



Innovating Water Governance in a Changing Climate in Pakistan

Knowledge Product for Climate Smart and Sustainable Water Supply Service Delivery Model

Catalyzing progress toward universal access to safe water – SDG 6.



MESSAGE FROM THE CEO, PSPA

Punjab Saaf Pani Authority is proud to present the Climate Resilient and Sustainable Safely Managed Water Supply Service Delivery Model—a pioneering initiative that redefines how equitable, safe, and resilient water services can be delivered in a changing climate, with sustainability at its core. This model is the result of collaborative innovation, deeply rooted in local realities and aligned with global aspirations. It integrates climate resilience, inclusive governance, robust



operation and maintenance mechanisms, and system-wide sustainability. This operational cost recovery & community ownership model is a commendable pilot project, which has the possibility of scale-up after adequate monitoring and evaluation.

This model reflects our commitment to the Government of Punjab's vision for sustainable water services for all and contributes meaningfully to Pakistan's progress toward Sustainable Development Goal 6. As climate change continues to challenge water security, PSPA remains steadfast in its mission to lead transformative solutions that empower communities, strengthen systems, and safeguard future generations.

We believe that by prioritizing equity, accountability, and long-term sustainability, this model offers a replicable framework for districts across the province and beyond. We deeply value the joint efforts of AGAHE and Welthungerhilfe (WHH), whose technical support and field-level engagement have been instrumental in shaping this model. Their contributions exemplify the power of collaborative innovation in advancing WASH systems and driving sector reforms in Punjab, Pakistan.

Mr. Naveed Ahmad
Chief Executive Officer
Punjab Saaf Pani Authority (PSPA)

Acknowledgement

MESSAGE FROM THE DIRECTOR GENERAL – PROJECTS

The development of the **Climate Resilient and Sustainable Safely Managed Water Supply Service Delivery Model** marks a significant milestone in our efforts to reform and strengthen water governance and service delivery systems in Punjab. This model encapsulates the essence of PSPA's project philosophy and directly addresses the persistent challenges that have led to the dysfunctionality of many Water Filtration Plants (WFPs) including



inadequate financial planning, weak operational mechanisms, and limited community ownership.

This model introduces **a sustainability-focused framework**, with innovative features such as the coin **vending machine-based tariff collection system**. This mechanism not only ensures financial viability for operation and maintenance but also promotes responsible water usage and conservation, critical in the face of growing climate stress and resource scarcity.

As we move forward, PSPA remains committed to scaling this model across Punjab, in alignment with the government's vision for **sustainable water services for all ensuring that no one is left behind**.

I commend the dedication of our partners AGAHE and Welthungerhilfe (WHH) and field teams whose insights and efforts have enriched this model. Together, we are setting new standards for water service delivery in Pakistan.

Mr. Aamir Khaleeq
Director General Projects
Punjab Saaf Pani Authority (PSPA)

Punjab Saaf Pani Authority gratefully acknowledges the invaluable contributions of AGAHE and Welthungerhilfe (WHH) in the conceptualization, development, and piloting of this model. Their technical expertise, community engagement, and unwavering commitment to climate-resilient WASH systems have been instrumental in shaping a model that is innovative, replicable, locally relevant and globally significant.

This partnership demonstrates the impact of collaborative action in addressing complex system and development challenges. PSPA looks forward to continued collaboration with AGAHE and WHH in scaling this model and advancing our shared mission of safe, climate resilient and sustainable water access for all.

We also extend our sincere appreciation to all the actors, including government departments, development partners and individuals whose contribution has translated this vision into reality.

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Chapter # 1

INTRODUCTION

Executive Summary

Pakistan's water sector is increasingly strained by climate variability, groundwater depletion, and service delivery inequities, particularly in rural and underserved areas. Despite ongoing efforts, conventional water supply systems often lack the resilience, inclusivity, and sustainability needed to meet the evolving challenges of the 21st century. There is a growing need for innovative models that not only deliver safely managed drinking water but also withstand climate shocks and empower communities. In response, AGAHE and Welthungerhilfe (WHH), in collaboration with key government departments including Punjab Saaf Pani Authority, Public Health Engineering Department, Punjab Rural Municipal Service Company, and LG&CD Department have conceptualized and demonstrated a **Climate Resilient and Sustainable Safely Managed Water Supply Service Delivery Model** under the WASH System Strengthening Program in Pakistan.

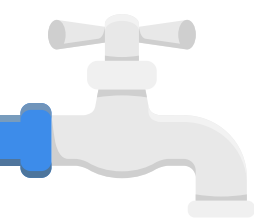
This knowledge product for this Water Supply Service Delivery Model presents a forward-looking framework that redefines how safely managed drinking water services can be delivered through a lens of climate resilience, technological innovation, and community-led governance. This Model is designed not merely as a field intervention but a scalable model to inform policies, national and provincial strategies, guide investments, and inspire replication.

At the heart of the model is a solar-powered water filtration plant, advanced treatment technologies, real time digital monitoring through PLC Based SCADA System. The key component of the model is a community-friendly Coin Vending Machine for Tariff Collection Mechanism that ensures affordability, promotes conservation and supports financial sustainability. These features are not just technical solutions, they represent a paradigm shift toward resilient, transparent, and financially sustainable service delivery. The model is grounded in participatory design, with communities actively engaged in planning, operations, and oversight, fostering transparency, ownership, and long-term viability.

This knowledge product distills the Water Supply Service Delivery Model's strategic relevance, operational architecture, and enabling conditions for scale up. It speaks to decision-makers, donors, and sector leaders seeking actionable pathways to achieve SDG 6 and climate adaptation goals. It also contributes to the global discourse on WASH systems strengthening by showcasing how localized innovation can inform broader policy and programming.

By documenting this Model, we aim to elevate a replicable solution that bridges the gap between grassroots innovation and high-level systems transformation. It is a call to action for integrating climate resilience into water governance, not as an add-on, but as a foundational principle for sustainable development.

1.1- PURPOSE OF THE KNOWLEDGE PRODUCT



This knowledge product has been developed to serve as a strategic learning and advocacy tool that elevates a locally demonstrated water service delivery model into the national and provincial policy space. It aims to showcase how climate resilience, inclusive governance, and sustainable operation and maintenance (O&M) arrangements can be effectively integrated into water systems to ensure long-term service continuity and equity to leave no one behind.

The product is designed to:

01

Inform Policy and Strategic Planning

By offering a replicable framework for climate-resilient and safely managed drinking water services.

02

Support Investment Decisions

By demonstrating the financial viability and sustainability of community-led O&M mechanisms.

03

Facilitate Cross-Sectoral Dialogue

By connecting water service delivery with broader climate adaptation, public health, and development goals.

04

Contribute to National and Global knowledge exchange

By documenting a scalable model that aligns with SDG 6 and climate resilience frameworks.

It is not a technical blueprint rather it is a high-level contribution to the discourse on WASH systems strengthening, climate adaptation, and inclusive service delivery in water sector in Pakistan.

1.2-TARGET AUDIENCE

This knowledge product is designed for a strategic and multi-sectoral audience that influences water governance, climate resilience, and sustainable development in Pakistan, particularly within the provincial context of Punjab. The following groups are key to its uptake, integration, and scale-up:



1

National and Provincial Government Actors

This includes policymakers, planners, and administrators from ministries and departments such as the Ministry of Climate Change, Ministry of Water Resources, PSPA, HUD&PHED, LG&CD, and PRMSC etc. These actors are shaping water sector policies, allocating resources, and integrating climate resilience into service delivery frameworks.

2

Development Partners and Donor Agencies

Different Development Partners, UN Agencies, Donors, Civil Society Organizations International Banks that are actively supporting WASH and climate adaptation initiatives in Pakistan. This knowledge product offers them a tested, community-led model that aligns with their strategic priorities, enabling targeted investments in scalable, climate-smart water infrastructure and governance systems.

3

Water, Climate and SDG Advocates

WASH Sector Leaders, Networks, Alliances, Organizations focused on climate resilience, Water governance, environmental justice, and sustainable development, such as SDG Units, climate coalitions, and civil society platforms will find this model relevant for advocacy and policy influence. It demonstrates how localized innovation can contribute to national commitments under SDG 6 and Pakistan's Nationally Determined Contributions (NDCs).

4

Academic and Research Institutions

Academic Institutions, Universities, Think Tanks, and Research Centres in Pakistan play a critical role in generating evidence, informing policy, and training future sector actors. This knowledge product offers them a case study for applied research, curriculum development, and policy dialogue on climate-resilient WASH systems.

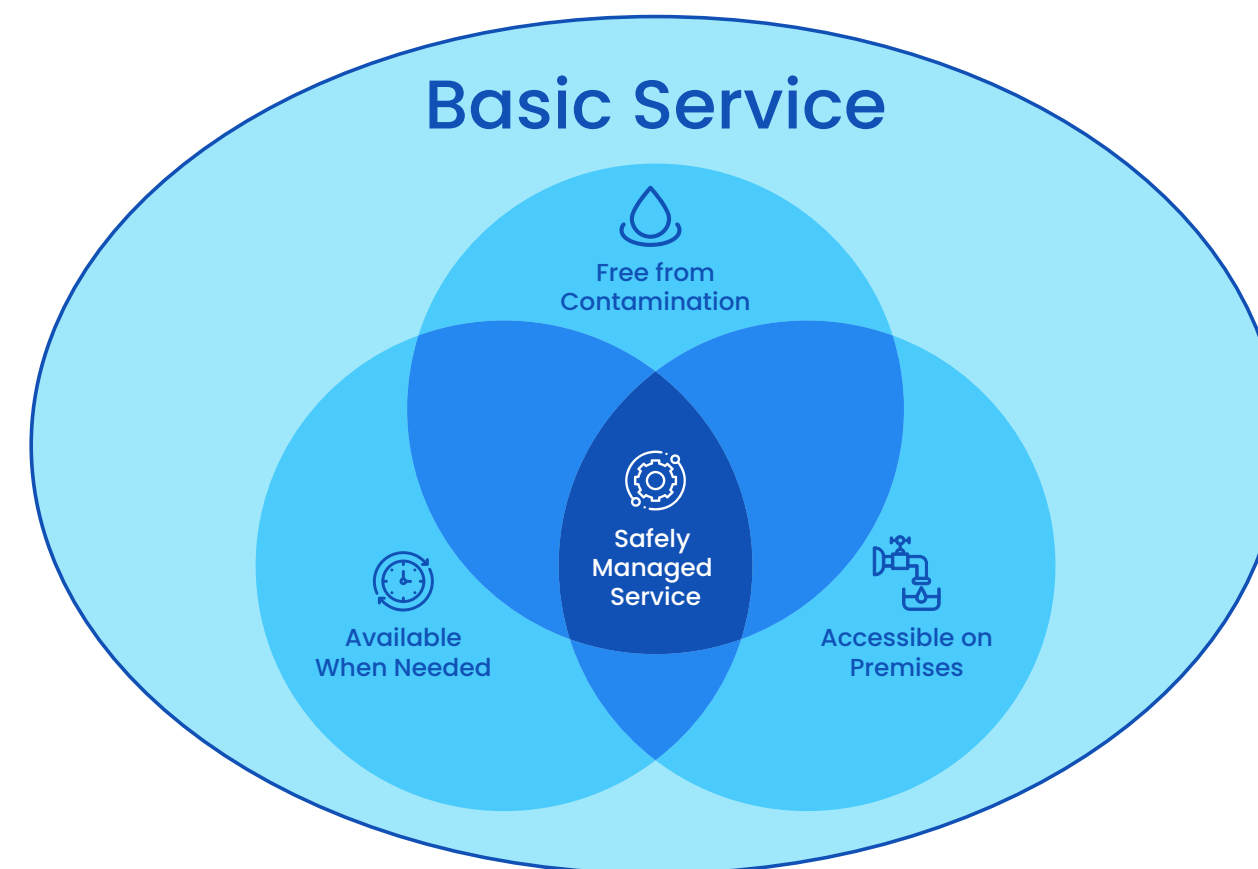
Chapter # 2

SAFELY MANAGED DRINKING WATER

GLOBAL & NATIONAL PERSPECTIVES

2- SAFELY MANAGED DRINKING WATER

According to WHO/UNICEF Joint Monitoring Programme (JMP), Safely Managed Drinking Water refers to: “Drinking water from an improved water source that is located on premises, available when needed, and free from fecal and priority chemical contamination.”¹



¹<https://washdata.org/reports/jmp-2024-country-consultation-wash-households>

2.1- NEED FOR AND IMPORTANCE OF SAFELY MANAGED DRINKING WATER

Safely managed drinking water is essential for public health, environmental sustainability, and community well-being, particularly in rural areas of Pakistan where water supply systems are often inadequate. Contaminated drinking water is a leading cause of waterborne diseases such as diarrhea, cholera, typhoid, and hepatitis, which disproportionately affect children and vulnerable populations. Ensuring access to safely managed drinking water reduces disease prevalence, lowers healthcare costs, and improves overall quality of life. Proper water management, including safe storage, treatment, and distribution, helps prevent pollutants from entering water sources, thereby preserving groundwater and surface water for future generations.

In addition to health benefits, safely managed drinking water is crucial for economic development. Communities with reliable access to clean water experience improved productivity, better educational outcomes, and enhanced livelihoods. Sustainable water supply systems create job opportunities, promote social equity, and contribute to achieving Pakistan’s long-term development objectives, particularly Sustainable Development Goal (SDG) 6: Clean Water and Sanitation for All. Investing in water safety measures not only safeguards public health but also strengthens resilience against climate change and water scarcity, ensuring a sustainable future for all.



2.2- CONTEXT ANALYSIS OF DRINKING WATER IN PAKISTAN

Access to clean drinking water is the fundamental human rights and essential for the well-being of individuals and communities. Currently, Pakistan is facing challenges regarding the provision of safely managed drinking water as despite 94% of population having access to some form of drinking water, only 50.6% have access to safely managed sources. This highlights a significant gap between basic and safe water access. Along with the challenges in access of people to clean drinking water, Pakistan is facing a severe sustainability crisis for water facilities due to different factors in governance and grassroot level. This situation underscores the significant challenges in achieving SDG 6 targets, particularly in ensuring access to safe, equitable, and sustainable water services for all.

Ensuring sustainable access to clean water services in Pakistan presents significant challenges which includes:

1. Climate Change Impacts

The country faces the constant threat of climate change impacts, such as frequent and intense floods, prolonged droughts, and changing rainfall patterns, which disrupt water supply systems and damage infrastructure.

2. Weak operation and maintenance (O&M) mechanisms

Including inadequate financial arrangements, insufficient skilled personnel contribute to the rapid deterioration of water infrastructure and services.

3. Weak Coordination

Lack of proper planning and coordination among stakeholders including government departments, development partners and communities in planning, implementation, monitoring, and sustainability results in dysfunctionality of water services.

4. Lack Tariff Collection Mechanism

The lack of robust revenue generation systems, particularly the absence of effective tariff collection, hinders the sustainability of water services by making it difficult to cover operational expenses and invest in sustaining the facilities and their upgradation.

5. Lack of Gender Responsiveness

Moreover, gender inequality exacerbates these challenges, as women and girls disproportionately bear the burden of water collection and lack access to adequate water facilities.

Punjab Context

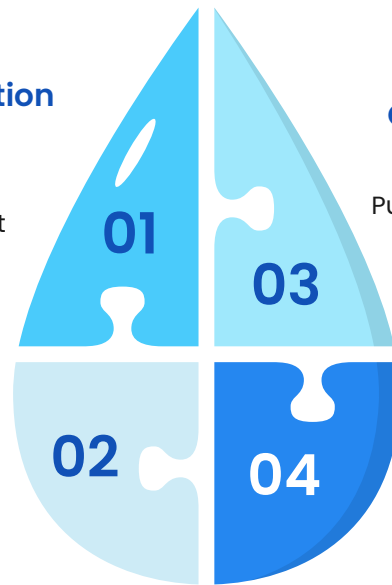
The Punjab Multiple Indicator Cluster Survey (MICS) 2024 has reported that about 99.4 percent of the provincial population uses an improved source of drinking water – 99.2 percent in urban areas and 99.7 percent in rural areas of Punjab. The Punjab MICS 2024 highlights the alarming presence of biological contamination (E. coli) in drinking water with 53.7 percent of the household population is exposed to E. coli contamination at source level and 76.7 percent contamination at the household level. Considering the SDG indicator of safely managed drinking water, defined as water sources that are on premises, free of E. coli, and available when needed, Punjab MICS 2024 reported 23.4 percent household in Punjab have access to safely managed drinking water services.

Industrial & Agricultural Pollution

Factories and agricultural runoff contaminate water with pesticides, fertilizers, and heavy metals, making it unsafe for consumption.

Arsenic Contamination

Groundwater in many districts of Punjab has dangerously high arsenic levels, posing severe health risks such as cancer and kidney diseases.



Over-Extraction of Groundwater

Due to intensive irrigation and overuse, Punjab's groundwater levels are depleting rapidly, leading to water shortages.

Aging Water Supply Infrastructure

Many water filtration plants and supply schemes are non-functional due to poor maintenance, leaving communities reliant on untreated water.



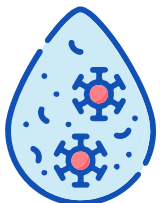
Muzaffargarh Context

Muzaffargarh, situated between the Chenab and Indus rivers, is one of Punjab's most water-stressed Muzaffargarh, despite its proximity to two major water bodies, faces a severe water crisis due to high contamination levels, inadequate sanitation, and limited access to safe drinking water. Seasonal flooding further exacerbates the situation by contaminating drinking water sources and facilitating the spread of pollutants, while climate change-induced rising temperatures and shifting rainfall patterns are making water availability increasingly unreliable. The district's water infrastructure is critically inadequate, with over 60% of water supply schemes reported as non-functional due to insufficient maintenance, lack of funding, and technical deficiencies (PCRWR, 2023). At the district level, Punjab MICS 2023–24 indicates that 89 percent of households in Muzaffargarh district rely on tubewells or boreholes as their primary sources of drinking water, followed by piped water at 9.7 percent. Punjab MICS 2023–24 reveals that only 43 percent of water samples collected at the source level in district Muzaffargarh are free from biological contamination, while just 22.9 percent of water samples at the household or consumer level are without E. coli. The comparison of Punjab MICS 2018 with the recently published in 2024 indicate that percentage of safely managed water in Muzaffargarh district has declined by more than half, from 62.9 percent in 2017–18 to 33.6 percent in 2023–24. Additionally, basic water services have experienced a slight decrease, with coverage dropping from 99 percent of households in 2017–18 to 98.2 percent in 2023–24.



Risks Associated with Unsafe Drinking Water:

Unsafe drinking water poses significant health risks, including:



01

Waterborne Diseases

Contaminated water is a primary source of cholera, dysentery, and other diarrheal diseases, leading to severe dehydration and malnutrition, particularly among children.



02

Bacterial and Viral Infections

Consumption of polluted water increases the risk of infections such as typhoid, hepatitis A, and E. coli-related illnesses.



03

Parasitic Infections

Unsafe drinking water can harbor parasites, leading to intestinal worm infections, schistosomiasis, and other chronic health conditions.



04

Chemical Contamination

Exposure to toxic substances such as arsenic, fluoride, and heavy metals can cause long-term health effects, including organ damage, developmental disorders, and increased cancer risks.



05

Stunted Growth

Repeated exposure to contaminated water can lead to nutrient deficiencies, impairing physical and cognitive development in children.



06

Increased Rates

Unsafe drinking water significantly contributes to child mortality and weakens immune responses, making populations more vulnerable to other infections and diseases.

Ensuring access to clean and safe drinking water is essential for protecting public health and preventing the spread of life-threatening diseases.

Global & National Perspectives

2.3.1- Global Perspective

Access to safely managed drinking water is a cornerstone of sustainable development and human dignity. Pakistan through the Sustainable Development Goals has committed to achieving universal and equitable access to safe and affordable drinking water by 2030. However, progress remains uneven, particularly in climate-vulnerable regions.

This model contributes to the global WASH discourse by offering a climate-resilient, community-led, and technologically enabled solution that addresses both service delivery and sustainability. It aligns with key global frameworks including:



SSDG 3: Good Health and Well-being

The model ensures access to clean drinking water, reducing waterborne diseases and improving public health, especially in vulnerable communities.



SDG 5: Gender Equality

By providing nearby, safe water access and involving women in planning, implementation, O&M committees, sustainability planning, the model reduces the burden on women and promotes their leadership in water governance.



SDG 6: Universal Access to Safely Managed Drinking Water

Directly contributes to SDG 6.1 by demonstrating a scalable approach to delivering safe, affordable, and reliable drinking water in underserved and climate-vulnerable communities. It goes beyond basic access by ensuring water quality, availability, and sustainability through advanced treatment technologies, solar energy, and community-led operation and maintenance.



SDG 11: Sustainable Cities and Communities

Supports climate-resilient infrastructure and decentralized service delivery, strengthening sustainability and inclusivity in rural and peri-urban communities.



SDG 13: Climate Action through Adaptive Infrastructure

It supports SDG 13 by embedding climate adaptation into water service delivery at the grassroots level. By integrating solar-powered systems, climate-resilient civil structures, and real-time digital monitoring, the model offers a practical example of adaptive infrastructure that reduces carbon footprint and enhances service continuity during climate shocks.

Sendai Framework for Disaster Risk Reduction

The Sendai Framework emphasizes the importance of strengthening resilience in essential services, including water supply. This model contributes by building community capacity, ensuring redundancy in energy systems, and enabling real-time monitoring to anticipate and respond to service disruptions. It enhances local preparedness and reduces vulnerability to water-related disasters, aligning with the framework’s goals of risk-informed development.

UNFCCC and Pakistan’s Nationally Determined Contributions (NDCs)

Pakistan’s NDCs under the UNFCCC highlight the need for climate-resilient infrastructure and community-based adaptation. This model operationalizes those commitments by demonstrating how low-emission technologies, inclusive governance, and resilient service delivery mechanisms can be integrated into local systems. It provides a tangible pathway for achieving climate goals while improving water access and equity for all.

2.3.2 – National Perspective: Policy Frameworks

The Climate Resilient and Sustainable Safely Managed Water Supply Service Delivery Model is firmly anchored in Pakistan’s evolving policy landscape, which increasingly emphasizes climate adaptation, decentralized governance, and sustainable service delivery.

This model aligns with and supports the operationalization of several key frameworks:

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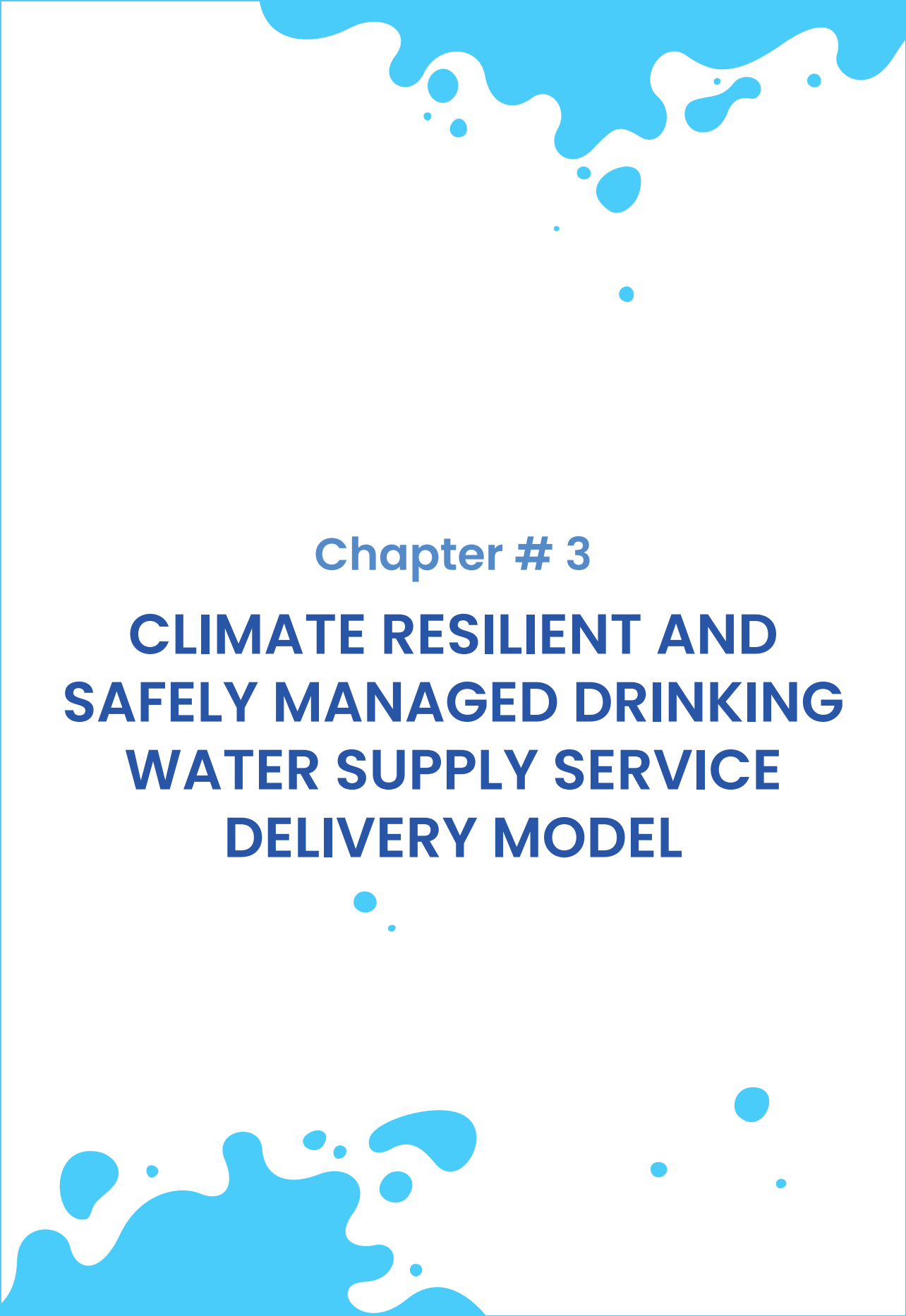
National Water Policy
This policy outlines the need for integrated water resource management, equitable access of clean drinking water, improved service delivery mechanisms and climate-resilient infrastructure across urban and rural areas.
- 

Pakistan Climate Change Policy
Emphasizes climate adaptation in water infrastructure, promoting low-carbon technologies and resilience-building in vulnerable communities.
- 

Pakistan’s Nationally Determined Contributions (NDCs)
Commit to enhancing climate resilience in water systems and reducing emissions through sustainable infrastructure and community-based adaptation strategies.
- 

Punjab Saaf Pani Authority Act 2024
Emphasizes service delivery standards, quality assurance, and coordination among stakeholders. The Act also supports public-private partnerships, community engagement, and monitoring mechanisms to improve transparency and sustainability in water supply systems.
- 

Punjab’s WASH Sector Development Plan (2022–2030) and Climate Action Plan
These frameworks emphasize expanding safely managed water services, strengthening governance and institutional capacities, promoting climate adaptation, risk-informed planning, encouraging community participation in operation and maintenance to ensure long-term functionality and equity.



Chapter # 3

CLIMATE RESILIENT AND
SAFELY MANAGED DRINKING
WATER SUPPLY SERVICE
DELIVERY MODEL

3.1- CLIMATE RESILIENT & SAFELY MANAGED DRINKING WATER SUPPLY SERVICE DELIVERY MODEL

AGAHE and Welthungerhilfe (WHH) in collaboration with Punjab Saaf Pani Authority (PSPA) and close consultation with PSPA, PRMSC, HUD&PHED and LG&CDD has developed "Climate Resilient and Safely Managed Drinking Water Supply Service Delivery Model" as a practical and scalable solution to address persistent challenges in water access, quality, and sustainability in climate-vulnerable regions of Punjab. This model is developed as demonstration to the government and nongovernment stakeholders for adoption and scaling up for responding to the growing need for service delivery systems that are not only technically sound but also socially inclusive, environmentally adaptive, and financially sustainable.

This model offers a comprehensive, community-cantered solution for reliable access to clean drinking water in climate-vulnerable settings. It is designed to be environment friendly, technologically advanced, and operationally sustainable, ensuring long-term functionality through robust operation and maintenance (O&M) arrangements.

Snapshot of features:

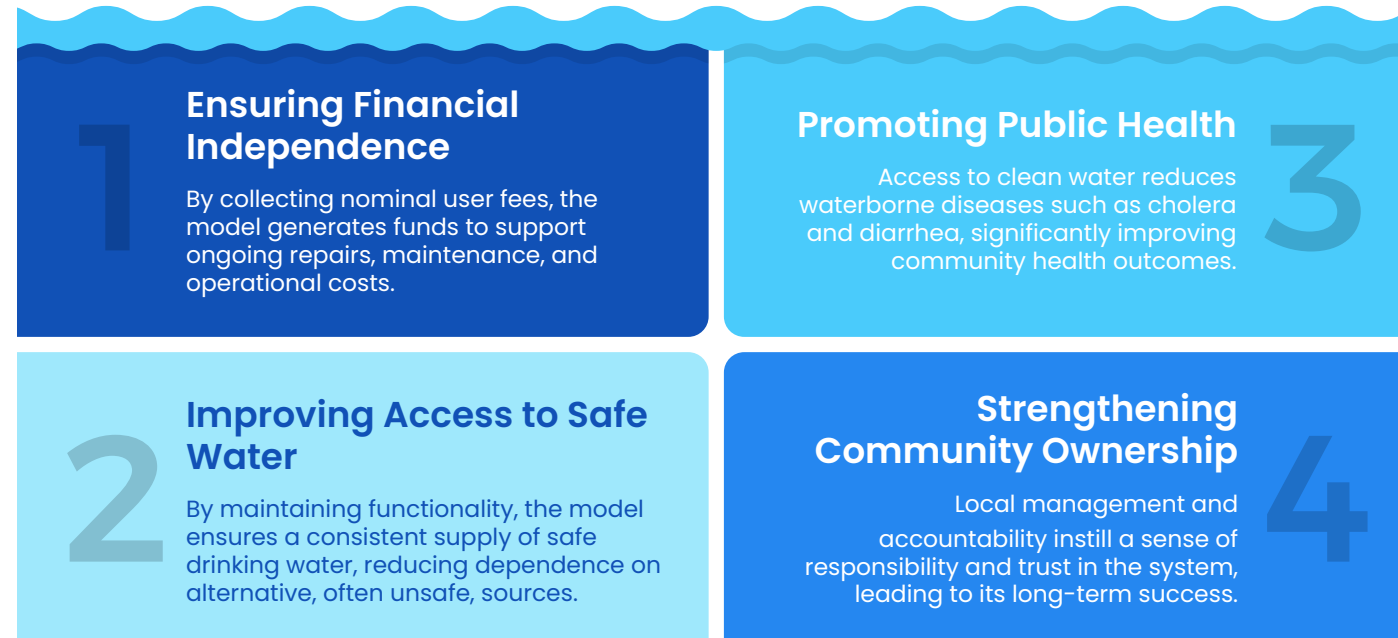
- A 1000-liter/hour water filtration capacity using multi-stage treatment technologies.
- Climate-resilient infrastructure with inclusive and appealing design.
- Integration of green energy solutions through solar power.
- Real-time monitoring and performance tracking via PLC based SCADA systems.
- A community-managed governance structure for transparency and accountability.
- A coin vending machine-based tariff collection mechanism to support financial sustainability.
- A structured O&M and sustainability plan to ensure service continuity.

This model represents a practical and scalable approach to delivering safely managed drinking water, aligned with climate adaptation and inclusive development goals.



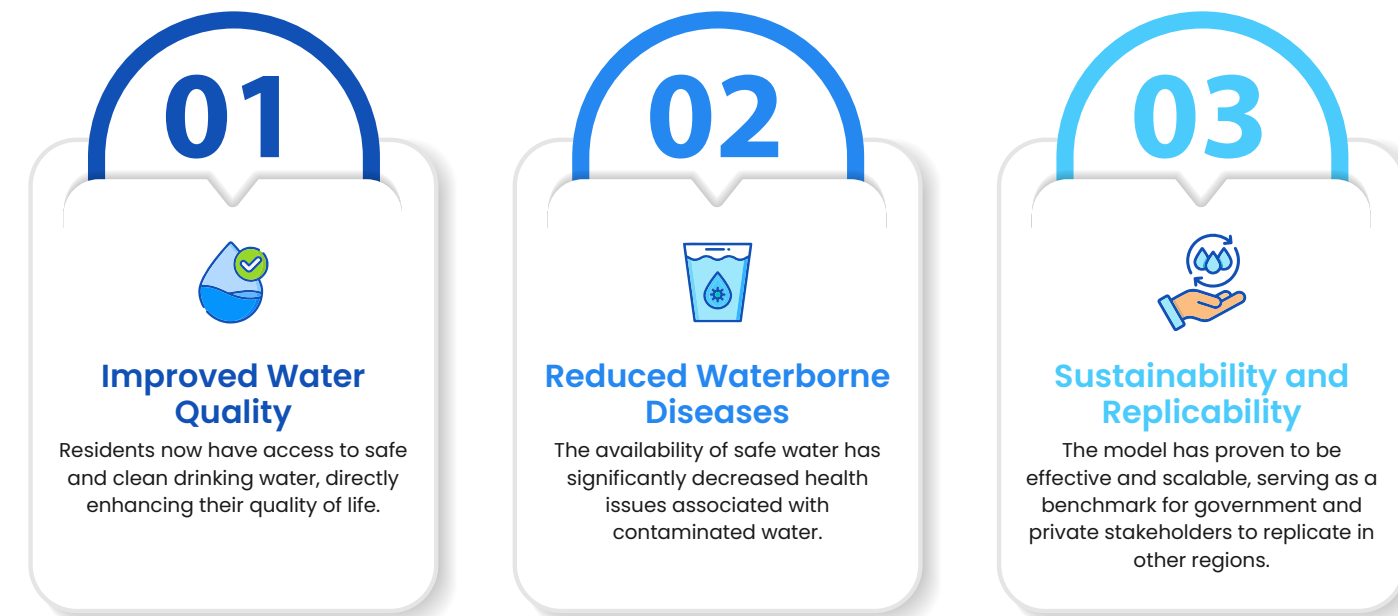
3.1.1- Need for and Importance of Model

The demand for clean drinking water in regions like Muzaffargarh is significant due to the scarcity of contaminated water sources. Many existing water filtration facilities have become non-functional because of insufficient funds for operations and maintenance. The WFP Model addresses these challenges by:

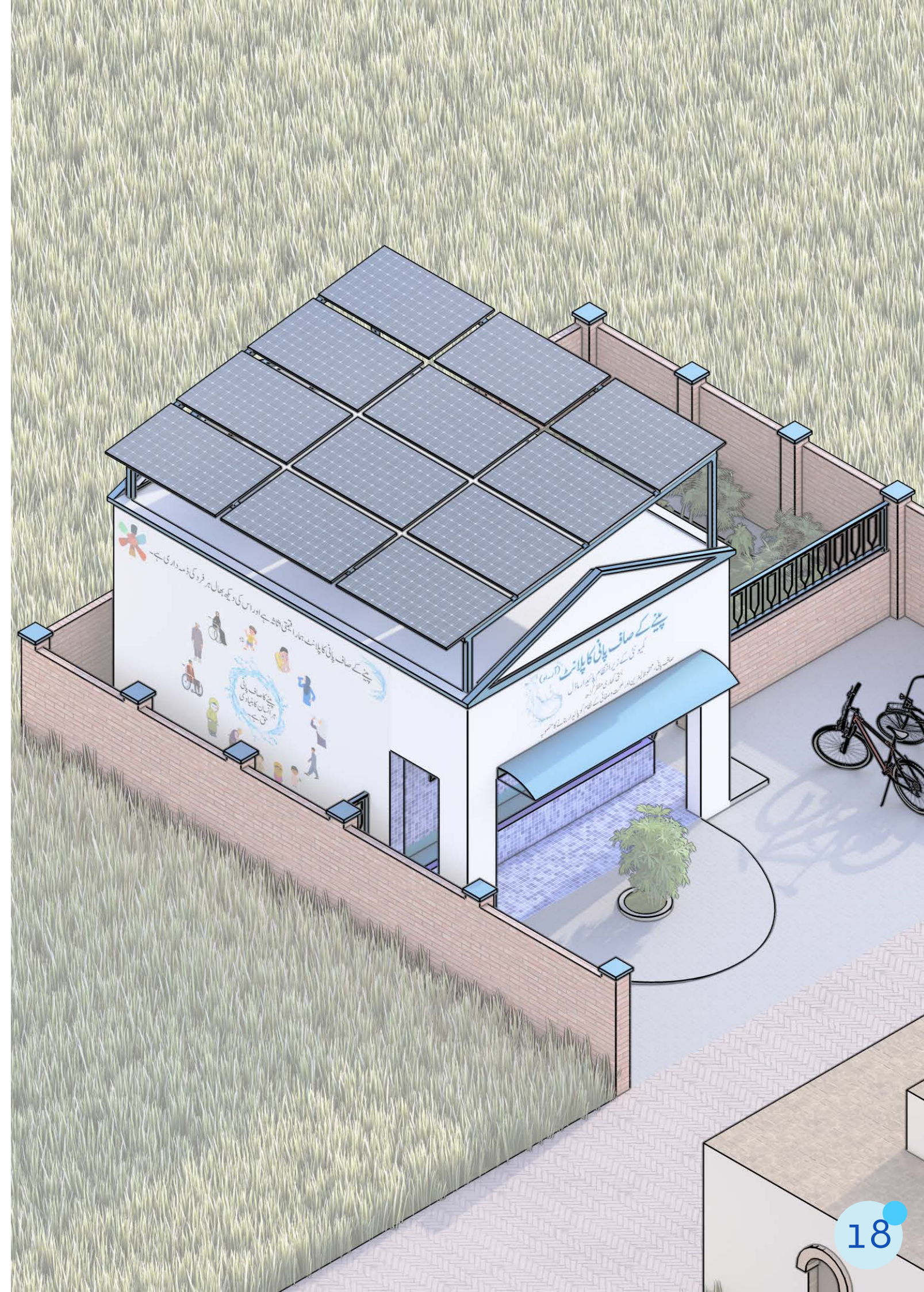


3.1.2- Impact of the Service delivery model

AGAHE's implementation of the service delivery model for drinking purpose in communities such as Basti Jalal Abad, Basti Khari, and Basti Mondka has yielded remarkable results:



The WFP service delivery model exemplifies a sustainable, community-driven solution to addressing water challenges, ensuring long-term benefits for both public health and environmental sustainability.



3.2- FEATURES OF THE MODEL

- 1 Approved Drinking Water for Human Consumption**
The water provided by the plant undergoes a rigorous multi-stage filtration process to ensure it meets the highest safety standards. It is tested and approved by relevant health authorities, making it safe for human consumption.
- 2 Innovative Water Filtration Technology**
The plant uses a sophisticated multi-stage filtration system, including sand, carbon, and cartridge filters, followed by reverse osmosis and UV treatment. This ensures that the water is free from contaminants, providing high-quality, potable water.
- 3 Coin-Operated Vending Machines**
Coin-operated vending machines are installed to provide users with easy access to drinking water, allowing for convenient payment and generating revenue to support the plant's maintenance and operational needs.
- 4 Expert Operation and SCADA Systems**
The plant operates under the guidance of skilled professionals, using SCADA systems for real-time monitoring and control. This allows for efficient operations and immediate response to any issues, ensuring optimal performance at all times.
- 5 Climate Resilient Structure**
The plant is constructed with climate-resilient materials, ensuring durability in extreme weather conditions. Boundary walls are built to add extra security and resilience, with the plant positioned at an elevated height to reduce the risk of flooding and other environmental challenges.
- 6 Solar Energy Powered**
A 6-kilowatt solar power system powers the plant, reducing dependency on traditional energy sources. Deep-cycle batteries are included to store energy, ensuring the plant remains operational even during low sunlight periods, thus supporting sustainability.

- 7 Plantation Area and Green Space**
The WFP infrastructure includes a plantation area that contributes to environmental sustainability, enhancing the site with greenery and helping to reduce the carbon footprint while providing a more pleasant
- 8 Accessible Parking and Inclusive Design**
The plant features ample parking spaces and is designed with accessible ramps and stairways that meet standard heights, ensuring that people with disabilities can easily access the site. This focus on inclusivity supports the overall functionality of the plant.
- 9 Wide Access Gates**
Wide in-and-out gates are designed to allow smooth movement for pedestrians. These gates help facilitate easy flow and efficient operations, ensuring timely access for deliveries, staff, and maintenance.
- 10 Space Accessible and Efficient Design**
The plant is designed with a proper social feasibility to ensure easy access to the community members for efficient operations and adaptability. The layout allows easy movement and accessibility, making it user-friendly for both operators and visitors.
- 11 Efficient Water Management**
Advanced water storage and drainage systems are integrated to optimize water usage, minimize waste, and ensure a sustainable water supply. These systems are essential for maintaining effective water treatment and ensuring the availability of clean water.
- 12 Sustainable Community Engagement**
The plant involves the local community through educational programs and awareness campaigns, encouraging responsible water use and ensuring the long-term sustainability of the facility. This community engagement helps to catalyze the sense of ownership and support.

3.3- DESIGNING & CONSTRUCTION OF SAFELY MANAGED WATER SUPPLY SERVICE DELIVERY MODEL.

This service delivery model has been developed by following the key steps outlined below:

01. Process for filtration technology designing

02. Developing capacity of the filtration plant

03. Designing of Civil Work

04. Solar System Designing

05. Incorporation of Emerging New & Innovative Technologies

06. Development of Drawing, Design & BOQ's.

07. Construction of the Water Facility.



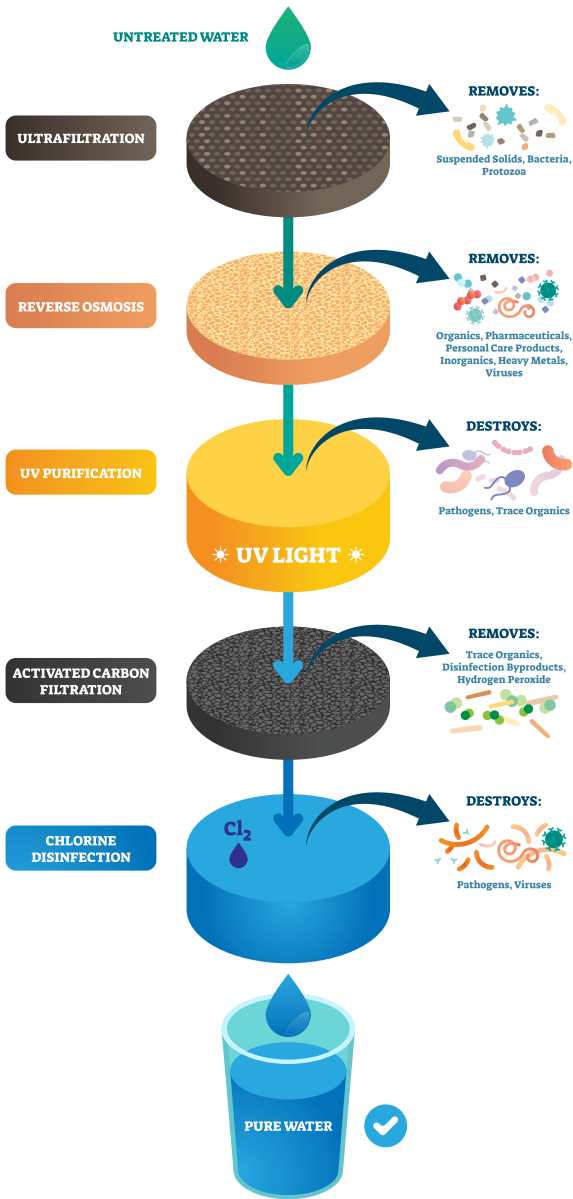
3.3.1- Process for filtration technology designing

Pre water Quality testing of Ground water:

To design the filtration technology for the water filtration plant in Basti Jalal Abad, groundwater quality testing was conducted to identify contaminants and determine the appropriate treatment process. The Community-Based Organization (CBO) conducted 3 to 4 tests of catchment area from the PHED laboratory in Muzaffargarh. These tests analyzed parameters such as pH, turbidity, total dissolved solids (TDS), Arsenic, Iron, Fluoride and microbial contamination. These tests helped to finalize the required filtration technology for providing safe and clean drinking water.

Designing of Filtration technology:

As the result of underground water quality test reports to treat the raw water and make it healthy for drinking purpose the following technology designed for treatment: including Pre Filtration, Primary Filtration and Biological Treatment.



a- Pre Filtration

This system filters the suspended particles, remove the smell and make the taste better for drinking purpose. **This filtration system comprises on following equipment's.**



Sand Filter

Used to filter out smaller suspended particles through a bed of gravel, and sand media. Water flows through a media bed, typically consisting of multiple layers of sand and gravel. Particles are trapped in the sand bed, and clean water flows out.

Carbon Filter

Activated carbon filtration is used for filtration of raw water to remove contaminants, improve taste and odor, and reduce chemical impurities. Activated carbon filters work through the process of adsorption, where pollutants are trapped on the surface of the carbon media. This method is highly effective in removing chlorine, making it an essential step in water purification systems.

Cartridge Filter

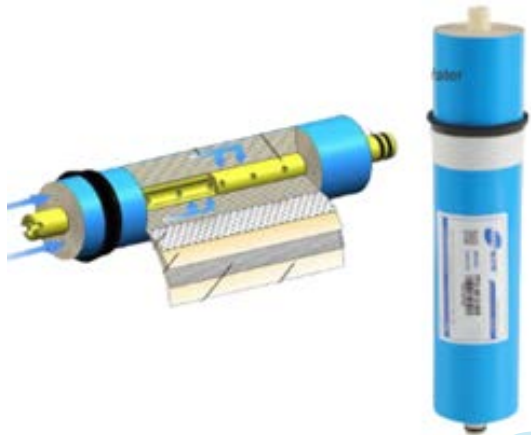
This filtration process is used to remove particles down to a specific micron size before water enters finer filtration or membrane systems. The raw water passes through disposable or washable filter elements, capturing particles larger than a 05 micron and 01 Micron.

b- Primary Filtration

In this filtration system the RO membrane is used to filter the water chemically, remove salts, here is the detail of this filtration system.

Reverse Osmosis Membrane

Is used to remove dissolved salts, ions, heavy metals, and other small contaminants from water. Its pore size is approximately 0.0001 microns, allowing only water molecules to pass through. Water is pushed through the membrane using a high-pressure centrifugal pump, which provides the force needed for separation. The membrane blocks salts, organic matter, and other impurities, producing purified water. In this model it is used for brackish water, purifying drinking water, and producing high-purity water for drinking purpose.



Arsenic Removal Filter

An arsenic removal filter used with activated alumina media, which effectively adsorbs arsenic from contaminated water. This media has a high surface area that allows it to trap arsenic ions, making the water safe for drinking.

All the filters are designed with both automatic and manual backwash systems.



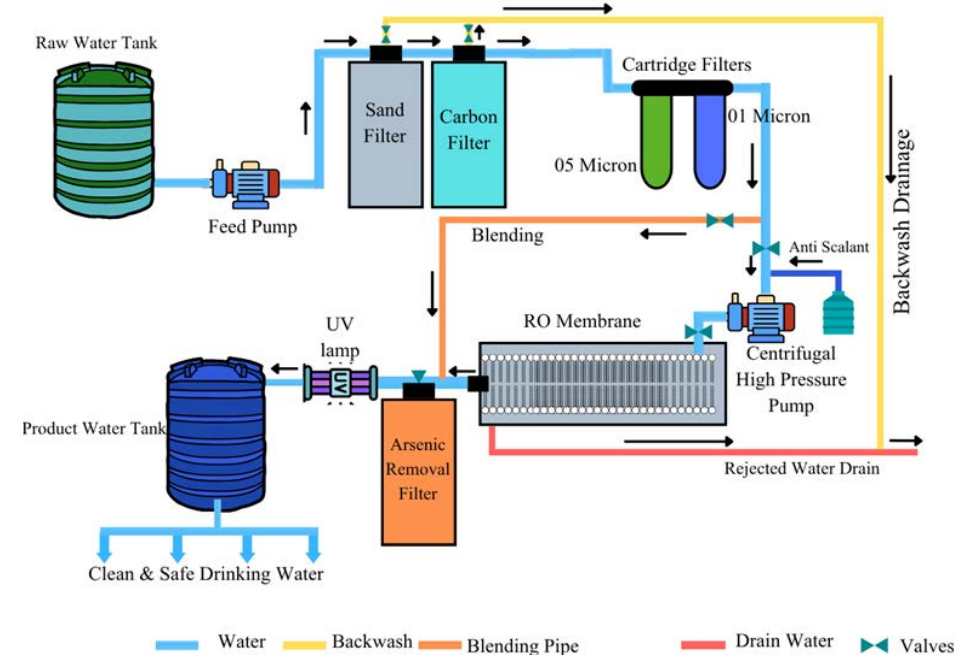
c- Biological Treatment:

After the chemical filtration process, an ultraviolet (UV) lamp is installed to disinfect water by killing harmful pathogens such as E. coli, B. coli, and total coliforms. As water passes through the UV chamber, microorganisms absorb UV light, which damages their DNA, preventing them from reproducing and causing disease.

The process is rapid, typically taking just a few seconds, and it does not introduce any chemicals into the water, so it does not alter the taste, smell, or mineral content.

Sr. #	Types of Contaminants	Types of Contaminants Characteristics	Source of Contaminant	Filtration/ Treatment Technology
1.	Physical Contamination	Visible particles that cause turbidity or cloudiness in water.	Sediment, silt, sand, and organic matter.	Sand Filtration, Cartridge Filter.
2.	Chemical Contamination	Dissolved substances	Heavy metals lead, arsenic, mercury, nitrates, dissolved Salts, fluoride.	Activated Carbon Filter, reverse osmosis membrane.
3.	Arsenic	Colorless, taste less, odor less, only detect in Lab, test.	Arsenic occurs naturally in the earth's crust, natural rock formations.	Arsenic removal media like active alumina.
4.	Biological Contamination	B-Coli, E-Coli Microorganisms, Pathogens, Bacteria,	Stagnant water, Unimproved Sanitation,	ultraviolet (UV) disinfection, membrane filtration (microfiltration, ultrafiltration)

Filtration Process



3.3.2- Capacity of water filtration plant

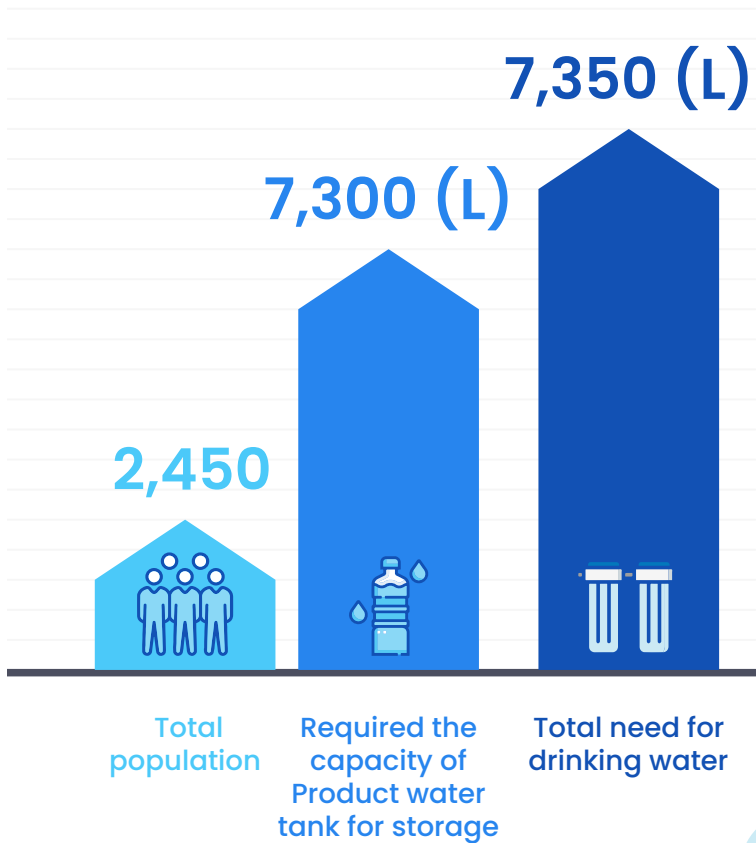
The water filtration plant in Basti Jalal Abad has been designed with a capacity to filter 1000 liters of water per hour, ensuring a reliable and sufficient supply of clean drinking water for the community. This capacity has been carefully calculated to meet the daily water needs of the local population while maintaining efficient operation. The capacity of plant is calculated as following:

Total population: 2,450

Total need for drinking water: 2450 x 3 = 7,350 liters

Required time to meet the capacity= 7,350/1000= 7.3 hrs. (designed as per the solar energy availability in southern Punjab per day).

Required the capacity of Product water tank for storage; As per capacity of water filtration plant the 2000-liter water storage tank takes 2 hours to fill then in 7.3 hrs it will fill 3.65 times= 3.65 x2000= 7,300 liters, which is according to the need of the community.



3.3.3- Designing of Civil Work

Site Selection:

For construction of civil work a site is selected with 35 ft width and 30 feet length covering total 1050 square feet area. The selected site is accessible and safe for water users including male, female, children and Person with special abilities. It is strategically placed, maintaining a minimum safe distance from neighboring boundaries, watercourses, and other infrastructure to prevent contamination risks. The location is free from encroachments, accessible year-round, and safe for users at all times.



Designing of Civil Infrastructure:

The civil infrastructure for the water filtration plant in Basti Jalal Abad has been carefully designed to ensure functionality, safety, and climate resilience. The plant includes a secure room for housing the filtration system, measuring 12' x 12', and a dedicated water fetching area of 5' x 12' for community access. A boundary wall with a steel grill, spanning 35 feet in length and 30 feet in width, has been constructed to ensure safety and security. Additionally, a grassy plot has been incorporated into the design to promote greenery and enhance the overall environment. The structure adheres to construction standards for climate resilience, accessibility, and safety, ensuring it is durable, user-friendly, and capable of withstanding environmental challenges. This thoughtful design aims to provide a sustainable and safe solution for clean water access in the community.

3.3.4- Designing of Solar system as a green Energy

The integration of a solar system to power the water filtration plant replaces reliance on WAPDA, ensuring uninterrupted operation even during power outages. This solar-powered solution enhances the plant's effectiveness by reducing operational costs and providing a consistent energy supply. It also contributes to environmental sustainability by utilizing clean, renewable energy and reducing carbon emissions. This approach aligns with global efforts to promote green technologies and sustainable development.

Total Load Calculation for Solar Panels:

Sr. #	Name of Equipment	Required energy in Watts
1.	Submersible Pump for fetching raw water 1HP	745
2.	Feed Pump 0.75 HP	560
3.	Centrifugal High Pressure Pump, 1.5 HP	1,118
4.	Ceiling Fan	150
5.	04 Lights	160
6.	03 Pumps for Coin vending Machines	558
Total		3291
Performance Ratio or Capacity Factor of solar Panel. 80%		=3,291/0.8= 4,113 watts say 4.11 KW

As per the above-mentioned calculation 6 KW solar system is designed to run this water filtration plant smoothly, in foggy or smoky weather conditions.



3.3.5- Innovative and Emerging Technologies

Real Time Monitoring through PLC Based SCADA System:

The modern emerging technologies used and aligned in these water filtration plants service models. A PLC (Programmable Logic Controller) based SCADA (Supervisory Control and Data Acquisition) system help automate and monitor the plant’s processes, making sure everything runs smoothly. A Human Interface Machine (HMI) allows operators to easily control and adjust the system. A TDS (Total Dissolved Solids) meter checks the water quality to ensure it’s safe for drinking, while water meters track how much water is being filtered and used. Together, these technologies keep the plant efficient and reliable for the community and also helps the operator for smooth operations.



Coin Operated Water Vending Machine Based Tariff Collection Mechanism:

The coin-operated water vending machine designed for the water filtration plant offers a convenient and efficient way for the community to fetch clean water. The machine is programmed to dispense specific quantities of water—10 liters, 20 liters, or 30 liters—when the corresponding coin is inserted. This system not only simplifies the process of water collection but also ensures tariff collection, making it easier to manage finances and maintain the plant. Additionally, by controlling the amount of water dispensed, the machine promotes water conservation, reducing wastage of water and encouraging responsible usage. This innovative solution combines technology, sustainability, and user-friendly design to benefit both the community and the environment.

3.3.6- Development of Design, Drawings and BOQs

The development of the Bill of Quantities (BOQ) and drawings for the water filtration plant included detailed layouts, cross-sections, and 3D designs to ensure a clear and accurate plan. The BOQ covered all costs, such as the water filtration technology, civil construction work, solar system installation, and public health sanitary fittings. The layout was designed to make the plant functional, accessible, and visually appealing. The 3D drawings helped visualize the final structure, ensuring all components, like the filtration system, solar panels, and water fetching area, were properly integrated. This detailed planning ensured the project was cost-effective, sustainable, and met the community’s needs for clean water.

Consultation with Stakeholders:

The design, drawings, and BOQs of the water filtration plant were shared with government stakeholders, including the Punjab Saaf Pani Authority (PSPA), Punjab Rural Municipal Services Company (PRMSC) and Housing, Urban Development and Public Health Engineering Department (HUD&PHED) for their review and feedback. The goal was to develop and construct a sustainable and effective water service delivery model to provide safe drinking water in rural areas. Stakeholder endorsement strengthened collaboration with government departments and ensures the project aligns with national standards. The feedback from HUD & PHED, PSPA, and PRMSC on the filtration technology and design, helped refine the system, confirming its technical quality and suitability for community needs. This endorsement not only validates the project but also paves the way for replicating the model in other areas, ensuring the design meets community requirements and can be scaled effectively.

Refinement of Design:

The feedback from all relevant departments, including Punjab Saaf Pani Authority (PSPA), Housing, Urban Development and Public Health Engineering Department (HUD&PHED), and Punjab Rural Municipal Services Company (PRMSC), was carefully incorporated into the design and Bill of Quantities (BOQs) of the water filtration plant. Their guidance helped refine the technical aspects of the filtration technology, civil infrastructure, and overall system layout to ensure compliance with national standards and best practices. This collaborative approach ensured the design was optimized for efficiency, sustainability, and community needs. This inclusive process not only strengthened the project’s technical quality but also enhance stronger partnerships with government stakeholders for future initiatives.

Finalization of Bill of Quantities (BOQs):

The Final cost regarding construction and installation of water filtration Plant is as follows:

Sr. #	Activity/ Work Type	Estimated Cost PKR	Remarks
1.	Cost of Civil Structure (Room + Water Collection Area+ Boundary Wall)	345,300	
2.	Providing, fitting & Installation of 1000 L/H RO filtration Plant	1,381,050	
3.	BOQ,s of Solar System 6 KW	495,000	
4.	Cost of 03 Coin Operated Water vending Machine	500,000	
5.	Cost for Installation of SCADA system	558	
Total		6,409,548	PKR

3.3.7- Construction of the Water Facility

Hiring of Vendor: AGAHE used a clear and fair process to hire a vendor for building and installing the water filtration plant in Basti Jalal Abad. The process started by inviting tenders openly, allowing qualified and experienced contractors to apply. All bids were carefully checked based on the contractor’s skills, costs, and past experience related to WFP. A fair and unbiased selection was made, following all rules and guidelines. The chosen vendor was picked because they could meet the project’s needs, provide good quality work, and finish on time. This open and fair process ensured transparency, accountability, and the successful completion of the water filtration plant for the community.

Engagement of Community Based Organization (CBO), operator in construction process:

AGAHE team conducted an orientation session for the Community-Based Organization (CBO) to ensure their active involvement in monitoring the construction process of the water filtration plant. Detailed drawings and cost estimates were shared with the CBO in Urdu to make the information accessible and understandable. To build local capacity, the operator was engaged throughout the installation of the water filtration plant (WFP) equipment, while a local electrician was involved in setting up electrical fittings and a plumber in installing sanitary fittings. This hands-on involvement ensured that the CBO and local technicians became well-aware of the installation process, enabling them to

address any future issues with the equipment or fittings independently. This approach not only ensured transparency but also empowered the community to maintain and manage the plant effectively in the long term.

Completion of Construction & Installation of Water Filtration Plant:

The construction and installation of the water filtration plant were carried out step by step with careful planning and monitoring. The AGAHE and WHH teams regularly visited the site to ensure everything was done correctly. They checked the quantity and quality of construction materials, the mortar mix ratio, and the quality of the water filtration plant equipment and solar system. Safety was a top priority during the construction process. Safety measures like warning tape, safety shoes, helmets, and proper safety dresses were provided to all laborers to prevent accidents. The teams made sure that all work met the required standards and that the plant was built to last. This careful monitoring and attention to detail ensured the plant was constructed safely and efficiently, providing clean water to the community.



Handing Over to CBO:

The water filtration facility was formally handed over to the Community Based Organization (CBO) to ensure community-led management and sustainability of the system. Before the handover, a comprehensive asset inventory list was prepared, detailing all equipment, filtration units, tools, and materials installed at the site. Each item from the inventory was physically verified, shown, and counted in the presence of the CBO members and the designated plant operator. This transparent process ensured mutual understanding of the assets being transferred and established a clear record of ownership and responsibility for future operation and maintenance.

3.4- COMPONENTS OF FINALIZED WATER FILTRATION PLANT (WFP)

A- Civil Infrastructure



6-kilowatt Solar System

Room for Water Filtration Plant

Plantation Area & Green Space

Fencing & Safety Barriers

Water Collection Area

Wide access gates and accessible ramps, stairways along with parking space

Plantation Area and Green Space

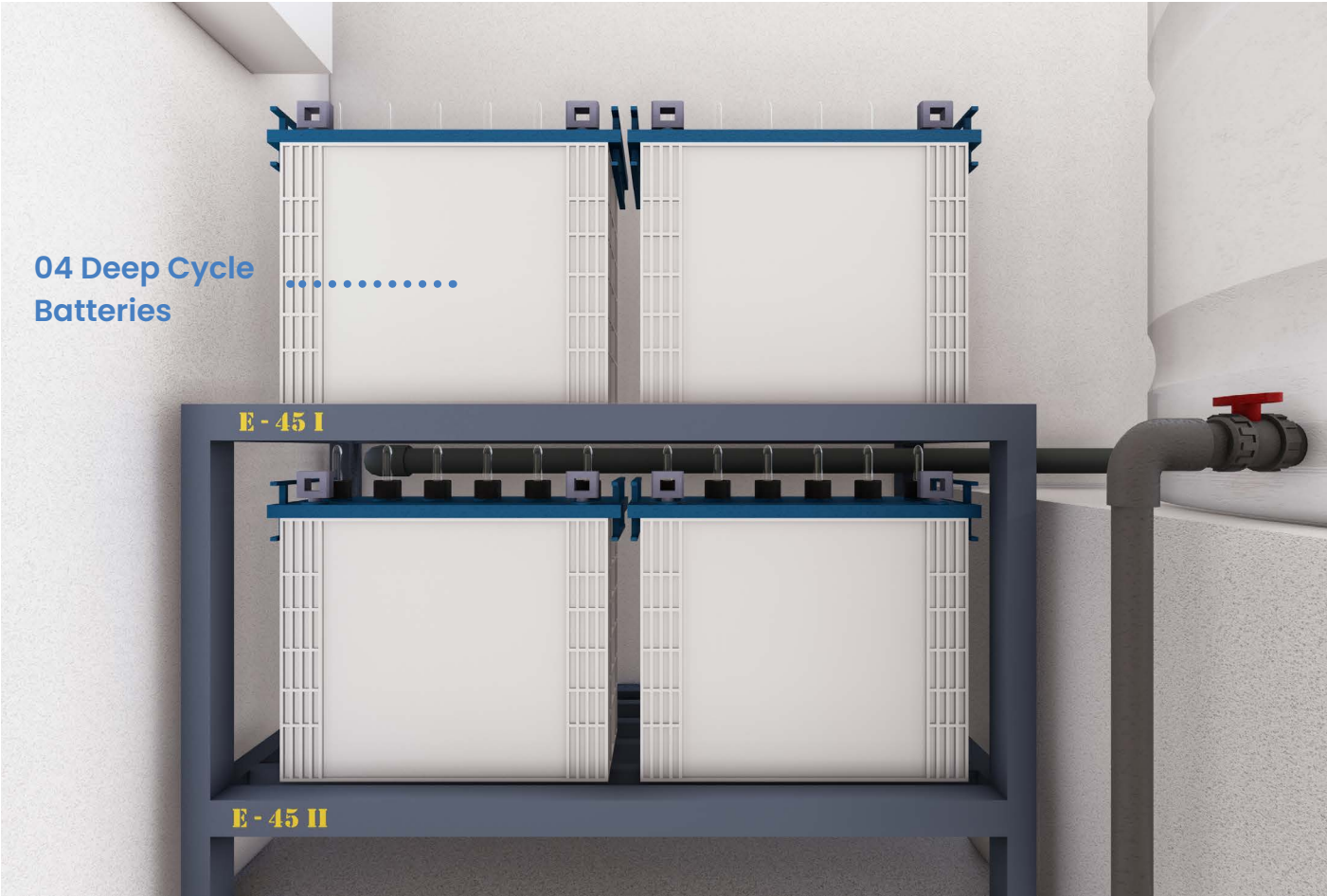
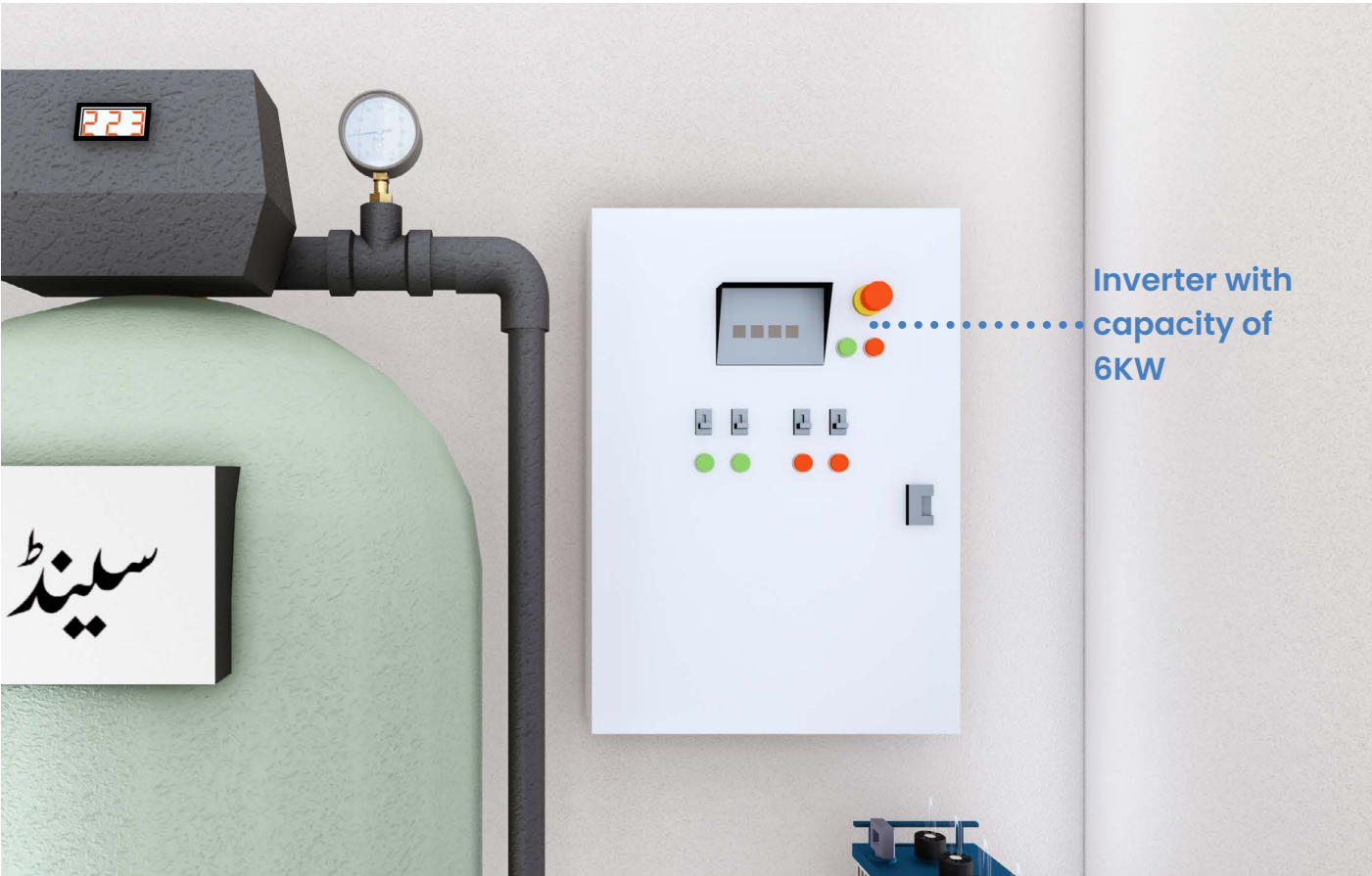


C- Solar Energy System (Sustainable Power Source)



B- Installations of Water Filtration Plant





D- Emerging & Innovative Technologies

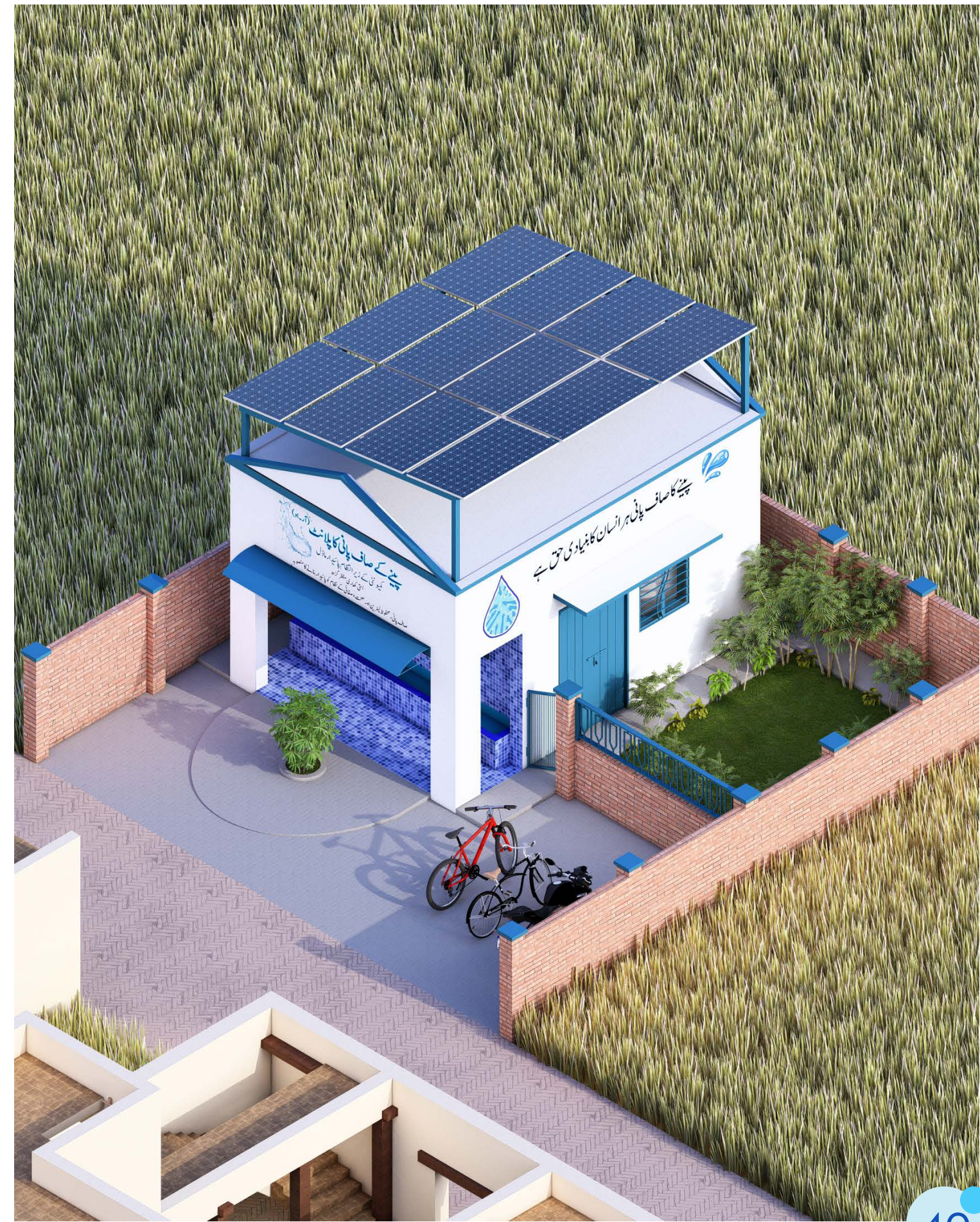
Coin Wending Machine



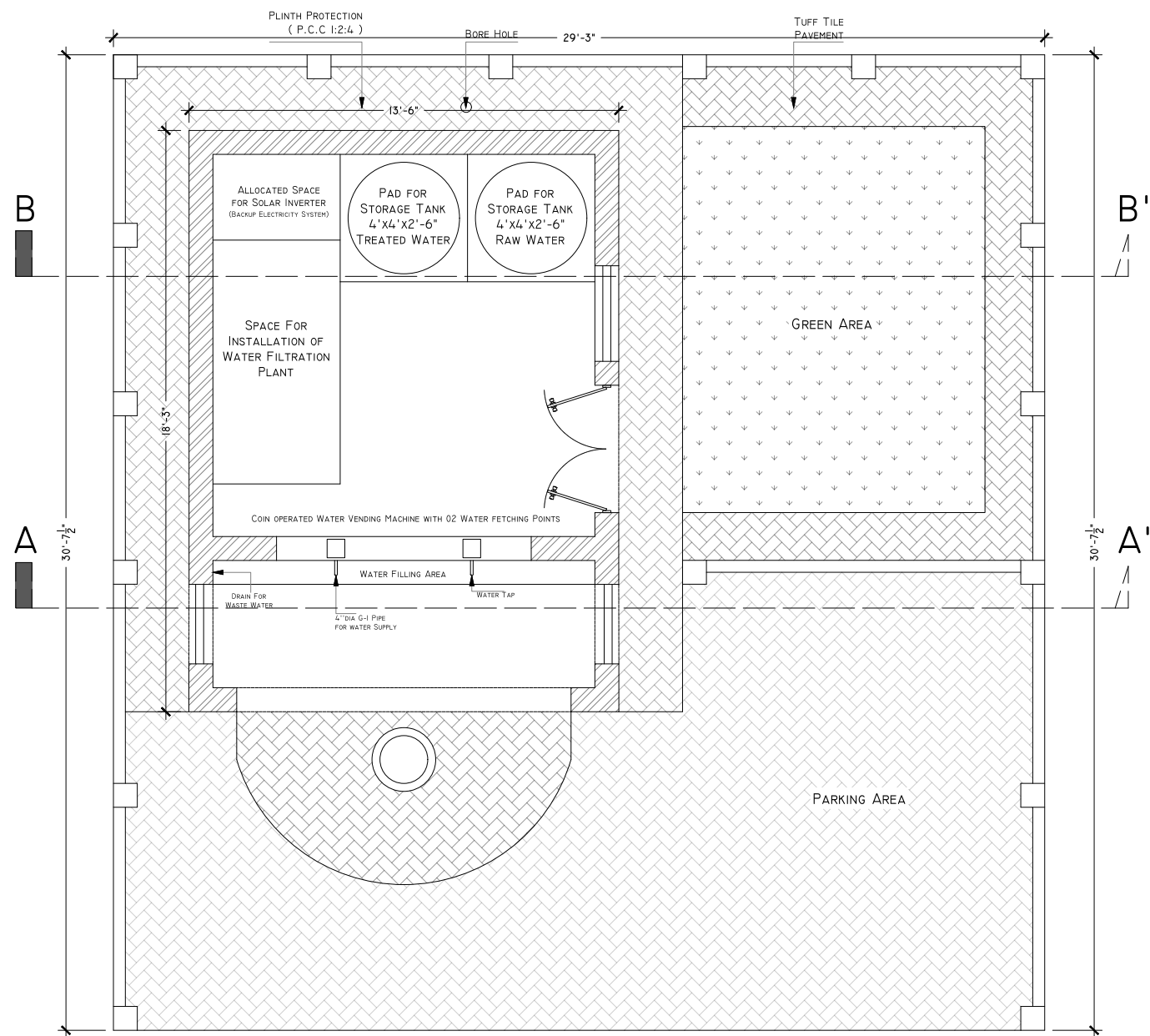
SCADA System



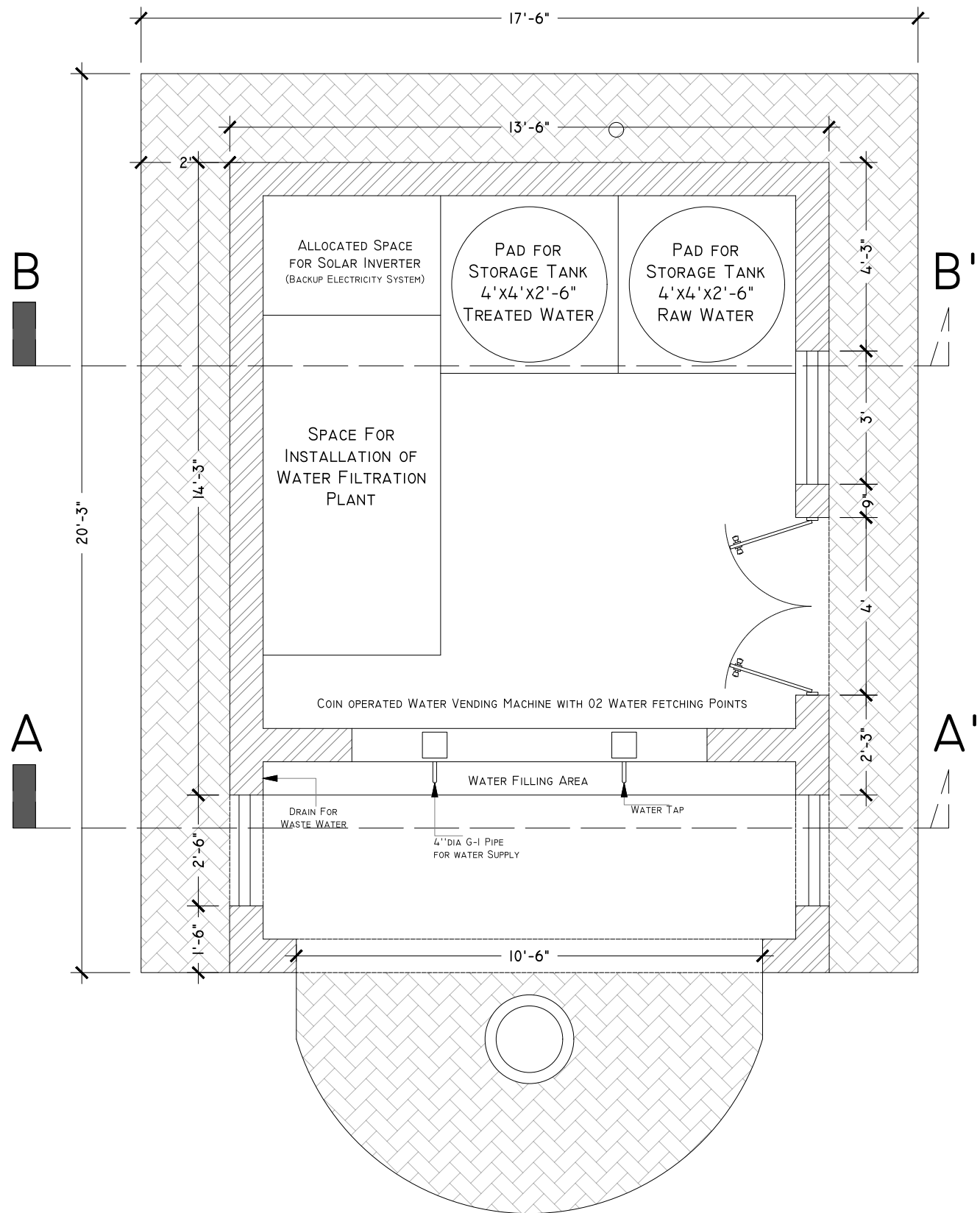
E- Drawing, Design and Layouts of Different Models



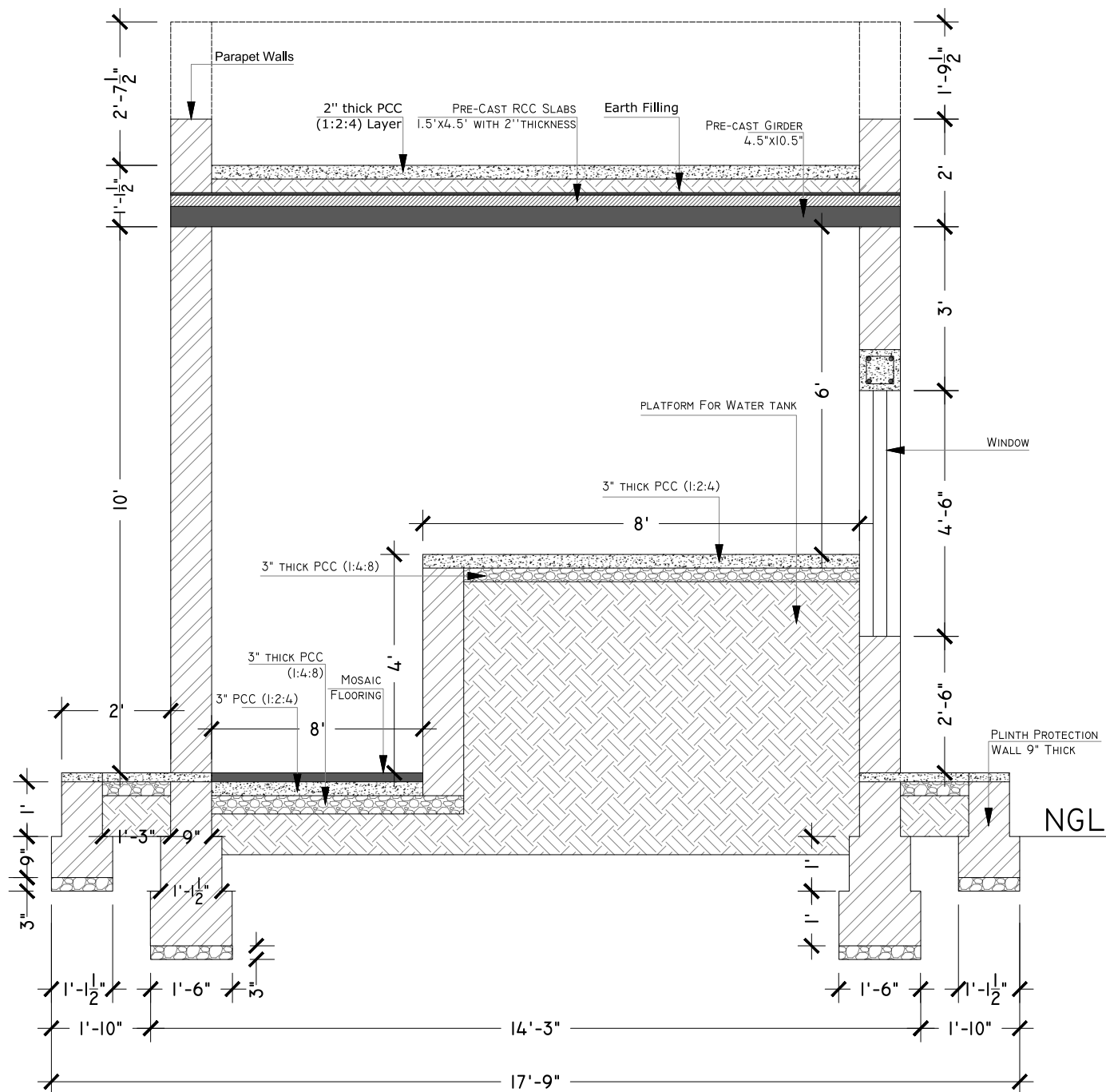
WFP building Site plan



WFP building plan

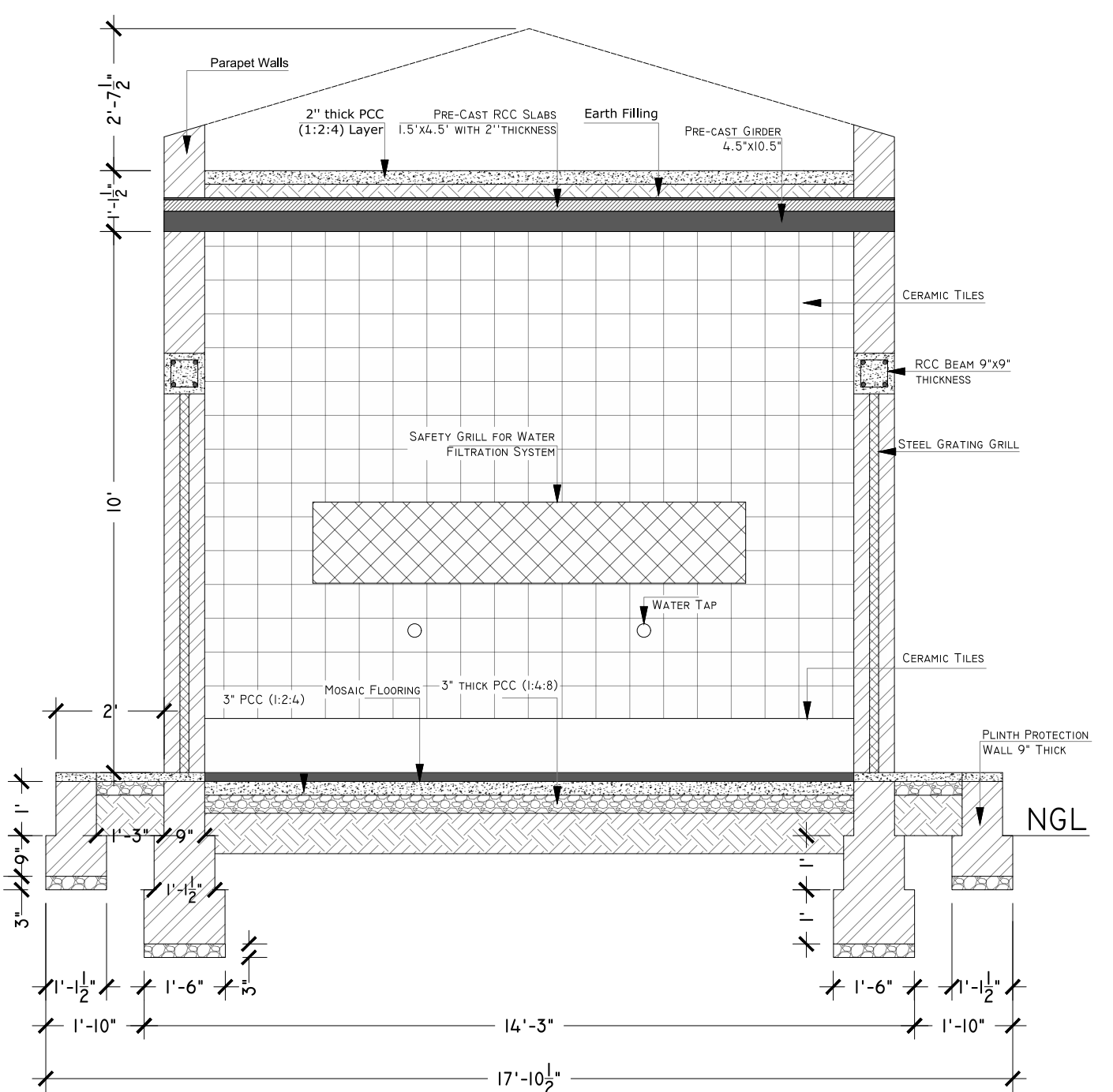


WFP building Section BB



Section BB"

WFP building Section AA



Section AA''

Chapter # 4

OPERATION & MAINTENANCE ARRANGEMENTS AND SUSTAINABILITY PLAN

4.1- Operation and Maintenance Arrangements & Sustainability Plan

The long-term viability of water supply systems hinges on robust, community-owned, and financially sustainable Operation & Maintenance (O&M) arrangements. The Climate Resilient and Sustainable Safely Managed Water Supply Service Delivery Model introduces a **comprehensive framework for O&M Arrangements** that addresses the systemic challenges that have historically led to the dysfunctionality of Water Filtration Plants (WFPs) in Pakistan. These challenges include inadequate financial planning, weak operational oversight, lack of community ownership, and absence of preventive maintenance protocols.

This model integrates five interdependent components to ensure sustained service delivery:

1. Community-Based Governance
2. Operator-Led Technical Management
3. Financial Sustainability Mechanism
4. Capacity Building of CBO & Operators
5. Monitoring, Linkages, and Community Engagement

Each component is designed to reinforce the others, creating a resilient and scalable system that aligns with the Government of Punjab's vision for universal access to safe water and contributes to achieving SDG 6.



4.1.1- Community owned Governance

The Community-Based Organization (CBO) plays a central role in the management and sustainability of the Safely managed drinking water service model established by AGAHE. **The key responsibilities of CBO are as under:**

Identification and Selection of Site

The CBO is responsible for identifying and selecting a suitable site for the installation and construction of the Safely Managed Drinking Water Service Delivery Model, in consultation with the community and AGAHE. The selected site must be centrally located, easily accessible to all residents, and provide adequate space for water collection and parking.

Selection of Operator

The CBO is tasked with selecting a reliable operator—preferably literate to some extent—who will be responsible for managing the daily operations of the water filtration plant and maintaining operational records.

Service Charges Management

The CBO is responsible for determining minimal service charges, which are publicly displayed. These charges are collected to cover the operation and maintenance expenses of the water filtration plant.

Monitoring and Supervision

The CBO oversees the construction and installation of the water filtration plant, ensuring that all work is carried out according to the design and technical specifications provided by AGAHE's engineering team during capacity-building sessions.

Financial Record Keeping

The CBO maintains transparent and up-to-date financial records related to the water filtration plant. This includes documentation of service charges collected and expenses incurred for operation and maintenance.

Development of Linkages

The CBO is responsible for establishing and maintaining linkages with relevant stakeholders, including government departments, local technicians, and market suppliers, to ensure the sustainability and improved service delivery of safe drinking water to the community.

Operation and Maintenance Supervision

The CBO regularly monitors the performance of the water filtration plant and coordinates timely maintenance activities to ensure uninterrupted service delivery.

Community Coordination

The CBO actively engages with the local community to address concerns, promote participation, and ensure fair and equitable access to clean drinking water for all residents.

Sustainability Planning

The CBO develops and updates sustainability strategies and plans based on actual operation and maintenance (O&M) costs and the service charges collected. This includes adjusting tariffs when necessary, planning for spare parts, and coordinating with local technicians and markets to ensure the availability of required equipment and materials.

4.2- Operator Led Technical Management

The operator, selected by the CBO, is responsible for the technical and operational management of the WFP. **Their duties include:**

1. **Plant Operation:** Responsible start-up and shutdown of the plant according to schedule and community needs.
2. **Water Quality Monitoring:** Regular monitoring using TDS meters and SCADA systems, with quarterly testing conducted by certified labs such as PCRWR or PHED.
3. **Filter and Membrane Maintenance:** Cartridge filters are replaced after every 30,000–40,000 liters. Backwashing of sand and carbon media and chemical cleaning of RO membranes (CIP) are performed to maintain filtration efficiency.
4. **System Inspection and Repairs:** Pre-operation inspections are conducted to identify leaks or faults. Prompt action is taken to address any issues.
5. **Equipment Supervision:** Continuous monitoring of dosing pumps, anti-scalant chemical levels, and overall infrastructure. The plant is shut down immediately in case of malfunction to prevent damage.
6. **Financial Management:** Daily records of service charges are maintained to support financial transparency and operational continuity.
7. **Community Accessibility:** Operating hours are set based on community convenience, with advance notice provided for any closures.
8. **Hygiene Maintenance:** Cleanliness is ensured through the use of hygiene kits, including brooms, dusters, and waste bins.

4.3- Financial Sustainability Mechanism

A cornerstone of the operation and maintenance arrangements model is its self-sustaining financial system, which ensures uninterrupted service delivery without reliance on external funding. The system encourages responsible water usage by requiring users to pay a nominal amount. All collected funds are reinvested directly into the plant’s operations, eliminating dependency on external funding sources. This innovative approach enhances the self-sustainability of the water filtration plants, ensuring long-term functionality and reliability for the community.

Key features include:

1. Coin-Operated Water Vending Machines

Installed at each plant to automate the collection of nominal service charges, promoting transparency and reducing administrative burden.

2. Tariff Structure and Equity

Charges are set at PKR 1 per liter, with provisions for vulnerable households to access water free of cost. This ensures affordability and inclusivity.

3. Operation and Maintenance Expense Forecasting

CBOs are oriented on expected operational costs, including filter replacements, chemical usage, operator salaries, water testing, and electricity.



The list of expenses is as follows:

Sr. #	Detail of Expense	Unit	Total Cost (PKR)	Frequency	Monthly Cost (PKR)
1.	Changing of Cartridge Filter	02	2400	Monthly	2400
2.	Anti scalant- Chemical	01	1000	Monthly	1000
3.	Washing of Sand Media	01	3000	After 06 months	500
4.	Washing of Carbon Media	01	3000	After 06 months	500
5.	Changing of Sand Media	01	10000	After 01 year	833
6.	Changing of Carbon Media	01	14000	After 01 year	1166
7.	Changing of Arsenic Media	01	3000	After 01 year	2500
8.	Replacement of RO membrane	01	200000	After 02 years	8333
9.	Monthly Pay of Operator	01	20000	monthly	20000
10.	Water Quality Test	01	6500	After 03 months	2166
11.	Electricity cost (Optional)	01	15000	Monthly	15000
Total			304,900	54,398	

Revenue vs. Expenditure Analysis:

The Tariff Collection and expenditure comparative analysis is as under:

Revenue Estimation	Total Households	350 Households
	Supposed if only 60% of households collect water from the facility:	210 Households
	Supposed 20% vulnerable households do not have ability to pay the service charges	70 Households
	Remaining Households who can pay service charges	140 households
	If 140 households collect water 20 litter per day, then Total daily revenue	140 Households x 20 Litter water x 1 PKR per Liter = PKR 2,800
	Total Revenue Per month	PKR 2,800 x 30 days = PKR 84,000

Revenue and Expense Analysis	
Total estimated O&M Expenses per month	54,398
Total Estimated monthly revenue (with free water to vulnerable H.Hs)	84,000
Monthly Saving	29,602

Emergency Savings Planning: Monthly savings are earmarked for emergency repairs and infrastructure maintenance, enhancing resilience of service delivery model for long term.

4.4- Capacity Building of CBO and Operators

A critical component of the sustainability plan for the Climate Resilient and Sustainable Water Supply Service Delivery Model is the capacity building of local stakeholders responsible for managing the Water Filtration Plants (WFPs). Recognizing the importance of technical competence and local ownership, AGAHE implemented a structured training program targeting both the appointed plant operators and the Community-Based Organizations (CBOs).

4.4.1- Practical Trainings

This program consisted of hands-on, on-site practical training sessions focused on the core aspects of Operation and Maintenance (O&M). Participants were equipped with essential skills in system management, routine maintenance, and troubleshooting. Through interactive learning, they gained the ability to identify and resolve common technical issues, thereby ensuring the smooth and uninterrupted functioning of the filtration plants.

The training initiative has significantly strengthened the capacity of both operators and CBO members to manage the WFPs independently. It has fostered a sense of ownership and accountability, while also contributing to the development of a skilled local workforce capable of sustaining water service delivery systems. This investment in human capital is a cornerstone of the model’s long-term sustainability and its potential for replication across other districts.

Provision of Maintenance Toolkits

To further enhance operational readiness, AGAHE facilitated the operator with a customized toolkit containing the necessary instruments for minor repairs and maintenance. This proactive measure enables operators to address technical issues promptly, minimizing downtime and reducing dependency on external support.

Tool Kit Details

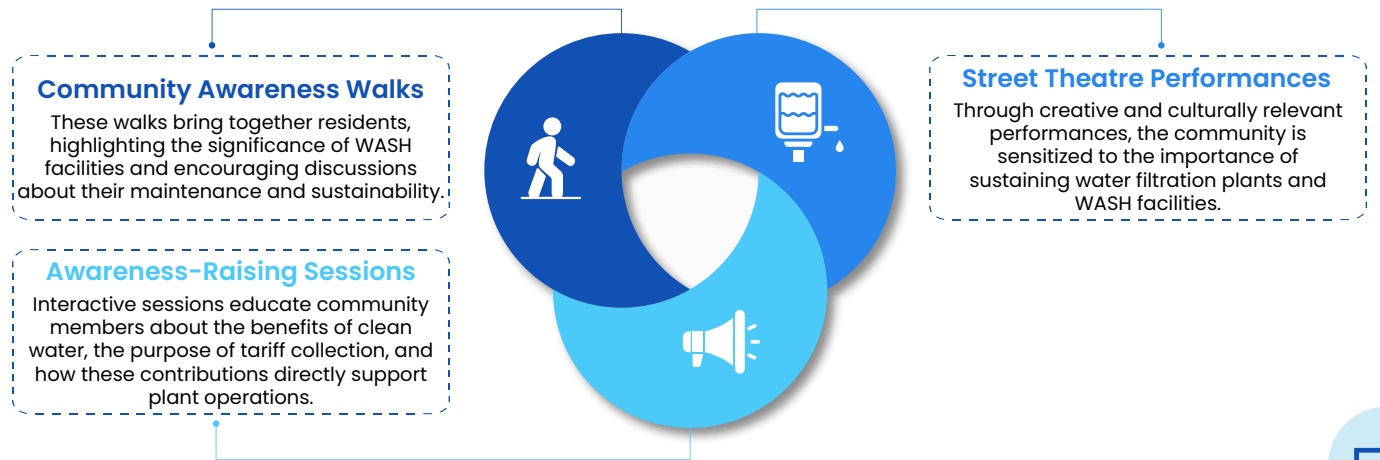
Each operator received a customized toolkit containing essential tools such as adjustable spanners, screwdrivers, filter keys, grip pliers, and display boards for water quality reports and plant schedules. The details of equipment are provided below:

Sr. #	Name of Items	Specifications	Unit	Quantity
1.	Screw Spanner Wrench	12-inch Steel Made with Adjustable Diameter and rubber grip.	No.	01
2.	L-Key Set Complete	9 keys set of stainless steel of total.	No.	01
3.	Screwdriver	Screwdriver tool set complete box with 09 screw drivers.	Set	01
4.	Grip Plier and Cutter	Made of steel with rubber grip 6 Inch Length.	Set	01
5.	Filter Key	For changing the Cartridge filter.	No.	01
6.	Soft Board	For display the Plant timings and Water quality reports.	No.	01
7.	Combination Snapper 04 keys Set.	Double sided (open-ended spanner and the other end is a ring spanner). Made of steel. Each Key Size: 14mm, 17 mm, 19 mm & 21mm.	Set	01
8.	Tote Bag.	To Carry Tool kit, Reusable, Denim stuff Made, with logos & title printing.	No.	01
9.	Stair.	Bamboo stairs 20 ft long for cleanliness of solar panels.	No.	01

4.5- Community Engagement

To complement the model, a Behaviour Change Communication (BCC) campaign has been launched to raise community awareness about the importance of contributing to the sustainability of these facilities. This campaign emphasizes the role of tariff collection in maintaining the functionality of water filtration plants and ensures that community members understand their critical role in the process.

The BCC campaign includes a variety of engagement activities:



4.6- Impact on Long-Term Sustainability

By integrating technology, financial mechanisms, and community engagement, the WFP Model offers a comprehensive solution to the challenges of water filtration plant sustainability. It addresses common issues like dysfunctionality, insufficient maintenance, and lack of operational funds, creating a framework that ensures long-term benefits for communities.

This holistic approach not only ensures the continuous availability of safe drinking water but also empowers communities to take charge of their resources, building resilience and improving public health outcomes. The WFP Model thus serves as a scalable blueprint for achieving sustainable water management in rural and underserved areas.

Sr. #	Types of Contaminations		Unit	Permissible Limits		
				PCRWR	WHO	PHED
1.	Physical	Turbidity	NTU	5	5	5
2.		Odor		Unobjectionable	Unobjectionable	Unobjectionable
3.		Color	TCU	Color less	Color less	≤15
4.		Temperature	C	NGVS	NGVS	NGVS
5.	Chemical	TDS	mg/l	<1000	<1000	<1000
6.		Hardness	mg/l	<500	<500	<500
7.		Chloride	mg/l	<250	<250	<250
8.		Sodium	mg/l	200	200	200
9.		Arsenic	ppb	10	10	10
10.		Iron	mg/l	1	1	1
11.		Fluoride	mg/l	1.5	1.5	1.5
12.		Carbonate	mg/l			
13.		Conductivity	μ-s/cm	NGVS	NGVS	NGVS
14.		Potassium	mg/l	12	12	12
15.		Magnesium	mg/l	150	150	150
16.	Biological	Total Coliform Unit	CFU/100 ml	0	0	0
17.		E-Coli	CFU/100 ml	0	0	0

