PPAF

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SECURING OUR FUTURE

WATER RESOURCE MANAGEMENT IN PAKISTAN

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LEADERSHIP FOR A WATER SECURE PAKISTAN

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The present discourse on water issues in Pakistan has created a scare that Pakistan will run dry by 2025, resulting in nervousness on part of the people, and kneejerk reaction on part of the policy makers. Pakistan has plenty of water - to water our growing population, cities, economy and even expanding agriculture, but we do not have the time to keep ignoring the water challenge. If timely actions are taken, Pakistan can move to become a water secure country, instead of being a water scarce country. It is a leadership challenge – but the time to act is now.

Pakistan's water situation needs to be addressed primarily on three fronts: water equity, water access and water hazards. Since Pakistan's total water supply is not in any threat of immediate and substantial reductions, we need to address three fundamental challenges to make Pakistan a water secure country - Inequitable water distribution, lack of fair access to all consumers and high susceptibility to water induced disasters (floods mostly in river-irrigated areas and droughts in rain-fed areas). Instead of addressing Pakistan's water challenge based along these three dimensions, the water debate in the country has remained confined to the large investments for construction of new infrastructure to meet Pakistan's inter-seasonal water demand and to create cheap hydro-energy. These are legitimate concerns but the federal level initiatives typically have come at the cost of provinces. The fundamental leadership challenge is to expand the discourse on water and to create space for social scientists, economists and hydrologists - in addition to the private sector, academia and think tanks. It is imperative, thus, to bring focus on a broader range of values that a society realises through water, and create leadership that incorporates social, economic and environmental aspects to the water discourse, policies and programmes at national and international levels, based on the critical prism of Equity, Access, and Hazards.

Pakistan's primary water sources

Pakistan's water resource constitutes predominantly of surface water and groundwater. From its eastern border along India, it enjoys unrestricted use of water from three rivers, namely Indus, Jhelum and Chenab, under the Indus Water Treaty of 1960. On its western border with Afghanistan, Pakistan receives surface water supply from River Kabul. Further, being one of the most arid countries in the world, over 75% of Pakistan receives rainfall less than 250 mm annually, and 20% of it receives less than 125 mm. Groundwater is a very central resource for agriculture and domestic consumption and contributes about 50 % of irrigation water and domestic needs of over 90 % of the population.

These sources of water supply will not disappear overnight, even if the upstream infrastructure and climate change can pose new - perhaps very serious – challenges in the coming decades. The test for Pakistan's water leadership, therefore, is to create common ground with all users on the basis of equitable benefit sharing to protect everyone's right. Real opportunities exist to explore new creative options with water neighbors, be they upper or lower riparian.

Key factors contributing to current water stress

More than 93 % of water is consumed in agriculture and the rest is used for industrial and domestic uses. From a per capita availability of water of around 5,500 cubic meters in 1947/48, current availability has reduced to less than 1,000 cubic meters, primarily due to the exponential growth in population. Fortunately, however, the per capita water availability in Pakistan is still more than per capita available in any of our neighbors - Afghanistan, China, India and Iran.

Surface water resources are under threat owing to climate change, as some studies have shown that there will be 8.4-10% reduction in precipitation by 2050. Groundwater sources are rapidly depleting due to large scale proliferation of tube wells. Quality of drinking water is also being severely affected due to seepage of sanitation water, chemicals and disposal of untreated urban wastes. The most worrying matter is the lack of harmony, foresight and preparedness in the wake of challenges of water scarcity. The political economy of these wasteful uses is complex and the biggest leadership challenge for our national and provincial leadership.

Leadership for equitable distribution of water

The socio- economic effects of the declining water tables vary among upper and lower riparian, plain and coastal residents, and small and large farmers. The upper riparian of the Indus River Basin - farmers in Northern Punjab - have access to canal heads and the river and are relatively water secure. The water table in these areas is high, as water is sufficiently recharged through seepage from

canals and rivers. However, downstream farmers face inequity. They receive less river and canal water, which also adversely affects recharge of their groundwater. Consequently, the cost of irrigation is 2.19 times higher in the tail end of the Indus River Basin. Depleting water table poses an additional challenge to farmers near the coastal areas, as seawater intrusion is rendering the land unsuitable for agriculture or drinking. There is also inequity within villages between small and large farmers. Wealthier farmers with large landholdings can afford installing tube wells, leaving poorer farmers to buy excess water from wealthier farmers. The various inequities arising from the depletion of ground water resources need to be tackled in order to develop a more efficient and fair distribution and demand-management system.

As a federation, Pakistan is not unique in terms of how powers are shared between the Centre and the provinces. Post 18th Amendment, provinces now have autonomy over most of the subjects. However the Centre in any federation plays a crucial role of ensuring a balance is maintained, providing inter-provincial equity in terms of financing and other resources, and that minimum criteria is being met. Negotiations on water or any other subject with neighbouring states or internationally, is the responsibility of the Centre. This means that water, even though a provincial subject, must require the federal government to play a role in ensuring expertise, dialogue and mutual agreement and compromise is made whether it be transboundary or inter-provincial so that all Pakistanis benefit equitably.

Leadership for ensuring equal access to water

The gender dimension arising out of groundwater abstraction also needs to be held in account. Women are often left out of the decision-making apparatus of water planning and management. The gender dimension in groundwater abstraction creates an interesting policy dilemma, between discouraging over-abstraction of water from tube wells and creating convenience for rural women. The solution to this problem lies in regulating groundwater abstraction for agriculture, so that the water table is recharged, and women can conveniently extract water from their home wells, rather than travelling long distances.

Local leadership around the conservation and management of water resources – be it in domestic or agriculture consumption – must incorporate women. Further, as women are more affected when it comes to disasters (such as floods), they must be the focus of disaster risk reduction activities as well. For this it is imperative that provincial and district government departments, be it Agriculture, or the District Disaster Management Authorities (DDMAs), create specific strategies to engage with women, and to create cadres of community women leaders who are trained to take forward the provincial water conservation and management strategies.

Leadership to avoid water related hazards

Pakistan is among the most disaster prone countries in the world. Pakistan experienced large scale natural disasters, including devasting earthquake in 2005 and 2010 flood in recent years. Hazards, when not assessed and mitigated systematically, can lead to disasters. Various factors which contribute to the transformation of hazards include uneven population density, unplanned development and poverty. Comprehensive assessment of water related hazards (hydro hazards), which frequently transform into disasters, in Pakistan is of utmost need. Disaster management, including disaster risk reduction and response, is being managed at the national and provincial tiers in Pakistan. Strengthening DDMAs is the best solution to optimally cope with hydro hazards. These authorities perform pivotal role in development and timely implementation of effective disaster risk reduction (DRR) plans at district level and should be given more importance and resources by defining clear roles and responsibilities (and institutionalising a focus on women's leadership for DRR). Capacity of local district level implementers need to be developed through trainings, to respond to hazards and disaster and with support of communities and other civil society organisations, contribute to resilience building.

ADAPTING TO AN UNFOLDING WATER CRISIS:
CRITICAL ACTIONS THAT NEED TO BE TAKEN BY STATE AND SOCIETY

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To understand water issues in perspective we must not lose sight of two basic realities. The total amount of water available in Pakistan is finite at about 145 million acre feet annually; galloping population growth decrees that its per capita distribution would continue to fall. From around 5000 cubic meter per person soon after Partition it has dropped to around 850 today, and continues to fall every year. Secondly, this shortage could be addressed by developing additional water reservoirs but only as a temporary palliative. Even when the present sixteen million acre feet reservoir is somehow doubled in the coming decades, shortages would continue to stalk us. Growing urbanisation, rising affluence and the increasing number of people would ensure that the water supply would remain short of the demand. It appears unlikely that we would ever experience water surpluses again. In the past half a century no leadership failure in Pakistan matches this default.

It is time we understand that the unfolding water crisis cannot be dealt with by water-sector experts or erudite hydrologists alone. A holistic approach is required, to employ a much used cliché. The sector's sustainability requires focus on other important variables. Water sustainability is dependent upon a stable population which in turn needs a hundred percent primary-level education especially for girls, basic health cover for all, presence of drinking water and sanitation facilities and above everything the free availability of family planning services for everyone. Today these four are all provincial subjects and provinces need to focus more on them. The bottom line is that unless the state and the society are able to lower the population growth rate to replacement levels very soon water shortages would get endemic.

Critical actions across four broad strands would be required to deal with the emerging water crisis in Pakistan. These include reducing the population growth rate to replacement levels, improving water governance, improving water efficiency and crop yields and finally developing additional water reservoirs.

Reducing population growth rate

The subject of water sustainability needs to be complemented with the human resource development and needs issues. A population growth rate of over 2% annually is simply not sustainable for the country. Nothing reduces the population numbers than education, especially for girls. Sadly, a decline in literacy rate has been witnessed in Sindh, Balochistan and Punjab while it remained stagnant in Khyber Pakhtunkhwa (KP) according to the Pakistan Economic Survey 2016-17.

Improving governance

The estimates of water and sanitation requirements, of our largest city Karachi, speak of 1100 million gallons per day while only 480 million is available. Lahore, Peshawar and above all Quetta are experiencing just as serious water shortages. The illegal mafia and the municipal officials therefore become willing partners in the illegal hydrants business. There is also an incentive to create artifical shortages. Rules and mechanisms need to be developed and implemented for accessing, using controlling water so that it becomes clear to both the state and society who gets water, how and at what time, and at what cost this right is realised.

Improving water efficiency and crop yields

According to a report released recently by the Pakistan Business Council – a business policy advocacy group, the crop yield per hectare of Pakistan's agricultural productivity ranges between 29% and 52% - lower than the world's best averages for major commodities. The national water mission statement should therefore consist of reducing the demand (and wastage) of water while increasing water efficiency.

Growing low delta crops: The case of agriculture is more acute. There is little effective regulatory framework to adopt a more judicious use of irrigation water. Canal water, being almost free of cost, the influential land-owners in the head reaches are blatant in its misuse. High-valued deltaic crops like sugarcane and rice are soaked in irrigation water conveyed by hundreds of miles of canals from Himalayan storages at a cost that is external to the growers. In the rest of the world such high water use crops are dependent on rainfall. Such misuse often leads to waterlogging and salinity as has been the case in parts of Sindh and Punjab where saline water levels have risen to within a few feet of the surface.

Agricultural productivity comparison of Pakistan

- Pakistan produces 3.1 tons of wheat from one hectare, which is just 38% of the 8.1 tons produced in France – the world's best productivity.
- Pakistan produces 2.5 tons of cotton per hectare, which is 52% of the 4.8 tons produced in China.
- Sugarcane yield stands at 63.4 tons per hectare in Pakistan, which is 51% of the 125 tons Egypt produces from every hectare.
- Maize productivity is estimated at 4.6 tons per hectare, 41% of the 11.1 tons that France is producing.

Need for a regulatory regime: Unregulated water use over time leads to the problem of the declining water aquifer especially in the Punjab. Almost 55 million acre feet of water is being pumped out annually in the country but the recharge is up to twenty percent lower only. Subsidised electric-operated tube wells are the main culprits. The State-subsidised irrigation tube wells in Balochistan have in a few decades sucked much of the subsurface water accumulated in the past centuries. Without a regulatory regime this was to be expected and this is not sustainable.

There is also the need to price water in economic terms except for the poor and deprived sections of the community. The price of water can conveniently be taken as the costs incurred including capital and O&M costs. For using water economically the O&M cost assessed as Rs 300 acre presently needs to be recovered. 'Free water leads to lowered efficiency, inequitable distribution of water and inefficient cost recovery. Treating water as a public good has led to its under-pricing which in turn results in resource misallocation, misuse, shortages, theft etc'. Currently a nominal service charge recovered to meet O&M expenditure in Punjab barely meets 45 percent of the O&M cost of the system. The farmer pays only Rs 4,000 per month for an electric tubewell irrespective of the electricity consumption. 'Pancho' system of irrigating rice fields which unnecessarily floods the field would need to be curbed. The Abiana rates across the board have decreased considerably in real terms compared to the rates prevailing in 1970. In terms of produce equivalence, it is only 14 percent for wheat and 35 percent for sugarcane.

Using efficient irrigation techniques: Water has to be used wisely as it is scarce. It takes one liter of water to produce one kilocalorie of food. This means that each person consumes 3- 4000 liters of water, just for food. For that reason it is crucial to invest in water efficiency and enhancing water productivity through sprinklers and drip irrigation systems. Modifying cropping patterns to enhance water productivity through supplemental (targeted) irrigation as 'protected agriculture' needs to be adopted. Field trials in several countries have shown massive increases in wheat and barley yields with small quantities of supplemental irrigation; yield increased

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PAKISTAN'S WATER: THE VEHICLE FOR PROSPERITY

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As global reports show, the fears of water stress and water shortages are coming true. Cape Town in South Africa is the first city that has literally run out of water. In Pakistan Tarbela and Mangla dams often go to dead level, as do other numerous smaller storages and dams that supply water to rural and urban areas. Actions are required across the board to move towards the rational use of water across Pakistan, and build the person power to manage water in the 21st century.

Pakistan's water sector has attracted attention for decades, whether it is the Indus Waters Treaty, taught in classrooms across global universities in numerous disciplines, or the Indus Water Accord (1991) among the provinces that prescribes shares of surface waters from the Indus river system. Pakistan has the largest contiguous surface irrigation system in the world with three mega dams, three huge barrages and a cascade of related infrastructure, right down to water channels at local level. The much disputed outfall drain system, the shrinking of the Indus Delta, seawater intrusion, upper and lower riparian rights and the destruction of traditional water systems have provided fuel to rising discord, expressed in entrenched political positioning. Because of our obsession with big infrastructure rather than concerted effort at doing 'small' actions for change, we have not done what was low-cost and technologically simple, thus letting our irrigation system fall into disarray. The water discourse in Pakistan is replete with the articulation of problems and the selective use of data to support entrenched positions.

SUSTAINABLE DEVELOPMENT GOAL 6

Ensure availability and sustainable management of water and sanitation for all

The latest State Bank Report brought out in 2018, has a full chapter on water sustainability[1], which is well referenced, but is mostly on problems and not solutions. The recent clamour on the media continues to highlight the failure of government to tackle water issues. But we have to get out of the language and disharmony of failure and finding scapegoats and move forward as a polity and society that analyses, plans and executes. Pakistan's Vision 2025[2] says that we want to be among the 10 largest economies of the world by 2047. If we want to get there, we must see Pakistan's economy as a water economy and the Indus Basin system as our asset. Nor do we have to choose between the two approaches of development and conservation in the water sector. We can actually have both.

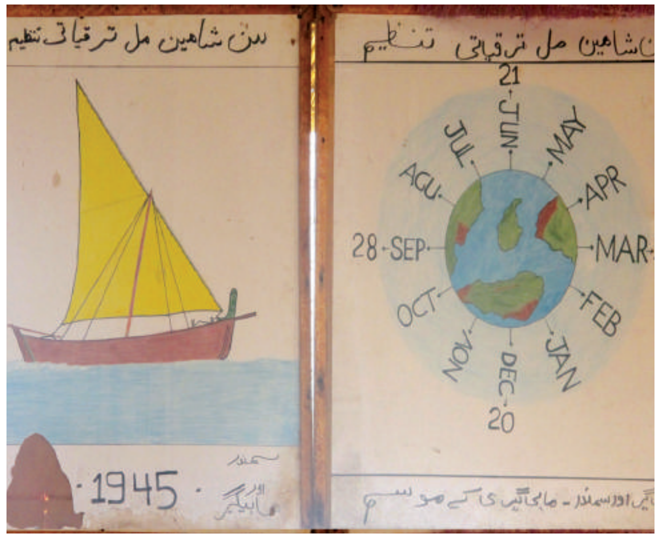
The current water policy environment

The government of Pakistan has recently made a giant existential leap. Chief Ministers of four provinces signed a Pakistan Water Charter for cooperation in the water sector in April 2018[3]. Its significance cannot be emphasised enough as it demonstrates consensus and political will. Pakistan's first National Water Policy (NWP) by Ministry of Water Resources, Government of Pakistan came out in April 2018[4], after three decades. The National Water Policy is broad-based and highlights the urgency of the situation. What it needs is an implementation framework with strategies for management and conservation, actions, timelines and financing options.

Some information can be availed from sources such as the Citizens' Water Policy[5] which incorporates among other strategic areas, improving access to water for the poor and landless; maximising water use efficiency; and improving water governance.

Pakistan is also a signatory to the Sustainable Development Goals (SDGs), where Goals 6 and 14 are specific to water (but nearly all goals have an indirect bearing on water). Targets under Goal 6 include for example: i) By 2030, achieve universal and equitable access to safe and affordable drinking water for all ii) By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.

[1] State Bank of Pakistan, Annual Report 2016 -2017 (State of the Economy), Water Sustainability in Pakistan: Key Issues and Challenges, Chapter 7, October 2017, pp: 93-104.
[2] Pakistan 2025, One Nation - One Vision, Planning Commission, Government of Pakistan, 2015
[3] Pakistan Water Charter, April 2018.
[4] National Water Policy of Pakistan, Ministry of Water Resources, Government of Pakistan, April 2018
[5] Recommendations for Pakistan's Water Policy Framework, Think Tank on Rational Use of Water, Hisaar Foundation, October 2016. Report



Water data and how it is used

For revamping Pakistan's water sector, it is crucial to look dispassionately at the data in use. The data source for water availability in Pakistan is mostly Water and Power Development Authority (WAPDA), which has been bringing out projections for decades.

Surface flow from all sources (including flash floods and civil canals outside Indus basin system) is shown in the textbox.[6]

Surface flow from all sources:	**154 Million acre feet**
Rainfall:	**8 Million acre feet**
Groundwater:	**50 Million acre feet**
Average flow to canals for last ten years: (against 114.35 MAF mentioned in the Indus Water Accord)	**104 MAF**
Maximum river flows (1959-60):	**186.79 MAF**
Minimum river flow (2001-02):	**95.99 MAF**
Source: WAPDA, 2016	

Out of the total water available per year through canals, about 97 percent is used for agriculture and 3 percent by urban population. Out of the 104 MAF of sweet water directed for use in agriculture, 69 MAF is lost due to poor transmission and seepage in canals[7]. Some of seepage contributes to sweet water aquifers in Punjab, but where there is seepage to saline aquifers as in Sindh, this water turns saline and is lost. When the Indus irrigation system was built, a drainage system was also designed. But it was never implemented, leaving a major waterlogging and salinity problem. The Indus basin is now laden with salts, and Pakistan has still to work towards a salt balance on its agricultural lands.

In order to work more positively and more proactively, a serious effort is required to re-think the way we look at data on water, where we have been using 'averages' based on past hundred years to make predictions in a world that has become anything but average. With climate change confronting us, Pakistan is a 'hotspot'. With the great variations and extremes witnessed in the past decade, we can no longer afford to make decisions based on last hundred or 70 year averages. We need new configurations of data, modelling and predictive sciences to determine the extremes. This means living with droughts and floods, storms and weather changes with concomitant changes in cropping patterns, planting regimes, heat island effect, and coastal area decay.

Water rights and payment for water

We need to stand the 'water problem' on its head and look at water and its value chains for Pakistan's economy, society, culture and preservation as a solution. Land and water are the endowment of the people of Pakistan, and putting them to best use will actually help Pakistan move out of poverty and deprivation into prosperity and stewardship.

While every Pakistani must have an allocation of water as a human right, any other use of water over and above that right, must have a value and a price, regardless of the source of water. This means licensing for extracting groundwater, using canal water, municipal water supplies, and industrial water.

In the irrigated areas, there is no reason why we cannot begin by first fixing our entire existing leaky infrastructure – responsibility and ownership must lie with government, and citizens. Investment in water resources needs to be combined with conservation, and this means tough decisions on allocations and pricing.

[6] One Acre Foot (MAF) means a foot of water standing on one acre of land.
[7] Accessed Online at: http://www.wapda.gov.pk

GLOBAL TEMPERATURE RISE AND IMPACT ON PAKISTAN'S WATER SECTOR

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Pakistan's water sector is one of the most sensitive sectors prone to the impacts of climate change. Pakistan has the world's largest contiguous Indus Basin Irrigation System. Indus Basin, the food engine of the country, is situated in arid to semi-arid conditions and requires irrigated agriculture to support its productivity. Irrigation is crucial for the economy, with agriculture contributing about 20% to the GDP; 90% of agricultural output is derived from irrigated lands and contributes to over two thirds of employment and 80% of exports. In addition to providing water for irrigated agriculture, the Indus Basin Water System resources also support the development of major cities, industry, growth centers and importantly hydropower generation which provides about 30% of affordable and environment friendly electricity to the country.

The primary sources of water to the Indus Basin are driven by melting of snow and ice from the mountains of Hindu Kush, Karakorum, and Himalayan (HKKH) that are nourished from the westerlies mainly during winters, the other contributor is the rainfall during the monsoon season originating from the Bay of Bengal and further nourished from the Arabian Sea. Water availability in the Indus River is highly seasonal, with 85 % of annual river flows occurring during a 90 to 120 day period (June to September). More than 70 percent of Indus River supplies are generated from snow and glacier melt during this period. Mean Annual River inflows (1976 -2016) to the Indus River System remained 144.85 MAF (Million Acre Feet) and outflows from IRS during same period was 28.56 MAF. Canal diversion during this period on average remained 98.55 MAF. There are exuberant water losses from Canal Head to the Farm Gate including 25% canal losses, 30% water course losses and 10% field losses then there are 25% field application losses. Major portion (50 MAF) of these losses are retrieved by pumping ground water in sweet water zones mainly in Punjab but significant part is lost to underground saline zones in Sindh and southern Punjab. Water is currently used in agriculture (92%), industries (3%), and domestic and infrastructure (5%). It is expected that in the future, sector water demand will increase due to socioeconomic development and the increase in population.

Climate change observations in Pakistan: During the last century, Pakistan's average annual temperature increased by 0.57°C compared to 0.75°C for South Asia, and average annual precipitation increased by 25%. The warming is mainly due to increase in winter temperature. A decrease of 17% to 64% in rainfall observed during the seven strong El Niño events in the last 100 years; the minimum temperature in summer over central parts of Pakistan has shown a pronounced warming trend while in the extreme north and south have shown a slight cooling trend in some climatic zones; the coastal belt in general and the Indus delta in particular have not shown any significant warming or cooling trends. During the last fifty years cooling in summer temperatures and warming in winter temperatures is noted in the HKKH region this also corroborates to the falling summer flows and increase in winter flows during same period.

Future projections: Pakistan's projected temperature increase is expected to be higher than the global average. Projected temperature increase in northern parts is expected to be higher than the southern parts of the country. The frequency of hot days and hot nights is expected to increase significantly. Pakistan's rainfall projections do not indicate any systematic changing trends. An increasing trend in the rainfall over the Upper Indus Basin and decreasing trend in the Lower Indus Basin. There will be increase in the intensity and frequency of floods and droughts, this shocking phenomenon of climate change has already set in and we have observed 2000-2009 drought followed by 2010 super flood that caused loss of 1600 lives and USD10 billion to the economy.

The "Task Force on Climate Change" in 2010 identified some climate change-related threats to water security, as follows:

i. Increased variability of river flows due to an increase in the variability of monsoon and winter rains, and loss of natural reservoirs in the form of glaciers;
ii. Increased demand of irrigation water because of higher evaporation rates at elevated temperatures in the wake of reducing per capita availability of water resources and increasing overall water demand;
iii. Increase in sediment flow due to increased incidences of high intensity rains, resulting in more rapid loss of reservoir capacity;
iv. Increased incidences of high altitude snow avalanches and glacial lake outburst floods (GLOFs) generated by surging tributary glaciers blocking main unglaciated valleys;
v. Increased degradation of surface water quality due to increase in extreme climate events such as floods and droughts.

Climate change has drastically affected our agriculture, crop cycle, and production of rice, wheat and cotton. Present drought like conditions describe well the situation that can happen in the future to the irrigated agriculture under the influence of climate change. Last winter snow fall was 30-40% less than previous year, this, coupled with late rise in summer temperatures resulted in considerable reduction river flows. The Indus River System Authority (IRSA) reduced the summer water supplies to canals by 45%. The cotton which is sown in early April was not sown by the mid of June in many parts of the country due to non-availability of canal supplies, consequently this will result in low cotton production and hence considerable loss to agriculture economy of the country.

It is projected by Pakistan Meteorological Department that there will be 4°C rise in mean temperature by 2100 with no significant change in precipitation. The latest study by the World Bank shows that increase in 0.4 °C per decade in temperature will result in no change in the inflows to Tarbela by 2050 which are 44% of total inflows to Indus River System, but inflows will be 10% more than the present inflows with rise of 4°C and no change in precipitation. For the tributaries Jhelum, Chenab and Kabul no credible study exists to describe the flows in these tributaries by the end of 2100.

Conclusion:

Climate change is reality and is affecting water sector drastically. For this reason the following recommendations are provided to provincial and federal governments:

- It is imperative to build water reservoirs to manage the variability and uncertainties in water flows.
- Develop temperature resistant and water efficient crop varieties.
- Build awareness about water conservation.
- Explore artificial recharge of flood waters to the ground in sweet water zone.
- Save water losses in irrigation by limning canals in saline water zones.
- Shift from flood irrigation to more efficient raised bed, drip or sprinkler irrigation techniques.
- Price the water for its efficient use.
- Population management essentially reduce pressure on water availability therefore it is imperative to reduce the population growth to world average.

CHANGING THE NARRATIVE

FROM WATER POLITICS TO WATER HYDROLOGY

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Before partition of Pakistan and India in 1947, the British Raj developed canal irrigation system based on run-of-the-river canal diversions. Major development of this system took place between 1880 to 1940. The canals were unpaved raised-ditches which fed the 'water courses' linked to the farms. The on-farm distribution of water was based on time allocation or warabandi. Time allotted to each farmer to withdraw water from his designated water course was based on the size of his farm. A schedule was to be followed where farmers would get their water for a fixed time duration as per their turns in the schedule. However, there were two key issues in the system. One, conflicts between farmers became a common happening both in making of warabandi schedules and its implementation – a compromise on communal peace within the villages; and, two, water delivered to the farm was applied to the field through flooding – an extremely wasteful method, the 20th century drainage system came with its own baggage.

As a consequence, today, there are hundreds of thousands of cases of rural feuds in our courts and most of these find their origins in water disputes. Due to wasteful methods of irrigation, too much water seeped down in ground, raising the groundwater levels to the extent that many irrigated areas became water logged and saline. While nothing noteworthy has ever been done at national scale to device any mechanism to reduce, mitigate or avoid feuds on water in the villages, serious investments were made to address water logging and salinity issues.

The second half of 20th century saw the next major intervention in the irrigation system when a massive network of irrigation drains and high capacity tube wells were installed – costing taxpayers billions of dollars. These projects were known as Salinity Control and Reclamation Projects or SCARP. Although there had been some positive outcomes of SCARP, but just like its predecessor of 19th century irrigation system, the 20th century drainage system came with its own baggage.

SCARP deep wells became unsustainable and got divested due to high operational costs. In many cases, the irrigation drains shifted the problem from bad areas to good areas. The dumping of saline waste from these drains into low-lying areas, streams and rivers is now a major environmental issue. Many of these drains and pipes are already choked. The drains, with their stagnant waters, now provide permanent breeding environment for mosquitos and other disease vectors[1]. Large irrigation drains in Indus Delta (like LBOD) were designed to discharge drainage water into the sea, but instead, these ditches provided ingress to the sea waves much deeper into the land and consequently tens of thousands of acres of farmlands and many villages have been eroded to the sea.

Parallel to the development of SCARP, the demand for food in the country kept rising owing to the population growth. Farmers were required to grow more. In order to increase per acre yields, agricultural chemicals (fertilisers, herbicides and pesticides etc.) and hybrid seeds were introduced. Every year, the combined cost of seeds and chemicals bought by the farmers in the Indus Basin runs in billions. This has increased the average per acre production at our farms, but yet again, the intervention has an accompanied baggage.

Hybrid varieties of crops demanded more water, putting more pressure on the limited canal water available, resulting in ever more pumping of groundwater by the farmers and depleting the aquifer further. Due to continued flood irrigation practices, the leachate of pesticides, herbicides and fertilisers seep down in the soil and pollute the underground shallow water. This polluted shallow water is generally the prime source of drinking water in the villages and is now the cause of many diseases in rural areas, especially among children.

The irrigation drains also collect these pollutants and dump them in the fresh waters of flowing rivers.

Today we are producing surplus food at the cost of coastal villages in Sindh delta eroding into the sea, polluted rivers, degraded environment, and, lo and behold, sick children.

[1] Abbas (2017), Irrigation Efficiency – Key to Ending Indus Water Shortages, The Third Pole.

> **"Instead of treating the symptoms over and over again, we treat the cause, once and for all – the water guzzling practice of flood irrigation."**

For every intervention to solve a problem in the Indus Basin, we have created two or more new problems. And to solve each of the newly created problem, our solutions have created two or more problems. This geometric progression of problems is basically rooted in the British legacy we inherited in the name of Indus Basin Irrigation System. And we all know it.

Looking closely, there is a chain of problems all emerging from the 19th century British legacy of flood irrigation through open canals. It is plain common sense that instead of treating the symptoms over and over again, we treat the cause, once and for all – the water guzzling practice of flood irrigation. We have the examples of hydrologic management and modern irrigation systems from other parts of the world that can replace the British legacy.

But unfortunately, our political system has also emerged from the same British legacy – powerful landlords with large holding within the canal command areas. Most of them are politicians. The system suits them the most. With it, they can not only generate huge revenues but also control the poor populace of the rural communities – their vote bank.

We cannot continue with a 19th century system in the 21st century. We have to look beyond politics and embrace the efficient irrigation technologies. We must push for a basin-scale drive for adoption of most modern piped irrigation systems. The technologies are available and would cost way less than building yet more dams, canals and drains. It is time to kill the mother of all water woes once and for all – the British legacy of flooding the farms and controlling the people.

WATER RESOURCES MANAGEMENT IN AGRICULTURE

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Irrigated agriculture of Pakistan consumes more than 90% of fresh water. This high water consumption in agriculture contributes only 20% to the GDP and two-thirds of employment. The Indus Basin Irrigation System was built for a 66% cropping intensity. The high demand for food pushed for increasing cropping intensity to more than 150% and promoted high delta crops (rice and sugarcane) at large tracts, that has necessitated augmentation of irrigation water supplies with groundwater, meeting 50% of the total crop water requirements at present. Highly variable climate has further exacerbated the situation by putting Pakistan amongst top 30 water stressed economies. Declining surface water availability, deepening underground water table, rising salinity levels and deteriorating environmental health due to contaminants, are amongst the major water related challenges. Water savings are possible through intelligent choice of crops and better irrigation practices.

Political economy considerations (choices) led to growing of low value (for water) traditional crops despite a potential to produce high-value crops. Four major crops are consuming 117 million-acre feet (MAF) of water, i.e. wheat (39 MAF), cotton (29 MAF), rice (26 MAF) and sugarcane (23 MAF) due to large acreages. The crop yields per cubic meter of water use are much lower. For example, the average wheat production per m^3 of irrigation water in Pakistan is estimated at 0.54 kg as compared to 1.22 kg in India, 1.39 kg in the Netherlands and 1.44 kg in USA. In case of rice, Pakistan is exporting around 3.5 MAF of virtual water, annually (Konar et. al., 2013).

In a controlled experiment conducted in Oman (Al Said et. al., 2012) Rhodes Grass (perennial fodder) was compared with a set of vegetable crops, showing a huge loss of value for water in growing a high delta fodder crop (Fig. 1).

Cultivation of low delta or high value crops should be incentivised for restricting area under rice and sugarcane. Our average irrigated wheat acreage takes five irrigations a season. That could be reduced to three (40% saving) with better genetics and precision planning to irrigate wheat at the critical points only (tillering, booting and grain filling). That would translate into saving more water than the entire storage in Tarbela and Mangla dams put together. Additional savings are possible by bed/furrow irrigation instead of broadcast sowing and flood irrigated wheat. In case of rice, introduction of direct sowing with seed drill can have benefits of labor saving (5 man days per hectare ha compared to 25 man daysper hectare (ha) in transplanted rice), time and water saving (12 – 30 %) and optimal plant population for better yields improving returns on volumes. There is a need for training and capacity building of the farmers to adapt to the emerging water crises.

Major factors limiting the yield are considered to be inadequate availability of irrigation water at farm gate,

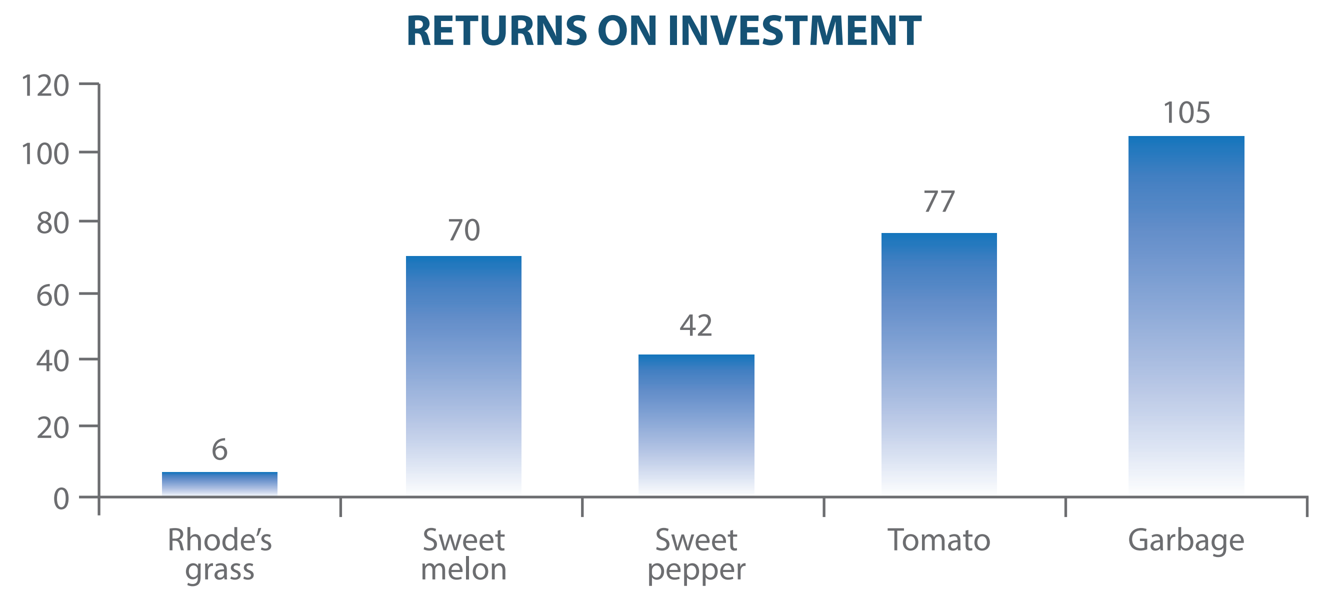

Figure 1: Returns on investment per Riyal Omani of water cosst (Source: Al Said et al., 2012)

unreliability and inequity in water supplies. A significant (20 to 25%) amount of irrigation water is being lost due to uneven fields and lack of precision in inputs especially water. This leads to excessive application of inputs and lower yields that increases production cost. Intensification of cropping systems continued to put more demand for water. While the canal water flows into the farm at fixed time slot per acre on weekly basis without any need assessment and storage arrangements at the farm level (receiving end). As a result, groundwater is being abstracted as a gift of nature without foreseeing consequences of lowering water table, deteriorating water quality and increasing energy cost.

The situation demands a sound strategy to efficiently utilise diminishing water resources of the country. There is a need for schemes for rainwater harvesting, flood canals, river dredging, river lakes/locks, canal water storage, on-farm storage and ground water recharge wells.

Some of the major reasons for chaotic water economy are lack of volumetric pricing mechanism and absence of groundwater rights and entitlements. The political realities led to freezing of water charges and deregulation of groundwater abstraction. Water thefts and distorted allocations are common. There is an urgent need to revisit water laws and regulatory mechanisms. As in absence of any legal rights, the fuel prices are mistaken as balancing force for groundwater abstraction. The cheaper energy sources (solar, biogas) and fuel subsidies will further hurt the groundwater economy. Restriction on groundwater pumping is to be imposed, sooner or later. Irrigation water should be priced (according to the depth of water table). Currently there is lack of proper data about the aquifers and their boundaries. The aquifers should be mapped so that the confined and unconfined aquifers transcending administrative boundaries should be protected through legal right and water policies.

There is a case for developing water stewardship to be socially equitable, environmentally sustainable, and economically beneficial. Water education can play a significant role in conservation and prevention of water pollution. Since the monsoon season is a narrow time bracket, rainwater harvesting is a low hanging fruit to prevent floods and to enhance water availability during droughts. Promotion of on farm storage and separation of rainwater flow from sewerage drains are important challenges that need to be addressed. The role of ICT in agriculture and precision in agricultural inputs is yet to be explored and has potential to give promising solutions to water scarcity issues of the country.

Industrial waste and untreated water going into peri urban agriculture has devastating consequences for environments and human health. Very soon, the urban/industrial water user shall start competing with agricultural users. For having buying capacity, the urbanites shall deprive the rural and agricultural users on many fronts. The shortages of drinking water are already being seen to emerge as potential catalyst of water riots.

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URBAN WATER MANAGEMENT: SOME PERSPECTIVES

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Life without water is unimaginable! Experts, civil society members and many other stakeholders consider access to potable water as a fundamental human right. In the urban context of Pakistan, particularly larger cities, this right is denied to a large cross section of the population. Research studies, practical evidences and common observations have proved the fact that water supply service in the urban and rural areas of the country is grossly faulty. The quantities are inadequate compared to the needs and the quality far below the prescribed standards for human consumption. Scarcity of water is more acute in inner city areas which are densely populated areas of old cities, such as Lahore, Peshawar, and Multan. Similarly multiplying peri-urban localities are also worst hit with poor supply of services. Karachi's water woes are being further exacerbated with the onset of climate change and the new types of 'disasters' such as heat-waves.

Water scarcity is now a commonly felt phenomenon in many cities across the country. Cities like Quetta are experiencing rapid depletion of ground water due to less than desired precipitation and over drawing due to rising urbanisation. People fear that some cities in the country may come close to a 'day zero' situation – as observed in Cape Town – where water reserves fell to dangerously low levels. One needs to become 'water wise' to ward off the risks associated with any such scenario. While most of the major urban settlements in Pakistan are aligned along Indus basin or other rivers, the risks of climate change induced water shortage can hit these cities any time plainly due to our unpreparedness, lack of planning and communication, disconnect of the water supply utilities with their consumers. Besides, the status of water supply in many locations is experiencing problems that can aggravate to any degree of severity, if not addressed with science-based solutions.

Understanding the future, the urban water management in the context of Pakistan requires the following measures.

Water conservation: Conserving water and raising awareness to use less water under ordinary circumstances is an effective way to manage potential shortage. This includes strict monitoring of pipes, faucets and other gadgets related to water use. It is a common observation that little care is given to fix leaking taps and pipes in public places or dwellings. Studies inform that one leaking joint or a tap can cause a loss of about 6,000 gallons per month. A sensible way to optimise access to water is to curtail its undesirable losses. Nowadays such monitoring equipment is available that can detect leaking water pipes that are buried in the ground.

In Cape Town, the municipal government decided to remove all taps in public toilets replacing these with hand-sanitiser so as to minimise water wastage. Similarly, 2-minute showers have become the norm for most residents of that city, while toilet flushing in homes has been reduced to only when absolutely necessary, as each flush uses over nine litres of water.

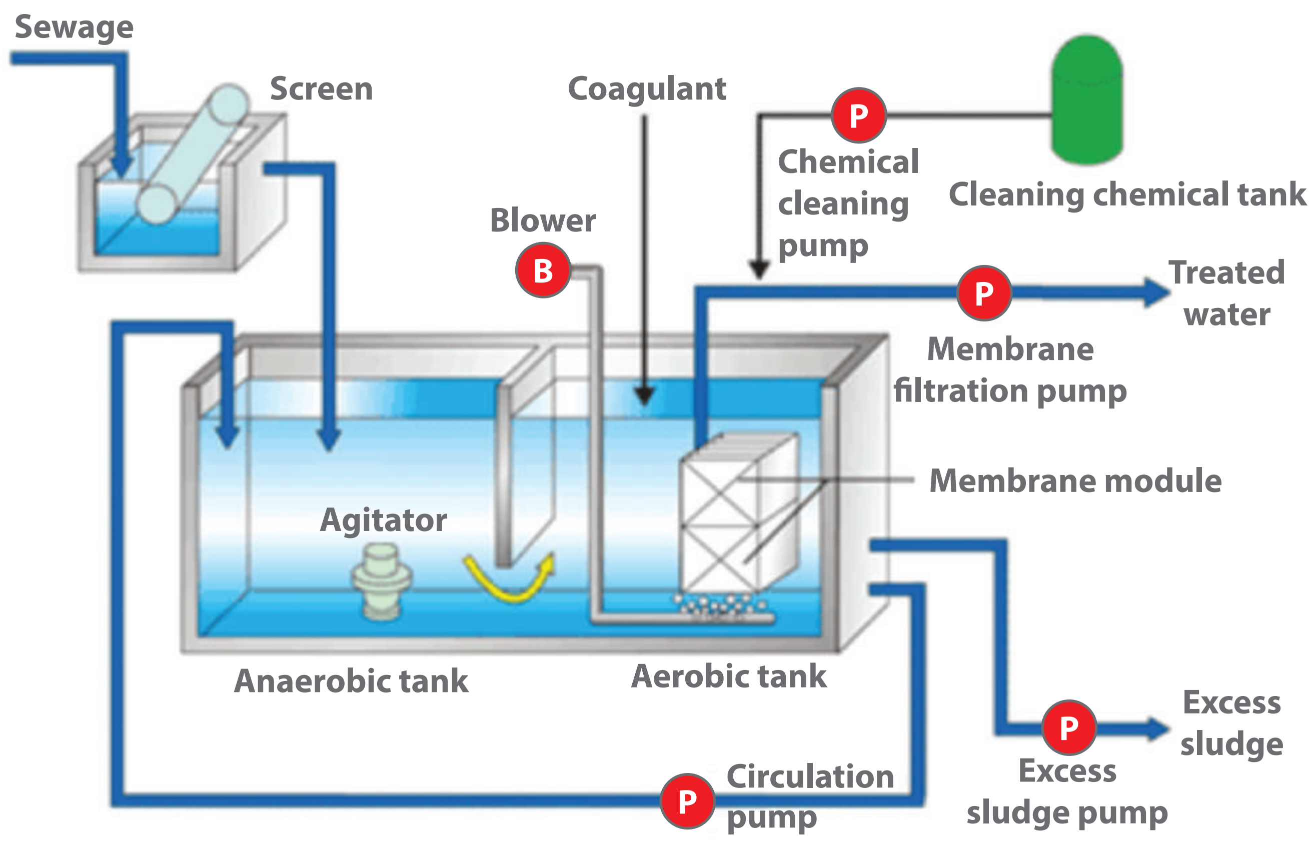
Reusing water: Statistics show that in Karachi, more than 10 percent of the water supplied to the city is consumed washing cars and other vehicles. Estimates show that about 60 gallons of water is spent in a normal car wash. With the exponentially rising number of cars and motorcycles, this quantity will increase and cause a much greater pressure on existing water resources. Similarly, over 200,000 mosques are present in Karachi. Sizable water is utilised in the ablution in each establishment. After a very basic treatment, this water can be directly used for gardening and horticulture support purposes.

There is also an enormous potential of developing smart approaches to store and re-use rain water during the monsoons and other rain spells. This can even be achieved even at the single dwelling unit. With slight alteration in the roof design and adjustment in house plumbing, substantial water quantities can be stored and used for various non-drinking uses by the respective households.

Wastewater management: Wastewater management in cities also needs a careful re-appraisal. Previously, the sewerage disposal was aimed to discharge in few centrally located treatment plants. Literature indicates that less than 8% of urban wastewater is treated in municipal treatment plants across the country [1].

[1] Murtaza, Ghulam and Munir H. Zia (2002), Wastewater Production, Treatment and Use in Pakistan;
Tribune (2017); https://tribune.com.pk/story/1362083/world-water-day-less-8-urban-waste-water-treated-pakistan-says-report/

DIAGRAM 1: MEMBRANE BIOREACTOR SYSTEM-SEWAGE TREATMENT SYSTEMS



Source: Hitachi Infrastructures Systems (Asia) PTE. Ltd.

In Karachi alone, about 450 million gallons of waste water is directly discharged into the sea without any treatment. This seriously impacts the marine life and our coastal environment. The situation may marginally improve after the inauguration of a waste water treatment plant by Chief Justice of Pakistan on 22 July 2018. Lessons may be derived from countries that have decentralised the waste water treatment at the neighbourhood and household level for better monitoring, operations and maintenance of the systems. Japanese cities display many worthwhile examples of using bioreactors – devices and systems for waste water treatment using biological and chemical processes – to efficiently reclaim the used water. Scientific solutions for this vital environmental protection function offers some interesting lessons to benefit from.

Behaviour change campaigns: There is a huge need to bring about attitudinal change amongst our peoples related to water. We need to devise strategies to sensitise all categories of water users about methods of its conservation and careful usage. From semi-literate domestic help workers to chief executives in the corporate organisations, each one needs to be informed about options of becoming prudent in water use. The recent verdicts of the Supreme Court in related cases have also directed concerned government departments to initiate water education on a comprehensive level. It is our collective responsibility to protect the earth-the water planet!

Political commitment and political economy: Finally, the role of city government, especially mayors, local politicians, and administrative heads of civic agencies require systematic realignment. Each one's roles and responsibilities need to be publicly communicated with a system of public response, user perception and possible score card models designed so that transparency and accountability (including putting in place penalties) can be strengthened. The activities of the water mafias, especially in Karachi, need to be curtailed, but this can only happen once systems of transparency, accountability and customer feedback are in place.

DEPLETING WATER RESOURCES IN BALOCHISTAN

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Pakistan is the third most water stressed country in the world with 1,020 cubic meters per capita annual water availability. The province of Balochistan is going through the most serious crisis where water scarcity has affected its agriculture sector.

Balochistan is located in arid zone where annual precipitation ranges from 50 to 500mm and evaporation rates are extremely high. In many parts of the province, women and children, with their buckets, have to search for water over a few kilometers. Local communities have the only option of storing rainwater in ponds, which may be contaminated by human and animal activity and hence extremely harmful for human consumption. People suffer from water borne diseases in these areas. Only less than 15% population of the province has access to safe water. Even in the provincial headquarters of Quetta, people have to purchase very expensive water from tankers; water crises in remote, sparsely populated areas is a persistent problem.

Water scarcity is an existential threat to Balochistan because the province is predominantly an agriculture driven economy. Almost 90% of water resources are used to grow food and livestock, which is now affected by the present drought condition. On the other hand water scarcity has badly affected agriculture sector which is its main economy supporting factor. The orchards are regarded as main sources of income of the province which are in crisis as production has been reduced by 70 percent. Many farmers are unable to continue farming anymore and support their family. Limited agricultural yield has compelled people to search for other jobs in urban areas, which have raised the unemployment in province. Some districts such as Khuzdar and Gwadar have plenty of water but not safe for drinking and farming. Gwadar has been in the grip of water crisis over the last several years. Neglected by the provincial government, residents of Gwadar are also compelled to collect water from distant areas. Gwadar's residents complain that many people have left the port city because of the water.

Balochistan has been facing drought condition since 1997 and has caused an alarming situation. Experts showed their serious concerns about unavailability of dams to store water and low groundwater recharge; these issues are turning the province into a desert. Half century ago, water could be seen flowing in the streams and coasts of the province. Water could be found upon digging a mere 20 feet to 25 feet into the ground. In Quetta Valley

groundwater level has declined by 24m since 1989. The government installed a large number of tube wells but did not build any dams nor took action against illegal drilling. Currently, over 35,000 tube wells of various capacities are pumping groundwater across the province. In addition to this, drought, climate change and increase in population have exacerbated the problem of water scarcity.

In the coming years if the provincial government continues to ignore the issues, the province will face chronic water shortage and instead of development, the province will continue to dwell in the past. There are a few suggestions to solve water crises in Balochistan. Most important practice could be construction of dams which can provide water around the year and enhance groundwater recharge. Latest and efficient irrigation techniques should be used to reduce groundwater exploitation. A shift from high delta crops and orchards to low delta crops must be made to sustain ground water resources. It will be helpful to introduce and popularise rainwater harvesting at local level and manage groundwater recharge at micro level. The most important recommendation - all stakeholders must put coordinated effort to cope with water issues in whole province.

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ADAPTING TO AN UNFOLDING WATER CRISIS: CRITICAL ACTIONS THAT NEED TO BE TAKEN BY STATE AND SOCIETY

from 1.25 t/ha to 3 t/ha in Syria, from 4.6 to 5.8 t/ha in Morocco, and from 2.2 to 3.4 t/ha in Iran.

Promoting traditional ways for harnessing water: Water harvesting is an effective, low-cost technology to conserve every last drop of available moisture. In the drylands, there is scope for harnessing traditional knowledge developed over generations by rural communities. Examples include underground cisterns, flood harvesting systems, and basins for collecting water and channeling it for household use and horticulture. Many dryland countries have a strong tradition of water storage. By building on these technologies, the resilience and adaptability of rural communities can be further strengthened.

Developing additional water reservoirs

Finally, the critical need is to develop additional water reservoirs of Diamir Basha (gross storage 8.1 MAF; power generation 4500 megawatt) and Mohmand dam (storage1.2 MAF; power generation 840 megawatt) over the next 5-10 years in the public sector. Financing is likely to be available for these through suppliers' credit, contractors' financing and the public sector development programme. The run of the river Dasu dam, also on the Indus, should be deferred till these two water storages are completed in eight years since water has emerged as a more serious issue than generating electricity only. There is little likelihood of funding all three of these simultaneously.

For the water starved province of Balochistan there is the urgent need to construct five water storages identified by WAPDA. These would not only provide food security but useful local employment to the people. The reservoirs in Hingol (Lasbela) would irrigate 65000 acres, Naulong (Jhal Magsi) 47000 acres, Pelar (Awaran) 25000, Garuk (Kharan) 12500 and Winder (Lasbela) 10000 acres. These five site in combination would store nearly 1.6 million acre feet of water at a cost of about Rs150 billion.

Similarly in the Khyber Pukhtunkhwa province (including the erstwhile Tribal Areas) three new reservoirs should be constructed after commencement of Gomal Zam and Kurram Tangi projects in Waziristan. These include the Bara dam (Khyber Agency) which would irrigate 41000 acres, Tank Zam (Tank district) 35000 acres and Daraban (DIKhan district). The total gross storage capacity would be 1,268,369 acre feet sufficient to irrigate 92,729 acres at a cost Rs 200 billion.

Finally, efforts need to be made for developing a consensus work on the Kalabagh Dam with a live storage of 6.1 MAF. Its power generating capacity would be 3,600 MW totaling about 12 billion energy units annually. Its maximum water retention level would be 915 ft which would be 35 feet lower than Nowshera.

It must also be emphasised that the Water Accord signed unanimously by all four provinces in 1991 should be made part of the Constitution for ensuring that the provinces water rights are secured.

WATER RESOURCE DEVELOPMENT FROM THE GROUND UP

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Pakistan Poverty Alleviation Fund (PPAF) employs a community driven development approach toward developing water resources and addressing the challenges arising out of the paradox of scarcity and abundance of water. Over 20 years, 1,037,572 households have benefited across Pakistan from water resource development work for drinking water, irrigation, and flood protection purposes. These interventions have integrated the needs of the community spread in varied geographic regions, reduced vulnerability of households, built resilience of the ecosystem, managed climate risk and helped households graduate out of poverty.

Securing water resources and reducing vulnerability

PPAF's water resource development interventions focusing on water conservation and management include: 1) Water supply schemes; 2) Drought mitigation and preparedness projects; 3) Integrated Water Efficient Irrigation Projects; and 4) Flood protection and land reclamation and conservation measures.

Drinking water supply schemes: With the participation of community, PPAF collects information on water sources, water uses, and water consumption pattern. Studies are then conducted to understand localised hydrology and thus knowing about the movement of water and other dynamic processes. Once found suitable for drinking purposes, water from the source is pumped into a tank. Three ways are considered for onward distribution. At places, households get water from the tank taps directly. Sometimes, water is supplied from the tank to communal standpipes serving a cluster of houses. Yet at other places households have individual connections.

Drought mitigation & preparedness project: In 2003, with a pilot in Balochistan, PPAF pioneered a drought mitigation and preparedness programme (DMPP) to secure our water resources in the less endowed and poverty stricken regions of the country. Since the pilot, PPAF has implemented 38 DMPPs covering a minimum of one UC up to six UCs benefiting on average 15,000 households spread over approximately 50 settlements.

A typical project comprises around 80 to 100 subprojects, which aim at: 1) increasing availability of water; 2) conserving water; and 3) managing the watershed.

Building resilience of the ecosystem

PPAF's interventions for rangeland management and natural resource management have protected watershed. In the foothills, mountains and valley bottoms which are uncultivated and not occupied by houses in and around villages, enclosures are marked for reseeding shrubs and trees species and the area is protected from grazing and cutting for a certain period of time. The species grown are native to the area, have low delta water requirement, improve the biodiversity, enhance the biomass production in the area, and contribute to the livelihoods of the people. To provide water on the rangelands, stock water ponds are constructed at strategic points where rainwater is harvested and provided for livestock drinking purposes. Communities are given awareness to plant grasses and shrubs on the mountain slopes in order to check gully erosion. These small-scale interventions provide long-term benefits in the form of flood protection, increased lands for grazing and the possibility of additional recharge to groundwater.

Sub Project Types of Drought Mitigation and Preparedness Project

1. Delay action dams and check dams
2. Rainwater harvesting ponds
3. Drinking water supply
4. Water efficient irrigation
5. Rangeland management
6. Natural resource management
7. Flood protection and land reclamation and conservation
8. Diffusion of innovative technologies

Managing climate risk

Communities are prepared to better manage extreme climatic events by having early warning system in place.

In arid areas of the country communities are trained in gauging rainfall to understand the rainfall pattern and monitoring groundwater levels to determine changes in water balance of the areas. Based on this information the community devises remedial measures, such as altering water usage, ways to recharge groundwater, crop selection, water conservation measures, and rangeland and natural resource management activities.

Awareness and behavioural change activities for managing climate risk comprise building capacity of community in crop optimization, water efficient cropping patterns and techniques, and maintaining livestock population size according to the rangeland caring capacity. PPAF sets up demonstration farms for communities to learn about water efficient irrigation methods, benefits due to changes in cropping pattern, cultivating new variety of crops and moving to low delta crops. At places nurseries are set up to facilitate the farmers of the areas to get healthy seeds.

CBDRM under Sindh Coastal Area Development

In flood prone areas PPAF has set up community response structure for an ASAP Response. During 2012-14, 52 Disaster Management Committees and 52 Emergency Response Teams were formed and trained at the Union Council level in 4 districts of Sindh. Grounding of expertise around resilience within local communities was realised through Community Resource Persons (CRPs) at the Union Council level.

What next: Water-wise rural areas

Water scarcity and water access are persistent problems in Pakistan, PPAF's goals are to: 1) ensure access to safe drinking water and sanitation and 2) develop effective water conservation and management systems at local level.

In all current programming, PPAF is focusing on diversifying sources of livelihoods to reduce water related vulnerability and achieve self-reliance by building on local assets, skilled workforce, and value added production and processes. In addition to this, men and women can be trained in green skills which will enable communities to manage their resources and natural assets in a better way as well as generate income out of it.

We need to look around in the regions for evidence-based solutions to sustainably manage water and land resources for food security, people's livelihoods and the environment and pilot those ideas.

PPAF promotes efficient irrigation techniques for a judicious use of water. Water storage and water recharge are the necessity of the day. Considering our own and other good pilots and examples to conserve and manage water at local levels, scaling up our interventions across the country is the option that PPAF needs to take forward, and this is our goal for the coming ten years.

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Drinking Water Supply Scheme.
Tharparkar, Sindh

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Seasonal map representing the fishing season in coastal areas.
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World Environment Day celebration at Government Primary School.
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Sprinkler Irrigation System.
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Water course for irrigation.
Chitral, Khyber Pakhtunkhwa

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