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Smart Water System for Semi Arid Regions: A Case Study on Mitigation Framework for *Deh Band Murad* (Semi Arid Region)

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ABSTRACT

Climate change captures the attention of many researchers and it is considered as the most vital research area. Climate change affects natural resources whether it is caused by nature or human intervention. Aquatic resources and its continual supply are considered being highest priority. Worldwide agencies have been mobilizing their efforts to ensure the sustainability of natural resources. This case study is expounded on the hazards and their impacts on water supply chain. Semi arid region *Deh Band Murad* is selected to demonstrate the effects of variation in water supply during long summer season. Supply chain mitigation framework cover identification of the cause of the problems, consequences for not solving problems, analysis of different approaches, selection of solution's right mix and finally benefits to the community.
KEYWORDS: wireless sensor based monitoring; smart metering and theft control.

1. INTRODUCTION

It was a scorching May after noon in 2015 as the teaching and staff of *Falah University*, assembled around the cafeteria's tea table in *Deh Band Murad* located at the outskirt of Karachi. It was 104 degree Fahrenheit outside, for four years there was no or very little rain fall, the water in the nearest Hub dam was at zero level and the underground water level dropped to 60 feet down, worst not to mention with the diminish supply; the quality suffers most, and it was no longer suitable for consumption.

Falah University, a project of Falah foundation, Pakistan was established in 1985 under the provincial charter. Falah foundation has a wide range of social and philanthropic activities including establishment of educational institutes, research laboratories, hospitals and low cost dispensaries. Endowment funds from Falah Laboratories are the driving force behind the various humanitarian activities for the under privilege areas of Pakistan.

The purpose of today's gathering was to converse the merits of a recent proposal from one of the assistant professor of the Faculty of Engineering Science and Technology to make a pilot project for ensuring quality standard for portable water supply.

While this thought was captivating, there was debate within faculty as to its merits. Waseem Khan, an assistant professor, summed up the situation.

Two year ago, I would have jumped at this proposal. All along, we have known that Water supplies is diminishing, we can no longer rely on Hub dam for continual flow. Now we have to take some immediate action to replenish supplies in long summer season.

But Shariq Ahmed, the head of environmental lab, offered a different opinion:

Why should not we over haul over distribution system? Going through a conventional reverse osmosis system we need to ensure that there will be enough water levels for coming years. With climate change patterns, it is estimated that we are not sure about the level of underground water, a primary source for reverse osmosis. Our objective is to build the complete solution for ensuring quality and supply needs for the local communities of arid regions of Pakistan. Smart water system for semi arid regions offers a very effective way of doing that. And if we don't do it now, local communities will no longer stay in these regions.

According to World Bank report, it is estimated that 1.6 billion inhabitants live in regions with absolute water scarcity, the numbers can be escalated to 2.8 billion inhabitants by 2025 [1]. Climate change hazards contribute the poor supply of water especially in arid and semi arid regions [2][3]. Long summer seasons reduces the supply of water from *HUB dam*, this quality suffers to an extent that it can no longer be used for human consumption. Mitigation framework highlights the different approaches to maintain the quality standards and to sustain the supply for yearlong demand. Low supply with poor quality is the major problem which has to be addressed on emergency basis.

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2. PROBLEM ANALYSIS

Scarcity of supply and quality degradation may arise for several factors including delayed or decreased patterns of rain fall, surface and ground water degradation, poor governance and regional conflicts. At global scale, the supply of water is challenged by various climate change hazards [4][5][6][7]. Global and local water scarcity is biggest challenge as highlighted in Figure 1 and Figure 2. If water scarcity is not addressed timely and efficiently, it will result in socio-economical outbreak.

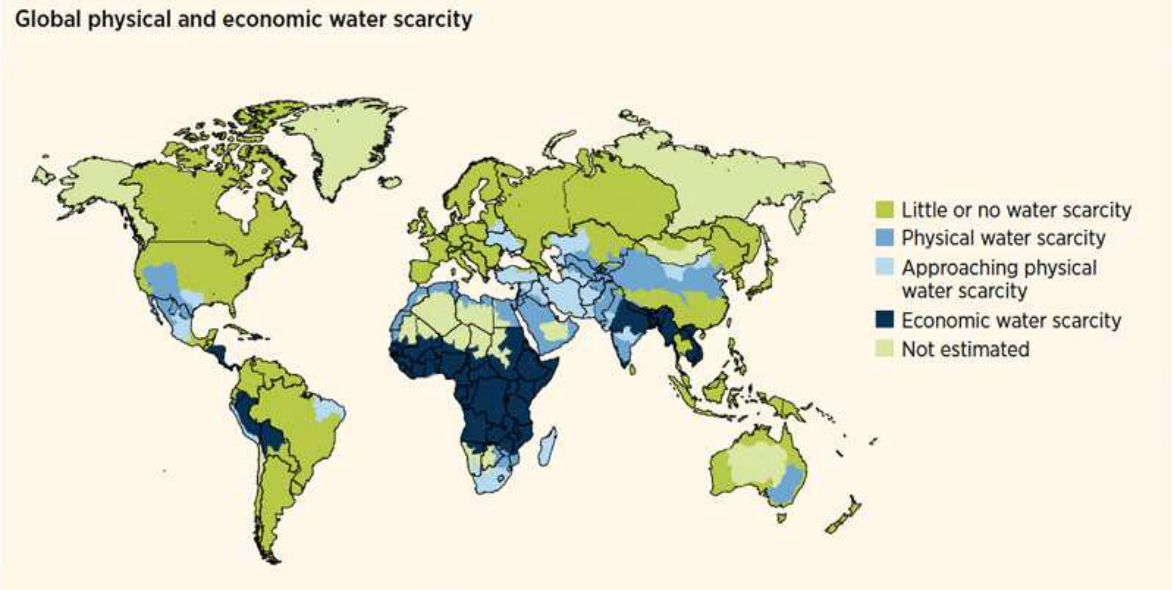

Figure 1: Supply Scenarios at Global Scale
Source: World Water Development Report 4. World Water Assessment Programme (WWAP), March 2012.

Figure 2(a): Supply Scenarios at Local Scale

Figure 2(b): Supply Scenarios at Local Scale

Following are the potential reasons behind poor supply and inadequate quality of the water.

Environment

1. Lack of Rain
2. Microbial pollutants
3. Industrial waste
4. Organic matter
5. Heavy metals
6. Ambient water quality
7. Suspended particles

Man Made

1. Inefficiency
2. Operation and Maintenance
3. Inadequate Infrastructure
4. Lack of Planning
5. Lack of Funding
6. Inexperienced Analyst
7. Theft

Machine

1. Materials of Construction
2. Pumping Machinery
3. Softening process
4. Highly-qualified Technicians
5. Medium-level Technicians
6. Rusty Distribution System
7. Rosette sampler

Measurement

1. Lab Error
2. Analyst
3. Improper Calibration
4. Calculation
5. Solvent Contamination

6. Supplier
7. In lab

Materials

1. Supplies
2. Pumping Plant
3. Power Systems
4. Pipeline and Trunk Main
5. Treatment Materials
6. Ware house
7. Inventory

Method

1. Primary water treatment
2. Aeration
3. Sedimentation
4. Reverse Osmosis
5. Disinfection
6. Solar Distillation
7. Chemical Treatments

Problem Identified: Inefficiency of surface distribution and treatment systems

Surface distribution and treatment systems have been adopted in *Deh Band Murad*. Following factors make surface distribution not feasible for catering the supply and quality standards.

1. Inadequate Storage facilities
2. Transmission mains
3. Poor Throughout
4. Quality Assurance
5. Significant Losses
6. Theft
7. Improper metering
8. Pumps
9. Valves and hydrants

Quality assurance refers to the activities and procedures responsible for defining and meeting the standards. The set of activities and procedures includes planning, documenting, analyses, training, validation and reporting. Quality Control is the set of activities of quality assurance for reducing errors throughout the process. Appropriate quality assurance procedure should be adopted. For maintaining quality standard of World Health Organization; accuracy and precision of control mechanism should be placed for all phases of water supply systems [1].

3. SMART WATER TREATMENT TECHNOLOGIES

Some of the recent researches in this domain include; Stochastic ANP-GCE approach for vulnerability assessment in the water supply system with uncertainties [8], E-coli inactivation in water using pulsed discharge [9], energy management system for stand-alone wind-powered-desalination micro grid [10], study of underwater channel estimation based on different node placement in shallow water[11], study of rural deep well two-stage water supply pumping station[12], an acoustic complexity index sensor for underwater applications [13], application of distributed wireless chloride sensors to environmental monitoring: initial results[14],underwater acoustic modems [15], optimization of portable water distribution and wastewater collection networks: a systematic review and future research directions[16], development of a calibrated transducer CMOS circuit for water turbidity monitoring [17], smart city wireless connectivity considerations and cost analysis: lessons learnt from smart water case studies [18], evapotranspiration variations in the Mississippi river basin estimated from GPS observations [19], a novel handheld fluorimeter for rapid detection of escherichia coli in drinking water [20] and monitoring aquatic debris using smart phone-based robots [21]. Some recent ICT trends in Smart Water Systems are also shown in Table 1.

Table 1: Recent ICT Trends in Smart Water System

Techniques	Description
Wideband modeling of the acoustic water pipe channel [22].	In this research, OFDM BPSK based wireless communication techniques have been used for analysis the acoustic characteristic inside water channels.
Fuzzy logic applications in water supply system management: A case study [23].	This fuzzy logic based study caters three important elements of water supply systems namely population growth, per capital water requirement and financial out lay.
An IoT based 6LoWPAN enabled experiment for water management [24].	This project is designed to harness IoT for quality monitoring and real-time water flow metering.
Real Time Wireless Monitoring and Control of Water Systems Using Zigbee 802.15.4 [25].	This study attempt to monitor the water level with the help of level sensors and Zigbee 802.15.4 module.
Multi-objective particle swarm optimization for allocation of water resources [26].	In this research, Multi-objective particle swarm optimization (MOPSO) algorithm investigated to generate a set of Pareto-optimal solutions. The task of study is to present multi-objective allocation model for water resources.
Smart metering implementation for enabling Water Conservation and water demand management: An investigation in Gauteng [27].	The aim of this study is to maintain Water Conservation and Water Demand Management (WC/WDM) in municipalities.
Intelligent control of capillary irrigation system for water-saving cultivation [28].	Capillary based irrigation system has been tested using a high capillarity fibrous medium for efficient water supply to the rooting zone of plant.
Smart water meter system for user-centric consumption measurement [29].	This research introduces the WSN Smart water meter system. This study proposed an intelligent and robust system using the IEEE 802.15.4 standard embedded in ContikiOS LibCoAP.
A thermal imaging based wireless sensor network for automatic water leakage detection in distribution pipes [30].	This study attempt to develop the thermal (IR) imaging and WSN based automated leakage detection system for distribution pipes.
System Dynamic Modeling for Behavior Pattern on Process and Operation of Water Treatment Plant [31].	The aim of this study is to dynamically model Process and Operation of Water Treatment Plant.

This case study is an attempt to further highlight the conventional and smart water treatment operations and processes as shown in Figure 3 and Figure 4. The motivation here is to propose a wireless sensor based monitoring, SCADA's system for managing pressure, detect leaks and pipe failure prediction, information aggregation, data analysis KPI monitoring and smart meters for recapturing revenue and detecting theft .

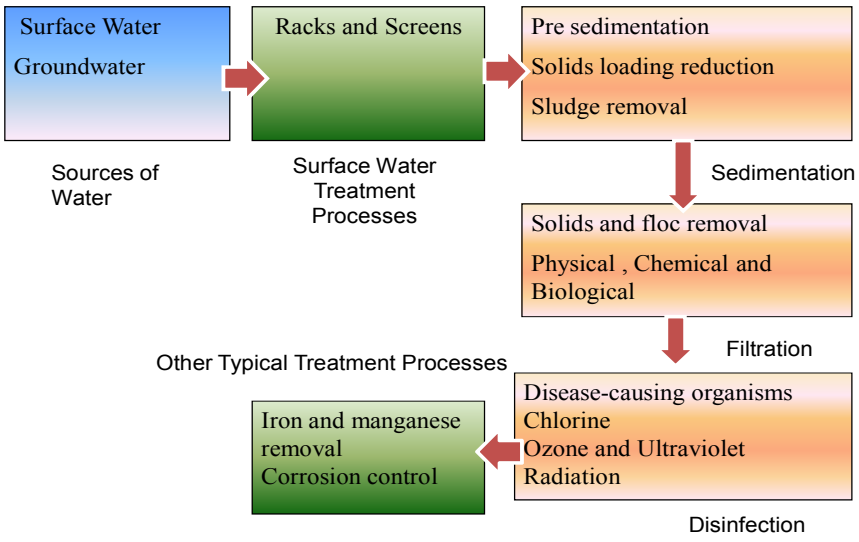

Figure 3: Conventional Water Treatment Operations and Processes

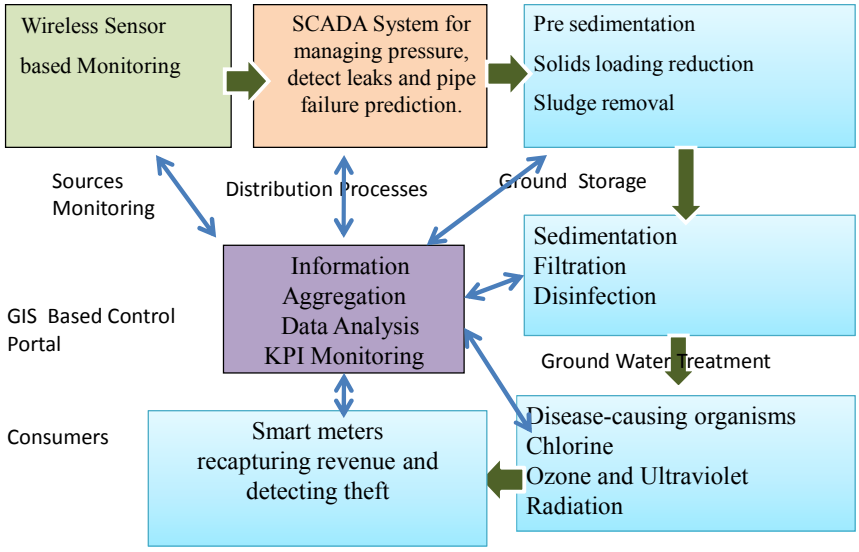

Figure 4: Smart Water System for Semi Arid Regions [32]

4. PLAN OF ACTION

The plan of action includes future growth in the population served.

Supply Side

Increasing Water Supply through various techniques

1. Water Catchment
2. Concealed Under Ground Storage for rain water
3. Reverse Osmosis Plants
4. Low cost portable solar desalinates
5. Smart Agriculture with dripping irrigations
6. Recycle Sewerage water

Distribution Channels

1. Prioritization of local and commercial clientele
2. Supply Pipeline and Trunk Main
3. Overhauling Pumping Stations

Demand Side

1. Forecasting
2. Usage Efficiency through smart metering
3. Theft control
4. Tariff on Usage

Funding Agencies

1. WHO,
2. UN for Water,
3. Global Water Partnership (GWP) and its regional programs

Private/Public Partnerships

1. Civil Societies
2. Non Governmental Organizations
3. Local Bodies
4. Centralized Authorities
5. Local Industries

5. CONCLUSION

Understanding climate change hazards and its impact on water quality and supply is the open challenge both for local communities and for global nations. Arid regions such as *Deh Band Murad are* facing acute degradation of supply and quality of water resources. In the near past, this region was flourished due to the continual supply of water from nearby streams but with continual drought, life is getting miserable. Through the joined hand among local communities, local bodies, civil societies, nongovernmental organizations, local industries, centralized authorities and by adapting smarter technologies, this suffering can be reduced and bring prosperity to the region.

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