Examining the Water Scarcity in Pakistan, Issues and way forward

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INTRODUCTION

Water is one of the greatest blessings of Almighty Allah. The impossibility of life without water implies its necessity for humanity. Water scarcity is a frightening situation that is already happening in Pakistan. The country ranks 14 among the 17 'extremely high water risk' countries of the world, a list that includes hot and dry countries like Saudi Arabia, UAE, Qatar, Iran, Bahrain etc. Over 80 percent of the total population in the country faces 'severe water scarcity' for at least one month of the year. In addition to surface water, Pakistan's groundwater resources—the last resort of water supply—are severely overdrawn, mainly to supply water for irrigation. If the situation remains unchanged, the whole country may face 'water scarcity' by 2025.

Water shortage is the condition when there is a lack of sufficient water resources. This includes a lack of access to safe water supplies and deprivation to meet basic water needs. According to UN-Water, "*water scarcity is defined as scarcity in the availability of water due to physical shortage or access due to failure in management and governance (Water Scarcity, n.d.). When the demand for water exceeds the amount available during a specific period of time, such a situation is known to be water-stressed (Green Facts, n.d.). Lastly, water insecurity, as defined by Norins, is the lack of sufficient water to meet all the needs and the inability to adapt to disasters (Defining Water Insecurity, n.d.)".*

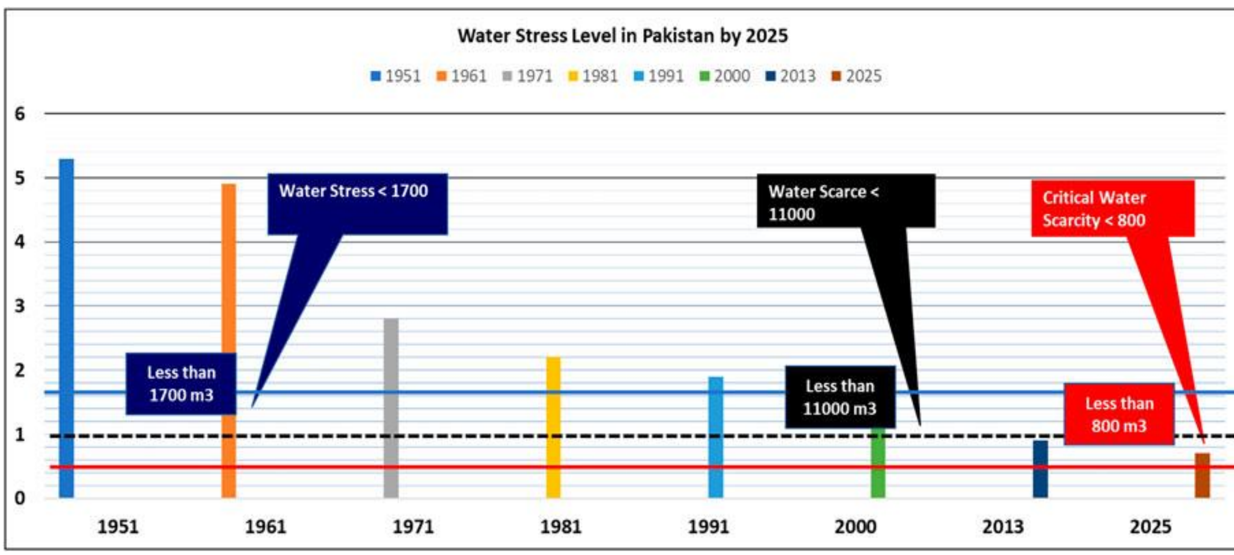
The continent of Asia is the hub of the water crisis where water emerges as a source of increasing competition and an underlying discord between the Asian states (Chellaney, 2012). India and Pakistan are prime examples of such discord. Asia faces a daunting challenge in the form of the water crisis that threatens its economy, political rise, and most importantly its environmental sustainability (Chellaney, 2012).

Due to Asia's water efficiency and productivity being the lowest in the world, it is a center of global water issues, be it crises or security issues. A South Asian country like Pakistan, which has been struggling in almost every aspect ever since independence, is no exception. Pakistan is amongst those countries of Asia that are on the hitlist of water issues be it in terms of a crisis, security, scarcity, or even shortage.

WATER SCARCITY IN PAKISTAN

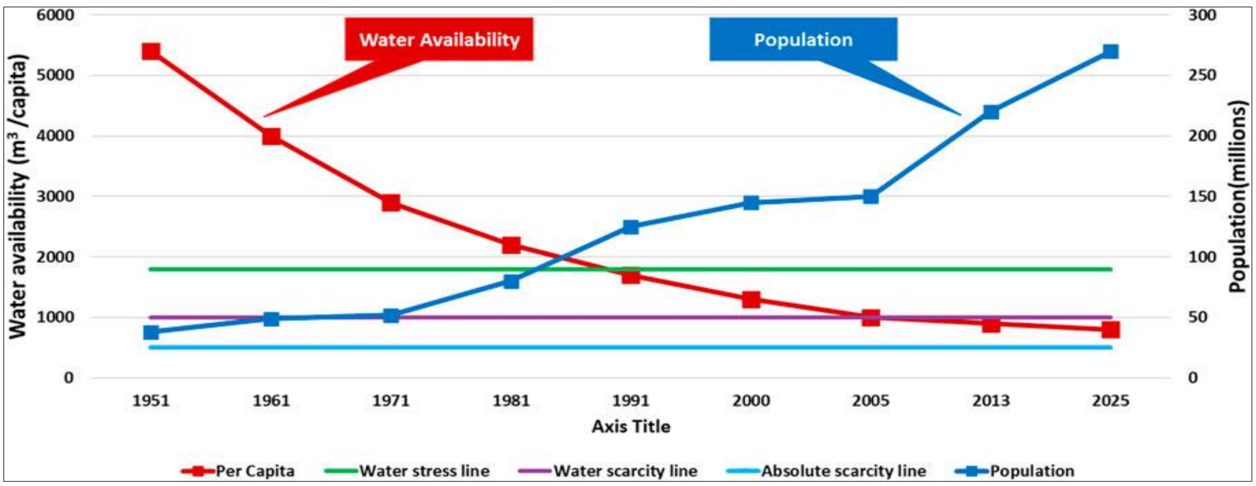
Pakistan is an agriculture based country. In Pakistan 67% of economy depends upon agriculture. The importance and usefulness of water in agriculture is unquestionable. Agriculture has depended on water since ancient times. World Economic Forum has identified water crisis as the most important threat in the long run and will have catastrophic consequence on society. Similarly, water resources system is the life line for Pakistan. It is a source of life and energy. It is the most critical factor of production in Pakistan's agriculture resources. The availability of water on annual basis is less than 1000 cubic meters. The demand of water will be reached around 274 million acre-feet by 2025, whereas the supply will be around 191 million-acre-feet. Pakistan has been a subject of several issues since its independence. But the most crucial and one of the biggest problems lurking in the country is the water shortage. According to International Monetary Fund (IMF), Pakistan will be fully dried and barren by 2025 if the necessary measures are not taken to preserve the water. People nowhere in the world can survive without water.

Being the sixth most populous country in the world, the population of Pakistan is predicted to reach almost 250 million by the year 2025. The Indus Basin occupies a total area of 566,000 km2 and 80% of Pakistan's total population lives within the Indus Basin. Over the last 10 years, Pakistan has become a water-stressed country. The United Nations (UN) has estimated that the per capita water availability of Pakistan has reached 1,090 m3 (Condon et al., 2014). The economic development of Pakistan has always been dependent on irrigated agriculture, and consequently, water.



However, Pakistan's water resources are under immense pressure due to the rapidly growing population. An increase in population means that there is a requirement for more food, but no new resources of water are there for its production. Water shortage has been identified as the most challenging of all problems by the Government of Pakistan because the water required for agriculture is vital for the growth of the agriculture sector and consequently for poverty reduction.

Pakistan is an underdeveloped country due to which it faces issues in many domains, where water scarcity has emerged as the most pressing national security issue. Pakistan not only faces a water shortage but also lags in clean drinkable water for the population. The construction of water reservoirs for storing and then systematically distributing water remains lopsided, despite the growing demand. Figure below shows the systematic path towards water scarcity as year on year basis, the gap between water availability, storage, and sectoral consumption is widening and water security is emerging as a vital national security challenge for Pakistan if remedial measures are not initiated now as the time is running out and we are only 3 years away from the water-scarce line.

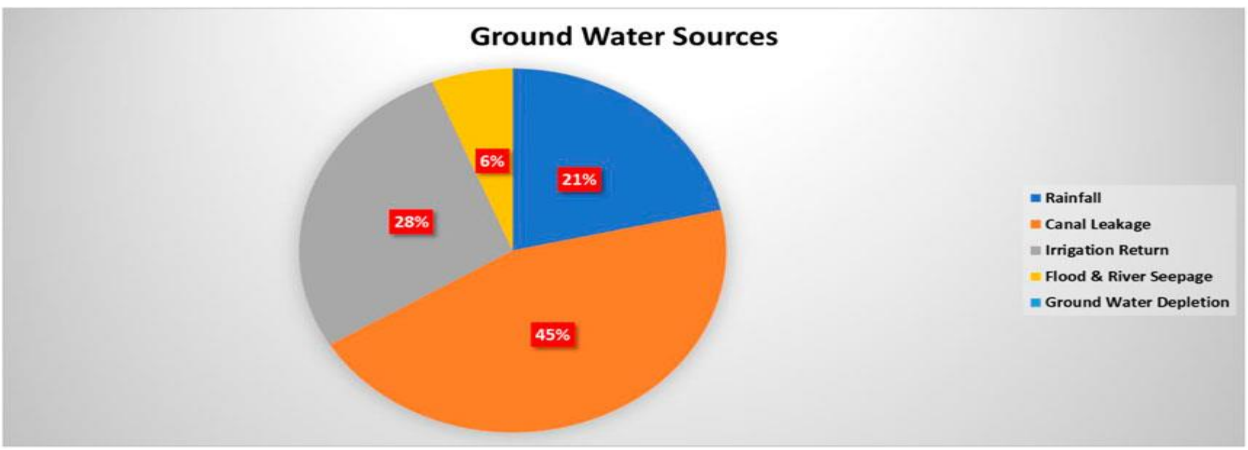


THE SUPPLY SOURCE OF WATER RESOURCES

Pakistan's Northern areas which include the provinces of Gilgit-Baltistan (GB) and Azad Jammu and Kashmir (AJ&K) are blessed with abundant glaciers with an approximate area of 13,680 sq km, which is approximately 3% of the mountainous region of the upper Indus River Basin (Ahmed et al., 2007a). The winter season from October to March every year receives plentiful snowfall which is the main source of icing of the glaciers. The melting process starts in the summer, roughly from late May to August, which feeds adequate water to Indus River Systems (IRS). River Kabul is another source of water to IRS as it enters Pakistan through Unai Pass in Southern Hindukush to the North of Khyber Pass in Khyber Pakhtunkhwa (KPK) Province at an elevation of 3,000 m above sea level.

Rainfall is complimentary to the melting of glaciers in the summer and monsoon seasons of Pakistan, which provide profuse water to IRS. On average, the rainfall is more than 200 mm from July to September each year. More than 70% of the rain is witnessed from the monsoon and the western disturbances. In northern parts of Pakistan, a low-level rain cycle continues at frequent intervals even during winter.

According to the World Bank report, groundwater provides 90% of domestic water in rural areas and 70% at the national level with its share of approximately 50% for agriculture (World Bank, 2022a). The main sources of recharging of groundwater are the seepage from IBIS, which sits as a freshwater layer even on saline water in desert regions of Pakistan and is considered the main source of drinking and irrigation. Similarly, rainwater also finds its way through the layers to submerge in groundwater. The percentage-wise sources of groundwater recharge are given in Figure below. Due to the unpredictability of canal water supplies, farmers across Pakistan have resorted to groundwater pumping, which is going on in a highly unregulated manner. The agriculture areas in the Indus Basin Irrigation System (IBIS) have installed approximately 500,000 tube wells, which are estimated to pump water of approximately 50 Billion Cubic Meters (BCM) (Ahmed et al., 2007b), whereas, the groundwater potential in Pakistan is approximately 55 MAF (Ebrahim, 2018). Even in the domestic sector, unmonitored groundwater misuse is on the rise, which is sharply decreasing the most precious commodity of nature.



Groundwater sources in Pakistan (World Bank Report)

Over the last few decades, Pakistan has drastically changed from being a water abundant country to a water-stressed country. With 2.8 percent of the global population, Pakistan accounts for 0.5 percent of global renewable water resources. Worldwide, the country ranks 36th in total renewable water resources compared to India's rank at 8th and Bangladesh's at 12th (2017). The country's dependence on a single river system is extremely risky: the Indus river system accounts for 95.8 percent of the total renewable water resources of Pakistan. Moreover, the water originating from outside of Pakistan accounts for over three-fourths (78 percent) of total water resources of the country, making it vulnerable.

Over 63 percent of globally produced wastewater is collected, 52 percent is treated (48 percent is released untreated) while 11 percent is reused. With a mere 1 percent treatment of collected wastewater, Pakistan ranks among the countries with the lowest water treatment rate.

ROOT CAUSES OF PAKISTAN'S WATER CRISIS

Pakistan's water crisis is explained mainly by rapid population growth followed by climate change (floods and droughts), poor agricultural sector water management, inefficient infrastructure and water pollution. This in a result is also aggravating internal tensions between provinces.

a) Rapid Population Growth and Unplanned Urbanization

The biggest challenge to deteriorating water resources and decreasing per capita water availability in Pakistan is population growth and urbanization. Between 1972 and 2020, Pakistan's population increased by 2.6 times, moving it in rank from 9th to 5th. Bangladesh's population increased by 1.5 times (from 66.6 million to 164.7 million) during this time. Total water use in Pakistan increased by about 0.7 percent per year between 1977 and 2017; while total water resources remained static at 246.8 billion cubic meters (BCM), resulting in a decrease in per capita water resources from 3,478 to 1,117 cubic meters per year.

b) Climate Change

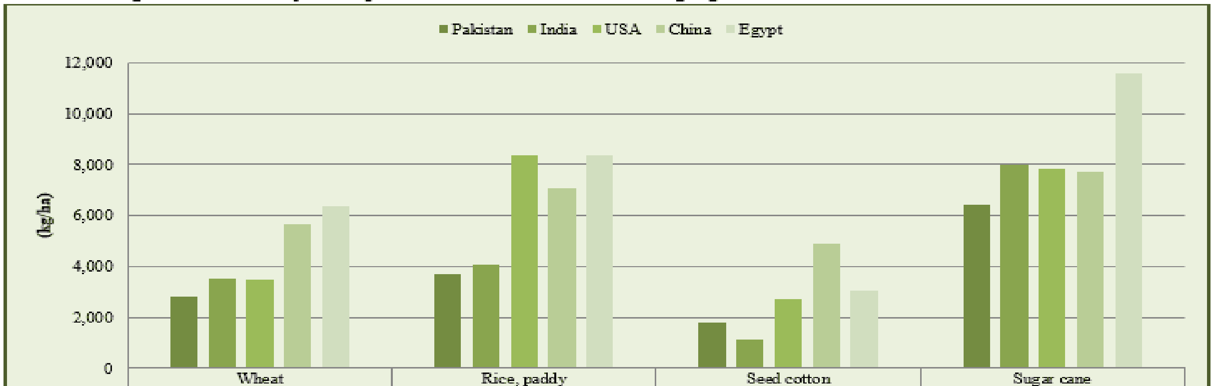
Pakistan is the 5th most vulnerable countries of the world to climate change according to IPCC. The country is already facing climate-related threats to water resources as is evident from the change in monsoon patterns, receding glaciers, rising temperatures and recurrence of floods and droughts. Climate change may decline aggregate water flows in the future. The Indus River Basin, Pakistan's chief water source, being dependent on glacial and snowmelt and precipitation, is highly sensitive to climate change. Given the fact that snow and ice melt runoff currently generates between 50 percent and 80 percent of average water flows in the Indus River basin, this will result in landslides, heavy flooding, dam bursts and soil erosion initially and drought and famine in the long-run.

c) Poor Water Management

Over 80 percent of the country's water resources are used by four major crops (rice, wheat, sugarcane and cotton) which contribute only 5 percent to GDP. The productivity of these crops is low in Pakistan compared to other major agricultural economies of the world. Though the farm sector accounts for one-fifth of GDP and almost half of the country's employment, it contributes less than 0.1 percent to total tax revenues, providing little finance for the maintenance of the irrigation system.

The crumbling of water infrastructure contributes to extensive water wastage. The country's irrigation is one of the most inefficient in the world with an overall efficiency of 39 percent, reflecting aging and poor maintenance of the irrigation system. Moreover, Pakistan can save only 9 percent of the available water in the Indus River System throughout the year, compared to the global average of 40 percent.

Fig. 6. Yield of Major Crops in Pakistan and Other Leading Agricultural Economies of the World, 2019



	Wheat	Rice, paddy	Seed cotton	Sugar cane
Pakistan	2,806	3,664	1,779	6,432
India	3,533	4,058	1,157	8,010
USA	3,475	8,374	2,712	7,840
China	5,629	7,056	4,881	7,729
Egypt	6,379	8,373	3,050	11,574

Source: FAO 2021.

d) Water Pollution

Every year about half of the two million produced wet tons of human excreta go on to pollute water in Pakistan. According to a study, in Pakistan 60 million people are at risk of exposure to high concentrations of arsenic in groundwater on the Indus Plain. Water-borne diseases are a leading cause of death and suffering in Pakistan. Overall, about 60 percent of people in Pakistan are suffering from one or more of the main diseases associated with inadequate provision of drinking water and improved sanitation.

e) Water Policies

In 2018, Pakistan formulated its first-ever National Water Policy. It acknowledges for the first time that water is a finite resource and that Pakistan has to at least recover the costs of the irrigation system. The policy also looks at future impacts of climate change on water, talks about water pricing and mentions the need for regional cooperation challenges. Some provincial-level initiatives also exist such as the Punjab Water Act 2019, the Balochistan Integrated Water Resources Management (IWRM) Policy 2006, Sindh's Agriculture Policy 2018 and KP's Drinking Water Policy 2015 and Climate Change Policy 2016. However, there are several shortcomings in these documents such as the absence of a scientific basis, the neglect of water quality issues, the absence of targets, and lack of clear reference to SDGs and gender inclusion. Such gaps need to be addressed during the implementation phase. Also, there is a need for clear timelines, capacity, political will and provision of financial resources.

f) Water Distribution Issue within Provinces

A growing scarcity of water resources in the country is increasingly becoming a source of conflict among provinces over the distribution of available water. Canal water is distributed among provinces under the 1991 Water Accord: a baseline volume of 144.8 BCF water is divided among the provinces, with about 48 percent going to Punjab, about 42 percent to Sindh, 7 percent to Khyber Pakhtunkhwa and about 3 percent to Balochistan. A mechanism has been defined for the excess supply of water. However, the accord does not introduce any apportionment for shortages. Lesser quantities of water in various months have caused water conflicts between the upstream province of Punjab and the downstream province of Sindh and between Sindh and Balochistan over the years. Sindh alleges Punjab of water theft while Baluchistan accuses Sindh of not giving its share from Guddu and Sukhar Barrages.

WATER USAGE IN AGRICULTURE SECTOR

The agriculture sector is also the biggest user (more than 90%) of water in Pakistan. The water availability in Pakistan is already below the scarcity level of 1000 m3 /person and climatic changes in the region may further worsen the situation. The minimum per capita domestic water requirement is 50 liters whereas it requires 2600 to 5300 liters to grow food for one person per day. Therefore, food security is directly related to the water security as 50 to 70 time more water is required to grow food than the water used for domestic purposes. About 90% food production in Pakistan comes from irrigated agriculture, whereas dryland (rain-fed) agriculture contributes only 10% due to scanty and low rainfall. The total benefits derived from irrigation are also 12 times the direct, onsite benefits when all quantifiable economic and social benefits are accounted for (World Bank).

Pakistan has one of the largest contiguous irrigation systems in the world, covering about 17 Mha of land. However, at the same time, it is one of the most inefficient irrigation systems where more than 60% water is lost during conveyance in the channels and application in the field. Table given below shows that maximum irrigation water losses occur essentially at water course level (30%) due to leakage and seepage, and at the field level (29%) due to poor irrigation methods.

Water Losses at Field Level

Location	Delivery at Head (MAF)	Losses (MAF)	Losses (%)
Canals	106	16	15
Distributary & minor	90	6	7
Watercourses	84	26	31
Fields	58	17	29
Crop use	41		
Total		65	61

Agricultural needs are increasing due to increasing population and ensuring food security is becoming a challenge. The need of water for irrigation is also increasing, while the availability of water is decreasing day by day. Climate change is causing severe water scarcity due to depletion of rainwater and over-exploitation of groundwater. To irrigate crops in rainfed areas, landowners irrigate their fields using mini-dams or ponds, but using conventional irrigation methods in this situation is highly inefficient, resulting in large amounts of valuable fertilizers and water being wasted and yield loss. There is a need to adopt a modern method of irrigation apart from the traditional method. In Orchards, vegetable and tunnel farming, the farmers should adopt modern, low-cost and efficient means of irrigation. Some of the important methods of modern irrigation are listed below:

1. Bubbler Irrigation System

The bubbler irrigation system, specifically designed for orchards and large trees, is a localized irrigation method that delivers water directly to the root zones of individual trees or plants. This system utilizes specialized bubbling emitters or bubblers strategically placed around the base of each tree to provide controlled and targeted watering.

For orchards and big trees, the bubbler irrigation system functions as follows:

- ✓ **Bubbler Emitters:** These are placed near the root zone of each tree, usually within the drip line, to release water directly onto the soil.
- ✓ **Slow and Controlled Water Release:** Bubblers emit water in the form of small bubbles or droplets at a slow rate, allowing water to seep deeply into the soil, reaching the roots.
- ✓ **Tailored Watering:** The system can be customized to meet the specific water needs of individual trees or types of plants within the orchard. Different flow rates and types of bubblers can be used based on the tree's size, age, and water requirements.
- ✓ **Efficient Water Usage:** Bubbler systems minimize water wastage by delivering water precisely to the root zone, reducing evaporation and runoff.

Ingredients or components commonly used in a bubbler irrigation system include:

- ✓ **Bubbler Emitters:** These are the main components that release water and are available in various flow rates.
- ✓ **PVC or Polyethylene Tubing:** These materials are often used to transport water from the water source to the bubblers.

- ✓ **Filters and Pressure Regulators:** These components help maintain the proper water pressure and ensure that the water is clean and free from debris that could clog the emitters.
- ✓ **Connectors and Adapters:** Various fittings and connectors are used to assemble the system and connect tubing to the water source and bubblers.

2. Drip Irrigation System

In drip irrigation, water is applied to each plant separately in small, frequent, precise quantities through dripper emitters. It is the most advanced irrigation method with the highest application efficiency. The water is delivered continuously in drops at the same point and moves into the soil and wets the root zone vertically by gravity and laterally by capillary action. The planted area is only partially wetted. Drip irrigation offers several advantages:

- ✓ **Water Conservation:** It efficiently delivers water directly to the plant roots, minimizing water wastage by evaporation or runoff.
- ✓ **Precise Nutrient Delivery:** Nutrients can be precisely administered along with water, ensuring the plants receive the right amount, promoting healthy growth.
- ✓ **Weed Control:** Targeted water delivery reduces moisture in non-plant areas, limiting weed growth.
- ✓ **Uniform Crop Growth:** Ensures consistent moisture levels, leading to even crop growth and reduced stress on plants.
- ✓ **Reduced Disease Risk:** Watering directly to the roots prevents foliage moisture, decreasing the likelihood of certain plant diseases.

- ✓ **Energy and Labor Savings:** Requires less energy and labor for irrigation compared to traditional methods, especially in large-scale operations.
- ✓ **Adaptability:** Suited for various soil types and can accommodate different crop types, making it versatile for tunnel farming.
- ✓ **Environmental Benefits:** Reduces fertilizer and pesticide runoff, minimizing environmental impact.
- ✓ **Maximized Yield:** Optimal water and nutrient delivery often result in increased crop yields in tunnel farming.

3. Micro Catchment Water Harvesting Systems

Micro catchment water harvesting systems (MicroWH) are designed to trap and collect runoff from a relatively small catchment area, usually (10 – 500 m2) within the farm boundary. The runoff water is guided into an application area where it accumulates in holes, pits, basins and bunds. It infiltrates into the soil, and is used to grow plants. The collected water is stored in the root zone and supplies crops such as sorghum, millet, maize, shrubs, trees or fodder crops. The ratio between the catchment (collection) area to the cultivated (application) area can vary between 2:1 and 10:1. The size of the catchment can be easily controlled by the farmer, which makes the system easy to adapt and replicate.

4. Rain Water Harvesting

Rainwater harvesting is an ancient practice that helped in meeting basic water needs and reduced water shortages mainly in arid and semi-arid regions. Rainfall, through runoff, can be captured downstream of a suitable "catchment" area. The capture and storage of rainwater can be beneficially used. Harvesting water depends not only on the rainfall amount, but also on its pattern and intensity and on the catchment and storage conditions. Storage is a vital component of rainwater harvesting systems and can be surface or subsurface reservoirs or simply a soil profile. Uses include domestic, agriculture, industrial and environment sectors. Micro-catchment rainwater harvesting (MIWH) systems are based on having a small runoff catchment, normally at the household or farm level. In MIWH, runoff flows as sheet flow downstream to a storage facility to be used later for various purposes. Among the most common MIWH types are the Household systems including rooftops and cisterns and the Farm and Landscape systems including contour ridges, bunds, small runoff basins and strips. The implementation of systems, however, faces several technical, social, financial, and environmental constraints. Recommendations to help overcoming those constraints are provided for the rural dry environments where the need for water and food is critical.

5. Sprinkler Irrigation System

Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water.

- **Suitable crops**

Sprinkler irrigation is suited for most row, field and tree crops and water can be sprayed over or under the crop canopy. However, large sprinklers are not recommended for irrigation of delicate crops such as lettuce because the large water drops produced by the sprinklers may damage the crop.

- **Suitable slopes**

Sprinkler irrigation is adaptable to any farmable slope, whether uniform or undulating. The lateral pipes supplying water to the sprinklers should always be laid out along the land contour whenever possible. This will minimize the pressure changes at the sprinklers and provide a uniform irrigation.

- **Suitable soils**

Sprinklers are best suited to sandy soils with high infiltration rates although they are adaptable to most soils. The average application rate from the sprinklers (in mm/hour) is always chosen to be less than the basic infiltration rate of the soil (see Annex 2) so that surface ponding and runoff can be avoided. Sprinklers are not suitable for soils which easily form a crust. If sprinkler irrigation is the only method available, then light fine sprays should be used. The larger sprinklers producing larger water droplets are to be avoided.

- **Sprinkler System Layout**

A typical sprinkler irrigation system consists of the following components:

I. Pump unit
II. Mainline and sometimes sub-mainlines
III. Laterals
IV. Sprinklers

Advantages of Sprinkler Irrigation System

a. Adaptable to a wide range of field circumstances
b. Water distribution that is uniform and efficient
c. Land loss is reduced, which means more land is available for cultivation
d. Water loss is kept to a minimum

e. Measurement of distributed water that is accurate and simple
f. Water-soluble fertilizers, herbicides, and fungicides may be added to water before being distributed to crops, which saves time and money
g. In the majority of situations, portable
h. Easy to operate

6. Central Pivot Irrigation

In the center pivot system, sprinklers are placed along a series of arched pipes which is pivoted at one end, and moved around the field in a circular fashion. Central pivot irrigation is a form of overhead (sprinkler) irrigation consisting of several segments of pipe (usually galvanized steel or aluminum) joined together and supported by trusses, mounted on wheeled towers with sprinklers positioned along its length. The system moves in a circular pattern and is fed with water from the pivot point at the center of the circle. The outside set of wheels sets the master pace for the rotation. Centre pivots will cover surface in relation with the number of arches and supporting tower up to 500m in length (circle radius) with widely used size being the standard quarter mile machine (400m) covering 125 acres.

Most center pivot systems are equipped with drops hanging from a u-shaped pipe called a gooseneck attached at the top of the pipe with sprinkler heads positioned a few feet (at most) above the crop, limiting evaporation losses and wind drift. Drops can also be used with drag hoses or bubblers that deposit the water directly on the ground between crops. This type of system is known as LEPA (Low Energy Precision Application) and is often associated with the construction of small diking along the furrow length.

Crops may be planted in straight rows or sometimes in circles to conform to the travel of the center pivot in crops like cotton. Movement of each tower is secured by either hydraulically driven systems or electric motor-driven systems mounted at each tower, and specific tyre dimension can be fitted to specific soil profile.

AGRONOMIC PRACTICES FOR WATER CONSERVATION

1. Raised Bed Planting

About 40% of irrigation water is wasted in the fields during its application due to conventional methods of irrigation such as flat basins or inappropriate sizes of the furrows resulting into loss of precious water, nutrients, energy resulting into overall low water productivity. This precious irrigation water can be saved and crop yields can be increased by growing crops on raised beds using a bed planter.

Salient features of the bed Planter

- Bed and Furrow sizes can be adjusted for individual crop
- Seed and fertilizer rate can be adjusted as per requirements
- Bed planter can be operated by a common tractor operator

Benefits of Bed Planting for Wheat Crop

- Water saving from 30 to 50%
- Yield Increase upto 25%
- Higher water and Fertilizer use efficiencies
- Less weeds and less lodging of the standing crop
- Easy crop harvesting

Sugarcane inter cropping with Wheat:

Additional benefits can be obtained by inter cropping sugarcane with wheat crop such as:

- Increase in crop intensity
- Less Fertilizer requirement
- Less cost of production
- Water saving for both crops
- Less weed infestation in sugarcane

Benefits of bed planting for maize:

- Water saving from 30 to 50%
- Increase in yield from 10-30% due to better plant density
- Higher water and fertilizer use efficiencies
- Less weeds in the standing crops

Benefits of bed planting for cotton:

- Water saving up to 30 to 50%
- Increase in crop yield from 10 to 20%
- Higher water and fertilizer use efficiencies
- Better drainage of water during rainy season

Benefits of bed planting for rice:

- Increase plant density resulting in 20-25% higher yields
- Water saving from 20 to 30%
- Energy and labor efficient
- No need of Puddling
- Less lodging of standing crop
- Improve grain size

2. Precision Land Leveling

Precision Land Leveling (PLL) is a farming technique that involves the mechanical process of grading and smoothing land to achieve a uniform and precise plane surface. This technique is becoming increasingly important in the face of water scarcity, as it allows for more efficient utilization of available water resources and can improve water productivity at the farm level.

The traditional method of PLL involves using bucket type soil scrapers and tractor mounted rear blades, but this process can be laborious and expensive. To overcome these challenges, new technologies have been developed to streamline the PLL process, such as laser-guided grading systems that use GPS to achieve precision and accuracy in land leveling. One of the main benefits of PLL is that it can help to reduce water consumption by ensuring that water is distributed evenly across the land surface, thus minimizing runoff and increasing infiltration. This can lead to significant water savings and improved crop yields.

Benefits of Precision Land Leveling with LASER Technology

Precision Land Leveling using LASER technology has several benefits that have been proven through impact assessment studies. The use of this technology reduces the cost of land preparation, saves irrigation water, and increases crop yields. LASER technology ensures a high degree of accuracy in a shorter amount of time compared to traditional land leveling methods, resulting in cost savings for farmers. Uniform land surfaces improve seed germination and increase fertilizer use efficiency, resulting in improved crop yields.

An impact assessment study carried out by PIPIP Monitoring and Evaluation Consultants in 2018 revealed that Precision Land Leveling using LASER technology resulted in a 25% water saving, 23% improvement in crop yield, 11% enhancement in fertilizer use efficiency, and 18% saving in farm labor. This translates to an annual net revenue generation of PKR 410,000 and an Economic Internal Rate of Return (EIRR) of 29.6%. Overall, LASER Land Leveling technology offers a range of benefits that can improve the efficiency and productivity of agriculture. Here are some of the key benefits:

- **Minimizes cost of operation:** LASER Land Leveling reduces the cost of land preparation by reducing the amount of soil that needs to be moved. This results in significant cost savings for farmers.
- **Ensures better accuracy in less time:** With LASER technology, land leveling can be completed with a high degree of accuracy in much less time than traditional methods. This saves time and resources for farmers.
- **Saves irrigation water:** Precision Land Leveling reduces water application losses and increases the efficiency of water use. This saves irrigation water and reduces the cost of water for farmers.
- **Uniform seed germination:** By creating a uniform land surface, Precision Land Leveling ensures that seeds are planted at a consistent depth, resulting in uniform seed germination and better crop establishment.
- **Increases fertilizer use efficiency:** With a uniform land surface, fertilizer can be applied more evenly, resulting in better uptake of nutrients by plants and increased fertilizer use efficiency.
- **Enhances crop yields**: Precision Land Leveling has been shown to increase crop yields by up to 23 percent, according to an impact assessment study carried out by PIPIP Monitoring and Evaluation Consultants.
- **Saves farm labor:** Precision Land Leveling reduces the need for manual labor, which results in cost savings for farmers and improves efficiency.
- **Gateway to mechanization:** Precision Land Leveling using LASER technology is a precursor for on-farm water management (OFWM) interventions and other mechanization technologies in agriculture.

Overall, LASER Land Leveling technology offers a range of benefits for farmers and agricultural practitioners, including cost savings, time savings, and improved water use efficiency, and increased crop yields.

PRACTICAL STEPS FOR RESOLVING WATER SCARCITY IN PAKISTAN

I. Policy, Reforms and Governance

There is a need to fill the vacuum between policies, reforms and their implementation by devising a detailed implementation plan. The government needs to institute a major paradigm shift that promotes the more judicious use of water. This will include water infrastructure maintenance, water conservation technologies and awareness-raising. Develop and implement comprehensive water management policies that address the equitable distribution of water resources among different sectors, considering both rural and urban needs. The entire political leadership and relevant stakeholders need to take ownership of the challenge of Pakistan's water crisis and declare their intention to address it. All stakeholders need to take ownership of this challenge and declare their intention to tackle it.

II. Recycling of Wastewater

The policy-makers need to rethink water policy by urging recycling of wastewater as is done in Israel and Singapore based on the principle of private sector participation and optimal pricing of water. Israel, which was water-deficient with 70 percent desert, has achieved water security by treating and reusing around 90 percent of its wastewater, primarily for irrigation, meeting around one-quarter of the country's demand for water. Similarly, Singapore – another water-scarce country – is meeting 40 percent of its water demand from recycled wastewater which is expected to reach 55 percent by 2060.

III. Increase Agricultural Efficiency of Water

It is key to leverage technology for efficient water utilisation, however, it is also crucial to choose the right innovation so it delivers the desired solution that is needed. Farmers can use precision watering rather than flooding their fields. Similarly, water-intensive crops as sugar cane and rice may be replaced with lower water demanding crops. Promote the adoption of modern and water-efficient irrigation methods, such as drip and sprinkler systems, to reduce water wastage in agriculture. Invest in the rehabilitation and maintenance of existing irrigation infrastructure to minimize losses during water distribution.

Encourage the use of climate-resilient crop varieties and farming practices to enhance agricultural productivity under changing climatic conditions. Promote agroforestry and conservation agriculture practices to improve soil health and water retention.

IV. Water Metering/Pricing

Another solution is making the metering of water compulsory for all users from domestic, agriculture or industrial units. Once the amount of utilisation is known, it enables better planning and management of the precious resource. The current pricing regime offers little incentive to consumers to conserve water. Pricing may be linked with income levels along with several other dimensions. Increasing the cost of water consumption will not only push consumers to use water more judicially but also generate sufficient revenues for the maintenance of infrastructure and water-conserving technologies.

V. Investment in Water Infrastructure

Upgrade and expand water storage facilities, including reservoirs and dams, to enhance the country's capacity to capture and store water during periods of abundance for use during shortages. Improve urban water supply and sanitation infrastructure to reduce leakages and ensure efficient water delivery. Rainwater harvesting systems may be promoted at individual and community levels to capture and store rainwater for various uses, reducing dependence on conventional water sources.

Implementation of sustainable groundwater management practices, including monitoring and regulation of groundwater extraction, to prevent over-exploitation and depletion of aquifers is very crucial. Encourage the recharge of aquifers through artificial means such as percolation ponds and recharge wells.

VI. Community Engagement

Involve local communities in water management and conservation efforts, fostering a sense of ownership and responsibility. Raising awareness about the importance of water conservation through education campaigns and community outreach programs will provide fruitful results.

VII. Research, Innovation & International Cooperation

Support research and development initiatives focused on water-efficient technologies, crop varieties, and sustainable water management practices. Encourage the adoption of innovative solutions such as smart water meters, sensor technologies, and precision agriculture. There is a dire need to seek assistance from international organizations and donors to fund and implement large-scale water projects and infrastructure development.

By combining these practical steps with a holistic and integrated approach, Pakistan can make significant strides toward resolving its water scarcity issues and ensuring a sustainable water future.

ROLE OF ZTBL IN OVERCOMING WATER SCARCITY CHALLANGE

Recognizing that over 95% of Pakistan's water is consumed by the agricultural sector, ZTBL acknowledges the pressing need for optimized water management practices. Inefficient water usage has been a longstanding challenge, contributing to the urgency of implementing effective solutions. Zarai Taraqiati Bank Limited (ZTBL) has taken a proactive role in addressing the critical issue of water scarcity in Pakistan through a recent initiative that focuses on financing the establishment of high-efficiency irrigation systems. The initiative is a strategic response to the challenges faced by the agricultural sector, particularly in the context of Pakistan's arid climate and the looming threat of absolute water scarcity.

1. Promotion of Sustainable Farming Practices and capacity building:

ZTBL may collaborate with agricultural extension services to educate farmers about sustainable farming practices that conserve water through its Zarai Baithaks. This may include promoting crop diversification, agroforestry, and organic farming methods that optimize water usage and reduce dependence on water-intensive crops. Capacity building of farmers on water management techniques will enhance their knowledge and skills and empower farmers to make informed decisions regarding water usage.

2. Collaboration with Government and Agriculture institutes on water management:

ZTBL can actively collaborate with government agencies and agricultural institutes already working on water conservation initiatives. By pooling resources and expertise, the bank can contribute to larger-scale projects aimed at improving water availability and management in agricultural regions.

3. Financing Scheme for High Efficiency Irrigation System:

Due to finite supply of surface water, around 2.5 million farmers of our country make use of ground water extracted through tubewells, to meet the irrigation demands of their crop. Keeping in view the water scarcity issue, ZTBL has introduced a comprehensive financing scheme designed to incentivize the adoption of renewable energy, specifically solar power, for irrigation purposes. Through connecting high efficiency irrigation systems with solar energy systems, farmers can achieve high water use efficiency, energy efficiency and most important to the farmer, cost-efficiency.

The primary focus is on the implementation of solar-powered tube wells and drip irrigation systems. This strategic shift toward sustainable and efficient irrigation practices aligns with global efforts to address water scarcity and reduce the environmental impact of conventional agricultural practices. The scheme targets creditworthy and reputable rural individuals with the capacity to repay the loans all over Pakistan. It includes loan for solar tubewell, installation of Drip Irrigation system and establishment of water reservoir/mini-dam for water storage. Moreover, technical knowledge of solar energy pumps and drip irrigation systems is considered essential for potential borrowers. The emphasis on renewable energy sources reflects a commitment to environmentally friendly and economically viable solutions.

CONCLUSION

Pakistan is characterized by water scarcity, with a per capita availability considerably below global averages, exacerbated by rapid population growth and urbanization. The unequal distribution of water resources among provinces has led to regional disparities and potential inter-provincial conflicts. Agriculture, a cornerstone of Pakistan's economy, places immense pressure on water resources, yet outdated irrigation systems and the cultivation of water-intensive crops contribute to inefficient water usage. Groundwater depletion, driven by over-extraction, poses a threat to aquifers, impacting long-term water sustainability. Water quality issues stemming from industrial discharges, agricultural runoff, and inadequate sanitation further compound the crisis, posing risks to human health and ecosystems. Climate change, including altered precipitation patterns and glacial melt, exacerbates the variability in water availability. Inadequate water storage infrastructure, governance challenges, and disparities between rural and urban water access add further dimensions to the issue.

The pressing issue of water scarcity demands immediate attention and concerted efforts to ensure the sustainability of agriculture. The profound impact of water scarcity on crop yields and food security underscores the urgency of comprehensive solutions. Financial institutions like ZTBL have a crucial role in addressing this challenge. By introducing innovative financial products, supporting technological advancements, and collaborating with various stakeholders, banks can contribute significantly to water-efficient practices in agriculture. The integration of smart irrigation systems and precision farming, coupled with community-based projects and educational initiatives, emerges as a holistic approach. Empowering local communities and fostering environmental and social responsibility are integral aspects of any strategy aimed at mitigating water scarcity. Overall, a proactive and collaborative approach, considering both immediate agricultural concerns and broader environmental and social impacts, is imperative for building a sustainable and resilient future in the face of water scarcity.

It is the need of an hour to establish and enforce regulations related to water usage in agriculture. This may include setting standards for water quality, regulating groundwater extraction, and monitoring compliance with sustainable water practices to ensure accountability within the agricultural sector. Government should establish robust monitoring systems to track water usage, assess the impact of policies, and identify areas for improvement.

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