WATER RESOURCES MANAGEMENT – ACHIEVEMENTS AND SUCCESS STORIES OF PAKISTAN COUNCIL FOR RESEARCH IN WATER RESOURCES (PCRWR)

Abstract

Water is lifeline for agriculture based economy of Pakistan, therefore, its conservation and management is imperative for sustainable growth. Water resources of the country are subject to quantitative and qualitative decline due to a number of reasons. Most of the water issues are related to planning and management. PCRWR has the mandate to conduct, organize, coordinate and promote research on all aspects of water resources. It undertook a number of initiatives and projects to cater some of the issues faced by the country and have success stories to its credit. The major achievements of the Council are: exploration of unutilized groundwater resources and quality mapping in Indus plain, development of national water resource database, improvement of design parameters and operational strategies of the skimming well, impact assessment of unsafe wastewater disposal and mitigation plan, snowmelt stream-flow relationship of Upper Swat basin, performance evaluation of locally manufactured raingun for sprinkler irrigation, rejuvenation of depleting aquifers through leaky structures in Balochistan, Reclamation of waterlogged land through mechanized tile drainage systems in Sindh, national integrated water management plan, water conservation and management programme in Northern Areas, growing rice with sprinkler and bed and furrow irrigation, water resources assessment and strategic utilization in Potohar, cost-effective design for economical lining of watercourses, estimation of shallow groundwater contribution to crop water requirements and regional management strategies. The paper details adoptability implications of the management practices and strategies thereof.

Introduction

Pakistan's economy is predominantly agrarian and agro-based industries which cumulatively contribute about 50% of its GDP and employs more than 70% of population. Water is lifeline not only for agriculture but also for other sectors. The ancient civilization in the area comprising Pakistan emerged primarily by harnessing water resources of the River Indus. It has the largest contiguous irrigation system of the world and ranks the 4th largest in terms of expanse of irrigated area (18 Mha) after India, China and USA but the lowest in terms of freshwater availability amongst the four nations. The annual rejuvenable water resources of the country are 225 BCM (Aquastat, 2010) which are not being properly managed due to insufficient storage reservoirs capacity, outdated and inefficient irrigation system, non-implementation of environmental protection laws etc. The current annual per capita water availability of the country is almost 1,100 m^3 ranking 142nd globally, whereas the figure for other regional countries like India, Bangladesh, Nepal and Sri Lanka are 1591, 7569, 7296 and 2492 m^3 respectively (Aquastat, 2010). Pakistan has, therefore, approached the threshold limit of water scarcity (1000 m^3/person/year) which is severe threat to its economy. There is direct correlation between access to freshwater and per capita GDP as the former serves as fuel to the economic activity. Despite having water scarcity, mismanagement and water use inefficiency prevails pre-dominantly in all the sectors of life. The reasons behind the issues faced by Pakistan are inter alia more of management type.

PCRWR is an apex research and development organization mandated to conduct, organize, coordinate and promote research on all aspects of water resources. Over the almost last fifty years, PCRWR has played its role by undertaking and promoting research in various disciplines of water sector, especially, irrigation, drainage, surface and groundwater management, rainwater harvesting, groundwater recharge, watershed management, desertification control, water quality assessment and monitoring, and development of innovative water resources conservation, management, and quality improvement technologies both at national and regional levels. It also coordinates with other provincial, national and international organizations and academic institutions related to water sector to remain updated with the latest research findings. Though the projects undertaken by the Council are mostly funded by the Government of Pakistan, but a number of projects have also been funded by international agencies. The Council has three major research areas namely (i) Water Management (ii) Desertification Control and (iii) Water Quality.



Water resources management

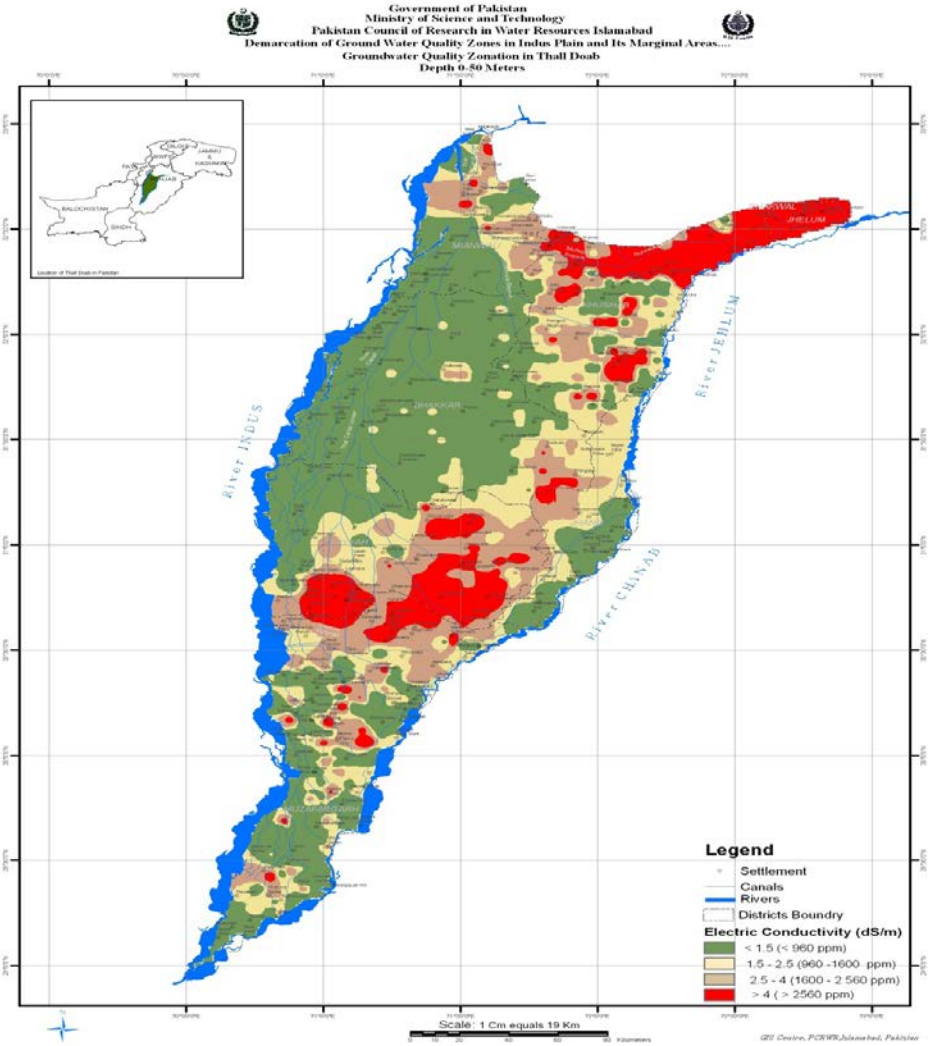
Water management is an activity of planning, developing, distributing and managing optimum and efficient use of available water resources for all uses and demands. Successful management of any resources requires reliable knowledge of the resource available, its uses and demands, measures and processes to evaluate the significance and worth of competing demands and mechanisms for actions on the ground. It is a challenging task and the Council maintains a separate section to cater the research demands in water management. Water Management section of the Council is equipped with skilled professionals facilitated with remote sensing and GIS lab, hydrological modeling software, survey, mapping and groundwater exploration instruments. It also maintains a network of research farms in different ecological zones of the country for carrying out region specific research activities. The section has credit of developing and implementing various projects in different parts of the country emphasizing farm level water conservation, high efficiency irrigation systems, crop water requirement estimation and groundwater contribution, groundwater investigation and mapping, artificial groundwater recharge, drainage and land reclamation, rainwater harvesting, conjunctive use of water and wastewater management. The water issues faced by the country and initiatives, achievements and success stories of PCRWR in catering those have been given in the subsequent sections.

The water availability situation is threatened due to unjustified interventions by India in violation of Indus Basin Treaty to build storage type hydropower projects on western rivers culminating in reduced river inflows to Pakistan. Similarly, climate change is causing recurrence of extreme events, increase in monsoon rainfall, and its shifting towards western side of the country. Though more area would come under monsoon belt increasing water resources of the country but is not likely to be temporally well distributed. Consequently, the country is likely to face frequent flooding and droughts because of not having adequate storage facilities. The storage capacity of country is as low as 144 m^3/person whereas that is 6000 m^3/person for USA followed by Australia and China and even lagging behind the regional countries like India, Nepal, Turkey and Iran. Moreover, storage capacity of existing reservoirs is also degrading fast due to sedimentation at an alarming rate of 0.2 MAF / annum. The freshwater availability is being further declined due to exponential population growth. Pakistan has, therefore, become water scarce as freshwater availability has almost touched the threshold limit of 1000 m^3/capita/annum. In the backdrop of water scarcity, the country should be having an efficient irrigation system which consumes more than 90 percent of water. While in contrast, the irrigation efficiency of IBIS is just 40 percent giving rise to huge losses during distribution in terms of evaporation or seepage. The seepage part is partly recovered through pumpage ; however the former is a permanent loss from the system. The same is the reason ; water productivity of irrigated areas is quite low. Similarly, the agricultural productivity of drylands is also very low, just 10 percent of the national productivity despite occupying almost half of

country's geographical area. Another constraint to efficient water management in the country is lack of centralized water resource database as it leads to frequent overlapping of data collection by various agencies resulting in capital and time loss to the country. It also leads to inappropriate policy and agenda formulations at the national level being based on insufficient and inconsistent information. Waterlogging, salinity, brackish groundwater and seawater intrusion are the constraints to agriculture sustainability and development in the lower Indus plain. The other issues faced by the country are huge generation of wastewater, its unsafe disposal, wastewater irrigation, and indiscriminate pumpage resulting in surface water contamination and quantitative depletion and qualitative deterioration of groundwater. This in turn is giving rise to water-table decline at a number of places particularly near urban centers and water-borne and water related diseases. The problems are mostly management type and, therefore, require nation goodwill and consensus, inter-regional harmony, institutional and expertise buildup, stakeholder awareness, mobilization and participation. PCRWR took up a number of initiatives and projects to cater and find solutions of the on ground real time field problems and has a number of success stories, a few of those have been summarized as:

Groundwater exploration and quality mapping

Domestic water supplies in Pakistan are mostly met from groundwater. In addition, the contribution of groundwater for irrigation is also rapidly increasing and it's now making up more than 60 percent of the irrigation withdrawals. The quantity and quality of groundwater, therefore, becomes imperative for sustainable development of the country. PCRWR took up the task to explore existence of unutilized groundwater resources in the Indus basin and mapping its quality profile. It has so far mapped groundwater profile in the districts of Mianwali, Khushab, Bhakkar, Layyah, Muzaffargarh. Most importantly, it has managed to explore 5 MAF of additional fresh groundwater from unexplored zones which may irrigate 1.34 million hectare of additional land.



National water resources database
Sustainable development has become conditional to integrated databases for numerous parameters. It has multiple advantages which most importantly include continuous refinement, integration and updation of data, readily pointing to the duplications, flaws and inconsistencies in information. The importance of developing integrated databases cannot be overlooked in any sector yet its importance increases manifolds for the water sector-lifeline for agriculture based economy of Pakistan. One of the main reasons for ongoing less efficient management of water resources in Pakistan is lack of any centralized water resource database. On one side it leads to frequent overlapping of data collection by various agencies resulting in capital and time loss to the country and on the other hand it doesn't become available in its right form to the research and policy making institutes. This, ultimately results in inadequate policy and agenda formulations at the national level based on insufficient and inconsistent information. As per mandate of PCRWR, it collaborated with the United States Geological Survey (USGS) to establish national water resource database by integrating all the water sector organizations of the country and now a link has been established in the USGS website under the name of Pakwaters, containing water resource data. The database is in infancy and data is being uploaded to make it available through a single intuitive user interface with different levels of access to different stakeholders.

Improvement of design parameters and operational strategies of the skimming wells
Groundwater contributes about 60% of water requirements in irrigated agriculture economy of the country. Exponential growth of groundwater development over the last five decades and especially in the recent drought period has been witnessed. Skimming wells are most popular in the areas having fresh layer underlain by brackish water. Groundwater development and pumping without due consideration of the design parameters and yield implications led to deterioration of pumped water as well as aquifer quality. PCRWR carried out a study for optimization of design parameters and operational strategies of skimming wells in the Chaj Doab (Sargodha area between the rivers Chenab and Jhelum). Based on the study, the optimum spacing for 28 lps skimming wells was found as 350 m and the optimum strainer diameter of 7.5 cm was found for 6-strainer well, to be installed at depth of 20 m. For such wells optimum continuous operational hours were found 4-12 hours/day depending on the source of recharge. These design and yield parameters were found of significant importance for mitigating the adverse effects on groundwater and pumped water quality (Ashraf *et al,* 2011).



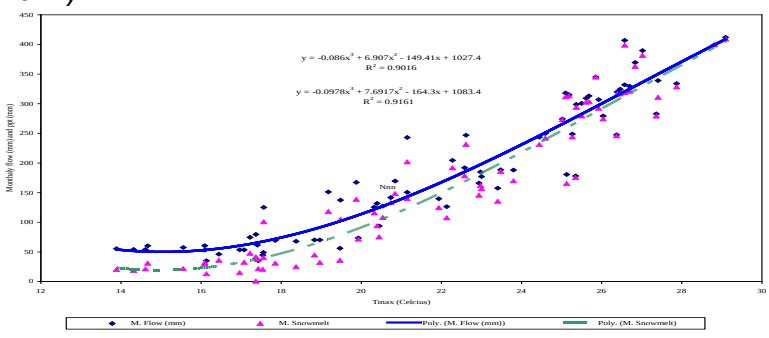
Impact assessment of unsafe wastewater disposal Resorting to wastewater for irrigation especially in water scarce countries is though common in the world but situation is rather worst in Pakistan, where about 35,000 hectares are irrigated with wastewater and about 25 percent of vegetables are grown with

that practice (IWMI, 2011). A study was, therefore, carried out at Faisalabad to document the impact of wastewater on surface and groundwater, agricultural soils and crops grown with wastewater. The study revealed that BOD (425 mg/l) and COD (980 mg/l) of wastewater before discharging into rivers were manifold higher than their permissible limits (80 mg/l and 180 mg/l respectively). The average percentage of microbiologically unsafe drinking water samples from various sources were found ranging 39 to 58 percent and average values of coliforms ranged from 2625-4849 CFU / ml, whereas excessive mercury concentrations were found in 8-9 percent samples. The chemical quality of wastewater was found entirely unfit for irrigation vis-à-vis WASA treated wastewater which was fit for irrigation but was not being used for productive purposes. Contrary to general perceptions of farmers, organic matter of wastewater irrigated soils was found low especially with depth. The vegetables grown with wastewater were found contaminated with heavy metals such as chromium, lead, cadmium and ferrous. Even the fish reared with groundwater showed excessive concentrations of all heavy metals, except cadmium and manganese, found in wastewater. The study proposed recommendations and strategic plan for mitigating wastewater impacts on drinking water and agricultural produce. It was suggested that irrigation with untreated wastewater was required to be banned immediately and low cost-treatment facilities might be provided at source together with strict implementation of environmental policy (Kahlown et al, 2006).



Snowmelt stream-flow relationship of upper Swat basin

Snowmelt generates 70 to 80 % of runoff of IBIS and its tributaries. Forecasting snowmelt generated flow is important for water management, reservoir operation and channel diversion. River Swat being not direct contributor to the existing reservoirs remained out of focus for characterizing its snowmelt regime. Thirty years (1971-2000) data of upper Swat catchment above Kalam gauging station was acquired from WAPDA. Normal monthly values over the period and average monthly values of each year were determined for stream flow, precipitation and temperature together with average monthly values of weighted and maximum temperature. Snowmelt regime was ascertained from plot of normal values of flow, precipitation and temperature. Using temperature index approach, average monthly flow over the snowmelt months (April, May and June) in terms of depth (mm) over the catchment was regressed on all the temperature indices using exponential, power and third degree polynomial functions. T_{max} was found the best index for snowmelt with R^2 as 0.902 for the third degree polynomial function. Runoff coefficient (ROC) for the total precipitation was conceptualized and through iteration was found as $T_{max}/100$. The optimized value of ROC was used to segregate rain induced and snowmelt induced runoff. The segregated snowmelt induced runoff was again regressed on T_{max} using the same function which slightly improved R^2 to 0.916. The model was tested for four years of data and forecasted flow was found reasonable in the context of simplicity of the approach. Such models can be very useful for characterization of individual watersheds and their integration into the model for the entire basin (PCRWR, 2012).



Performance evaluation of locally manufactured raingun for sprinkler irrigation

Due to water scarcity and public awareness about water conservation, use of high efficiency irrigation system is gaining popularity among the farming community. Locally manufactured systems are preferred owing to their low cost and easy availability. However, local manufacturers seldom provide water distribution parameters of the rainguns which may result poor distribution efficiency and low crop yields thereof. Water distribution performance of locally manufactured potable sprinkler gun (22 mm) was evaluated and found giving 75% uniformity of application at 66 psi (4.5 bars) working pressure, which was, therefore, considered optimum operating pressure for the local raingun. The uniformity of application was found increasing up to 91% with 100% overlapping of the rainguns at the optimum operating pressure. Thus the 66 psi (4.5 bars) pressure with 100% overlapping of the wetted radius was considered the optimum for the local raingun (22 mm) for maximum uniformity of application.



Rejuvenation of depleting aquifers through leaky structures in Balochistan

The surface and groundwater resources of Balochistan are extremely limited and scarce. There are a number of small perennial and non-perennial rivers and streams, floodwaters of which accumulate in the lower reaches with no outlet and eventually evaporate, if not harvested and conserved appropriately. Delay action dams were constructed by Irrigation Department for enhancement of groundwater recharge, but those dams became ineffective with time due to sealing of the bed of the pond area. PCRWR introduced and implemented the concept of leaky dams whereby the stored water was allowed to discharge slowly through specially provided valved pipes for getting seep down into the unsealed downstream reaches of the nullahs/rivers. The idea worked effectively at 9 leaky structures constructed by PCRWR, which rejuvenated several karezes those were otherwise dried up due to groundwater decline. In addition, a number of other structures namely injection wells, eyebrows, ditches *etc* were constructed for rainwater harvesting and groundwater recharge and piezometeric data confirmed their effectiveness. The successful practices are being replicated throughout Balochistan for groundwater rejuvenation. (PCRWR, 2012)



Reclamation of waterlogged land through mechanized tile drainage systems in Sindh

Waterlogging and salinity have always caused a great set back to irrigated agriculture in arid and semi arid regions. In Pakistan about 3.6 Mha is severely waterlogged (water table depth upto 1.50 m), more than half of which falls in Sindh province (Agri Statistics of Pakistan, 2008), where mega level salinity control and reclamation projects (SCARP) also did not meet with great success due to lack of incentives for farmers to use low quality water which in turn surfaced operation and maintenance issues. PCRWR through its Drainage and Reclamation Institute, Tando Jam, has promoted the concept of collaborative approach for farm level tile drainage systems with farmers' participation. It has so far successfully completed 14 tile drainage small units at farmers' fields in Sindh and Balochistan with active support of farming community. The farmers' participation was in the form of labour and taking responsibility of operation and maintenance. The projects have so far reclaimed 2500 hectares of land and have proved sustainable as well due to farmers' participation. The efficacy of the systems has led PCRWR to enhance the facility for providing services on large scale.



Water conservation and management in Northern Areas

Northern mountainous areas of KPK and Gilgit-Baltistan are one of the most rugged regions of Pakistan. The major constraints to agricultural production in the region are extreme weather, lack of land and water due to scanty rainfall and uneven topography which severely limits the expansion of farmland. Water in streams and rivers generally flow in deep depressions due to which people even living along the streams banks are unable to use it, whereas that coming from upslopes could not be used due to lack of storage facilities. Other physical constraints include remoteness/inaccessibility, marginality, and fragility in terms poor soil conditions, short growing season and other socio-economic limitations. All these lead to under utilization of resources and limit economic growth in the region. PCRWR launched a pilot project in the area to identify water and soil management issues, extension of innovative water conservation / utilization technologies at selected sites and water analysis of surface and groundwater resources. Under the project, water storage reservoirs and conveyance systems were constructed at 33 sites, lift irrigation systems were installed at 34 sites and high efficiency irrigation systems at 27 sites. As a result of the extended integrated water conservation technologies, per capita farm income was reported to increase by 235 percent at the sites due to more water availability and increased farm production. The maximum component of farm income came from vegetables and fruits.

The pilot-sites are also serving for continuous metamorphic evolution and further improvement of the implemented water conservation technologies, besides continuous awareness of the farmers. The water quality status report serves as a baseline for launching mass scale water quality improvement programme for the areas, particularly in the context of provision of safe drinking water (Malik and Bhatti, 2011).



Growing rice with sprinkler irrigation

In Pakistan rice is grown with traditional flood irrigation and is a major water consumer. It is grown on about 5.2 million acres with an average yield of 797 kg per acre. The water productivity of rice is 0.45 kg/m^3 vis-à-vis Asian average of 1 kg/m^3. PCRWR successfully conducted research trials on growing rice with sprinkler irrigation as compared with conventional irrigation practice of flooding. Rice grown under sprinkler irrigation gave 18% more yield with 35% less consumption of water as compared with traditional irrigation system. It was estimated that adopting sprinkler irrigation for the entire area under rice could save 10 million acre feet of water. Similarly, trials on growing rice under bed and furrow irrigation showed that 8 million acre feet could be saved if the practice is adopted for entire rice tract against conventional method. The benefit–cost ratio showed raingun sprinkler irrigation for rice is a financially viable option for farmers. Waterlogging caused by growing rice with conventional method could also be avoided by sprinkler irrigation (Kahlown et al, 2007).



Water resources assessment and strategic utilization in Potohar

Potohar is the largest contiguous block of dry land farming in Pakistan. Assessment of the resource to be exploited is key to the knowledge based decision making and strategic planning for development and management. PCRWR assessed water resources of the area and found that only 3.5 percent of the potential runoff is being harvested with the construction of mini dams. Total runoff of the basin was estimated as 3437 MCM of which only 123 MCM could be harvested by mini dams. More than 27

percent of the inflow was going out of the basin without being utilized. Whereas the average rainfall in the basin has descending trend, groundwater exploitation, dependency on which is 50 percent, was rising due to population increase and resultantly average water table drop of 0.15 m/year was observed in the basin. Due to poor utilization of potential water resources, the cultivated area and agricultural output were almost stagnant over the last two decades. It was thereby suggested that substantial outflows of the basin might be harvested to improve water availability and agriculture in the region. Comprehensive strategic plan was proposed for sustainable development of water resources of the area (Ashfaq et al, 2007).



Watercourse design for economical lining

The irrigation system efficiency in Pakistan is as low as about 40 percent. The irrigation water losses occur at various stages of the distribution system. Maximum losses, however, take place at the community maintained field watercourses. Several conventional and low-cost sections were tested to evaluate effectiveness of different types of linings in reducing the seepage losses. Those included six conventional rectangular brick masonry and four trapezoidal concrete sections having varying thickness of walls and bed lining materials. Whereas, the low cost sections consisted of six each rectangular brick masonry and trapezoidal sections having different thickness of wall and bed linings. Bed lining was not provided in some of the low cost sections. Water loss rates of field channels were recorded immediately before construction, after construction and 24 years post-construction of lining. For conventional sections, higher seepage rates were observed in the cement–concrete sections as compared to the brick masonry sections having plaster on the inside walls. Water loss rates recorded for concrete sections exhibited that quality control was more crucial than the thickness and ratio of the cement-concrete mix. Cost-benefit analysis revealed that low cost linings were a better investment option than the conventional linings. Low cost lining with 11 cm thick brick masonry in vertical walls, or inside plastered 2:1 sloped walls, without bed lining was recommended. Fired tiles or pre-cast concrete slabs lining on 2:1 slope were also cost-benefit ratio wise good investments subject to proper plastering of joints (Kahlown and Kemper, 2003).



Shallow groundwater contribution to crop water requirements

Waterlogging adversely affects agricultural cropping and yields. However, it may be managed to augment crop water requirements and reducing irrigation demands thereof. The prospects of integrated use of surface and groundwater were required to be explored particularly in the context of reducing irrigation water requirements without significantly reducing yields. PCRWR, therefore, conducted a lysimetre based study to determine adoptability implications of exploiting shallow water table for meeting crop water requirements and yields. Water tables at requisite depths in the lysimeters were maintained with Marriot flasks. It was found that under very shallow water table conditions (0.5 m depth), wheat extracted almost all of requirements from groundwater, whereas sunflower extracted more than 80% of its requirements. Maize and sorghum were found to be water sensitive as their yield decreased with decrease in water table depth. Maximum sugarcane yield (over 70 tons/ha) was found with 1.0 m water table depth whereas drastic decrease in sugarcane yield with further decrease in water table depth (less than 15 tons/ha) was observed. Water table depth of 1.5-2.0 m was found to be optimum depth for all studied crops except sugarcane. Therefore the present system of irrigation supplies especially in the areas, where water-table is shallow needs modification to avoid in-efficient use of water. However, salt accumulation was also observed in the rootzone for which periodic flushing of salts after harvesting of crops was recommended for sustainable crop production (Kahlown et al, 2003).



National integrated water management plan

The major agro-ecological zones of the country include irrigated areas of Punjab and Sindh, rainfed areas of Pothwar, Cholistan desert, coastal areas of Sindh, northern mountainous areas of KPK and upland mountainous areas of Balochistan and Azad Jammu & Kashmir. The site-specific water management package was developed and implemented for different regions considering native conditions and feasibility of technologies in consultation with stakeholders and local agriculture department. Farmers were also made responsible for operation and maintenance to ensure sustainability. An integrated water management plan was developed as an outcome of the project. The technologies found feasible for irrigated areas include watercourse lining, improvement in farm layout, precision field leveling, improved irrigation techniques like bed and furrow for cotton, zero tillage for wheat, ditch/trickle irrigation for orchards, sprinklers for a few field crops and use of good quality groundwater by skimming wells with proper irrigation scheduling. For rainfed areas of Potohar, construction of mini dams, watershed management, sprinkler irrigation system and afforestation were found feasible. The northern mountainous areas of KPK were found suitable for hydraulic ram pump, lift irrigation system, sprinkler system, trickle irrigation system, and improvement of water channels. In the Cholistan desert, the feasible technologies were found to be rainwater harvesting ponds, sprinkler irrigation and trickle system and installation of deep turbine wells. Upland mountainous areas of Balochistan were found requiring leaky dams and injection wells coupled with trickle irrigation to

improve water availability for irrigation of orchards. The feasible technologies for coastal areas were sorted as rainwater harvesting ponds, desalinization of saline water through reverse osmosis technology and skimming wells. The Azad Jammu and Kashmir area was found a good agricultural source whereby irrigated agriculture could substantially improve national productivity; the technologies found feasible were check structures across nullah, lift irrigation system, sprinkler irrigation systems for field crops and drip system for orchards. It was, however, found that fully subsidized technologies proved unsustainable as farmers did not bother for its proper operation and maintenance. Mass replication of the integrated program targeting whole country particularly those with small landholdings on participatory basis was recommended to improve agricultural productivity (Malik and Bhatti, 2011).



Indigenous development of water management instruments

For various research and monitoring activities in agricultural water management, the availability of requisite instruments has always been expensive due to import involved. The Council has made achievement by indigenously designing, fabricating and manufacturing such instruments like tensiometer, gypsum block, water level indicator, sprinkler heads, rainguns, and salinity sensor, which are being provided at a low cost to various research and development organizations in the country. Moreover, establishment of Technology Demonstration Centre at Lahore is underway for the regular development of the indigenous technologies with stakeholders' participation. Similarly, establishment of a consultancy cell for providing consultancies and services like laser land leveling, farm layout planning, high efficiency irrigation systems, and growing high value crops *etc* is in progress as well.

Ongoing/Prospective Projects:

The water management section of the Council is currently implementing or plans to undertake the following projects

- Integrated Water Resources Management in the Highly Depleted Pishin-Lora Basin of Balochistan (Approved)

- Evaluation of Interceptor Drains and Scavenger Wells in SCARP North Drainage Division, LBOD Component (Shaheed Benazirabad) (Approved)

- Demarcation of Groundwater Quality Zones in Indus Plain and Marginal Areas for Sustainable Development and Management of Groundwater Phase-II (Lower Indus Plain) (Under consideration for DDWP)

- Strengthening of Research Infrastructure at PCRWR's R&D Centre near Sial More Sargodha and Transfer of Water Conservation Technologies to Farmers (Under consideration for DDWP)

- Water Resources Development and Management in Kohistan Area of Sindh (Under consideration for DDWP)

- Innovative Watershed Management Practices for Sustainable Development of Upper Indus Basin (Under consideration for DDWP)

- Establishment of Regional Centre for Water Management Research in Arid Zones in Pakistan under the Auspices of UNESCO (Under consideration for DDWP)

- Establishment of a National Water Resource Data Warehouse (Under consideration for DDWP)

- Integrated Approach for Control of Waterlogging and Salinity in Low Lying Areas of Old River Beds (Under consideration for DDWP)

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