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The Pakistan Civil Engineer

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Head Office: 17 Km Shahdara – Kalakhtai/Narang Mandi Road, Distt Sheikhupura, Pakistan

Liaison Office: 14 A/1, Block P, Model Town Extension, Lahore 54700, Punjab, Pakistan

Tel.: +92 42 3571 3362; +92 42 3571 3363; +92 42 3571 3364

Email: psce@psce.org.pk

URL: www.psce.org.pk

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Editorial

This issue focusses on an important question: Is the water supply and sanitation system of our cities falling apart? The answer, if in the affirmative, poses an existential threat to our community.

The Pakistan Civil Engineer invites its readers to ponder on the question and contribute to our future issues.

Looking forward to feedback from the readers,

Rizwan Mirza, CE
Editor-in-chief

Cover Story

Water and sanitation – The state of preparedness.

Rizwan Mirza, Chief Editor

Access to water and sanitation constitute the centrepiece of sustainability objectives. Health, economic growth and sustainability are underpinned by this sustainability goal.

According data, that was available by 2022, over 2 billion people lived in areas subject to water stress. Similarly, around 3.4 billion people – 45% of the global population – lacked access to safely managed sanitation facilities. According to independent assessments, the world will face a global water deficit of 40% by 2030. Climate change is major factor that would continue to exacerbate the situation.

The data for rural Pakistan is as follows:

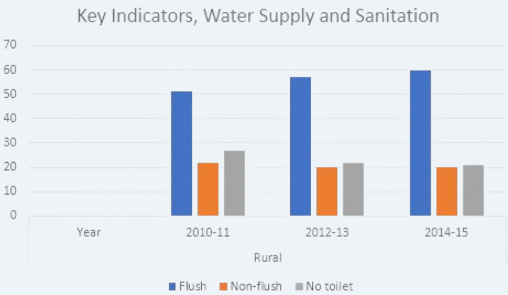

Figure 1: Access to sanitation -- rural Pakistan (2022 data)

Official statistics show that 32 percent of households in overall Pakistan are using piped water as main source of drinking water. Moreover, the percentage of households depending upon poor sources of water i.e. dug well, stream, river, pond or canal, either remained unchanged or slightly decreased.

But these figures hide more than what they reveal. This is because the mere fact that state statistical offices often record a figure in a very superficial manner. Outright obsolescence or deteriorating conditions of facilities do not reflect in such general-purpose statistics. These are the aspects where parts of the problem lie. As an example, if piped water supplied to households is not clean, the mere fact that the supplied water is piped, is not a positive indicator, in itself.

Continued and reliable availability of water – potable or not – is also a major issue for Pakistan. Pakistan's failure to store excessive water in reservoirs and the alleged inadequate administration of the Indus Basin Treaty, have greatly contributed to our vows. In a country richly supplied with water resources, problem of water shortage is one our own creation.

Cases of rampant pollution of aquafer by industries, in some cities, is also a cause of concern. Leaking sewers and leaking water supply pipes, have marred the quality of drinking water in many settlements. Disposal of municipal and industrial waste water in an unexemplary manner, and in utter contempt for National Environment Quality Standards (NEQSs) of Pakistan Environmental Protection Agency (PEPA) and its counterpart provincial agencies, is common, even in case of government's own agencies. In some instances, untreated municipal sewerage is being directly disposed into aquafer.

There may be inadequacies in national laws, but the major problem is absence or inadequate national planning, complacence, lack of will and non-enforcement. Our passive and active national policies and conduct, in respect of water and sanitation, have come home to roost.

It is felt that if key policy-making, planning and enforcement positions in the relevant offices are held by duly trained civil engineers, the entire process made transparent to all and adequate funding made available, things may potentially move in a positive direction.

■

The sewerage system of Multan, Pakistan – A case study

Bilal Siddiq, P.E. Pakistan

Background

Multan is Punjab’s seventh-largest city by population. It is a part of the southern Punjab plain and is located on the east bank of the Chenab River, more or less in the country's geographic centre.


Figure 2: A view of Multan city

Multan is a part of the abandoned flood plain of the Chenab River sloping from northeast towards a southwest direction. Vast plain ground dissected by the rivers, canals and narrow water channels.


Figure 3: River Chenab

The elevation, above mean sea level, of the central Multan City at Shah Rukne Alam tomb is around 142 m (464 ft) and drops to around 113 m (370 ft), at the bed level of the River Chenab at the Shershah Bridge. The city's average altitude is around 122 m (400 ft), and river Chenab at the upper western periphery is 128 m (419 ft) above mean sea level. The natural 6 m (20 ft) drop in elevation of the area toward the city from the River Chenab is a permanent source of recharge of the aquifer.

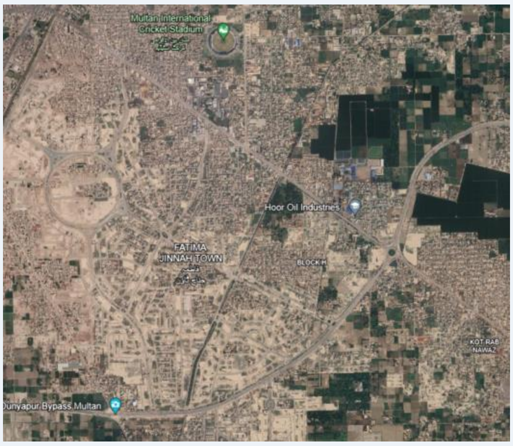

Figure 4: Multan -- a satellite view

Presently, Multan Water and sanitation Authority (MWASA) is providing operation and maintenance services in major built-up areas of Multan city (approx. 153 km^2) but does not cover the whole Multan Development Authority (MDA) designated area (i.e., 584 km^2). MWASA is responsible for the planning, designing, developing, and maintaining the water supply, sewerage and the drainage system in Multan. It was established in 1992 under the Punjab Development Cities Act, 1976. It is administratively aligned to the Housing, Urban Development and Public Health Engineering Department, Punjab, with a mandate is to carry out the related functions of the MDA, within the defined MDA boundaries.


Figure 5: A view of old city

Evaluation of the Existing System

Introduction

The existing sewerage in the city is collected through a network of sewers, discharging into the trunk sewers for the ultimate transfer at selected locations to intermediate lift stations and subsequently to the final disposal stations. Presently, the unserved areas dispose-off their wastewater at locations of their choice, mostly into the nearby fields and canals through open drains. Apparently, about 1,236 km of sewerage network has outlived its useful life – having been laid between1972 to 1999 – but is still in operation, while the remaining network, installed after 1999, can be considered under, at least, satisfactory conditions.

The following figure[1] shows the growth, over the years, of the length of sewerage system.

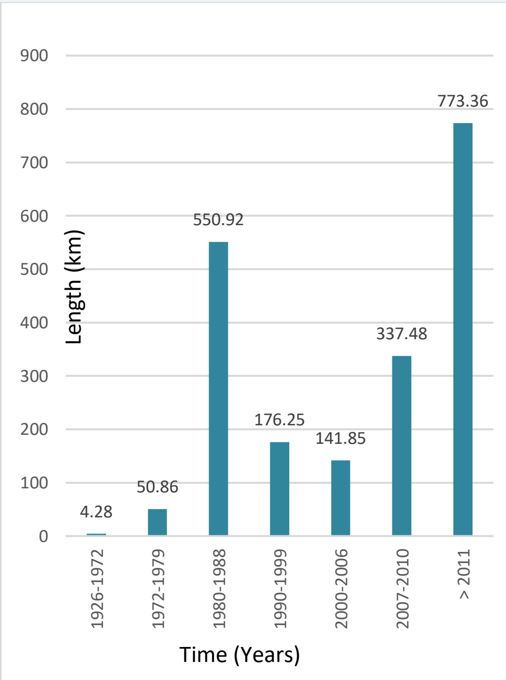

Figure 6: Growth of the installed sewer length

A summary of the lengths of different diameters of lateral sewers has been graphically produced in the figure below.

The following figures[2] shows the breakdown of different diameter sewers:

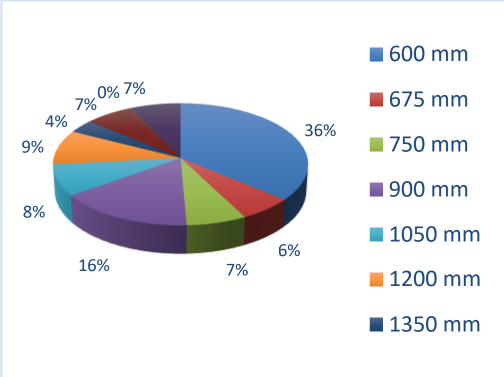

Figure 7: Breakdown of sewer sizes installed

Emerging Issues

Complaints of choked sewers and contamination of drinking water with sewage are common in most areas. In addition, trunk and sub-main sewers have been rendered too small due to the increasing population and the resulting sewage generation. As identified by MWASA, in most of the areas the sewers are running full and mostly overflowing at the problematic areas of the city. The problematic and ponding areas have been identified in the figure below[3]:

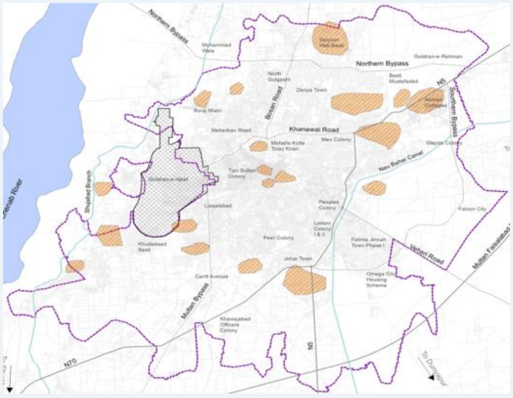

Figure 8: Ponding areas

Figure 9: Sewerage flowing into a pond

[1] Source: MWASA
[2] Source: Master Plan, 2015-40
[3] Source: Master Plan, 2015-40

Wastewater Pumping and Disposal Stations

There are twenty-five (25) pumping stations in Multan City, according to MWASA data. The fifteen disposal stations (DSs) and ten intermediate lift stations (LSs) are serving all the three sewerage zones of MWASA. The intermediate lift stations are used for pumping the sewage to the main disposal stations, which are used for the final disposal of wastewater into existing water bodies available in the area and agricultural fields.

Existing Wastewater Treatment Plants

The Wastewater Treatment Plant (WWTP) of 268 MLD[4] (59 MGD[5]) capacity is located at Suraj Miani in the North Zone of Multan. It was constructed under Southern Punjab Basic Urban Services Project (2008 to 2009) to serve the city's population in the Northern zone. It is spread on an area of 0.75 km^2 (184 Acres). It has one screening chamber (two compartments), twelve anaerobic ponds and thirty-six facultative ponds with no maturation pond. Some images of Northern WWTP has been depicted in the figures below:

Figure 10: Northern waste water treatment plant

Locations of existing disposal stations have been shown in figure below[6]:

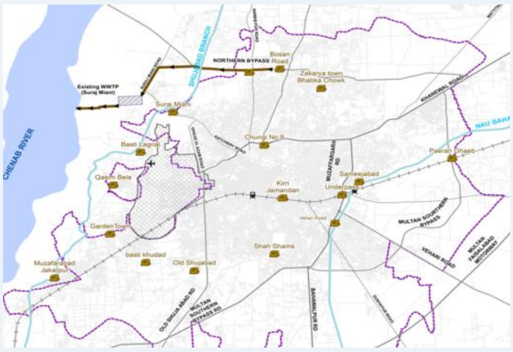

Figure 11: Location of disposal stations

Sustainability

Since the launch of the Sustainable Development Goals (SDGs) in 2015 globally. communities, organizations, and individuals around the world have translated the SDGs into an agenda for action. Nearly all the countries in the world have promised to improve the planet and the lives of its citizens by 2030. They have committed to 17 life-changing goals, outlined by the UN in 2015. These targets, include ending extreme poverty, giving people better healthcare and equal access to water and sanitation.

Pakistan’s long-term development agenda, the provincial development strategies and the five-year plans are all aligned with the SDGs. All tiers of the government are actively participating in the SDGs’ implementation. Water and sanitation are covered under the Category 1 goal out of the 3 categories, which is covered under SDG 6 i.e. Clean Water and Sanitation.

[4] MLD = Million liters, per day
[5] MGD = Million gallons, per day

[6] Source: EDCM Study on Spatial Planning Report (2021 – 2050)

The objectives of The National Sanitation Policy (2018) are:

a) To ensure an open defecation free environment; safe disposal of liquid, solid, municipal, industrial and agricultural wastes; and promotion of health and hygiene practices.
b) To link and integrate sanitation programs with the city and regional planning policies, health environment, housing and education.
c) To facilitate access of all citizens to essential sanitation services, including installing sanitary latrines in each household in rural and urban areas, schools, bus stations and important public places, and community latrines in densely populated areas.
d) To enhance the capacity building of the government agencies and other stakeholders at all levels for the better sanitation, particularly avoiding the incidents of the waterborne diseases.
e) To develop and implement strategies for the integrated management of the municipal, industrial, hazardous, hospital and the clinical wastes at the national, provincial and the local levels.
f) To change the attitude and behaviour on the use of the sanitation facilities and services.
g) To increase mass awareness on the sanitation and the community mobilization.

Towards Improving Sewerage System of Multan

The overall objective of preparing the Master Plan of Multan City was to improve water supply, sewerage, and drainage services of Multan.

The key issues are:

a) The sewers are currently surcharged, with chronic overflowing
b) During rainstorms, the undersized sewerage system, which can hardly handle the dry weather discharge and overflows.
c) The existing sewerage network in many areas is over 20 years old and needs replacement.
d) Silting of sewers and open drains resulted in choking of the network at many locations.
e) Crown failure of trunk sewers causes severe maintenance problems.
f) No sewerage collection & disposal facilities are provided in unserved areas, which results in flooding & ponding in these areas, especially during rainfall.
g) Wastewater is disposed into water bodies & agricultural fields without treatment, resulting in several glasses of water-borne diseases.
h) Non-operation of existing disposal stations. Inadequate pump operations due to poor maintenance.
i) At most pumping stations, the installed pumps do not fulfil the state-of-the-art standards in terms of efficiency and capacity in handling the future demand.

Findings

Following are, potentially, some of the solutions:

a) Replacement of Outlived Sewer
b) Proposed new Sullage Carrier against new WWTP
c) Proposed new Wastewater Treatment Plant
d) Augmentation/Proposed Disposal Stations

Spatial Planning Report, 2021-50

Following were the key findings:

a) Approximately 40% of sewers have outlived their useful life and are in a poor condition
b) History of frequent crown failures
c) Recurrent clogging and overflowing of sewers and sullage carriers
d) Twenty percent 20% (5 out of 25) DS/LS are under-capacity and unsatisfactory condition of some DSs/LSs
e) Inadequate operation and maintenance of the sewerage infrastructure
f) Treatment efficiency and condition of the WWTP Suraj Miani
g) Contamination of receiving water bodies, groundwater aquifer and emission of green house gases (GHG)
h) Untreated wastewater in open channels, including canals, and ponding leads to stagnation and fouling conditions, diseases spread by mosquitos and other factors.

i) High incidence of waterborne diseases and resulting nuisance to the population

Spatial Planning Report of EDCM

Following solutions were proposed by the Spatial Planning Report of EDCM:

a) Construction of southern Sullage Carrier WWTP (179 MGD) at Multan
b) Augmentation and improvement of disposal stations
c) Replacement of outlived and/or under-capacity Sewers and provision of sewerage services in left over areas of North, South & Central Zones, WASA Multan

Summing Up

Following are the few points comprising the summary of this article:

a) As observed from above discussion, the existing waste water system along with connected assets need proper rehabilitation and periodic maintenance.
b) From different studies, it is witnessed that most of the sewers are outdated and need remodelled pipes foresing the future demand.
c) Both studies recommended Augmentation and Rehabilitation of existing Disposal Stations and proposed Disposal station to serve unserved areas
d) Disposal Stations along with single Treatment Plant is insufficient to cater whole MC Multan cities. Both new studies suggested new Southern Treatment Plant with proposed disposal stations.
e) Asian Development Bank funds allocated to Punjab Intermediate Cities Investment Improvement Program for rehabilitation and catering unserved areas foreseeing 2050 scenario.
f) The projects reflected in both studies if properly executed in time can solve the sewerage system issues high scale.
g) Executing these projects can accomplish the global agenda of Sustainable Development Goals.
h) During and after the new scheme completion, entire responsibilities lies upon Multan WASA regarding robust and regular operation and maintenance (O&M) of Sewerage System under its jurisdiction.

Figure 12: Sewerage discharged into Nou Bahar Canal

Bahawalpur, Pakistan – A water-stressed city

Bilal Siddiq, P.E. Pakistan

Background

Bahawalpur was one of the largest princely states of British India. It used to be a developed, serene and quiet city, when the Abbasi family ruled it. Attention is drawn to the living testimonies of the progressive and visionary world view of the ruling families.

Figure 13: Sadiq Public Library

Some of the important state legacies are Bahawal Victoria Hospital, Sadiq Public School, Sadiq Egerton School, Sadiq Public Library, Bahwalpur Museum, Bahwalpur Zoo, The Historic Fountain, Abbasi Jamia Masjid, Masjid al-Sadiq, Tomb of Bibi Jaiwindi, Noor Mehal, Gulzar Mahal and Darbar Mahal.

Figure 14: More than a century old Bahawal Victoria Hospital

The city is located on the south-eastern side of Punjab province near the south bank of the Sutlej River and it is 90 km from Multan city. Bahawalpur city is topologically divided into three parts: river, plain, and desert areas. The river area lies close to the Sutlej River, which flows from the north along its boundary with Vehari, Lodhran, Multan, and Muzaffargarh districts. The irrigated track is higher than the river area.

Most of the land has been brought under cultivation. The desert area is known as Cholistan. The elevation of the city ranges from 118 to 128 meters above sea level. Most of the area has sandy soil, but alluvial soil has also been established near the banks of Sutlej and near its tributaries. The eastern part of the region has sandy loams with terraces of the Hakra River, India, sand ridges, inter-dune valleys, and saline lakes and flats.

Figure 15: Sadiq Garh Palace of Bahawalpur -- A legacy of the princely state

Following figure shows a map of the city[7]:

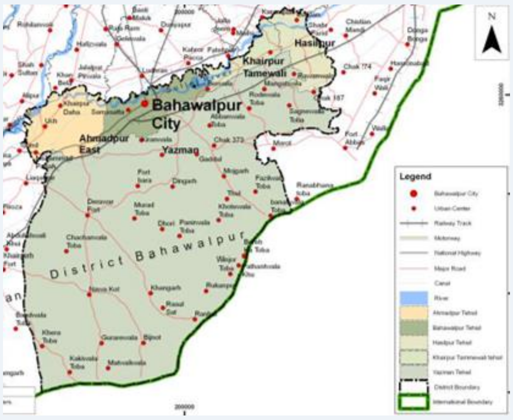

Figure 16: Map of Bahawalpur city

[7] Source: Punjab Cities Improvement Investment Project, Urban Unit of Punjab, funded by the Asian Development Bank.

Evaluation of the Water System of Bahawalpur

The population of Bahawalpur is about 3.67 million, according to the census year 2017[8]. The aim of major water projects implemented in this city is to improve the quality of life of the residents and restructuring the urban infrastructure with more efficient operation and maintenance capacity for the urban water supply services.

This article presents the general concept of the water supply condition and available sources in Bahawalpur to meet future demands. The necessity of water supply is not only to fulfil the requirements of water but to meet the global demand for sustainability. Pakistan is committed to the 2018 to the 2030 Agenda for Sustainable Development Goals (SDGs) to provide equitable services and resources to the public.

Water and Sanitation are duly covered under SDGs, i.e. Clean Water and Sanitation. The Government of the Punjab developed and approved its Punjab Water Policy 2018 which seeks an integrated approach for water conservation and management. In 2019, government of Punjab formulated the new Drinking Water and Sanitation Policy which was well aligned with SDGs and new policy frameworks for water management and climate change.

Following points describe the potential pathways towards attaining a sustainable approach towards water:

a) Promoting sustainable consumption and production patterns throughout the water sector from the exploitation to the alternate water sources.
b) Augmentation of the available water resources of the country through judicious and equitable utilization via reservoirs, conservation and the efficient use
c) Improving availability, reliability and quality of the freshwater resources to meet the critical municipal, agricultural, energy, security and the environmental needs
d) Improving urban water management by increasing system efficiency and reducing the non-revenue water through the adequate investments to address the drinking water demand, sewage disposal, handling of wastewater and the industrial effluents
e) Upgrading water sector information systems for the improved asset management and to derive evidence and the data driven decision making.
f) Regulating groundwater withdrawals for curbing over-abstraction and promoting the aquifer recharge.
g) To change the attitude and behaviour on the use of water.
h) To increase mass awareness on water and community mobilization.

[8] Pakistan Bureau of Statistics

Ground Water Quality and its Potential

In Bahawalpur, the major source of water supply is ground water. Most of the aquifer in Bahawalpur City is brackish. The water quality of groundwater for the major part of Bahawalpur is brackish. No regular water quality monitoring has been reported by the municipal corporation (MC). Groundwater quality is generally fresh along the abandoned flood plain of the Sutlej River. In the city, however, groundwater quality is fresh to marginal due to mitigation caused by recharge through water losses from Ahmadpur Branch and distributaries passing through the city.

According to one survey[9], around 24% of the water samples were found to be polluted with E. coli, 52% is contaminated with coliform bacterium, and 76% possessed excess Arsenic (As), with most of the samples containing more than 50 ppb. This is five times more than the limits set out by the WHO.

The recent results obtained, in May 2018, from the PCRWR showed the following results:

a) The water testing results indicated that 7% of the total coliforms, 60% of arsenic and 13% of
b) TDS samples had values above WHO guidelines. Groundwater is therefore not fit for the human consumption in Bahawalpur

[9] Survey of major cities of Punjab, undertaken by The Pakistan Council of Research for Water Resources (PCRWR).

c) In a similar study by the PHED on the water filtration plants and tube wells in October 2018, 40% of the samples contained arsenic above the WHO guidelines.

The ground water table is approx. 30 m (90 feet) deep in the city. Similarly, some areas in the city, like Muhalla Qurashian, Muhalla Chishtian, have good ground water quality. However, in most of the city area, the ground water quality is poor.

Ground Water Level

The seepage water from the eastern canal system is the main recharge source for the aquifer beneath Bahawalpur and its downstream area. As reported by the MC, the groundwater level in the city ranged between 8 m to 9 m in 1988. The present water level in the city is reported to be around 21 m to 24 m, which means the water level has dropped at around 12 m in around 30 years. That means the aquifer below Bahawalpur city is under stress, and the water level in the city is depleting at around 0.3m (1ft) per year[10].

Dependence of Domestic Water Demand on Existing Tube-wells

The MC Bahawalpur is using seepage ground water through shallow tube wells, which are mostly installed along the Sutlej River and the Ahmedpur canal bank to supply water to the consumers. Some tube wells (deep well) are also installed in the city area. Currently, most tube-wells are installed along the Ahmadpur canal banks, Sutlej River and some private tube wells with in the city. It would be useful to undertake electrical resistivity survey (ERS) for these locations to estimate the extent, quality and life of the available water sources.

According to the data secured by the MC, at present there are 74 tube wells; out of which twenty-26 tube wells are being operated as part of the municipal water supply system, the remaining 48 tube wells were installed recently in SPBUSP project (2019), however they are not in operation. Out of 48, 44 tube wells were installed between 2008 and 2012 under the SPBUSP project. Ever since, these wells were not taken over by the MC and were not utilized for their intended purpose. The functional condition of these tube wells and their M&E equipment is unknown. As has been stated earlier, the quality of aquifer within the city being poor, the water supply of the Bahawalpur city is predominantly dependent on the shallow tube-wells, located close to the Sutlej River and drawing on the recharge by the Ahmadpur Canal and the drying up river.

Some deep tube-wells are also installed within city area. There also exist private bores in the city, which are used for domestic purposes other than drinking. For drinking purposes, the residents of the city use the filtered water available at filtration plants (UF/RO type) installed at the various locations in the city. Generally, water quality is good along river and canal banks and requires only chlorination before distribution to the consumers.

Surface Water Sources

The Sutlej River passes very close (about 6 km) from the center of the city on the north-western side, flowing from the north-east direction to the south-west direction. The approximate length of the river is 1,500 km and an average discharge is 500 cumecs (17,657cusecs). The Sutlej River was closed for Pakistan under the Indus basin Treaty of 1960, executed between India and Pakistan. Presently, the Sutlej River generally remains almost dry and flows only during the monsoon flood season.

The Bhawal canal (3LBC) which is originating from Lal Sohanra head and is partially lined and perennial. This canal flows on the southern side of the city. The Ahmedpur branch is partially lined and non-perennial, and the subsidiary of 3LBC canal which has a design discharge of 67.39 cumecs (2,380 cusecs). Both flowing almost northeast to south-west

[10] Groundwater Quality map of the Bahawalpur, for pre-monsoon 2013, published by Irrigation Department of Punjab.

The branch of Lal Sohanra head canal is called Bahawalpur Distributary (Desert canal), flow up to the city from the eastern side. The Bahawalpur distributary runs within the main city. The design discharge of the distributary is 5.09cumecs (180cusecs). The design discharge is 6.43 cumecs (227cusecs). Similarly, the Desert branch canal, which has a higher discharge capacity of around 86.4 cumecs (3,050 cusecs). This canal also originates from Lal Sohanra head.

Details of potential surface water sources (canal) present in Bahawalpur City, have been tabulated below[11]:

Table 1: Potential surface water sources of Bahawalpur

Sr. No.	Canal	Length km	Nature	Design Discharge M^3/s
1	Sutlej River	1,500	Non-Perennial	500
2	Ahmedpur Branch Canal	23.35	Non-Perennial	67.50
3	Bahawalpur distributary	11.60	Perennial	5.09
4	Bhawal Canal	52.34	Perennial	6.43
5	Desert branch canal	61.45	Perennial	86.4

Key Reason of Ground Water Depletion

Low Precipitation

Due to the effect of greenhouse gas emissions, Pakistan has become one the water-stressed zones of the world. Bahawalpur has very hot and dry climate in the summer and dry and cold climate in the winter. The maximum temperature rises to 48ºC in the summers while the minimum temperature falls to 6ºC in the winters. Wind and dust storms are common during the summer. Most of the rainfall occurs during monsoon season, from July to September. Per 1980-2010 data, the mean annual rainfall was about 179.2 mm. Per 1991-2020 data, the mean annual rainfall observed at Bahawalpur Meteorological station was about 184.6 mm. The wettest recent year was 1973, with an annual total rainfall of 671 mm. The number of average rainy days in a year are 21, per data of Pakistan Meteorological Department. The city falls in the arid zone. Results of low precipitation and the absence of significant recharge from Chenab River have resulted in lowering of the ground water level of the city, posing a serious threat to the ecosystem.

Population

Population is generating pressures on the water resources of the city. This city has a covered area 24,830 km^2, and is second most populated city of the province of Punjab. According to Punjab Urban Unit report on Sixth Population & Housing Census 2017, 9 out of 10 districts with the highest number of households, are located in Punjab. Lahore is at the top of the list with 1,758 thousand households, followed by Faisalabad, Rawalpindi, Multan, Gujranwala, RYK, Muzaffargarh, Sargodha and Bahawalpur districts. With the existing bulk population in the city, the only ground water source (shallow and deep Tube wells) is reaching alarmingly low level due to huge pumping rates of government owned and private boreholes.

[11] Source: Irrigation Department, Punjab

Non-perineal Sources

Currently in Bahawalpur City, seepage of canals through shallow tube-wells installed along Sutlej River and Ahmadpur canal banks are the main source of water supply. Generally, water quality is good along the river, and canal bank tube-wells of 0.014 m^3/s (0.5 cusecs) and 0.028 m^3/s (1 cusecs) capacities are already installed along the bank. However, the source is non-perineal.

Neglect and Illegalities

One of the big issues faced by developing countries is lack of maintenance of water supply system, resulting in leakages. According to MC, illegal connections and unauthorized boreholes are also creating a pressure on water resource.

Mitigation Measures for Water Supply Resilience

Following measures may be adopted for mitigation of the identified problems:

Rehabilitation of Existing Tube-wells

As has been mentioned above, only 26 existing tube-wells are currently operational, which are insufficient for meeting the demand of the current population of Bahawalpur district, which was 3.67 million, per 2017 census. The rehabilitation of 48 existing non-operational tube-wells may be undertaken to augment the present water supply.

Augmenting Existing Water Sources

In 1960, after the signing of the Indus basin Treaty, the river of Sutlej has been drying up, and residents of Bahawalpur may face serious challenges in future, in meeting their demand by the year 2050. Groundwater is marred by unacceptable biological inclusions and its continued illegal private use is a health threat. Therefore, in the long run, it would be imperative to place reliance on surface water in order to augment the present reliance on the tube wells installed along the Sutlej River and Ahmedpur canal.

The following figure shows various potential sources of surface water:

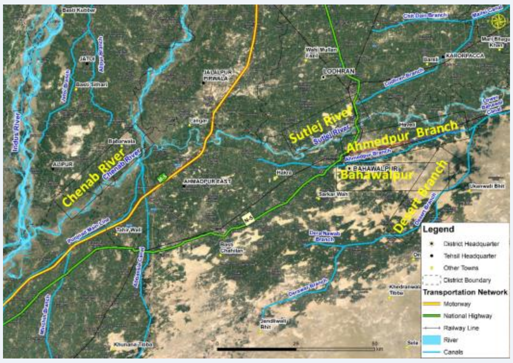

Figure 17: Potential sources of surface water

The above options have been discussed below:

Option 1: Ahmadpur Canal

The use of Ahmadpur Canal as a source of surface water needs to be considered.

Option 2: Chenab River

It would be wise to explore the Chenab River as an alternate water source. In this regard, installation, along the bank of Chenab River, of new tube wells of 0.028 m^3/s (1 cusecs) capacity shall be a viable option. In addition, a new transmission line shall be required to carry water from Chenab River to the city centre*.

Option 3: Desert Branch Canal

Lal Sohanra head has three distributaries. i.e. Desert Branch, Ahmadpur and Bhawal canal (3LBC). The Ahmadpur is non-perineal while the other two are perineal. Of the two, the Desert Branch has a higher discharge (86.4 cumecs).

Figure 18: A view of Desert Branch

Discussion

Comparative evaluation of the above options may be summarized as follows:

Option-1: This option sees the Ahmadpur Canal as surface water source. However, this canal has been non-perineal for a long time. Due to this limitation, this option becomes an undependable solution, at the moment. However, if this canal becomes perineal at some point in time, in future, this option must be considered.

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Option-2: First of all, the distance from Chenab River bank to city south side has been roughly estimated to be around 66 km. Secondly, if the average distance between two tube-wells is taken as 150 m (about 500 ft), the total distance along River Chenab, for the installation of 400 tube-wells would be 60 km. Thirdly, the ground water is known to be brackish and excessive water exploitation and resulting draw-down would further lower the water table. This option, therefore, also seems unfavourable.

Option-3: The desert branch canal is perineal at present time and its distance from the city is around 26 km, which is shorter than that of Chenab River. Secondly, this canal has high discharge capacity, which may be adequate for meeting the expected future demand. Its use, however, would need a permission from the Irrigation Department. This water shall be treated with the provision of water treatment plants.

As such, Option-3 seems to be the most responsive to the needs and quite reasonable as per studies conducted i.e. "Spatial Planning for Water Supply in Seven Cities by EDCM in 2022".

Conclusive Remarks

Important issues taken up in this article are as follows:

a) As noticed in EDCM study conducted recently, water resource has become inadequate as the quality ground water has become unsuitable, precipitation is low and water demand has increased due to increasing population.
b) The number of operational tube-wells located along River Chenab and Ahmadpur Canal is inadequate.
c) Chenab River does not seem to be a cost-effective source of surface water or a source of ground water.
d) Desert canal branch, carrying high discharge of 86.4 cumecs, appears to be a response source of surface water for the next two to three decades.
e) Taking steps for ensuring water supply would be consistent with Goal No. 6 of Global Agenda of Water Supply Sustainable Development.

Figure 19:The historic fountain of Bahwalpur

Transportation Engineering

Enforcement of Axle Load Limits

Rizwan Mirza[12]

Overloading of freight transport vehicles is posing a threat to the national asset of highways and motorways. This has been reported in survey(s) conducted in this regarded. One major corollary of such damage is that the economic and financial analysis of the asset breaks down.

Last year, the federal government of Pakistan directed that, starting 15th November, 2023, full adherence to the axle load regime, prescribed by NHSO, 2000[13], would be made on national highways and motorways. Following is a list of prescribed loads:

Sr. No.	Shape	Code	Maximum Gross Weight (Tons)
01		1.2	17.5
02		1.22	27.5
03		1.2-2	29.5
04		1.2-22	39.5
05		1.22-2	39.5
06		1.22-22	49.5
07		1.2-2-2	41.5
08		1.2-2-22	51.5
09		1.22-2-2	51.5
10		1.22-2-22	61.5
11		1.2-222	48.5
12		1.22-222	58.5

Figure 20: Single, Tandem, Tridem-Axle Load and Gross Vehicle Weight

Following axle load limits have been prescribed:

Table 2: Axle load limits

Sr. No.	Description	Load Ton
1	Single Axle	12.0
2	Tandem Axle	22.0
3	Tridem Axle	31.0
4	Front Axle	5.5

Following tyre pressure limits have been prescribed:

Table 3: Tyre pressure limits

Sr. No.	Description	Tyre Pressure Lb/in^2
1	Rear Axle	120
2	Front Axle	100

The writer feels that road and bridge infrastructure of a country is a costly asset and deigned to meet its evolving needs. The most appropriate design loads as well as the controls over vehicle geometry and loads, shall be professionally prepared as a part of a long-term policy, in an open and transparent manner, in consultation with all concerned parties, including political leaders, political scientists, economists, traders, transporters, vehicle manufacturers and the relevant government departments.

It may also be noted that, in the interest of flexibility in regional trade through roads, a country needs to have such loading and geometrical limits as would allow its freight vehicles to enter its trading partners. The author concludes, in the light of a relatively older data, that Pakistan ranked at serial 1, 1 and 4 in a list of 32 Asian countries, in having the heaviest permitted load limits, for total vehicle load, load on a combination of axles and load on a single axis, respectively. These loads were 48.86%, 29.17% and 20.00% higher than the most commonly adopted values.

As has been argued, the question of placing controls over vehicle geometry and loadings is a multi-facetted issue that requires a very careful evaluation.

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[12] CEO, Rizwan Mirza, Consulting Engineers

[13] National Highway Safety Ordinance, 2000

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Formerly, Vice President, NESPAK

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Liaison Office: 14 A/1, Block P, Model Town Extension, Lahore 54700, Punjab, Pakistan

Tel.: +92 42 3571 3362; +92 42 3571 3363; +92 42 3571 3364
Email: psce@psce.org.pk
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Editor-in-chief: Rizwan Mirza, CE