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CENTRE FOR PEACE, SECURITY AND DEVELOPMENTAL STUDIES

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# Water Resources Management Karachi : The Uroos-ul-Bilaad

## Mitigation Intervention & Strategies to Enhance Safe Drinking Water Availability and for Improved Health and Hygiene Environments

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# BACKGROUND

The **Center for Peace, Security and Developmental Studies (CPSD)** is a public policy think tank that aims to project strategic foresight on issues of national and international significance through objective and independent analyses. Our mission is to undertake research which leads to cultivation of new ideas for resolving problems which are faced by society at the local, national and global stratum.

Karachi, being the country's most populous and demographically diverse metropolis, is indispensable to Pakistan's economy. Its development and the subsequent preservation of resources is directly proportional to Pakistan's socio-economic progress. After a period of chaos, terrorism and political turmoil, this relative peace period now demands for better and sustainable governance measures. The general sentiment from the city however, projects it as neglected, underdeveloped and mismanaged.

CPSD has envisaged an ambitious research program titled **"Karachi: The Uroos-Ul-Bilad"** to produce a series of policy reports advising the Government of Pakistan on concrete solutions addressing challenges to Karachi's development indicators: Water, Health, Education, Energy (Power) and Human Resource development.

According to the World Resource Institute, Pakistan is among the leading five nations that face extremely high water scarcity and low access to safe drinking water and sanitation. Similarly, the UN has categorized Pakistan amongst those few unfortunate countries where water shortage is speculated to destabilize and jeopardize its existence in the next few decades. Despite being Pakistan's microcosm, Karachi is beset by a lack of basic civic amenities, primarily clean and hygienic water for drinking and domestic use, in addition to a general water shortage that has prevailed in recent years due to poor water management and global climate change.

Keeping a holistic view in mind, CPSD's effort focuses specifically on producing a policy document to address the gap in proposing concrete solutions to manage Karachi's increasing water woes.

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## Introduction

1. Pakistan currently faces the grave issue of water scarcity and contamination, which not only adversely impacts, public health but also over shadows economic development. The water resources management has also been deteriorating as, 80-90% of drinking water received by consumers in Pakistan's mega cities, is also contaminated due to discharge of raw sewage into water bodies. Nearly, 25 % of water is lost due to flood irrigation practices and a sizeable quantum is lost due to unlined watercourses, and in the evaporation process. The main contributing factors for this water lossage are unsustainable water resource management approaches, devoid of strategies & action plans and irresponsible water governance.

2. In light of the status quo, and the catastrophic impact the water crisis can potentially have, The Centre for Peace, Security and Developmental Studies (CPSD) took the initiative of hosting the first roundtable meeting in 'Karachi titled as The Uroos-ul-Bilad' on 24th May 2018. The conference focused on water crisis management, with the main aim of proposing sustainable water resources management strategies. The specialists and panellists discussed the pressing issues of water scarcity, distribution, quality and role of civil society in dealing with such crisis.

Through this roundtable, CPSD aimed to act as a catalyst, and facilitate ideas and policies addressing the issue of water scarcity in Karachi. In light of the recommendations, a detailed paper on water resources management was written by a water sector specialist with conclusive policy recommendations. Views and suggestions of all the stakeholders were solicited in the form of meetings and site visits. Details as under:

a. Consultative meeting with local water sector development and management professionals from UNDP, Alpha Group of Companies, techno consultants, D-tech waste solutions and Hangzhou jinjiang group solid waste management company-Karachi (Chinese solid waste management company.

b. Meeting with deputy managing director - KWSB.

c. Keenjhar lake visit to assess its storage potentials and pollution loads for the purpose of its rehabilitation.

d. Visit of wastewater treatment plants ( TP-1, 2 & 3) and NED university , managed by KWSB.

3. A detailed, and thorough research paper on " water resources management - Karachi " has been written, with the main aim of enhancing water availability and contamination reduction. Bad water governance has been observed which has contributed largely to water scarcity and contamination. Unmanaged wastes (solid & liquid) are the main cause of massive water contamination, for which nature based treatment solutions have been suggested. The policy recommendations, mentioned in this paper are at international, national and Karachi specific levels;

4. The recommendations of the round table conference are meaningful which need to be translated into sustainable water resource management approaches, strategies and action planning. Following the above-mentioned recommendations, CPSD aims to formulate adaptation approaches , strategies , mitigation and action plans for the decision makers / Government of Sindh .

# Part-1- Water Resources Management - Situational Analysis-Pakistan

## 1.0 Water Crisis - Pakistan

### 1.1 Water Profile - Pakistan

As per the findings of the 2006 UN report "there is enough water for everyone and water insufficiency is due to mismanagement, corruption, lack of appropriate institutions, bureaucratic inertia and shortage of investment in both human capacity and physical infrastructure".

Water security is an important issue driving state stability and safety in many regions of the world. The direct and indirect effects of water stress, such as increasing trends of migration from rural to urban centers, food shortages and general destabilization—transcend national boundaries. As water stress increases in the coming years, prioritization of water resources in domestic and global security policies will become even more essential.

Over the past few decades growing urbanization, economic growth, poor population management, climatic change and other challenges have put an increasing pressure on Pakistan's water resources. The per capita surface water availability in the country has undergone drastic changes declining from 5260 cubic meters per year in 1950, to around 1000 cubic meters in 2016. Per capita water availability in Pakistan is expected to fall to 860 cubic meters by 2025 , against the international threshold of 1000 cubic meters. Pakistan is feared to be one of the most water stressed countries by 2040. The water stress levels have been shown in figure 1, below;

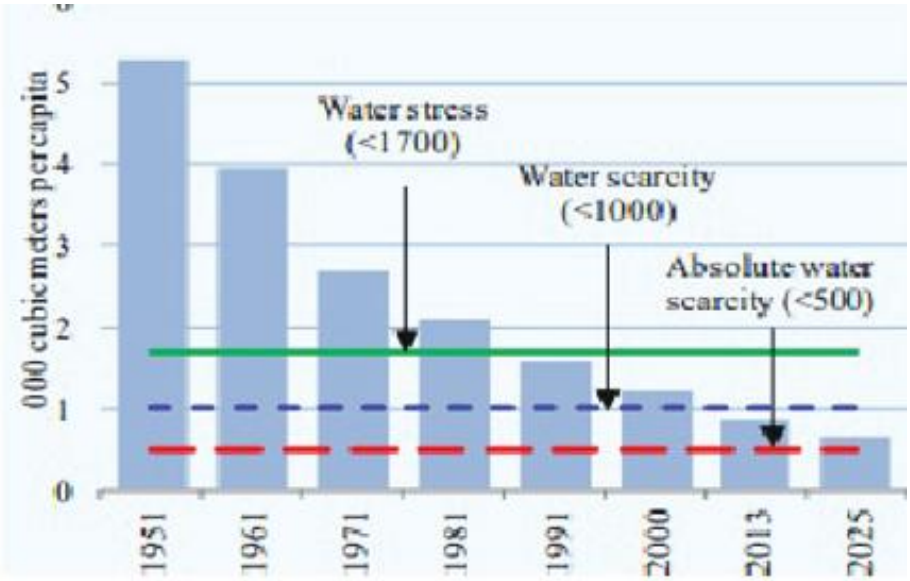



**Figure 1: Water stress level - Pakistan**

Source: Annual report of state bank of Pakistan 2016-2017 ( though draft national water policy)

The groundwater depletion in the country has outpaced surface water depletion posing serious threats to the sustainability of this valuable resource. Additionally, pollution of existing water resources has further aggravated the issue of water scarcity, reducing its usability and degrading the ecosystem manifold. Alarmingly, Pakistan has been ranked among top ten countries with lowest access to clean water.

Climatic changes have further compounded water issues leading to increased frequency and intensity of floods on one hand and prolonged droughts on the other. In view of potential colossal impacts of water shortages on human lives and economic productivity, a framework is gravely needed to address the water issues. Though many policies existed in Pakistan which deal with specific aspects of water related issues, like the National Drinking Water Policy, National Climate Change and now National water policy, but it lacks implementation .

The Express Tribune – said that the per capita designed live water storage capacity available in Pakistan is 121, instead of 150 - previously being quoted, cubic meters per person which is only higher than that of Ethiopia report compiled by (UNDP) in Dec, 2016."

## 1.2 Water Resources Base

The details of water resources of Pakistan are appended below;

| | | | |
|---|---|---|---|
| a. | Surface water | 138 | MAF |
| b. | Total available storage | 16 | MAF ( which has reduced to 11 MAF) |
| c. | Sedimentation in storage reservoirs | 0.16 | per annum |
| d. | Canal diversion | 106 | MAF |
| e. | Ground water availability | 55 | MAF |
| f. | Ground water withdrawal | 50 | MAF (only of documented tube wells) |
| g. | Irrigated Area | 18 | mha ( million hector area) |
| j. | Available for additional cultivation | 12 | mha ( million hector area) |

## 1.3 Water Usage Patterns

Water usage patterns have been shown in table 1, below;

| Sector | Water Use Percentage | Remarks |
|---|---|---|
| Agriculture | 91.6 | |
| Domestic | 3.3 | |
| Industrial | 2.5 | |
| Environment | 2.6 | |

Source: Water Sector of Pakistan: A Situation Analysis, Development Advocate Pakistan Volume 4, UNDP.

This shows the significance of agriculture in the country. Pakistan still has the world's largest interconnected & continuous irrigation system. In 1999-2000, the total irrigated area in Pakistan was 181,000 km² , which is one of the world's largest gravity-flow irrigation systems. Details are as under;

a. Three reservoirs
b. 19 barrages
c. 12 river interlinking canals and
d. 59,200 kilometres of distribution canals.

More than 160,000 watercourses comprise the water distribution network that takes water directly to the farms. More than half of these watercourses are in Punjab—the largest of the country's four provinces and the greatest agricultural producer. The system commands a land area of 14.3 million hectares, making it the backbone of Pakistan's agriculture and contributes one-fourth of country's total gross domestic product (GDP).

## 1.4 Water Management Practices - Pakistan

UNDP defines water governance as "The range of political, social, economic and administrative systems that are in place to develop and manage water resources and the delivery of water services, at different levels of society". On a more concrete level, as per the text suggests, "Water governance is the set of systems that control decision-making with regard to water resource development and management." Hence, water governance is the way decisions are made such as how, by whom, and under what conditions decisions are to be made for sustainable water development and management.

In any country, good governance is critical for sustainable development. Similarly, good water governance is a pivotal factor in providing sustainable water development and management. Since the water crisis is essentially an outcome of the water governance crisis, addressing ineffective water governance becomes a prerequisite for facing the challenge of prevailing water crisis in Pakistan. Water conservation, its management and efficient use are of paramount importance even speaking from the national security viewpoint. A country's security will be in peril if its agriculture sector suffers a huge blow due to water shortage.

Water security is indeed synonymous to national security as mentioned above. Statements by the Indian prime minister, "blood and water cannot flow together" pose a grave threat to our national security. The Pakistan leadership decried such a public statement of the Indian prime minister as an 'act of war'. Sabre rattling and challenging roar of the country's leader aimed at capitulating Pakistan will not succeed. The blustering of the Indian prime minister was meant to increase his vote bank, at home. Strategies like the above gained, gained the BJP a landslide victory. It is speculated that, the BJP government, might continue playing on Pakistan's fear in order to extract concessions to build more dams on the rivers of Indus River System, notwithstanding the binding obligations imposed on the signatories.

Following the above, judicious water utilization is not practiced as per the international standards of integrated water resources management (IWRM) which allocates water for economic development, for human needs and for environment. The absence of IWRM, results in a huge quantum of water being diverted for agriculture with minimal returns.

Apart from declining water availability as indicated above, the absence of appropriate and stringent regulations on water exploration, groundwater in the country is also depleting at a rapid rate as water imbalances in terms of supply-demand gap has led to increased ground water exploitation. Another aspect of mismanagement was revealed by a 2017 report of Indus River System Authority, according to which "Pakistan dumps water worth approximately $21 billion into the sea each year due to lack of water conservation system."

## 1.5 Indus Water Treaty

The World Bank, who mediated in 1960, is the guarantor of the Indus Water Treaty. In accordance with the treaty – sponsored by the UK, Germany, Australia, New Zealand and Canada – India and Pakistan were given control of three rivers each, originating from Jammu and Kashmir.

Later, Indian Premier Jawaharlal Nehru invited American expert David E Lilienthal to survey the situation. Lilienthal's determinations favoured Pakistan's position, thus failed to win Delhi's support. The matter remained unresolved as the WB sponsored several rounds of talks in Washington from 1952 to 1960. The pact allocated the eastern rivers (Ravi, Sutlej and Beas) to India and the western rivers (Jhelum, Chenab and Sindh) to Pakistan.

The Indus Water Treaty (IWT) is the most significant confidence-building measure between India and Pakistan. Despite the wars and hostilities, the IWT has functioned well since it was signed in 1960. However, one cannot ignore the challenges of future supplies of freshwater between the two countries.

Since India and Pakistan's independence in 1947, both states have fought over the disputed territories of Kashmir to gain control of water supplies, which are strategically valuable. Even in recent times, the countries are facing constant threats from each other over several separate issues. India and Pakistan's water conflicts are long-standing and relate to Indian infrastructure on the western tributaries. Pakistan is of the view that India is robbing Pakistan's water supplies and building its water management capacity only as a political manoeuvre to gain political supremacy by practicing hydro-hegemony. On the other hand, India maintains that it is only constructing infrastructure within the scope of the Indus Waters Treaty (IWT), thus the decreased water flows in Pakistan are due to climate change. Owing to Indian construction works on the western rivers and the Pakistani interest in safeguarding its water supplies, water disputes are routinely referred to the legal mechanism prescribed in the IWT. Recently, the tension over water conflicts between India and Pakistan has been soaring. India has threatened that it will scrap the IWT entirely. In response, Pakistan has stated that such a revocation of a bilaterally agreed treaty would be considered an act of war. This extraordinary intensity in political rigidity between Pakistan and India has a solution enshrined in the legal framework of the IWT to alleviate water disputes.

Despite the legal competence, the option of inviting a neutral expert is also susceptible to external influence. Over the years, India has invested in its clout in the World Bank. Just last year, it became the seventh largest shareholder in the World Bank with a better voting share in its affair. India's voting power now rests at 2.91 percent while China's at 4.42 percent. Due to anti-China posturing, India has been winning western support at the global multilateral institutions. Thus, without giving up on arbitration option, Islamabad may also launch diplomatic and political offensive in the light of IWT provisions as well as being a lower riparian, raising environmental and food safety concerns. The existing yearly data already suggests, that the water inflow has been decreasing vis-a-via the precipitation received in catchment areas. The takeaways from IWT are ;

- Unfair Indus Water Treaty of the past (1960) appears to be the best mechanism in hand for Pakistan at present.

- India is not a friendly country & hence we need to focus on ways & means to ensure the implementation of IWT in its true letter & spirit.

The UNDP publication that gives a clear and succinct situational analysis of the water sector of Pakistan. A few points that need to be highlighted are, as under;.

- The Indus Water Treaty has failed to address two issues namely- the division of shortages in the dry years between India and Pakistan and the cumulative impact of storages on the flows of Chenab River into Pakistan.

- While water availability is restricted with the current population at 190 million (2016), an increase of 14.2 percent of water will be required by 2025 when the population would increase to 217 million. The demand would also increase with higher demand for multiple water uses.

- The storage capacity of waters for Pakistan is only for 30 days compared to the Colorado river which is 900 days.

- Glaciers constitute a huge reservoir of fresh water to the area. The river flows are highly variable and give rise to water crisis frequently.

- Ninety two percent of the country is semi-arid to arid.

- Pakistan has been negligent in conducting a sound analysis and delays in presenting cases to the Indus Water Commission or World Bank have caused the issue to hang loose and remain unaddressed.

- Water has been highly politicised in Pakistan and there is an extreme deficit of trust among the provinces.

- WAA 1991 is very unfair to Punjab but it is a done deal and for the sake of Pakistan, we need to learn to live within the allocated share of river-flows.

- Legislation on water sources and watershed area protection, water source protection actions can involve regulations, economic incentives, and collaborative partnerships.


Figure-2: Map of the Indus River basin. Credit: Kmhkmh, Wikipedia Commons.

## 1.6 Policy Option

### 1.6.1 International Level

Instead of futile renegotiation treaties between India & Pakistan, as a policy line, we should press for all required and effective Confidence Building Measures (CBMs), under the Indus Water Treaty for the trans-boundary river water supply management like:

"Neutral monitors, telemetry system, Joint watershed management and unrestricted access by the members of the Indus Water Commission, etc".

### 1.6.2 National Level supply side

- Federal government to reach a consensus, to build dams only at major rivers to streamline turbulence during, skewed seasonal river flows.

- Provinces to be allowed to build their own off-channel storage facilities (like piggy banks) to conserve their legal share under the WAA 1991.

- Measures such as, intelligent and integrated Micro watershed management to be tapped in all the provinces, whereas NESPAK study identifies that approximately 18 MAF area based rain water harvesting potentials exist. Pothohar and Rodhkoi (Deragahazi khan - Kou-e-Suleman area) in Punjab and, likewise in Sindh and Balochistan.

- Diversion of flood water into three dysfunctional eastern rivers for multifaceted purposes, to augment bio-diversity , local ecosystem, irrigation and, improving ground water recharge. China is a good example for this, having diverted excess / flood water into 30 rivers.

- Provinces to be encouraged to build water storage facilities at canals, watercourses and farms to conserve water, as per demand and delivered when required.

- At provincial level, new departments for groundwater development and management to be instituted or on-farm Water Management Directorates to be renamed to, "Integrated Community Water Management Departments", with an additional mandate of surface and groundwater supply management.

- Watershed Management (area based on rainwater harvesting & water storage) to be used in Rodhkoi area, in Pothohar and Baluchistan.

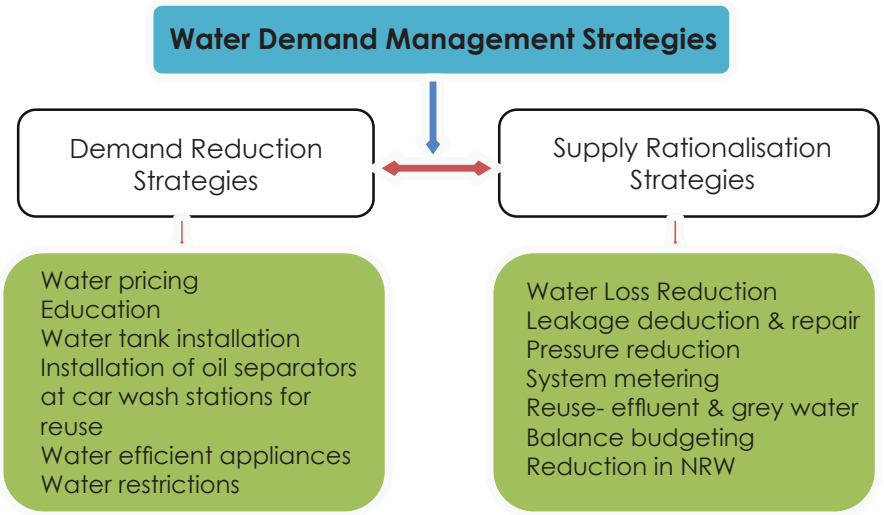
- Small-medium dams will be endowed to deliver water on volumetric basis via the pipe – supply network.

- Till the installation of the wastewater treatment facilities, the wastewater will only be utilised for growing forest plantation around urban centers instead of agricultural crops.

- Comprehensive and pragmatic strategies to be chalked out by provinces for water sources and watershed area protection from natural & anthropogenic activities and management, both surface & groundwater.

### 1.6.3 Policy options for Demand Side

Salient features on demand side water management are shown in figure-3, below



- Incentives will be provided to reduce demand on water availability by providing technologies like LASER land leveling, growing drought resistant crops, pressurized irrigation, bed-planting, use of treated wastewater, virtual water savings, etc.

- Disincentives will be enforced to discourage overuse or inefficient use of water by pricing water close to groundwater market price.

- Starting from small dams, pilot projects will be initiated to make use of canal outlets for delivering water on volumetric basis.

- All social devices, including political will, will be implemented to enforce demand-side water management.

### 1.6.4 Policy option for water governance

a. Ineffective water governance is the main hindrance of integrated water resources management. Stressing upon good governance, the current irrigation & drainage reforms (PIDA) must be taken to their logical end, and their mandate should be extended to cover other water use sub-sectors.

b. Basin specific Integrated Water Resources Management (IWRM) concept of water allocation amongst for all the areas (like water for economic development, water for human needs and water for environments) to be put into place for judicious water allocation

2.0 Existing Water Resource Management and Environmental Sanitation Practices-Karachi

Karachi is ranked among the top ten largest cities in the world. Currently, the population is around 15 million (Census-2017) which is expected to increase exponentially. Apart from in-migrants from other provinces, a large number of migrants from other countries have settled in the city. The number of households in 2001 was about 2.1 million and by 2020, it is speculated to increase to 3.9 million. Roughly, 75% of the households fall in the category of poor and low income group while the rest 25% constitutes the middle and high income groups.

An Overview of Existing Status of Provisioning of safe Drinking Water and Sanitation Services by KWSB- Karachi.

The administrative and service areas of KWSB and Cantonment board is shown in figure-4, below

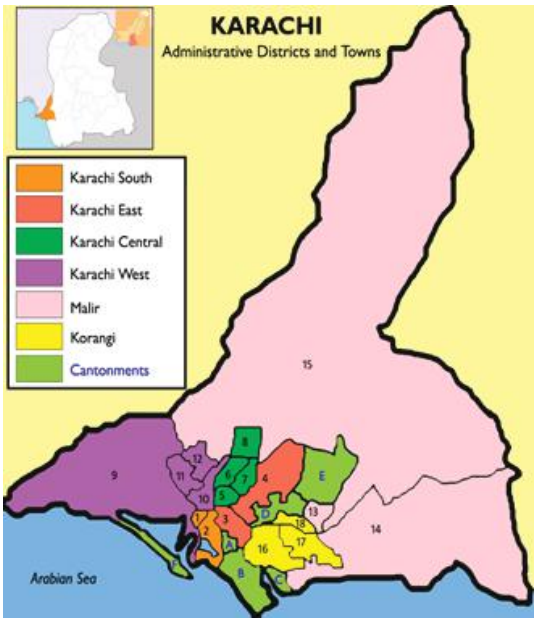



Figure-4: Administrative and Service areas of KWSB and cantonment board-Karachi

## 2.1 Water Availability and Water Sources - Karachi

The main reliance is on surface water from Keenjhar lake and Hub dam and there is no appreciable ground water sources, being brackish with high total dissolved solids( TDS). The details are as below;

a. The present supply to Karachi from Indus (Keenjhar lake and Hub source is approximately 650MGD (2925 ml/day).

b. The per capita water demand @ 54 GPCD for 20 Million population is estimated to be 1080 MDG.

c. Approximately, 5 MGD water is being provided from Domlottee wells, which are charged by pumping surface water and water is delivered through Domlottee conduit on gravity flow regime. Previously, Domlottee wells were recharged through infiltration galleries originating from seepage water from Miler river

d. The current shortfall is anticipated as 430 MGD.

e. Main water sources are Keenjhar Lake (Indus River) and Hub dam from where water is pumped through three main pumping stations located at Dhabeji, Gharo, and Hub.

f. K-4 project for conduction of 260 MDG water is in progress.

g. The existing water supply network is shown in figure-5, below;


Figure-5: Existing water supply network and its present status
( leaking & outlived pipes ) - Karachi metropolitan

Some of the water sources development and water supply network were laid , in 1887 till to-date, are also shown in figure-5a, shown below;

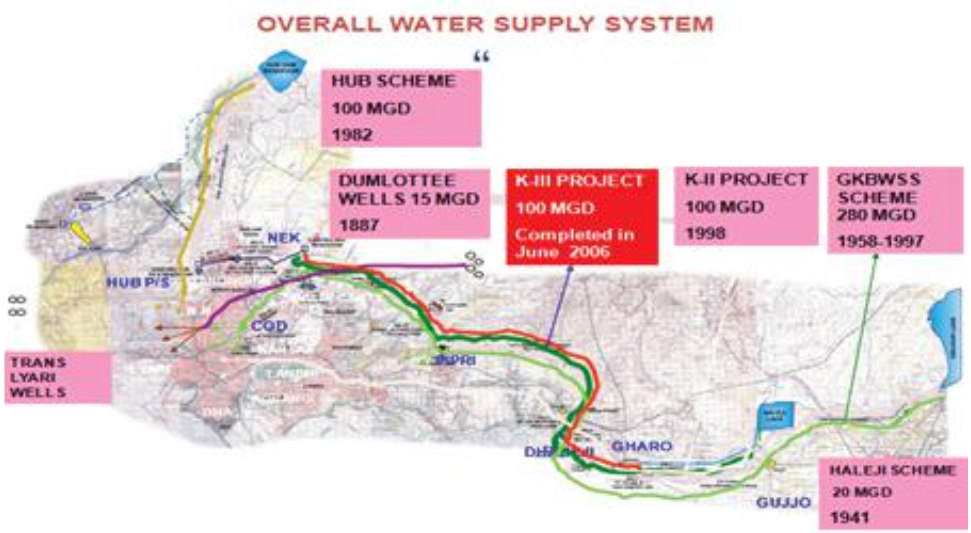



Figure -5a: Water sources Keenjhar & Hub Dam - Overall Water supply network , laid during various periods of times ,

## 2.2 Wastewater Generation and Management Practices- Karachi

There are a total of eight wastewater treatment plants in Karachi, five are manned by KWSB , namely, TP-1, TP-2 , TP-3, TP-4 and TP-5 constructed in the 1960's and three are owned by the private sector, like two by DHA & cantonment board, one by steel mill and one by NED university etc. All these five STP's of KWSB are dysfunctional and now TP-3 , which entails a capacity of treating 77 MGD wastewater, has recently been upgraded and made functional and up gradation work on TP-2 is in progress .

Lagoon cum oxidation ponds technology has also been employed, which, too has its inherited disadvantages of H2S gas emission and subsequently formation aerosols of H2SO4 (sulfuric acid) which pose a grave threat to the population residing around these treatment plants. Moreover, no treated water reuse strategy has been planned, and treated wastewater will be disposed into the sea which will be a wastage of scarce water resources.

Photographs of dysfunctional sewage treatment plant (TP-2) and wastewater treatment generation and treatment plant locations have been shown in figure-6, below;

Figure-6: Dysfunctional Treatment plant ( TP-2) , wastewater generation treatment locations management practices

## 2.3 Sewage Disposal in Open Channels

Most of the generated sewage is disposed off- in open channels & drains which adversely impacts public health, in the form of emission of H2S gas and its subsequent conversion into aerosols of H2SO4 after reacting with atmospheric water vapors. These deadly acidic aerosols cause cardiac & vascular disruption. Few of the sewage disposal into open channels and drains/ Nullahs are shown in figure-6a & 6b, below;

Figure-6a: Sewage disposal into open channels and Nullahs

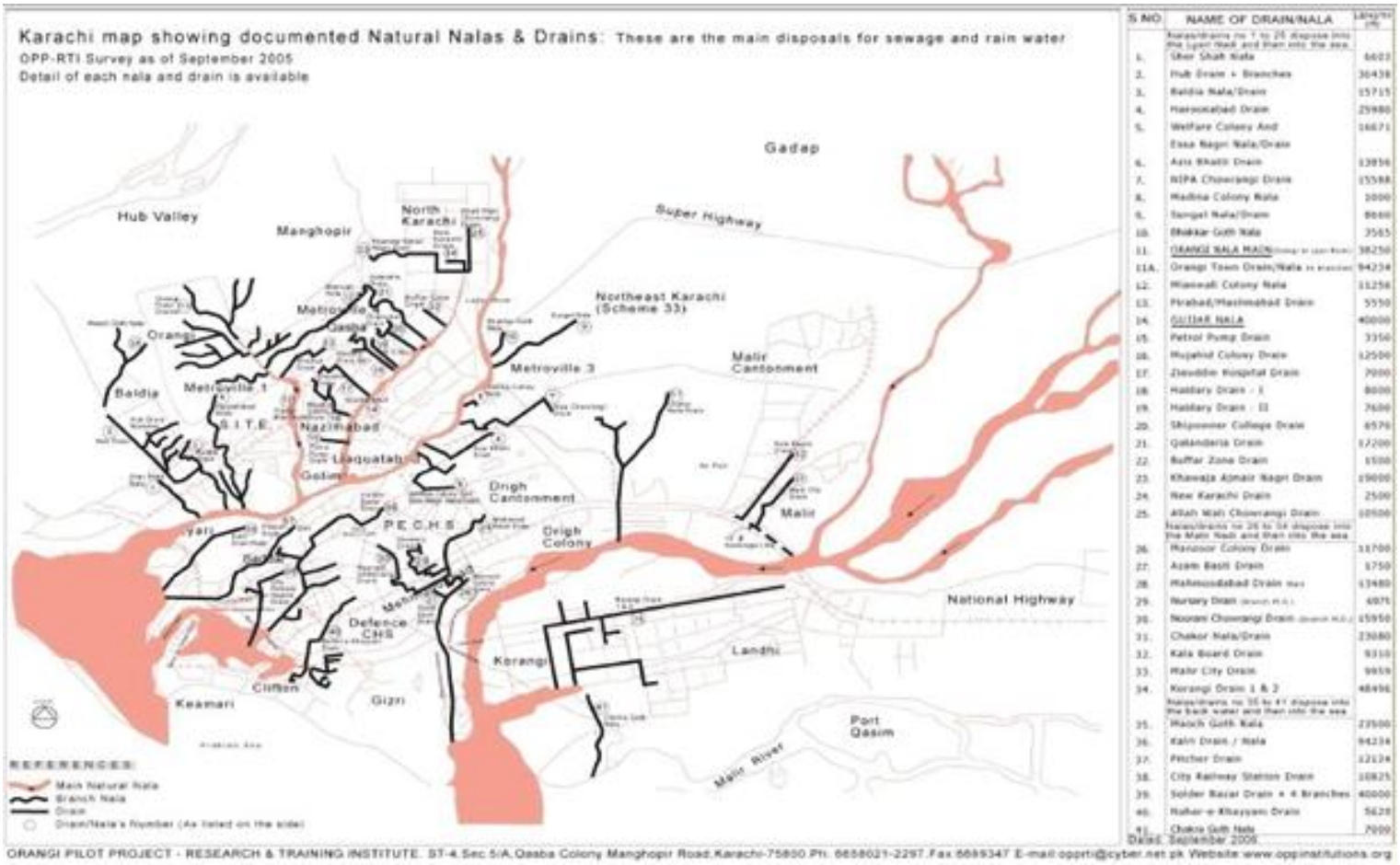



Figure-6b: Map showing Sewage disposal into various Nullahs, drains and open channels

## 2.4 Solid Waste Management Practices - Karachi

Today, Karachi is a facing a severe garbage outbreak, which is now spreading across the city from developed to underdeveloped areas. In many areas such as Lyari and Malir, where communities live in close proximity to garbage dumps, this has led to increased illnesses and a health catastrophe,as flies and unhygienic disease carrying substances spread across the city. Consequently, there has also been a rise in deaths, especially amongst infants who fall victim to these diseases. About 20, 000 tons of solid waste is produced everyday; however only 2,000 tons is transported to landfill sites outside Karachi. This waste is usually left on streets or dumped wherever space is available.

The overall situation of solid waste management in the entire city poses big health and hygiene concerns to public health. Though the Sindh government ( the Sindh Solid Waste management Board ) has outsourced solid waste collection and disposal of solid waste of Karachi. The vendor just collects and dumps huge quantum of solid waste and no benefits like the conversion of waste to energy or RDF, are being reaped from this. Lechetin from unmanaged solid waste contaminates water sources.

The statistics of solid waste generation, management practices and locations of dump sites are mentioned in the map, as shown in figure-7, below;


Figure-7: Location map of solid waste management collection and disposal sites

## 2.5 Multifaceted Issues, Problems and Challenges - KWSB

a. Limited natural water resources, like nearby area based rain water harvesting and non-availability of ground water sources,

b. Increased rural to urban migration trends , unmanaged urbanization and exponential increase in population growth

c. Planned and unmanaged water thefts in the form of Tanker Mafia

d. Lack of proper water related infrastructures, old and leaking water supply network and leaking main, secondary and tertiary water supply network.
e. approximately, 45-50 % unaccounted for water and non-revenue water which are very high as opposed to international best practices of around 6%.
f. Unmetered water supply which over consumption of water.
g. Illegal unauthorized and unmanaged housing colonies.
h. Use ofsuction pumps throughout the supply network which causes water contamination at consumer's end.
i. Private and illegal connections by boring into the KWSB main lines.
j. Expansion of the city limits, DHA, ever increasing industrial activities in Port Qasim, more and more industrial zones, burden the water supply of KWSB.
k. Incompetence of management within KWSB, having 60% establishment expenditures of the total budget which are very high as compared with international best practices of 16%.
l. Profuse political interferences in the utility affairs has overshadowed its efficiency.
m. Intermittent water supply practices which is the main element of drinking water contamination.

## 2.6 Beyond Urban Water Security - The vulnerabilities of Intermittent Water Supply - Karachi

Globally, many cities, including Karachi, today are at risk of running out of water, with water unavailability now cited as one of the greatest risks to business continuity and growth. It is clear, that a lack of proper water management, poses serious risks to human wellbeing and sustainable development. Imagine going through your day with limited access (only for a couple of hours per day or a couple of days per week) to store water in your home for drinking, cooking, washing or bathing. The condition where water is provided for a limited period of time is called Intermittent Water Supplies (IWS), and affects at least 1.3 billion people around the world. The implications of the intermittent water supply (IWS) are many and complex, leading to adverse impacts upon society, along various dimensions which are as under:

a. IWS service costs more than continuous service.

b. Intermittent hours of water supply force customers to rely on black-markets or informal vendors, often serving higher-income citizens, thereby exacerbating inequalities among users.

c. It also weakens the social contract between governments and their communities when water utilities fail to deliver basic water services, perpetuating a downward spiral of water insecurity and fragility in many developing countries including Karachi.

d. Impacts of climate change on IWS can act as risk multipliers in fragile contexts, contributing to conflict, violence, or migration.

e. Water quality problems due to the potential suction of non-potable water by negative pressures, biofilm detachment, and microbial re-growth especially when static conditions occur. Roof tanks often encourage bacterial re-growth.

5.6 Keeping in view the above issues and challenges faced by KWSB , The present status of services delivery to the consumers can best be described by the downward spiral , as shown in figure- 8, below;

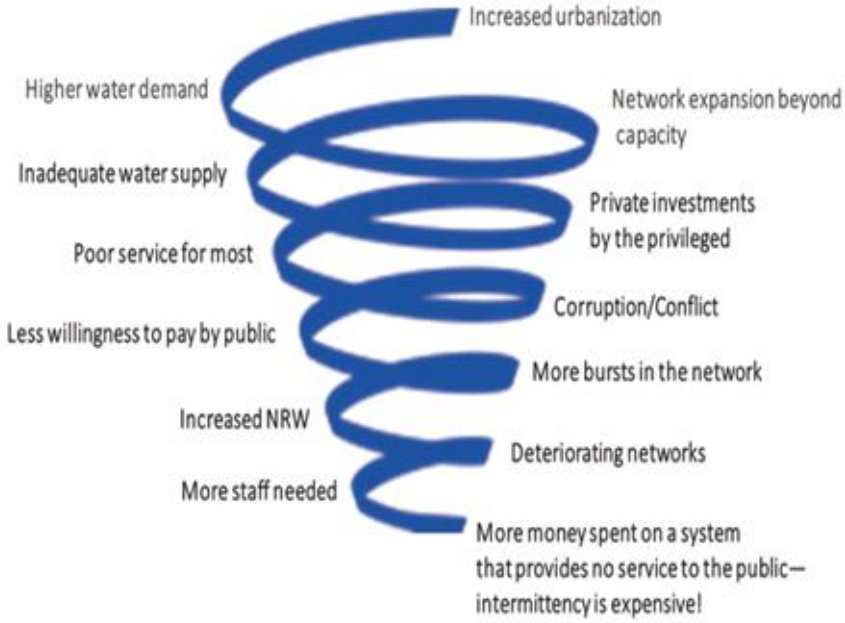



Figure: 8 The downward spiral of IWS / Source: Charalambous, B. and Laspidou, C. (2017).

## Part-2 , Enabling Environments, Legal Framework, Policies and Practices for efficient Water Resources Management

### 3.0 Better water governance posits upon well thought of enabling environments, legal frameworks and policies & practices. Various conceptual and legal frameworks of water and sanitation governance, essentially required for better service deliveries, are as follows;

### 3.1 Enabling Environments for Water Governance Functions

Water resources management, particularly, safe drinking water provisioning is the joint function of all the stakeholders which calls for prudent coordination and cooperation amongst all the stakeholders to develop an effective sector which can be seen as the core water governance functions. There is no commonly agreed set of core functions, and they can vary depending on the level of development of the water sector in the city, province and in the country context. In a country with medium to low level of access to services.

Before, undertaking mitigation measures to enhance water availability in Karachi, following set of core WASH governance functions and definitions are suggested for analyzing and understanding to resolve water governance in Karachi, as shown in figure-9, below;


Figure-9: Diagrammatic representation of core water governance functions

## 3.2 Integrated Water Resource Management ( IWRM)

Globally, equitable water distribution amongst various stakeholders is carried out under IWRM, which specifies water allocation for economic development, for human needs and for environment. Therefore, the IWRM strategy for fair and efficient water allocation is suggested for industries, human needs and for environments in Karachi as well. The conceptual framework for IWRM is as shown in figure-10, below;

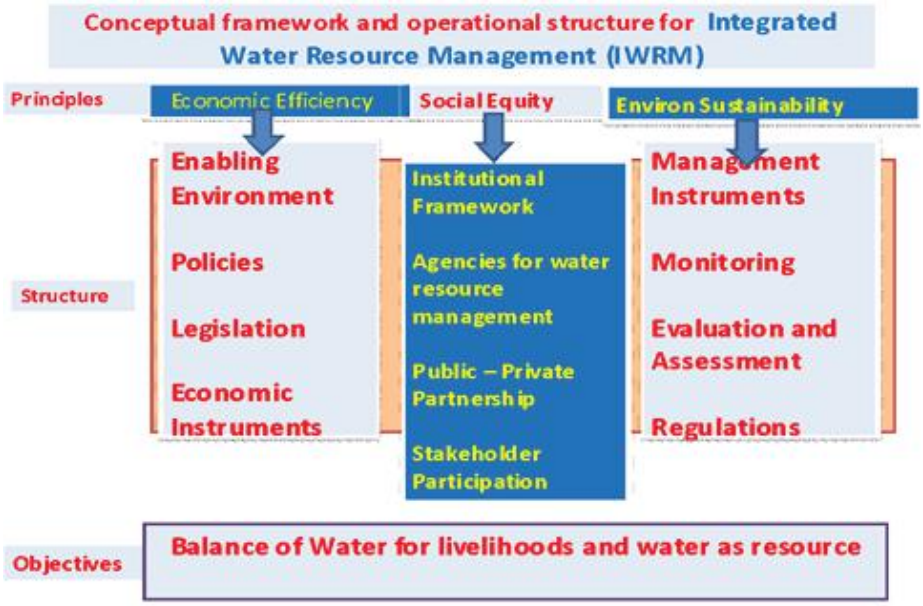



Figure-10: IWRM conceptual framework for equitable water distribution

## 3.3 Policies and Water Management Practices

To tackle water scarcity and to reduce drinking water contamination in Karachi , following water governance policies and practices are suggested, as shown in figure-11, below;

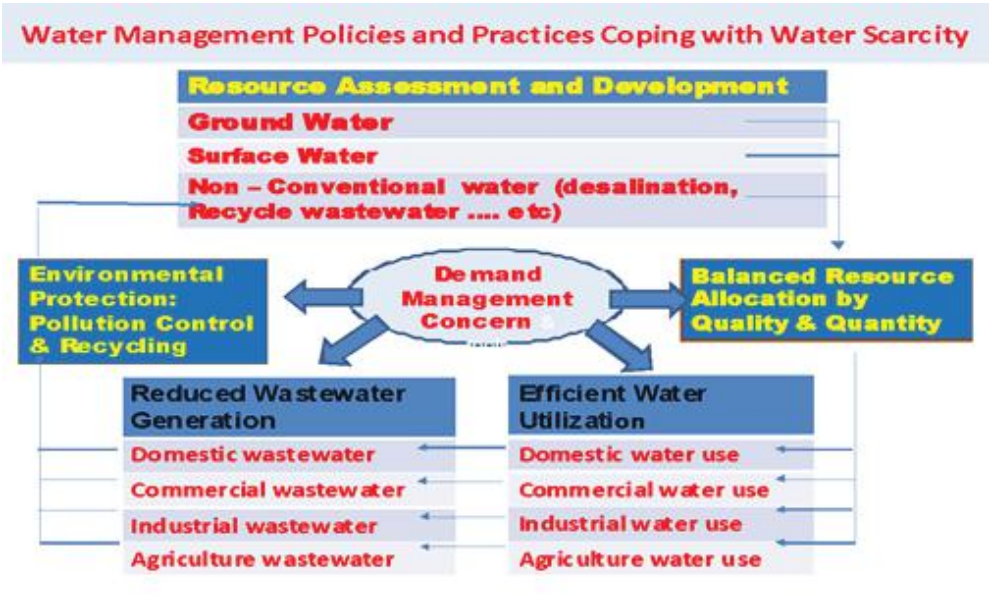



Figure-11: Water Governance policies and practices

## 3.4 Water Resources Management and Mitigation Approaches to Enhance Water Availability and to Reduce Drinking Water Contamination

Overtime, it has been observed that mechanical types of wastewater treatment installed in Islamabad and Karachi- in the sixties could not complete their design life cycles and became dysfunctional, due to sophisticated equipment and processes, besides high capital & operational costs. Therefore, maximum emphasis to be laid on adopting nature technologies where site conditions are suitable. Financially & economically viable and technically & environmentally sustainable approaches are suggested and will be followed to address water scarcity and contamination issues in Karachi . The suggested approaches are as under;

a. Circular Economy model to enhance water availability and to address water contamination issues within the available water assets.

b. Nature based treatment concept and methodologies to ensure their sustainability

c. Decentralized approach for water resource management which includes provisioning of safe drinking water, wastewater and solid waste management and its recycling & reuse in the areas of their generation for better operational & maintenance control

### 3.4.1 Circular Economy Concept / Model to Make-up Water Shortages in Karachi

A shift to a circular economy could help save more than 400 billion m3 of water, per annum. In contrast, a traditional, linear economy is one where an asset is produced, used, and then disposed off which creates enormous problems for the environment and for the people . In a circular economy, a resource is kept in circulation as long as possible through recovery and reuse, extracting maximum value. The diagrammatic description of circular economy approach which is suggested to be adopted for undertaking water resources management measures in Karachi,

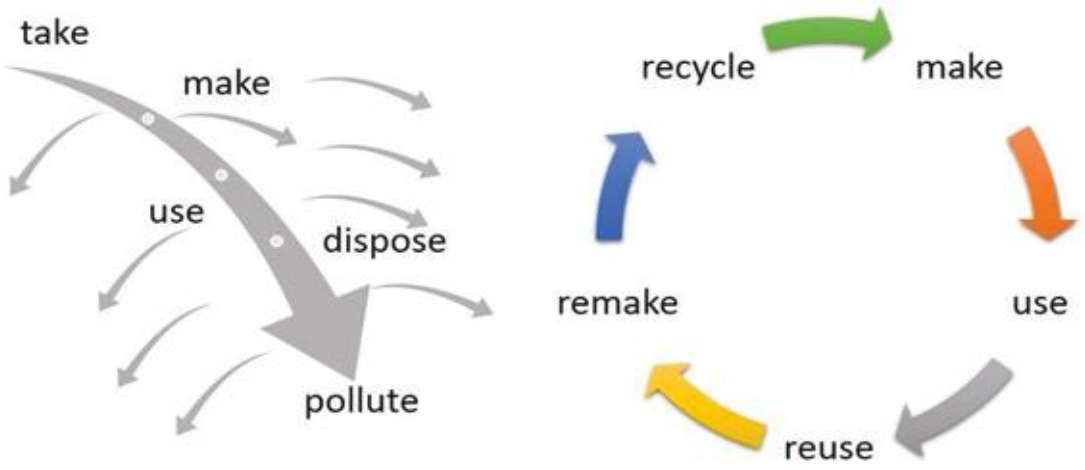



Figure-12: Diagrammatic representation of Circular Economy to be applied on wastewater and solid management - Karachi

### 3.4.2 Urban Water Cycle - Model

The urban water cycle (The Bentley water solution), based on a circular economy model, is proposed to be adopted for Karachi, as shown in figure-13, below;

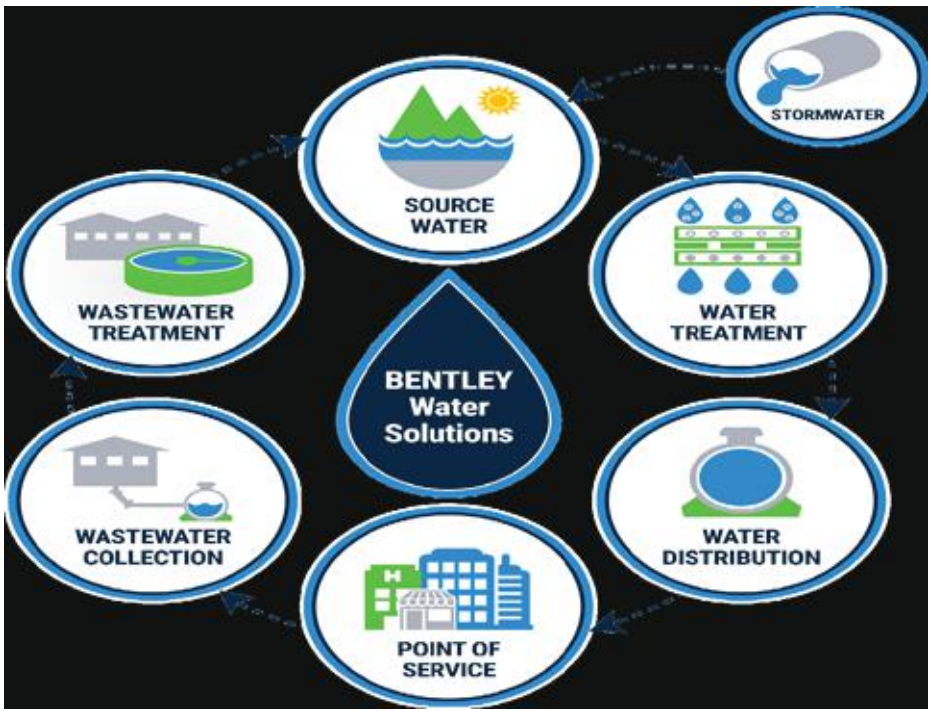



Figure-13: Urban water life cycle, developed on circular economy model

**Part-3, Suggested Interventions to Enhance Safe Drinking Water Availability and Improved Hygiene & Sanitation Environments in Karachi**

### 4.0 Mitigation Strategies Needed to Enhance Water Availability and Water Contamination Reduction - Karachi

In the backdrop of problematic water governance situation in, as mentioned above, following interventions are needed to be undertaken to improve water management in Karachi;

a. Restructuring of KWSB on corporate governance model and transformation to a financially & operationally sustainable and user friendly entity with clear social and commercial objectives. Details are mentioned in subsequent para

b. Wastewater is a resource which is required to be treated through financially , technically and environmentally sustainable wastewater treatment technologies. Preferably through " Decentralized Hybrid Constructed Wetlands". Wherever feasible and treated water be recycled for non-portable purposes to make up percentage of water scarcity and to reduce drinking water contamination.Solid waste management through "Decentralized Integrated Resource Recovery Centre" ( IRRC) system to reduce water contamination to improve health & hygiene conditions

c. Water augmentation of local aquifer through treated wastewater and rainwater harvesting - recharge of aquifer through inverted , pressure and deep wells

d. Creation of water banks - Rehabilitation and Restoration of contaminated lakes - manchar and Keenjhar, by installing bio-reefs at the junction point of recharging streams and lakes. Solar Bees are also useful for oxidation of organic ontaminants.

e. Rehabilitation and Restoration of abundant percolation Dumlottee wells, constructed during the pre-partion era in the catchment area and along Miler. Nadi/River. Previously, these wells were being charged through infiltration galleries, originating from River Miler bed seepage water.

f. Remodeling and micro watershed management of Hub dam to enhance its capacity.

g. Micro watershed management in the catchments area of Manchar , Keenjhar and Hub dams etc.

h. Assessment of ground water potentials and management - three dimensional groundwater modeling for Managed Aquifer Recharged ( MAR) for water storage and recovery - Karachi and surroundings.

i Enforcing Water Conservations strategies, like installation of oil separators at car washing stations for recycling of water, installation of double action flushing system.

j. Sponge city concept of low impact development, for stormwater management to be used for recharge of local groundwater aquifer.

k. Green city, with vertical gardening and construction of swales for rain water percolation in ground water aquifer.

l. Geographic area and water utility specific water safety plans ( WSP) to be prepared which ensures the provision of safe drinking water from “catchments area to consumers end”.

m. Conversion of polluted Nullahs, carrying wastewater, into wetlands by planting aquatic plants in segmented portion of Nullahs and drains to uptake contaminants and reducing H2S gas emission. The plantation of aquatic plants in Nullahs and drains will act as carbon sink which reduce air pollution in Karachi

n. Similarly, water utilities and city governments are suggested to prepare "climate change resilience plan" to mitigate adverse impacts of climate change on water resources to ensure water availability, continuity and water contamination

## Part-111- Action Plan- Detailed Description of Suggested Interventions.

### 5.0 Suggested Salient Policy Recommendations for approval of various Interventions to Improve Water Availability and Drinking Water Contamination Reduction- Karachi

### 5.1 Restructuring of KWSB

KWSB is responsible for the provisioning of safe drinking water and improved sanitation services to the citizens of Karachi . But unfortunately, due to a downward spiral organizational outlook, bad water governance and political interference, KWSB has failed to deliver quality services to their consumers.

Therefore, keeping in view the above mentioned issues and challenges, restructuring of KWSB is suggested as per the following model, as shown in figure- 14, below;

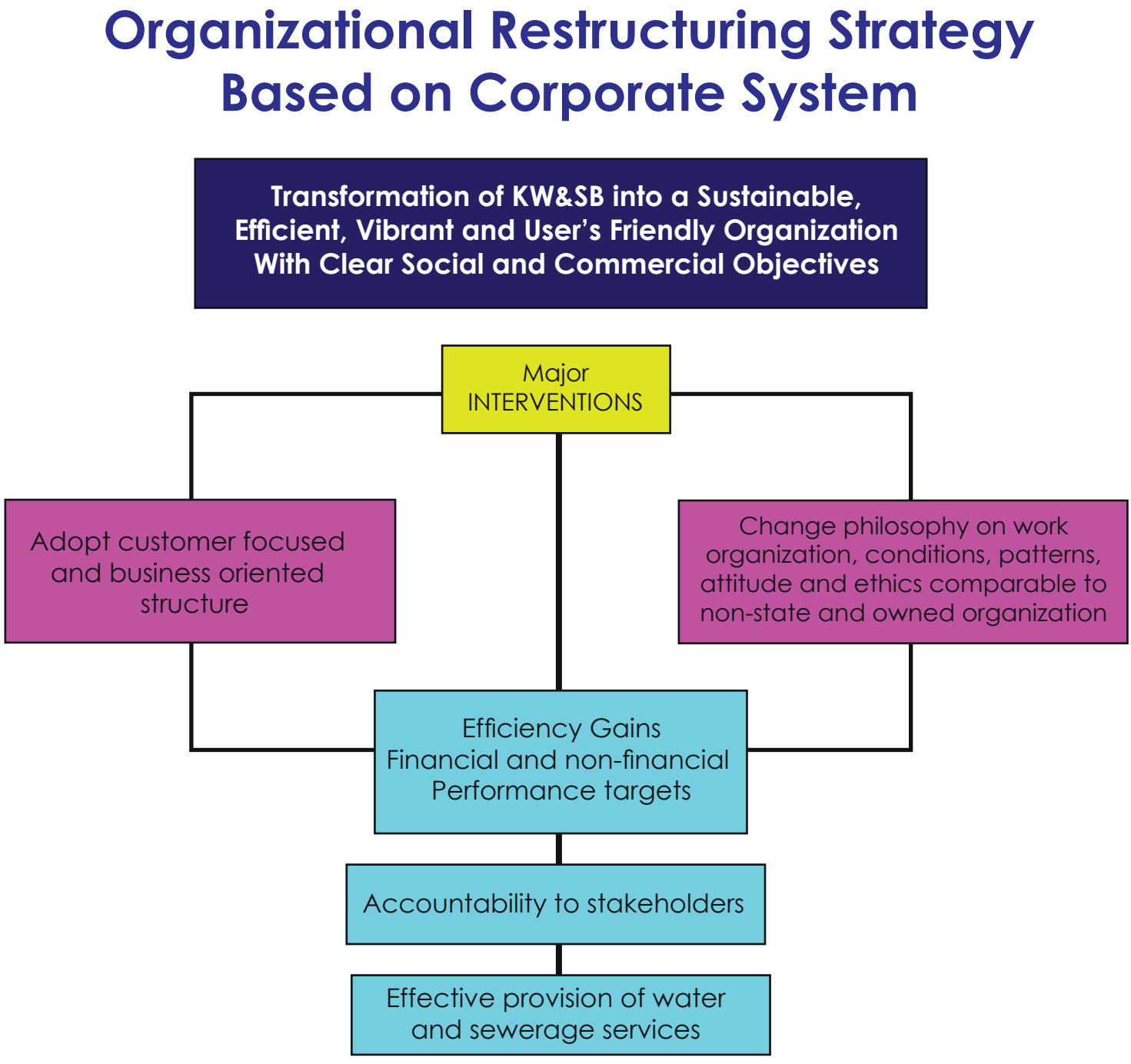



Figure-14: Suggested organizational restructuring for KWSB

World Bank, in collaboration with the Sindh Government, is currently working on the restructuring of KWSB since the last couple of years and due to political reasons, the subject intervention has not been completed. Therefore, it is suggested that the Sindh Government, at appropriate levels ,must be requested for expeditious conclusion of KWSB restructuring process.

## 5.2 Water scarcity in Karachi can partially be met by the "Circular Economy Model"

In the backdrop of issues and challenges as mentioned above, following Mitigation interventions, measure and strategies are suggested for better water governance in Karachi;

Wastewater is to be recognized as a resource which must be treated and reused for non-portable purposes, along with recovery of nutrients. The selection of a treatment process and technology is the mainstay of sustainability. The nature based solution of wastewater treatment may ensure system sustainability. Therefore, bio and phytoremediation of wastewater treatment is suggested , wherever site conditions permit which is as follow;

### 5.2.1 Decentralized Sewage Treatment through Hybrid Constructed Wetlands for Water Recycling and reuse at the Site of its Generation

In Karachi, approximately 380 MGD wastewater is produced and discharged into water bodies which is not only a waste of useful resource, but also contaminates ground and surface water sources which causes environmental pollution. There are variety of wastewater treatment technologies in use & being employed world over. The major technologies are activated sludge process, membrane filtration and electrocoagulation and electro-dialysis etc. All these technologies are cost intensive, both in terms of capital and operational costs. Therefore, keeping in view the financial & economic situation (both in public and private sectors in Pakistan) , nature based decentralized concept of wastewater treatment through "Hybrid Constructed Wetlands System" is better suited for those industries and urban dwellings which are hydraulically isolated and posses some vacant land segments.

This nature based concept of wastewater treatment is financially & economically viable and technically & environmentally sustainable. The aquatic plants (duckweeds, water Lucite, Taifa water hycine etc) planted in various wastewater ponds up-take target contaminants which are periodically harvested (after 14 days interval) and use to prepare poultry feed, fodder for animals and for making organic manure. Detailed technical details of Hybrid Constructed wetlands are shown as annexure-A. Where ever possible, this technology for treatment of industrial and domestic sewage is recommended to be adopted. Otherwise, suitable mechanical sewage treatment technology to be adopted after carrying out detailed feasibility studies, compatible with site requirements.

The treated water can be used for irrigation, landscaping and in construction industry where normally chlorinated / or portable water is being used. The schematic diagram and functional Hybrid constructed wetland- NARC, Islamabad is shown in figure- 15, below

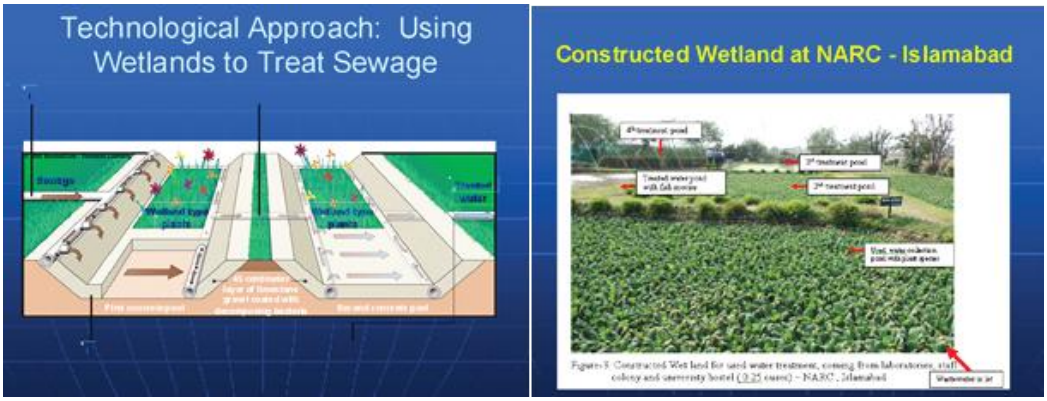



Figure-15: Schematic diagram / process flow and functional Hybrid constructed wetlands - NARC, Islamabad

The application of the concept of circular economy on wastewater management will facilitate in saving fresh water which is otherwise being used for non-portable purposes.

Decentralized Hybrid constructed wetlands wastewater treatment system are recommended to be installed for scattered / clusters of industrial units and for isolated, dwellings / communities, housing schemes / societies

### 5.2.2. Latest Wastewater Treatment Technology - The Omni processor - Mechanical types of Technology for wastewater treatment

This is the best example of "judicious use of wastewater ", equipped with latest technology which produces energy from sewage itself and is then used for the cleaning of wastewater.
More than 2 billion people across the world are affected by not having access to clean water or proper sanitation, resulting in the death of over 700,000 children each year. Solving this problem isn't as simple as installing sewer or septic systems, as they require more energy and infrastructure than could be effectively maintained in many developing countries. Waste from latrines most commonly used in these areas are left untreated and merely dumped into local rivers and other bodies of water, where they greatly contribute to the spread of disease.

The latest venture from Bill Gate and Melinda Foundation seeks to resolve this problem by creating a wastewater treatment method that eliminates disease-causing sewage from the environment and converts it into clean, drinkable water. The steam engine-powered device is called the Omni processor, manufactured by Seattle-based Janicki Bioenergy.

The Omniprocessor can convert human waste into clean, drinkable water in a very short span of time, while generating energy to incinerate the remaining waste solids and leave 250 kilowatts to spare. The resulting ash does not have an odor and will not contain disease-causing microbes.
Using the waste from 100,000 people, the Omni processor will produce 86,000 liters of water per day, enough for 43,000 people. Though there is a deficit in supply and demand, this will be a tremendous relief for people in these areas. This isn't meant to be strictly charity, but a means of creating self-supported economies. The Omni processor plant is shown in figure-16, below;


Figure-11: Peter Janicki & Bill Gate drinking treated water a prototype of the Janicki Omni processor from the Omni processor plant

These types of wastewater treatment plants are recommended to be installed at later stages in Karachi

### 5.3 Exploration of groundwater potentials in and around Karachi

Three dimensional groundwater aquifer mapping to ascertain groundwater potentials is suggested to be undertaken around / near river banks, Miler River etc

## 5.4 Managed Aquifer Recharge (MAR) for underground Storage, Transfer Recovery

Managed aquifer recharge (MAR) is a very crucial technique for improving groundwater recharge and maintaining aquifer levels. There are many examples from around the world that demonstrate the advantages of managed aquifer recharge. Despite the numerous benefits and demonstrated advantages of MAR, uptake has been lower than expected. The financial and economic performance of MAR is a key determinant of its global uptake. There are few studies of the financial characteristics and performance of different kinds of MAR schemes. This study contains an analysis of financial data from 21 MAR schemes from five countries. Although MAR schemes are highly heterogeneous, it is possible to draw some conclusions about factors that affect the costs of storing water underground and recovering it for use. The costs of MAR schemes vary substantially. Schemes using infiltration and spreading basins using untreated water are relatively cheap. Schemes using recharge wells, bores and expensive infrastructure are relatively costly. When advanced water treatment is needed, this involves significant extra costs. Other key factors that affect MAR scheme costs include the range of objectives to be met, frequency of use of the scheme, hydro-geological conditions that affect infiltration rates and well yields, and the source and end use of water stored underground.

Inverted, pressure and deep wells are used to recharge groundwater aquifer by channelizing storm water . These interventions will augment the local groundwater aquifer and will enhance local the ecosystem and biodiversity. One of the best examples of ground water recharge in USA and in Gujranwala Pakistan are shown in figure-17a & 17 b, below;


Figure-17a A groundwater recharge facility for the Coachella Valley adds water imported from the Colorado River to the valley's main aquifer and prevents the land from sinking and damaging the surrounding infrastructure.

The details and prototype designs of inverted wells, pressure wells and deep wells are attached as annexure- B

## 5.5 Intelligent Watershed Management and Micro Watershed Management in the catchments area of Miler and Hub Rivers etc

As per The Master Feasibility Studies for Flood Management of Hill-Torrents, (NESPAK, 1998) ,1.36 Million Acre ( MA) have been identified for micro watershed management potentials, with the capacity of harvesting 0.72 million acre feet of water. After detailed feasibility studies, sites for small micro watershed management projects with 70-100 acre feet capacity can be built for storage of hill torrents water. Subsequently, this water can be channelized to the nearest natural reservoirs. The Intelligent Watershed Management programme aims to leverage developments in instrumentation, controls and information technology for hydrological, hydraulic, water quality and ecological research.

Using their expert knowledge and model simulations, water researchers can forecast future events and plan efficient countermeasures, thereby enhancing KWSB's capability in managing its catchments and reservoirs.

## 5.6 Rehabilitation of Dumlottee Wells / abundant Wells along Miler River

Dumlottee wells were constructed during the pre-partition era and recharged through infiltration galleries, originating from seepage water from Miler River. With the passage of time, seepage water infiltration galleries have become dry due to lifting of sand & conglomerations from Miler River bed which used retain flood water to seep into river bed.At the moment,KWSB is pumping 5 MGD water into these wells and then supplied, through Domlottee conduit to Karachi. Therefore, it is suggested that a study should be conducted to construct check dam/slow action dams in the up-stream of Miler River to reactivate infiltration galleries for charging of Dumlottee wells. At the same time, the Government of Sindh should impose complete ban on lifting of sand from Miler River bed.

## 5.7 Rehabilitation, Restoration and Remodeling of Man char and Keenjhar Lakes

Keenjhar lake q major sweet water source, with a water storage capacity of approximately 24 million cubic meter (M M3). Keenjhar lake not only serves as a main water supply source, through K1,K2,K3, to Karachi, but also a source of livelihood for the local population. But, with the passage of time, both these water sources have been contaminated due to anthropogenic activities. The charging streams of Keenjhar lake carries contaminated wastewater from 43 industries which discharge their process influent into recharging Stream of Keenjhar Lake. The presence of Total Coliform and E.Coli reflects disposal of municipal waste into the lake," as per PCRWR report which indicates that no serious issue of heavy metals was found in the water of the lake, but only mercury (Hg) was found in higher than the threshold values.

The described presence of Persistent Organic Pollutants (POPs) in the water can cause death and illness, including disturbance of the endocrine,reproductive and immune systems, neurobehavioral disorders and even cancer.

Therefore, both these lakes require rehabilitation and restoration to preserve these important sources of water.The cheapest and most environmentally sustainable methods to rehabilitate these lakes and recharging streams will be through bioremediation, the details are as under;

a. By installing bio-reefs and solar bees at the junction point / location of reservoir and recharging streams . Microbial Bacteria is attached with Bio Reefs which reduces all the organic & inorganic contaminants present in the recharging streams are , as shown in figure-18 & 19, below;

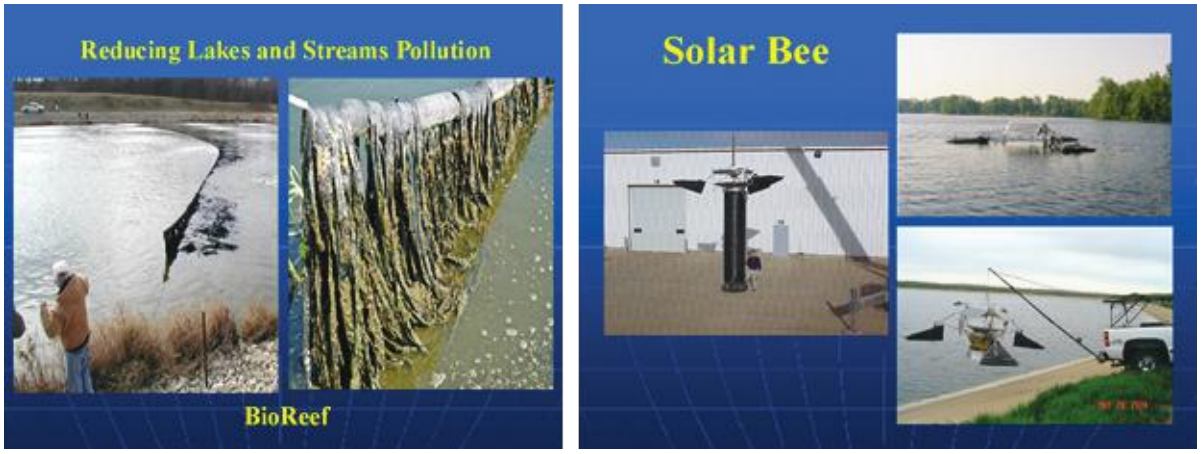



Figure-18: Installation of Bio-Reefs and solar bees for restoration of contaminated lakes


Figure-19: Performance efficiency of bio-remediation by Installation of Bio-Reefs and solar bees for restoration of contaminated lakes

**b. Sun-Activated LilyPads Remove Contaminants Without Chemicals**

Puralytics LilyPads are barely noticeable in ponds, lakes, and catchment areas where they are deployed. They are made of mesh and plastic, the flat, 1-meter diameter disks could even be confused for their plant namesake if not for their white color.

Puralytics' light-activated photochemical contaminant-removal technology — utilized in the LilyPads — has been recognized with the USTech H2.O Exemplary US Water Technology award, the International Water Association Global Honour Award for Drinking Water Supply, the BlueTech Innovation Tracker award, and many other honors.

The technology can safely remove pesticides, herbicides, heavy metals, petrochemicals, pharmaceuticals, and micro-organisms from water bodies without any chemicals or waste discharge and with minimal installation and maintenance requirements. Each LilyPad can treat 1 cubic meter per day of contaminated water without impacting the health of the fish and plant life that reside there. The lily pads are shown in figure -20, below;

Figure-20: Lily Pads for removal of contaminants and water reservoirs

c. Potential Areas of Application Retention Ponds, Catchment areas, StormWater Management, Industrial Water Treatment . Agriculture and Mining Water Treatment, Rain Water Purification , Water Storage Tanks Application, Algae Suppression and Water Feature Aesthetics.

More technology details of bio-remediation are attached/ placed at annexure-C

d. River Training works are recommended to be carried out along and in the catchment ''areas of Manchar, Keenjhar lakes and along Miler and Hub Rivers" to channelize flood water and area based rain water flow, and to enhance storage capacities of these reservoirs.

## 5.8 Creation of Geographic Specific Area Water Banks

One of the best techniques for water governance is the geographic area specific water banks. When demand is less, the water banks store water and when demand increases the stored water is use. The water banks also provide new recreational facilities & aquaculture sites everywhere. Water banks help in enhancing biodiversity and local ecosystem.

There are numerous sites along River Indus and other seasonal drains & ravines where water banks can be installed to store water from "area based rain water harvesting, ground water and diversion of flood water etc."

The irrigation department of the Sindh government is suggested to carry out a detailed study of this technique and indicate potential sites for establishing water banks (along River Indus) all over the Sindh province and around / near Karachi as well.

**The diagrammatic representation of water banks is shown in figure-21, below;**

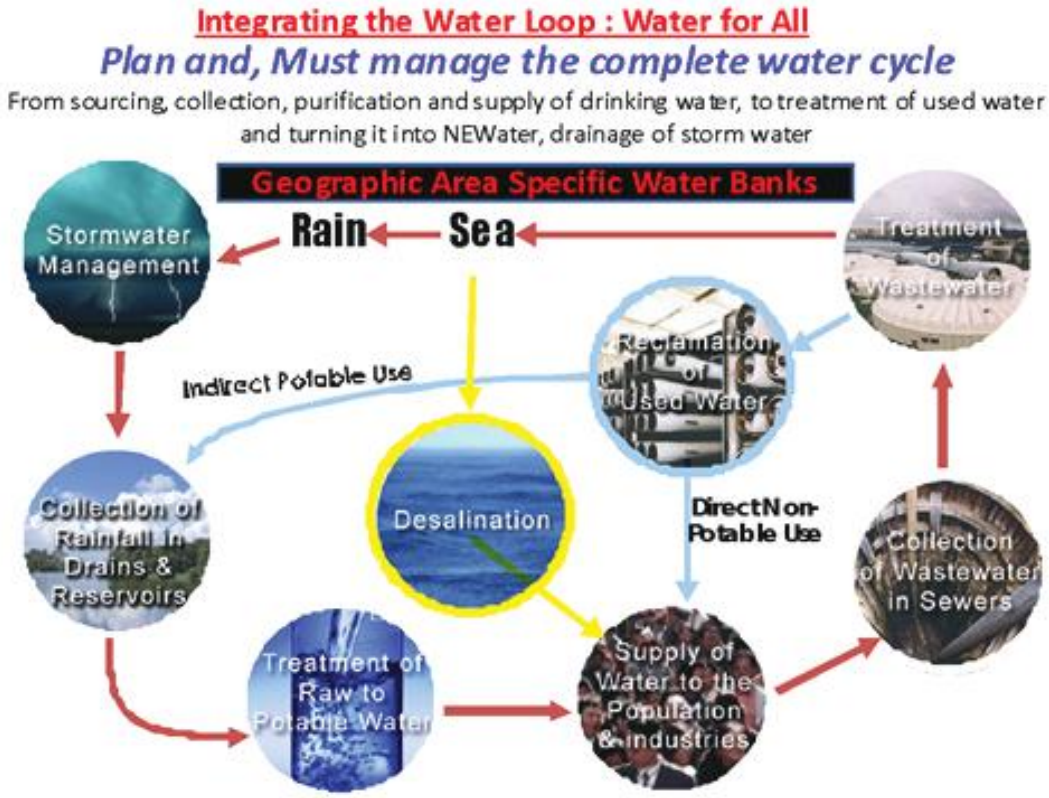



Figure-21: Diagrammatic representation of water bank

## 5.9 Desalination of SeaWater for Drinking Purposes

Karachi lacks approximately 600 MGD portable water, resulting in grave health and hygiene problems. Singapore and Israel are the leading countries, producing and meeting 30%-40% of their drinking water demands through desalination of seawater . Therefore, some percentage of water deficiency of drinking water demand can be met from desalinating seawater , but since it is very cost intensive and has very high operational costs, it should be considered as a last option.

An overview of desalination projects of Singapore is shown in figure-22, below ;


Figure-22: Singapore Desalination Journey

Desalination process for producing drinking water is cost intensive , both in terms of capital and O&M costs , and should be considered as a last source of water to be taped. Therefore, a pilot desalination project of 30 MGD is suggested to be installed in Karachi which can be upgraded if found to be financially and economically viable. The technical details of desalination is placed at annexure-D.

## 6.0 Water Conservation Strategies and Action Plans

### 6.1 Metered Water Supply

Smart water meters are key to intelligent decision-making with rapid urbanization and climate change increasing water scarcity, cities and their respective water utilities are turning to smart meters and related technologies to manage water more efficiently. From the water utility's side, smart meters provide multiple benefits including leak detection, energy reduction, demand forecasting, enhanced awareness campaigns, promotion of efficient appliances, and performance indicators. From the consumer's side, smart meters can provide information on when/where is water being used, comparisons of own water use against other customers, and quick leak detection. Smart apps to be developed so consumers can compare and contrast their water usage with neighbors in the same street or suburb,compare water consumption with standard profiles (consumers with the same socio-demographic factors), compare their water consumption with the most efficient users in the city, or forecast their next water bill.Some examples of leading cities implementing smart meters to ensure the efficient management of scarce water include Dubai, Singapore, and San Francisco. Therefore, legislation to be passed for installation of water meters, and KWSB must ensure metered water supply to its consumers, and its implementation which will be a remarkable step towards water conservation in Karachi.

### 6.2 Installation of wastewater meters

Wastewater meters at effluent outlets of industrial units are suggested to be installed, and accordingly industrial unit to be billed according to pollution load being discharged. The price per unit ( volumetric unit like cubic meter or galleons)of effluent discharge to be doubled/ twice than drinking water tariffs. This will discourage the industries to conserve clean water.

Similarly , wastewater meters may also be installed at domestic levels , which will make water for cautious use of clean water with the aim to generate less waste water . This practice ( wastewater metering at household levels is very much in practice in advanced countries , as in Atlanta-Georgia - USA, wastewater metering is in use with twice the tariff of clean water .

### 6.3 Installation of Oil Separators for Water Recycling at Car Wash Stations

Car washing stations, to use fresh water indiscriminately for every car wash . Globally, oil separators to be installed,to treat water and reuse it for the next car wash. In this way huge quantums of fresh water can be saved. The Environmental Protection Agencies ( EPA) of the respective countries ensures implementation through strict monitoring.

Provincial Environmental Protection Agency ( EPA) Government of Sindh must ensure installation of " Oil Separators " at car wash stations to treat and reuse the treated water More details are attached / placed at annexure-E. Wastewater treatment process at car washing station for recycling.

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Provincial Environmental Protection Agency ( EPA) Government of Sindh must ensure installation of " Oil Separators " at car wash stations to treat and reuse the treated water More details are attached / placed at annexure-E. Wastewater treatment process at car washing station for recycling is as shown in figure- 23, below;

**Figure-23: Recycling ( after separating oil from used water ) of treated water at car washing station in Sydney- Australia**

**The advanced oil separator system , schematic view is shown in figure-23a, below ;**

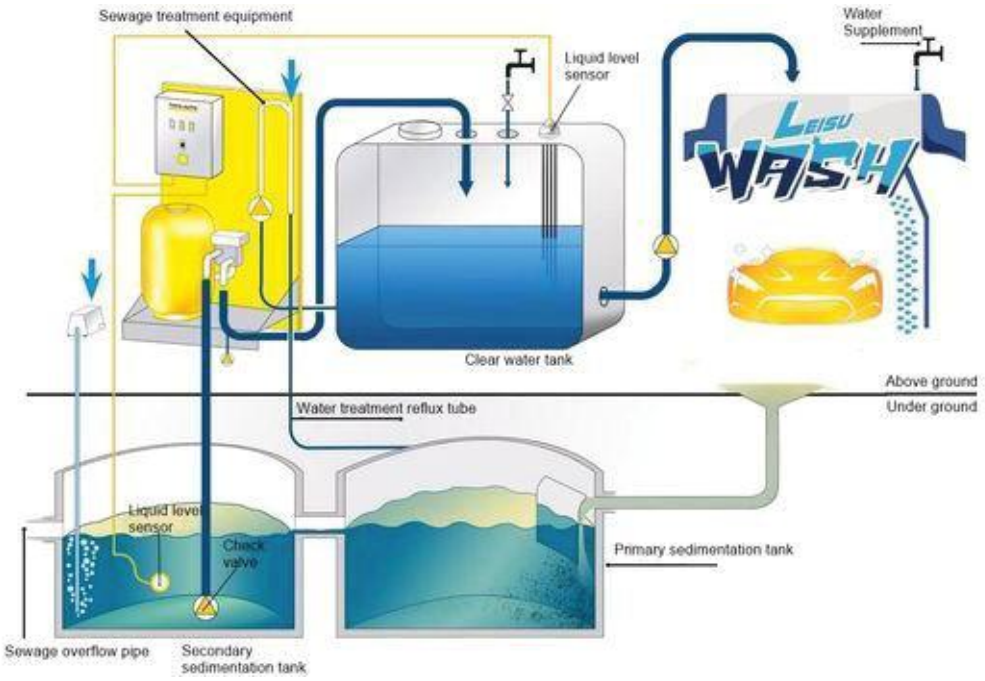



**Figure-23a: Wastewater treatment process for recycling at car washing station**

## 6.5 Installation of Water Efficient Appliance at Commercial and Household Levels

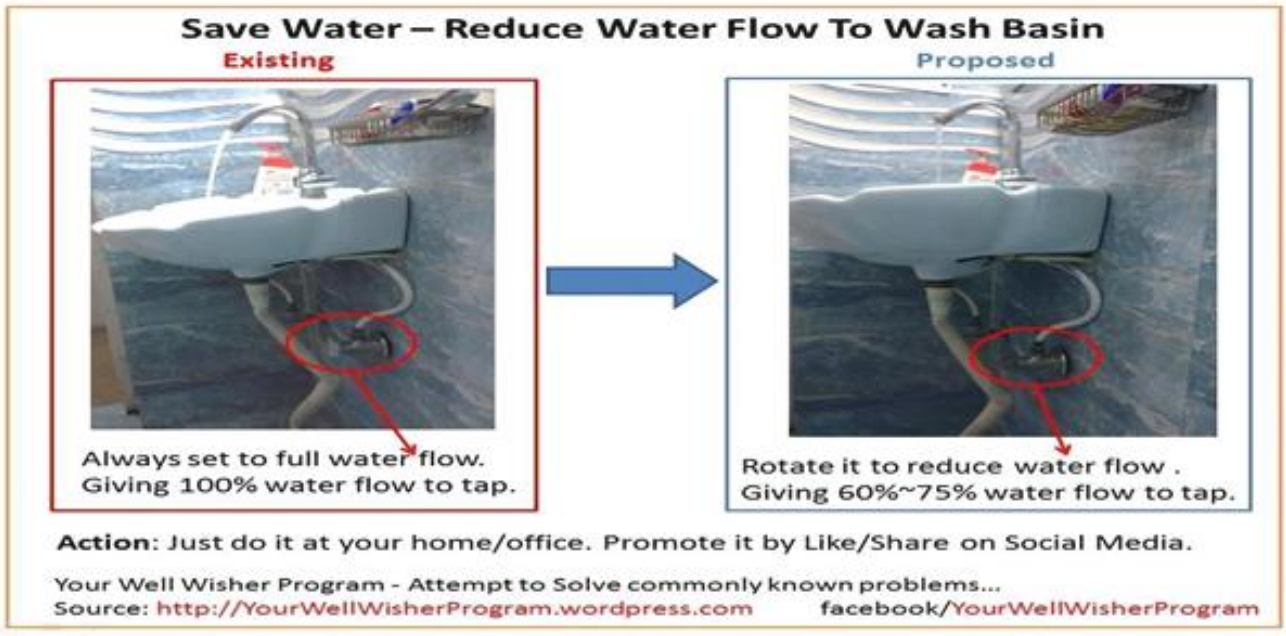
Water efficient appliances like "double action flushing tanks in washrooms " are one of the best examples of water conservation techniques. Similarly, wash basins and showers , fitted with sensory devices can help in saving the huge quantum of water. To start with , all the commercial buildings must be encouraged to install water efficient devices ( double action flushing tanks ) through building laws. The example of water efficient shower (As showers account for 29 per cent of a household's monthly water consumption, being used in Singapore is shown in figure-24, below ;

**Figure-24: A smart meter is installed on the showerhead to track water usage**

## 6.6 Water Conservation Practices at HouseHold and Commercial Levels

Common types of water conservations at household and commercial levels are needed, to prevent water wastage.Even manufacturers of sanitary items should be taken on board and encouraged to design and manufacture water efficient sanitary items .The consumers to be made aware of thorough behavioral change communication strategies by the Sindh government and civil society organizations ( NGOs and INGOs ) . Some examples of water conservations are given in figure-25 & 26 , below






## 8.9 Low Impact Developments and Sponge Cities Concept

Figure- 25 & 26 : Various water conservation techniques

## 6.7 Sponge City Concept for Conserve Run-off Water

'Sponge' cities–to slow, sink and store runoff exemplify a universal struggle of urban planners united with water professionals against a volatile climate . Low Impact Development (LID), also known as green infrastructure, is a stormwater management approach that maintains natural hydrology during site development. LID minimizes impervious surfaces and utilizes existing natural site features along with conservational

controls to manage stormwater. In LID, stormwater is viewed as a resource rather than a waste product, and the site is developed with this key concept in mind. Often, LID replaces traditional stormwater management practices that focus on moving storm water off-site with curbs, pipes, and ditches.

LID is useful for creating functional, attractive, and environmental friendly residential, commercial, and industrial sites, and is both sustainable and cost-effective. Some of the benefits include improved water and air quality, reduced stormwater runoff volume, increased natural habitat and recreational space, increased property values, improved groundwater recharge, and community beautification. The best examples are Grassed Swales, Rain Gardens, Green Roofs , Permeable Pavements, Disconnected Impervious Surface (DIS), Bioretention Basins, Alternative Street Design, Bioretention Curb Extensions (Stormwater Bump Out), Stormwater Planters, Tree Boxes and Rain Barrel/Cistern.

**The Sponge city concept is being practiced in china, in water stressed cities, as shown in figure-27, below;**

Figure-27: Sponge city concept , being practice in china - low impact developments to allow rain water to seep into ground and to avoid run-off

The details of low impact development is placed at Annexure-F

### 6.8 Preparation of Water Safety Plan- Karachi

Water safety plan ensures "provision of safe drinking water from catchment area to consumer's end".

KWSB to prepare a "Water Safety Plan" ( WSP) to ensure provision of safe drinking water to the citizens , residing in KWSB service area.

### 6.9 Climate Change Adaptation and Climate Change Resilience Plan - Karachi

More than 50 % the freshwater comes from mountain, runoff and from snow melt which are exposed to extremes of climate change. The relationship between water , energy, agriculture and climate change is one which is closely intertwined, but is now falling out of balance , thereby , jeopardizing food, water and energy. Water is the main driver which translates adverse impacts of climate change on human life . Therefore, preparation of geographic area and water utilities / KWSB specific climate change

action plan is inevitable for adaptation and mitigation of adverse impacts of climate change.

### 6.10 Demand and supply Side Water Management Rationalization Strategies

#### 6.9.1 Demand Side Water Management Strategies

**Pricing Policies:** Incentives like subsidies on water saving technologies and disincentives like charges for overuse or water pricing policies

**Education:** (Sensitization campaign, capacity building in relevant agencies, development of institutions through effective participation of beneficiaries, enforcement of legal framework, monitoring and evaluation, and having political will to own and implement demand side water management as an effective tool)

**High Efficiency Systems:** (like state of the art & nature based water purification plants and wastewater treatment plants)

**Water restrictions:** Portable water should not be used in construction industries and landscaping etc.

#### 6.9.2 Supply Side Water Management Strategies

**Water loss reduction:** Maximum efforts to be made by KWSB to reduce its non-revenue water by employing high-tech equipments and immediate repair of leaking pipes .Vigilance teams be formed to check water thefts or illegal hydrants etc .

**System metering:** Both bulk and household levels metering should be carried out which ensure water accountability.

**Reuse** – wastewater should be treated be reused for non-portable purposes.

#### 6.9.3 Climate Change Scenarios - Water Resources Management Technologies and Measures

To guard against adverse impacts of climate change on water resources , effective water resources management technologies are suggested to be employed under wet weather and drought scenarios for better water resources management. Besides , increasing water demands due to rapid increase of world population and rapid urbanization. Following water resources management technologies / measures are mentioned in figure- 28, below ;

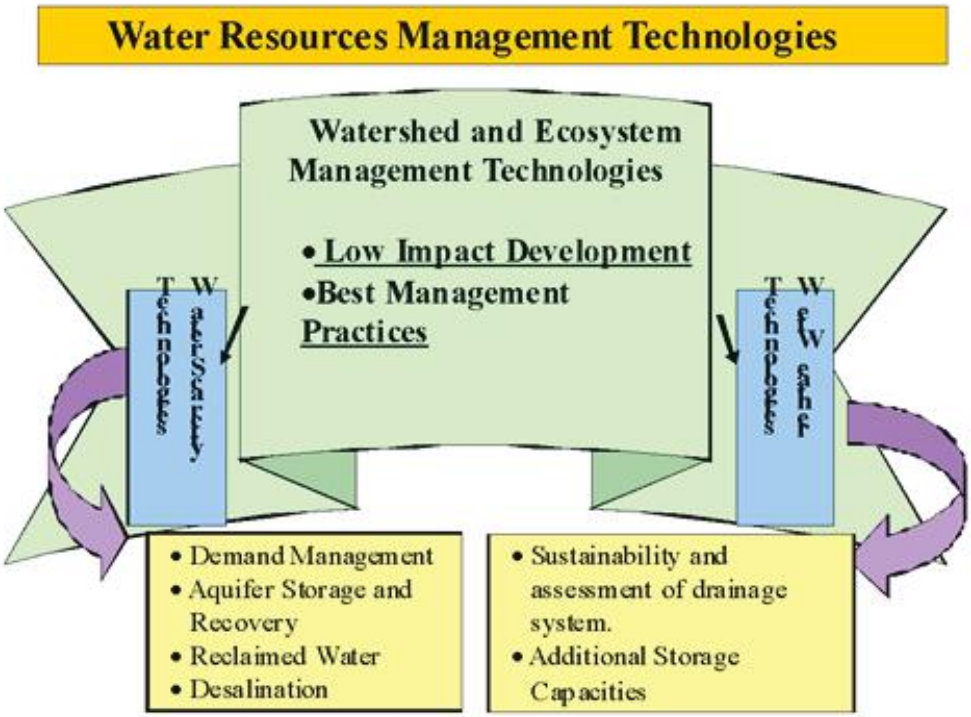



**Figure-28: Water Resources management framework**

## Part- IV- Summary of Suggested Policy Recommendations to Enhance Sustainable Water Availability and Contamination Reduction - Karachi

### 7.0 Summary of Policy Recommendation- Karachi

We are a circular economy with nature based and decentralized water resources management. We recommend the following policies for the perusal and approval of the Government of Sindh;

**7.1** Keeping in view, the down spiral in-efficiency trends; restructuring of KWSB is suggested as per the model in paragraph 12. The World Bank and the Government of Sindh are already in consultation on the restructuring of KWSB since last couple of years and due to political reasons, the subject has not been completed. Therefore, we request the Government of Sindh to conclude the restructuring process of KWSB expeditiously.

**7.2** In relation to Nature Based Decentralized Hybrid Constructed Wetlands, we recommend a Wastewater Treatment System to be installed for scattered/clusters of industrial units; isolated dwellings / communities; and, housing schemes/societies where conditions of the site permits and can be up-scaled. Subsequently, the mechanical types of Wastewater Treatment Systems for producing energy & nutrients (FOG) recovery can be installed such as the,"Omni Processors Unit" which cleans water by recovering energy from the wastewater.

**7.3** Decentralized solid waste management has the concept of "Integrated Recovery Resource Centre (IRRC)"- a business model approach for post project sustainability.

**7.4** We advocate for the exploration of groundwater potentials, both within and around Karachi by undertaking the three dimensional groundwater aquifer mapping which will ascertain groundwater potentials around / near river banks and Miler River catchments area. We further suggest an immediate ban to be imposed on lifting sandstone / crush aggregates from the Miler River bed etc.

**7.5** We advocate for the Managed Aquifer Recharge (MAR),which can play a pivotal role in improving groundwater recharge and maintaining aquifer levels. An Inverted pressure and deep wells are used to recharge ground water aquifer by channelizing stormwater. This intervention will augment the local groundwater aquifer and will enhance local ecosystem and biodiversity.

**7.6** We recommend Intelligent Watershed Management and Micro Watershed Management in the catchment areas of Miler and Hub Rivers etc. As per the findings of the Master Feasibility Studies for Flood Management of Hill-Torrents (NESPAK, 1998), 1.36 Million Acre (MA) have been identified for a micro watershed management potential, with a capacity of harvesting 0.72 million acre feet of water.

**7.7** We advocate for the Rehabilitation of Dumlottee Wells / Abundant Wells along Miler River. The Dumlottee wells were constructed during the pre-partition era and were recharged through infiltration galleries originating from seepage water from the Miler River. With the passage of time, seepage water infiltration galleries have become dry due to the lifting of sand & conglomerations from Miler River bed which used to retain flood water, which then swept into the river bed.

**7.8** We propose the Rehabilitation, Restoration and Remodeling of Manchar and Keenjhar Lakes and bioremediation by installing bio-reefs and solar bees. Keenjhar Lake is a major sweet water source with a water storage capacity of approximately 24 million cubic meter (M M3). Keenjhar Lake serves as a main water supply source through K1, K2,K3 to Karachi and it is also a major source of livelihood for the local population.

**7.9** We recommend the creation of "Geographic Specific Area Water Banks" which is regarded as one of the most advanced and sophisticated water management practices. In times of low demand, water banks of specific geographic areas are instituted to store water, and then used to meet demand, when high.The irrigation department of the Government of Sindh is recommended to carry out a detailed study of this procedure and indicate the potential sites for establishing water banks along River Indus; all over Sindh; and, around / near Karachi.

**7.10** We recommend a "Metered Water Supply" by putting in place a bulk of commercial, industrial and domestic water meters for water accounting and budgeting. Therefore, legislation can be passed and amalgamated for installation of water meters. Furthermore, KWSB must make certain that metered water is supplied to its consumers and that the supply is legally and regularly monitored.

**8.1** We recommend the installation of Oil Separators at car wash centers across Pakistan including Karachi so that fresh water is indiscriminately used for every car wash. It has been consented globally, that oil separators which are installed to treat used water, which is then reused for the next car wash; saves a huge quantum of fresh water. The Environmental Protection Agencies (EPA) of respective countries ensures that there is implementation through strict monitoring. It is further recommended, that the Provincial Environmental Protection Department (EPD) and Government of Sindh must fortify the installation of Oil Separators through legislation.

**8.2** We highly encourage the usage of water efficient appliances like Double Action Flushing Tanks in the lavatory/toilet which is the best example for conserving water.Similarly, wash basins and showers fitted with sensory devices can aid saving a huge quantum of water. In order to initiate this process, all the commercial buildings must be directed to install water efficient devices (Double Action Flushing Tanks) through passing bylaws and codes.

**7.6** Intelligent Watershed Management and Micro Watershed Management in the catchments area of Miler and Hub Rivers etc. As per. Master Feasibility Studies for Flood Management of Hill-Torrents, (NESPAK, 1998), 1.36 Million Acre (MA) has been identified for micro watershed management potentials, with the capacity of harvesting 0.72 million acre feet of water.

**7.7** Rehabilitation of Dumlottee Wells / abundant Wells along Miler River Dumlottee wells were constructed during pre partion era and recharged through infiltration galleries, originating from seepage water from Miler River. With the passage of time, seepage water infiltration galleries have become dry due to lifting of sand & conglomerations from Miler River bed which used retain flood water to seep into river bed.

**7.7** Rehabilitation, Restoration and Remodeling of Man char and Keenjhar Lakes bio-remediation, by installing bio-reefs and solar bees . Keenjhar Lake is the major sweet water source, with water storage capacity of approximately 24 million cubic meter (M M3). . Keenjhar lake is not only serves as a main water supply source , through K1,K2,K3 , to Karachi , but also a source of livelihood for the local population.

**7.8** Creation of Geographic Specific Area Water Banks - One of the best management practices of water governance, geographic area specific water banks are established to store water when it is in lesser demand & used it when its demand goes up. The irrigation department of government Sindh is suggested to carry out detailed study of this concept and indicate potential sites for establishing water banks ( along River Indus) all over the Sindh province and around / near Karachi as well .

**7.9** Metered water supply by installation of bulk, commercial, industrial and domestic water meters for water accounting and budgeting. Therefore, legislation be made for installation of water meters and KW&SB must ensure metered water supply to its consumers its implementation which will be a remarkable step towards water conservation in Karachi.

**7.10** Installation of oil separators at car washing centers, as everywhere in Pakistan including Karachi, fresh water indiscriminately is used for every car wash.

World over , oil separators are installed, to treat used water and reuse it for the next car wash, in this way huge quantum of fresh water can be saved. The Environmental Protection Agencies (EPA) of the respective countries ensures implementation through strict monitoring. Provincial Environmental Protection department (EPD) Government of Sindh, through legislation, must ensure installation of "Oil Separators "at car wash station to treat and reuse the treated water.

**7.11** Water efficient appliances such as the "double action flushing tanks in washrooms" are prime examples of water conservation. Similarly, wash basins and showers, fitted with sensory devices can aid in saving huge quantums of water. To start with, all the commercial buildings must be facilitated to install water efficient devices ( double action flushing tanks ) through building bylaws/ building code.

**7.12** Low impact developments with Sponge City Concept to Conserve Run-off Water. 'Slow, sink and store runoff' exemplify a universal struggle of urban planners united with water professionals against a volatile climate. The Low Impact Development (LID), also known as green infrastructure, is a stormwater management approach that maintains a natural hydrology during site development. Low impact development must be made part of master plan while developing in area in the city premises and civic agencies must ensure its implementation.

**7.13** Proposing a water safety plan (WSP) which ensures the "provision of safe drinking water from catchment areas to consumer's end".

**7.14** Policies to combat climate change and prevention measures, ensure safety of water infrastructure. with sufficient availability under sewer climate change adverse impacts KWSB is suggested to prepare " Karachi specific climate change resilience plan to guard against climate change adverse impacts on water resources .

**7.15** The desalination process to produce drinking water, should be reverted to as last resort, as it is heavily cost-intensive, both in terms of capital and O&M costs. Fortunately, Karachi has been blessed with a huge quantum of surface water sources, like Keenjhar Manchar , and Haleji lakes . Therefore, a desalination project of 30 MGD is suggested to be installed in Karachi as a last resort.

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