure Investment Bank) funded project is Rs 21.045 billion. The completion of its first phase will supply surface water to four sub-divisions of WASA Lahore, using 100 cusecs (50 MGD) of water from the BRBD Link Canal. The work of this big project is underway these days.

Water conservation drive in Government Offices.

The JWC directed the instant repair and replacement of all faulty pipes and water taps in government departments, prisons, and other facilities in Lahore. To prevent the wastage of water, all toilets connected to taps are to be closed after office hours. Additionally, water tanks are to be constructed at mosques in government premises for ablution to reuse for horticulture purposes.

Crack Down by the JWC on groundwater contamination in Lahore:

The JWC took some excellent measures for the stoppage of groundwater contamination in the provincial capital. These steps are the following:

Policy drive to install the Effluent Treatment Plants in industries:

Lahore is home to 1023 industrial units, contributing generously to the GDP of Pakistan. However, the economic benefits of these units have been shadowed by the externalities caused by the discharge of untreated wastewater into the aquifers, resulting in increased microbiological and chemical contamination of the groundwater of the provincial capital. A first-ever survey on the wastewater treatment plants, in the environmental history of Lahore was conducted by Mr Ali Ijaz, a seasoned officer from the Environment Protection Authority (EPA), in 2019 at the direction of Mr Justice(Rtd) Ali Akbar Qureshi. This Survey, an audacious and unprecedented step taken, unearthed shocking and dismal facts that not even a single industry in Lahore installed an international standard Waste Treatment Plant, corroborating an existentialist threat to urban sustainability. 99% of factories did not have any treatment plant. As seen in Table 4, the survey established that 416 industries were incessantly and directly injecting extremely hazardous untreated waste into the groundwater through the channel of underground wells. Based on the disturbing revelations from the survey, the JWC resolved to fight this groundwater contamination heroically. Consequently, Mr Ali Ijaz spearheaded a crackdown against the environment-polluting industries in Lahore, sealing over two hundred units and giving legal notices to over eight hundred industries. As a result, at least two hundred and ninety-seven units_ including the pharmaceutical, chemical, tanneries, steel and food industries_ installed effluent treatment plants, marking a meteoric progression in the environmental safety drive in Lahore.

Other industries have gone on litigations. They are bound to install wastewater treatment plants in the future for environmental safety. This is indeed an unprecedented drive for saving groundwater in Lahore.

Table 4
Industries in Lahore contaminating the groundwater:

Types of Industry	Types of waste seeping into Groundwater revealed by JWC's survey in 2019	Health Hazards
Steel Industry	- Leaching of heavy metals (Lead and Chromium) into aquifers	Neurological issues, organ damage, and developmental problems
Cold Storage Industry	- Refrigerant leaks (e.g., ammonia).	- Disturbed respiratory systems and damaged internal organs
Tanneries	- Chromium and harsh effluents can significantly alter water pH	- Change in pH scale of water - Skin ulcers and increased cancer risk
Pharmaceuticals	- Residues of Antibiotics, chemicals and drug residues	- Microbial imbalance in aquifers, antibiotic resistance, hormonal disruption, and carcinogenic effects
Automobile Industry	- Spills of oil, grease, and lubricants infiltrate soil - Heavy metals	- Can cause kidney damage, neurological disorders and bone weakness.
Cement Industry	- Alkaline waste - Dust and particulates	- High alkalinity in groundwater
Paper Industry	- Chlorinated compounds - High organic load	- Carcinogenic effect and harmful bacterial growth

Chemical Industry	- Toxic chemicals (acids, solvents, phenols) - Heavy metals	Liver/kidney damage, neurological disorders, and cancer.
Food Industry	Nitrates and Phosphates	- Can cause methemoglobinemia ("blue baby syndrome")

Source: (Ghaffar & Iqbal, 2020; Podgorski et al., 2017; Aram et al., 2021)

Introduction to Combined Effluent Treatment Plant (CETP)

The Punjab Industrial Estates Development and Management Company (PIEDMC) are spearheading a project named CETP for the Quaid-e-Azam and Sundar Industrial Estates. The project is going on. The JWC has directed urgent action to address the issue of waste discharge into the Ravi River, which is hitherto threatening the water table and marine life. This is a great leap towards the stoppage of groundwater contamination.

Results and Discussions

Lahore is on the verge of a water crisis, thanks to incessant water extractions and continuous contamination of the aquifers by domestic and commercial users. The Judicial Water Commission has been playing a leadership role in the water conservation drive since 2019. With the installation of Effluent Treatment Plants in industries and the introduction of water conservation strategies, the speedy peril to the aquifers is on the decrease. However, the best results cannot be achieved unless and until the Judicial Water Commission adapts more advanced water conservation strategies and receives popular support.

Conclusion

The Judicial Water Commission is scripting a remarkable chapter on water conservation in the environmental history of Lahore. With the introduction of aquifer charges, water recycling systems, water reservoirs in mosques, rainwater-harvesting systems, and the operationalization of the Lahore Branch Canal, the JWC is saving millions of gallons of clean water on a daily basis. The installation of wastewater treatment plants in the industries of Lahore is a great stride toward staunching and stifling groundwater contamination in the provincial capital (JWC, 2020; Thompson, 2015). However, this excellent drive for fighting the NTS of water crisis should integrate the advanced water conservation strategies of the developed countries in the world such as Australia's Managed Aquifer Recharge systems and Singapore's NeWater Program into the policy framework of the JWC (Wycisk et al., 2003). In addition, the investment in public awareness for saving clean water, green infrastructure, and adherence to technological solutions, such as GIS-based groundwater monitoring, will be extremely beneficial for supporting the mission of the JWC (Svetina et al., 2024). The JWC is making no stone unturned in saving clean water in Lahore. In this epochal mission, the JWC has planted the seeds of optimism, but the orchard of its success will bear fruit only with the popular support and inclusiveness to this urban sustainability drive,

Recommendations

Although the efforts of JWC are commendable and unprecedented. However, many loopholes in the conservation and protection of groundwater in Lahore need to be addressed at the earliest with the following categories of recommendations for the JWC:

Policy recommendations regarding household consumers:

- Install water-efficient appliances in every house in Lahore.
- Make rooftop rainwater harvesting for non-potable uses (Thompson, 2015).
- Promote the use of greywater for horticulture and floriculture to reduce reliance on freshwater (Deines et al., 2019).
- Regularly do water leakage audits in houses.

- Introduce sensor taps in the households of Lahore.
- Educate households about the techniques of water conservation through community workshops (Svetina et al., 2024).

Policy recommendations for agricultural users

- Adapt modern agricultural technologies like drip irrigation to minimize the wastage of groundwater (Barilari et al., 2020).
- Build farm-level storage ponds to save rainwater and reduce the extraction of groundwater.
- Encourage the cultivation of low-water-demand crops to conserve water resources (Deines et al., 2019).
- Train farmers to use fertilizers and pesticides smartly and limited to prevent the contamination of groundwater
- Build farm-level storage ponds to save rainwater and reduce the extraction of groundwater.
- Encourage the cultivation of low-water-demand crops to conserve water resources.
- Train farmers to use fertilizers and pesticides smartly and limited to prevent the contamination of groundwater

Policy recommendations for industrial users

- Reuse of all wastewater through advanced systems of Zero-Liquid Discharge (ZLD) (Wycisk et al., 2003).
- To enforce stringent regulations for all remaining industries to install waste treatment plants to save urban aquifers (Wycisk et al., 2003; Thompson, 2015)
- Conduct regular audits to optimize water in the industries (Barilari et al., 2020).

Policy recommendations for commercial users

- Ensure Green Building Standards and enforce compliance with standards like LEED for water conservation and recycling (Carlson et al., 2011).
- Implement the recycling of greywater for uses like landscaping (Thompson, 2015).
- Install smart meters to monitor and optimize water usage.
- To continuously check the working of Water recycling systems in Service Stations

Policy recommendations for spatial planners

- Build shared rainwater harvesting structures in public spaces to recharge aquifers and encourage the construction of Managed Aquifer Recharge (MAR) to store the rainwater underground and reduce surface runoff contamination. This practice is in vogue in California.

- Implement the models of Denmark and Japan to reduce agricultural runoff and urban surface pollutants through the establishment of buffer zones and controlled fertilizer usage
- Regularly conduct audits of leakages in public water supply systems (Svetina et al., 2024).
- Construct recharge wells to accumulate rainwater in aquifers (Wycisk et al., 2003).
- Install domestic water meters for generating and collecting bills.
- Give NOC to only those housing societies, colonies, and towns that have incorporated sewerage treatment and disposal mechanisms in their layout plans.
- Promote the use of recycled wastewater for industrial and horticultural purposes. This strategy is effectively used in Singapore through its NEWater program, which turns treated wastewater into safe and reusable water for non-potable applications (Thompson, 2015)
- Adopt green infrastructure solutions in the shape of making permeable pavements, bioswales, and urban wetlands to enhance groundwater recharge (Wang, 2006). This model is in practice in the Cities of Copenhagen and Rotterdam (Carlson et al., 2011).
- Initiate localized conservation programs, following Kansas' Local Enhanced Management Areas (LEMA), to empower stakeholders to reduce groundwater pumping (Deines et al., 2019).
- Harness the technologies of real-time sensors, GIS-based mapping and predictive models for effective groundwater usage and monitoring, as practised in cities like Phoenix and Arizona (Svetina et al., 2024).

References

Adimalla, N., & Qian, H. (2019). Groundwater quality evaluation using water quality index (WQI) for drinking purposes. *Ecotoxicology and Environmental Safety*, *176, 153-161*.

Ahmad, S., Khan, M. S., Khan, A., Ghazi, S., & Ali, S. (2012). Sewage water intrusion in the groundwater of Lahore, its causes and protections. *Pakistan Journal of Nutrition, 11(6), 484–488.A*

Ahmad, W., Iqbal, J., Nasir, M. J., et al. (2021). Impact of land use/land cover changes on water quality and human health in district Peshawar Pakistan. *Scientific Reports, 11*.

Akhtar, M. M., Tang, Z., & Mohamadi, B. (2014). Contamination potential assessment of potable groundwater in Lahore. *Polish Journal of Environmental Studies, 23*(6), *2341–2347*.

Ali, W., Rasool, A., Junaid, M., & Zhang, H. (2018). A comprehensive review of current status, mechanism, and possible sources of arsenic contamination in groundwater. *Environmental Geochemistry and Health, 41*, *737-760.*

Anwar, S., & Gaffar, A. (2018). Patterns of Ground Water Pollutions along Charrar Drain in Lahore–Pakistan. *Journal of the Punjab University Historical Society*, *31*(2).

Ashiq, M., Rehman, H., & Khan, N. (2020). Impact of large diameter recharge wells for reducing groundwater depletion rates**.** *Environmental Earth Sciences*, *79(18), 456*.

Barilari, A., Londoño, M. Q., Paris, M., Lima, M. L., & Massone, H. (2020). Groundwater contamination from point sources: A hazard index to protect water supply wells in intermediate cities. *Groundwater for Sustainable Development, 10, 100363*.

Basharat, M. (2016). Groundwater environment in Lahore, Pakistan. *Pakistan Journal of Engineering and Applied Sciences*, *18, 45–54.*

Carlson, M., Lohse, K., McIntosh, J., & McLain, J. (2011). Impacts of urbanization on groundwater quality and recharge in a semi-arid alluvial basin. *Journal of Hydrology, 409, 196-211.*

Deines, J. M., Kendall, A. D., Butler, J. J., & Hyndman, D. W. (2019). Quantifying irrigation adaptation strategies in response to stakeholder-driven groundwater management in the US High Plains Aquifer. *Environmental Research Letters*, *14*(4), *044014*.

Edberg, S. C. L., Rice, E. W., Karlin, R. J., & Allen, M. J. (2000). Escherichia coli: the best biological drinking water indicator for public health protection. *Journal of Applied Microbiology*, *88(S1), 106S-116S.*

Farooqi, A., Masuda, H., & Firdous, N. (2007). Toxic fluoride and arsenic contaminated groundwater in Lahore and Kasur districts. *Environmental Pollution, 145*(3), *839–849.*

Ghaffar, A., & Iqbal, N. (2020). Impact of wastewater irrigation on groundwater in Lahore. *Water Supply, 20*(3), *758–771.*

Judicial Water Commission (JWC). (2020). *A success story: Judicial Water Commission*. Lahore: Judicial Water Commission. Retrieved from https://jwec.info/.

Lahore High Court (LHC). (2019). *Judicial Water Commission establishment order*. Lahore High Court Ruling, *W.P. No. 228707/2018*.

Méndez, J., Audicana, A., Cancer, M., Isern, A., Llaneza, J., Moreno, B., & Lucena, F. (2004). Assessment of drinking water quality using indicator bacteria and bacteriophages. *Journal of Water and Health*, *2(3), 201-214.*

Muzaffar, M., Fern, Y. S., & Yaseen, Z. (2023). Governance Dilemma: A Way Forward For Third World States, *Journal of Research Administration 5*(2), 9792-9803

Muzaffar, M., Fern, Y. S., & Yaseen, Z (2024). Good Governance and Citizen's Trust in Pakistan: A Moderation Effect of Unethical Behavior**,** *Asian Journal of Human Services, 26*, 91-108

Podgorski, J. E., Eqani, S. A. M. A. S., Khanam, T., Ullah, R., Shen, H., & Berg, M. (2017). Extensive arsenic contamination in high-pH unconfined aquifers in the Indus Valley. *Science advances, 3(8), e1700935.*

Raza, M., Hussain, F., Lee, J. Y., Shakoor, M. B., & Kwon, K. D. (2017). Groundwater status in Pakistan: A review of contamination, health risks, and potential needs. *Critical Reviews in Environmental Science and Technology, 47(18), 1713-1762.*

Rehman, M., van Herwijnen, M. V., Krauskopf, J., Farooqi, A., Kleinjans, J., Malik, R. N., & Briedé, J. (2019). Transcriptome responses in blood reveal distinct biological pathways associated with arsenic exposure. *Environment International, 135*, *105403.*

Sanjrani, M. A., Mek, T., Sanjrani, N. D., Leghari, S. J., Moryani, H. T., & Shabnam, A. B. (2017). Current Situation of Aqueous Arsenic Contamination in Pakistan. *Journal of Pollution Effects and Control, 5, 1-8.*

Shafqat, M. (November 25, 2017). Groundwater to drop below 70 metres by 2050. *The Express Tribune*.

Shahid, M., Niazi, N., Dumat, C., Naidu, R., Khalid, S., Rahman, M., & Bibi, I. (2018). A meta-analysis of arsenic-contaminated groundwater in Pakistan. *Environmental Pollution,* 242*(Pt A), 307-319.*

Solley, W. B. (1998). *Estimated use of water in the United States in 1995*. U.S. Geological Survey Circular.

Svetina, J., Prestor, J., Jamnik, B., Auersperger, P., & Brenčič, M. (2024). Contaminant Trends in Urban Groundwater: Case Study from Ljubljana (Central Slovenia). *Water*, *16*(6), 890.

Thompson, C. (2015, December). Increasing Distributed Wastewater Recycling to Mitigate Groundwater Depletion. In *2015 NGWA Groundwater Expo and Annual Meeting*. Ngwa.

Vansteenbergen, F., & Oliemans, W. (2002). A review of policies in groundwater management in Pakistan. *Water Policy, 4*, *323-344.*

Wycisk, P., Weiss, H., Kaschl, A., Heidrich, S., & Sommerwerk, K. (2003). Groundwater pollution and remediation options for multi-source contaminated aquifers (Bitterfeld/Wolfen, Germany). *Toxicology Letters, 140-141*, *343-351*.

Yates, M. V. (2007). Classical indicators in the 21st century—far and beyond the coliform. *Water environment research, 79(3), 279-286.*

Younas, A., Mushtaq, N., Khattak, J., Javed, T., Rehman, H., & Farooqi, A. (2019). High levels of fluoride contamination in groundwater. *Environmental Science and Pollution Research, 26(36), 35728–35741.*