RECOMMENDATIONS
By
PAKISTAN ENGINEERING CONGRESS
On
WORLD WATER DAY 2015
Held on 22nd March, 2015

Pakistan Engineering Congress celebrated World Water Day on the theme of **"Water and Sustainable Development"** on 22nd March, 2015. Honourable **Engr. Syed Abdul Qadir Shah**, Chairman, Pakistan Engineering Council, was the Chief Guest. Welcome Address was presented by Engr. Iftikhar Ahmad, President Pakistan Engineering Congress. Twenty (20) papers were presented by Water and Irrigation specialists. It was a very well attended event and was widely covered by News & Electronic Media. The Papers are being printed in a book form and will be distributed free of cost.

Given below are the recommendations made by the Speakers:-

RECOMMENDATIONS

Paper: **Water and Sustainable Development in Pakistan**

Author: Engr. Dr. Izhar-ul-Haq, Mr. Asim Rauf Khan

Recommendations:

Water is precious resource. Its availability varies in time and space. Climate change has increased the level of uncertainty in the availability of water. Therefore, its optimal use is crucial to the survival of our society.

In view of the impending climate change and its impacts on our water resources, it is extremely important to invest more in hydrological investigations for developing a better understanding of the snow and ice regimes of the Upper Indus Basin (UIB). Monitoring the Upper Indus glaciers in particular for detecting any changes in UIB glaciers by using advance remote sensing and GIS techniques is extremely important in this context. Furthermore, mass-balance studies should be carried out in the field for major glaciers.

By adopting proper practices and through the use of technology and infrastructure development and improvement along with intensive hydrological investigation of our river systems, we could make the most efficient use of water while meeting the requirements for food, agriculture, energy, environment and the general livelihoods of the people of Pakistan.

Paper: Water and Sustainable Development Contextual Global and National Overview

Author: Engr. Riaz Nazir Tarar

Recommendations:

GLOBAL CONTEXT

i. 97.5% of all water on earth is salt water in oceans and seas leaving about 2.5% as fresh water.

ii. Only under 1% of world's fresh water is accessible for direct human use and found in lakes, rivers, reservoirs and those underground sources that are shallow enough to be tapped at an affordable cost.

iii. Total estimated annual river run-off is about 40,700 km^3 out of which:-
   a. Only 32,900 km^3 is geographically accessible.

   b. Considering base flow and surface run-off controlled by dams currently estimated available run-off (AR) is 12,500 km^3 per year. With increased regulation through dams AR could go upto 13,700 km^3 by 2025.

iv. Total annual appropriation:-
   a. At end of 20^{th} Century was 4705 km^3.

   b. By 2025 it could go up to 9830 km^3 (over 70% of AR).

v. Clearly, humanity is approaching the limit of fresh water supply. On the other hand, only about half of the diverted water is being consumed. Therefore, efficient water management and modern technology can stretch even scarce water supply further. Similarly, water conservation through better planning, management and technologies offers great promise.

vi. Even now, a large proportion of world's population is experiencing water stress which may become critical by 2025.

vii. Sustainable development of water resources is the dire need of mankind as it is more essential even for existence of human communities.

viii. Deliberations for water allocation should always include provisions for maintaining integrity of freshwater systems including need of minimum in stream ecological flows.

ix. Sustainable water resource development:-
   a. Is key to conservation of its quantity and quality as well as security, economic health and societal well being.

   b. Can improve human's productive power without damaging or undermining society or the environment.

   c. Implies progressive socio-economic betterment without going beyond ecological carrying capacity within Earth's twin capacities of natural resource generation and waste absorption.

x. Following three principal elements provide the foundation of sustainability:-
   a. Economic vitality compatible with nature

   b. Ecological integrity of natural ecosystem capacity

   c. Social equity to provide access to jobs, education, natural resources and services to all peoples.

xi. Focus of evaluation strategy should be that:-
   a. Current piecemeal and consumption oriented approaches to water policy may be substituted by systematic approach that considers ecological integrity and ecosystem service which natural sources can provide.

   b. Besides increasing public awareness about the challenges the world is facing in relation to water, we must also change the way water issue is being perceived from being a driver of conflict to being a catalyst for collaboration.
   c. Recognizing our limited ability to see needs of the future, any attempt to define sustainability should remain as open and as flexible as possible through the use of adaptive management.

NATIONAL CONTEXT

i. While global approach to sustainable water resource management is somewhat generic, the national context requires focus on sustainability of already developed surface and groundwater resources consistent with food, fibre and energy requirements of rapidly growing population.

ii. Indus Basin Irrigation System (IBIS), the mainstay of national economy, is basically dependent on diversion of surface water from Indus River. Currently, it is facing an average shortage of about 11% over the post-Tarbela developed uses after completion of the Indus Basin Project. This is basically due to:-
   a. Rapid siltation in live storage capacity of the storages at Tarbela, Mangla and Chashma (already reduced by about 30%).

   b. No construction of any new mega storage after commissioning of Tarbela in 1977, while about 29 maf surplus water is escaping to sea.

iii. Pakistan is facing an energy crisis for the past few years with perpetual load shedding in the range of 2000-4000 MW. This has been basically caused by heavy reliance on thermal generation costing upto 8 times WAPDA's Hydropower System. To overcome this crisis at affordable tariffs, it is imperative to harness vast hydropower potential through multi-purpose mega storages instead of the present focus on run-of-river development.

iv. Stunted growth of agriculture in the face of rapidly growing demand for food and fiber warrants not only sustenance of post-Tarbela canal diversion into IBIS, but further development. In this regard:
   a. It is estimated that by 2025 additional storage of about 18 MAF will be needed.

   b. The main focus should be for priority development of 5 multi-purpose already identified storages and principally approved by GoP in 2005.

   c. Considering engineering preparedness, core construction may be immediately started on DiamerBasha Dam Project with live storage of 6.4 MAF and cheap annual energy generation of over 20,000 GWh through its installed capacity of 4500 MW.

v. Besides surface water, a very large scale extraction and use of groundwater for irrigated agriculture has already taken place. Consequently, about 45 MAF of fresh groundwater is being pumped at the farm gate thus providing over half of crop water requirements.

vi. Though sustainable groundwater yield is estimated about 55 MAF, the remaining potential is located in areas where the quality is poor.

vii. Unregulated and uncontrolled use of groundwater has diminished the relative accessibility. The trend of continuous decline of groundwater has been observed in many areas of the Indus Plains which illustrates serious imbalance between abstraction and recharge. Depletion of groundwater is more pronounced in non-command areas of Punjab where agriculture is heavily dependent on this source.

viii. As groundwater management in Pakistan has received no attention, many aquifers have come under severe stress thus threatening sustainability of this resource.

ix. Effective groundwater management is dire need of Pakistan to ascertain sustainability of this precious water resource through:-
   a. Taking farmers into confidence to implement possible technical, scientific and political tools to protect key aquifers with regard to quality and quantity.

b. Effective conjunctive use of surface and groundwater to remove disparity between head and tail enders of canal distribution system.

c. Introduction of policy reforms to regulate aquifer usage for exploitation of groundwater on the basis of effective quantity and quality monitoring.

d. Putting in place a range of corrective mechanisms before problem becomes insolvable or not worth solving.

Paper: Sustainable Development of Water Resources: The Deepening Crisis in Pakistan

Author: Engr. Asrar-ul-Haq, Ms. Afaf Ayesha

Recommendations:

1.1 The Framework

In the wake of the water crisis looming large, urgent need for sustainable development and management of water resources in Pakistan cannot be over-emphasized. Towards this end, the principles and guidelines of sustainable development have to be adopted. These include conservation, sustainable use, infrastructure optimization, institutional restructuring, better governance, caring for the poor and unprivileged, sections of the society, value enhancement, capacity building, public participation and stewardship to enable the future generations to meet their needs.

1.2 Surface Water Management

The Indus Basin Irrigation System reflects a situation in which the primary resource constraint on agriculture production is water. Pakistan has very little water storage capacity and can barely store 30 days of water. When river flow is variable, then storage is required in order the supply of water can more closely match water demands. Growing shortfall in water availability compared to demand will continuously increase in future. Holistic policies for water resources development and management are therefore required to sustain growth in the context of resource limitation. Development of 15 to 20 MAF of additional water storage and interventions for improving water availability through water conservation are imperative.

Water has always played a key role in economic development. Investment in water management has been repaid through livelihood security and reductions in health risks, vulnerability and ultimately poverty. While most of the old challenges of water supply, sanitation and environmental sustainability remain, new challenges such as adaptation to climate change, rising food and energy prices, and ageing infrastructure are increasing the complexity and financial burden of water management.

Competition for water and shortcomings in managing it to meet the needs of society and the environment call for enhanced societal responses through improved management, better legislation and more effective and transparent allocation mechanisms. The specific interventions in this regard include additional storages, rehabilitation and upgradation of irrigation infrastructure, ensuring equitable supplies to all stakeholders, encouraging the participatory management approach by associating farmers in management at gross root, and taking steps for financial sustainability of the system. In addition conservation measures comprising lining of distributaries and water courses, improved farm lay-out, precision land levelling and modern irrigation technologies (drip, sprinkler, etc.) need to be adopted. A comprehensive and real time monitoring system also needs to be put in place along-with improved drainage and flood control interventions.

1.3 Groundwater Management

Groundwater has become a vital and major part of the overall water resources in the Indus Basin irrigation system. The groundwater use is however reaching to the sustainable limits. The fast growing cities and industries looking for large increases in water supply are adding to the challenge. An effective monitoring and management system that encourages the management sustainability of this water source is needed. An effective framework for groundwater management needs to be put in place. The experience in this regard suggests to follow a phased and incremental implementation strategy with initial focus on groundwater monitoring and gradual shift to groundwater management. The awareness raising campaign is also very important for sensitizing the stakeholders about groundwater issues, self-regulation, groundwater monitoring and management interventions. It is relevant to point out that the upcoming institution of Farmers Organizations can play an effective role for management of groundwater in their respective areas (Haq et al, 2012).

1.4 Integrated Water Resources Management (IWRM)

Strengthening IWRM and water management capacity is needed to deal with both the existing and emerging water challenges taking into account the issues like climatic changes, groundwater use, water quality, pollution, urbanization and industrialization, licensing access to water etc. A continuum for decision making in water resources management is to be prepared, identifying the fundamentals of IWRM implementation by addressing the resource condition and allocation issues at the basin level.

The distinct elements for progressing IWRM and to address the resource conditions and allocation issues are shown below (Donald, 2008):

IWRM Fundamentals

- How much water (surface and groundwater) is available
- What are the risks / opportunities associated with these resources – climate change / pollution / new dams
- What is the quality of water
- Who is authorized to use it and under what conditions will this authorization be changed
- Who will have policy and decision making responsibility for an integrated approach for water management that will take into account all the competing issues and sectors

1.5 Institutional and Policy Reforms

Holistic institutional and policy reforms to improve the management and maintenance of the Indus Basin Irrigation System are required to ensure its long-term physical and financial sustainability, reforms to make inter and intra- province water allocation and distribution more transparent, service delivery reforms to improve the quality, efficiency and accountability through farmers participation in irrigation management at the gross root level and strategies to improve water use efficiency and the on-farm productivity (Haq et al, 2012).

1.6 Managing Climate Change Impacts

It is now clear that climate change is already affecting the western glaciers. While the science is still in its infancy, best estimates are that there will be fifty year of glacial retreat, during which time river flows will increase. This with the predicted flashier rainfall is likely to exacerbate the already serious problems of flooding and drainage. But then the glacial reservoir will be depleted, and there are likely to be substantial decreases in river flows in one hundred years

time. The emerging impacts of climate changes would add a new dimension to the water challenges, which call for adequate knowledge base, strategic planning and proactive management initiatives (World Bank 2005).

A Task Force on Climate Change was set up by the Planning Commission of Pakistan in October 2008 with the view to take stock of country's situation and to recommend the national climate change strategies. The Task Force finalized its report in February 2010. The salient recommendations of the Task Force are summarized as under.

National Climate Change Strategies / Recommendations

- Providing incentives for adoption of more efficient irrigation techniques
- Development of local rain harvesting measures
- Enhancing public awareness to underscore the importance of conservation and sustainable use of water resources
- Protecting groundwater through management and technical measures like regulatory frameworks, water licensing, artificial recharge especially for threatened aquifers, and adopt integrated water resources management concepts
- Developing wastewater recycling and its reuse in agriculture, artificial wetlands and groundwater recharge
- Protecting and conserving water 'catchment' areas, and reservoirs from degradation, silting and irrigation system contamination
- Encourage active participation of farmers in water management along-with line-departments
- Development of contingency plans for short-term measures to adapt to water shortages that could help to mitigate drought
- Legislating and enforcing laws and regulations required for efficient water resources management, conservation and participatory management
- Legislating and enforcing laws related to industrial and domestic waste management
- Strengthening the present hydrological network to monitor river flows and flood warning systems
- Developing and extending technologies and techniques for domestic and drinking water
- Enhancing country's water storages capacities
- Ensuring the rehabilitation and up-gradation of existing irrigation infrastructure in the country, which can sustain the climate change related expected extreme weather events
- Developing infrastructure to harness the Hill Torrents potential

1.7 Addressing Water Quality Issues

The water quality challenges need to be addressed in an integrated manner by adopting pollution prevention strategies as presented below (Ayesha, 2012):

- The monitoring of water quality is required at the government level on regular basis. For this purpose, capacity building of staff, fully equipped laboratories, recurrent budgets, latest technologies, data-sharing and analysis, and management institutions should be strengthened.

- The development of new technologies for improving water quality is required. This may be required for the deployment, maintenance, and operation of systems to collect, transport, and treat human wastes, used water, stormwater, industrial wastes and agricultural runoff.

- Strict enforcement of water quality rules and regulations need to be ensured in order to prevent the discharge of untreated effluents from the industries and municipalities.

- The industries may be required to install wastewater treatment plants. The technologies need to be scaled up rapidly to deal with the tremendous amount of untreated wastes entering into water bodies daily; and water and wastewater utilities need financial, administrative, and technical assistance to implement these approaches.

- Appropriate solid waste management system should be put in place to prevent the dumping of solid waste into the water bodies and leachate generation.

- A sustainable pollution control strategy needs to be devised in order to reduce the wastewater volumes at sources. This approach may include the segregation of wastewater streams, process modification techniques and recycling and reuse of wastewater.

- The public education and awareness campaigns about the importance of water-quality needs to be launched. Media and non-governmental organizations (NGOs) can play a vital role in this aspect.

1.8 Providing Safe Drinking Water and Sanitation

In September 2009 the government approved the National Drinking Water Policy that aims at providing safe drinking water to the entire Pakistani population by 2025, including the poor and vulnerable, at an affordable cost. A main objective is a clearer separation between the functions of service provision and regulation. The right to water for drinking precedes all other uses, like industrial or agricultural water use. Women are recognized as main actors of domestic water supply, and their active participation in the sector is sought. Towards this end, low-cost indigenous and efficient systems may be installed, particularly in the saline groundwater areas. Public awareness, participation by the stakeholders and focused subsidies for ensuring continued operation of the schemes may be ensured.

The National Sanitation Policy (NSP), approved by the federal government in 2006, promotes the grassroots concept of community-led total sanitation (CLTS) in communities with less than 1,000 inhabitants. In larger communities, the NSP promotes a "component sharing model", under which sewage and wastewater treatment facilities are provided by the communities in case that local government-developed disposal is not available. For improving sanitation, technical support and targeted subsides may be provided involving NGOs, local governments and communities in the process.

Recommendations:

Kalabagh Dam Project (KBD) stands ready for implementation since 1988. Delay in its implementation has hit the national economy hard in every sector. For reducing dependence on very costly thermal power, and saving foreign exchange, it is recommended that Kalabagh Dam Project be implemented without any further delay only as a "POWER PROJECT". It would be a "RUN-OF-RIVER", project which would generate 3600 MW of power and would not supply any water for irrigation to any Province. It will maintain the present position of full out flows, below Kotri to Sea. This will give a boost to the economy of Pakistan and substantial relief to its people who have been hit hard by load-shedding of electricity continuing over the last 10 years.

Paper: **Water Crises and Future Options in Pakistan**

Author: Dr. Muhammad Nawaz Bhutta

Recommendations:

The following action plan is proposed for the augmentation of water resources in Pakistan.

- As a short term measure, work on another large dam having hydropower potential should be started concurrently with DiamirBhasha Dam Project.
- A long term plan for storing additional 50 MAF upto year 2050, needs to be prepared and a ranking system devised to prioritize projects for implementation.
- An awareness campaign about the needs and benefits of water reservoirs needs to be launched immediately.
- Rainwater harvesting and groundwater recharge plans be prepared and initiated.
- Steps to be taken to protect water from pollution due to sewage and industrial waste.
- Sprinklers and drip irrigation shall be introduced at feasible locations.

Paper: **Sustainability of Water for Pakistan**

Author: Mr. Abdul Khaliq Khan

Recommendations:

1 Water availability per capita is reducing with time. Transfer of water from ample summer flows to the lean winter flows is essential. Build storage dams on Indus river and its tributaries to meet the future needs.

2 Climate change poses further threats by way of glacier melting, frequent events of higher magnitude floods and longer duration droughts. Monitoring and research in these fields and preparation of adaptation programs should be taken up more seriously.

3 Storage dams and recharge dams can improve the water availability situation in Balochistan. These should be built on priority and drip irrigation should be promoted.

4 Small and medium size dams should be built in areas outside the integrated irrigation system to meet the local needs. Drip irrigation projects should be implemented in their command areas.

5 Hill torrents areas have large potential of improving water availability. Delay action dams, water disposal and irrigation systems as well as drainage of surplus flows to the Indus

should be implemented. In this regard D. G. Khan area Hill torrents should be taken up on priority.

6 Sindh has flat topography. Surface drainage projects along with improvements of existing drainage infrastructure are urgently required.

7 Among the co-sharers of Indus waters, Balochistan is the downstream most user with Sindh on its upstream side and Punjab & K P K on the upstream side of Sindh. The upstream users should take enough measures to satisfy the downstream users to deliver their share as per Water Accord of 1991.

8 Constitute Kalabagh Consensus Commission with authority to interact with all provinces and stakeholders to agree and prepare a revised plan of Kalabagh Dam for its timely implementation.

9 The management and Control of ground water should be taken up as a project, with a start and end point to be subsequently handed over to the operating organizations in the provinces.

10 Create conducive environment for effective water conservation practices;

11 Considering the ever increasing scarcity of water and with climatic changes, the supply and demand side water management are imposed options to be given due attention for action.

12 With all our short-comings, we still are very lucky nation to have the Indus Water Treaty of 1960 and the Water Apportionment Accord of 1991. We should divert all our energies to make sure that these agreements are implemented in original letter and spirit.

13 We should modify the design criterion of equitable water distribution systems to be based on actual ground conditions and crop water requirements to bring more areas under irrigation.

14 The most important task should be to make rigorous studies for the preparation, prioritization and scheduling of all above recommendations and devise workable financial plans for their implementation.

Paper: **Groundwater Environment and Evaluation of Long-Term Sustainability of the Aquifer Under Lahore**

Author: Engr. Dr. Muhammad Basharat

Recommendation:

Following are the recommendations for reducing the gap between recharge and abstraction:

- With passage of time, non-WASA water use is increasing; water governance and economic policies for avoiding wastage or reduction in water use are almost absent. Therefore, the role of a central groundwater organization is strongly recommended, assuming the responsibility of comprehensive awareness raising campaign about coming water shortage and its efficient use along with future planning and development of water supply and sewerage.

- Three components i.e. ‘Policy & Legislation’, ‘Stakeholders’ Participation’ and ‘Institutions and their Capacity Building’ needs to be focused as much as possible for taking the

masses onboard, so as to achieve successive reduction of abstraction-recharge gap and ensure long-term sustainability.

- Water supply sustainability situation can be quite alarming after within 10-20 years from now. Therefore, a comprehensive groundwater model of the Lahore district and adjoining areas, being need of the day, is strongly recommended. The model needs to be kept permanently alive and improved for studying appropriate management interventions under current and expected future conditions.

- Each and every use of existing groundwater above 0.20 cusecs should be registered and each new user should getting permit before installation of pumping equipment, should be charged with groundwater development surcharge;
- Building bye-laws should be amended to get maximum possible rainwater harvesting and its recharge to the aquifer by declaring it as mandatory for certain set and dimension of buildings, along with certain incentives;

- Waste water disposed by all entrepreneurs should be monitored, with the option to treat it at source, or otherwise pay extra charges for untreated load, for its collective treatment;

- In order to avoid pollution of the aquifer, sewerage being disposed into Ravi should be conveyed into a lined channel along both banks of the river;

- At least two small weirs may be constructed, one at Shahdra and the other about 20 km below Shahdra, for enhanced recharge to groundwater, with good quality river water, especially during floods.

- Just like Karachi, Hyderabad and Islamabad, surface water needs to be allocated (at least 0.5 MAF) from Indus Basin Irrigation System, for water supply and additional recharge to the aquifer to improve the groundwater situation.

Paper: Using Compost in Bio-Retention Systems for Storm water Management

Author: Hamid Iqbal, Muhammad Anwar Baig, Markus Flury and Jessica M. Mullane

Recommendation:

When mature compost is applied to bio-retention systems or roadsides, there is a potential for leaching of organic substances, nutrients, and metals. This leachate can cause pollution of receiving waters. As bio-retention systems are designed to remove pollutants from storm water, and roadside compost applications may be near environmentally sensitive areas, leaching from compost itself can be of concern. Our study indicates that freshly-applied, mature compost can leach substantial amounts of dissolved and particulate organic matter within the first flushes, but that after about 2,000 to 4,000 mm of flux, the leachate clarifies. Along with organic matter, nutrients and metals also leach out. The discoloration of the leachate, which can render the leachate brown to even black, is also of concern when the leachate is discharged into surface waters due to optical considerations. Leaching from compost, i.e., the initial leachate, has to be considered a potential environmental hazard when compost is applied to bio-retention systems or roadsides.

Paper: The Application of Yield Models in Reservoir Optimization of Large Dams

Author: Engr. Usman-e-Ghani

Recommendation:

The goal of this study was to refer to the approach of estimating the yield of surface water reservoir systems and to note about the uncertainty inherent in water supply yield estimates for a wide range of reservoir systems subject to the hydrologic variations, which could be expected in many parts of the world. For understanding to this effect, one may start by developing a generalized Storage Reservoir Yield (SRY) relationship based on a global dataset of 729 rivers, with minimum of 25 years of monthly stream flow records (introduced previously by McMahon et al., 2007b), or through another appropriate technique. The yield models have shown that various SRY regressions (global, regional or local) exhibit a high level of goodness-of-fit, which could aptly be utilized for subsequent use. The reservoir yield models assess the variability of the estimates of water supply yields based on actual stream flow observations as well. Using the coefficient of variation of the yield estimates, for e.g. Cy to denote the variability of yield estimates, it has been noticed that the storage ratios (storage capacity divided by mean of the stream flows) and reliability of the yield estimates do not influence the variability of the yield estimates. This is an extremely important result which may enable us to report the relationships useful for describing the variability of reservoir yield estimates under general conditions. The findings also indicate that the length of the stream flow record, and the coefficient of variation of flow, say Cq, is the only two factors that appear to influence Cy. The variability of the yield estimates increases as the variability of flow increases, and decreases as the length of record increases.

Regional hydro climatologically models could also be combined with the generalized SRY relations for the purpose of evaluating the impacts of climate change on the water supply yields from water supply reservoirs. As changes in hydro climatology continue due to changes in land use, climate and other anthropogenic influences, there will be a continued need to evaluate the impacts of such changes on water supply yields. It would be worthwhile to note as well that storage reservoirs do provide an important societal adjustment or intervention, because they enable increases in the reliability of future water supply yields.

As has previously been discussed, the establishment of a reservoir water supply yield is now an important process in risk assessment. Risks and benefits are discussed and weighed during the resource management decision process of selecting a water supply yield. For instance, taking the reference of Kanopolis Reservoir as discussed above, the KWO recommended a water supply yield of 13.9 cusecs per day from the Reservoir for consideration of the Public Water Supply Subcommittee of the Kansas Water Authority. Based upon public comments, however, the regression equations were revised to more accurately simulate the Kanopolis inflows during the 2000-2006 droughts. The most significant change to the yield analysis was created with the assumption that simulated monthly inflows for the water-supply yield analyses would not exceed the reported monthly inflows from the 1952-1957 droughts. The result of this assumption reduced the yield excedence curves. The KWO subsequently recommended a water supply yield for Kanopolis Reservoir of 10.1 cusecs per day based upon the results of this evaluation. The KWO believed this yield to be maximizing the water-supply benefit to the public while reasonably maintaining the balance in case of drought with a two percent chance of occurrence in any one year.

In line with the discussion above, it would indeed be crucial to note the recent trends of variation in flows in the Indus Basin too, particularly in the basin tributaries, indicate wide inconsistencies in contrast to the predicted forecasts by the various agencies. This signifies not only the need for a review of operational criteria at the various controls build over the IBI System but also the further fine-tunings of such operations so as to develop still a better chance of optimization of all the projects/works.

It would also be important to bear that our current major reservoirs, i.e. Tarbela, Mangla and Chashma, the lives of which stand as our important concern, were built as replacement works to augment the flows of Eastern Rivers, i.e. Ravi, Sutlej and Beas, lost by Pakistan on signing of Indus Waters Treaty in 1960. Hence, the significance of these projects for the national economy

of Pakistan, and also for the food security, just cannot be overemphasized. Their vitality is pertinent not only for the rivers upon which they have been built but also for agriculture in the basins, which have the commands spreading over several millions of acres, pursuing the goal of our national food security.

Paper: **High Efficiency Irrigation Systems "A Transformation in the Conventional Irrigation Practices in the Punjab"**

Author: Ch. Muhammad Ashraf, Dr. Muhammad Asif, Hafiz Qaiser Yasin

Recommendation:

HEIS technology, especially drip irrigation has exhibited huge impacts in terms of water saving, reduction in fertilizer use, enhancing water and crop productivity besides other tangibles and intangible benefits. It is still at the nascent stage in Pakistan and requires continuity of government policies and financial support to build confidence amid stakeholders. Moreover, its adoption/promotion require extensive mass awareness and capacity building involving a complete paradigm shift from archaic traditional flood irrigation method and associated agricultural practices to the more efficient modern irrigation technology. The pace of adoption of HEIS technologies is picking up and it is expected that their province wide demonstration will further accelerate its promotion, which is highly essential for sustainability of irrigated agriculture in the country.

Paper: **Sustainable Efficient Irrigation Method for Rice and Wheat Crops**

Author: Engr. Zamir Ahmed Soomro

Recommendation:

- Bed and furrow irrigation method with 40 cb. stress of water should be used for rice and wheat crop to save irrigation water without any loss in yield.
- To reduce the cost of land preparation and increase net benefits, Bed and furrows for rice and wheat crop should be prepared with bed and furrow shaper instead of manually.

Paper: **Evaluation of Different Techniques for the Safe Usage of Manchar Drainage Effluent for Growing of Crops**

Author: Engr. Muhammad Saeed, Engr. Munawar Ahmed, Engr. Asim Saeed Malik, Muhammad Qaim Channa, Munawar Ali, Khalid Mahmood Subhani

Recommendation:

It is recommended that chemical treatments may be adopted to avoid the adverse effect of Manchar Lake drain on physical and chemical properties of soil.

Paper: **Sustainable Conjunctive Use of Groundwater for Additional Irrigation**

Author: Dr. Naveed Alam

Recommendation:

Based on a model analysis, it was shown that skimming technologies cannot prevent

salinization, irrespective of parameters of subsurface, for which some unique pumping tests were analyzed and geophysical measurements were carried out in the Punjab.

The findings of the PhD research led to the following three main conclusions: (1) skimming wells cannot prevent long-term salinization; (2) recirculation wells can substantially delay salinization as a mid-term solution but will not prevent it; and (3) scavenging may be the only option to solve the long-term salinization problem.

Paper: Integrated Water Resources Management - Case Study of Alborz Project, Iran

Author: Dr. Mansoor A. Hashmi
Recommendation:

IWRM and associated ESMP is a valid approach to address the competitive needs of sustainable development and environment and social planning. This method is yet to be applied in Indus Basin, perhaps due to its large size and complexity aggravated further by transboundary issues in four countries. A Pilot sub-basin approach may be used to evaluate the benefits of this approach.

Paper: Seepage and Economics of Canal Lining in LBDC-Worksheet Model Application

Author: Engr. Ijaz Javed, Engr. Asim Saeed Malik and Engr. Hafeezur-Rehman

Recommendation:

- The pre-lining and post-lining investigation gave relatively higher seepage rate as compare to the results observed in other areas of Pakistan where similar inflow-outflow tests were conducted. The result indicated higher reducing loss rate in concrete lining whereas, brick lining showed moderate degree of seepage reduction of the actual seepage. The variation in estimation of seepage rates by the same inflow-outflow method is evidenced through a number of other investigations by various agencies. Uncertainty of estimation can be attributed to some systematic or random errors in discharge measurements and need further investigations. This leads towards the need for considering reasonable tradeoff between huge investments on canal lining and the expected water savings. Thus this invites attention to selective lining of those channels/reaches which shown to have a high seepage rates.

- The study proposed that economic justification of selected sites of LBDC canal lining may not be clear-cut even while applying multiple scenarios of discount rate and expected life. Critical decision factors for the economic justification include method of seepage estimation, irrigation water price, the true expected life and discounted factors to be used for the analysis.

- Water conservation via canal lining can be captured more quickly than other options. The economic value of water saved per acre-ft as a result of canal lining is the highest and incremental, among all known sources of production /conservation of irrigation water.
- The canal lining in saline groundwater areas is feasible, it is therefore emphasized that lining of all irrigation networks in the saline zone should be ensured. This will not only supplement drainage in saline zones but also save recharging fresh water from the wastage.

Paper: **Significance of Water Conservation for Sustainability of Water Resources of Pakistan**

Author: Engr. Ishteqaq Ahmad Kokab, Engr. Husnain Afzal, Engr. Adnan Yousaf

Recommendation:

Following actions must be taken to conserve more and more water:

- It is considered to be of paramount importance that an effective and responsive institutional structure is made available for implementation of policies that supports linkages between practice, science, policy and decision making so as to facilitate at various levels of sustainable solutions for water resources conservation.

- A comprehensive campaign may be launched in print and electronic media to sensitize the people to use water efficiently and to promote rainwater harvesting for domestic, commercial and industrial use. Information about importance of water, its scarcity and depletion, non-availability of sweet water in far flung areas and examples of how other nations are using water efficiently etc may be communicated.

- Domestic and industrial users are approached through pamphlets/leaflets communicating the importance of conservation and efficient usage of water.

- Business sector which have intensive water usage in industrial processes may be encouraged to implement modern water conservative industrial process. Groundwater extraction and piped supply to industrial consumers must be metered and substantial water rates may be charged to encourage them for adoption of efficient processes. They may be subsidized for recycling and treatment of water.

- Schools and community buildings (e.g. mosques, hospitals etc) must be installed with water efficient toilets, urinals, taps and showers etc.

- Leak management may consists of active leak detection and repair, pressure management to reduce unnecessary high pressure areas in the system, improved response time to main breaks and leaks and improved flow metering. Masses may be encouraged to report any such event through a toll free number or online complaint registration. The system may be monitored against response time and fault removal inspections mechanism.

- Course and articles on water conservation may be incorporated in the syllabi at all levels.

- Increase water productivity by bringing high value crops in the cropping system.

- Water statistics must be made more reliable and transparent; Ministry of Water & Power must issue final figures for water resources after consulting with WAPDA, Provincial Irrigation Departments, IRSA and Water Resources Council.

- In coastal areas drinking water can be obtained by installing low cost water treatment plants that use solar energy for the desalination of sea water, the salt obtained from this process can be used in commercial and industrial applications.
- More multi-purpose dams must be constructed to store the water during monsoon season.

- The rain water runoff must be stored through developing appropriate water structure and check dams to strengthen the water shed management programmes.

- The telemetry system must be made functional.

- Incentives to those farmers who are adopting high efficiency irrigation techniques.

- Awareness among farmers may be promoted through “Farmers Associations”, educating them on the use of water efficient techniques and growth of low delta crops.

- The political consensus on construction of dams and reservoirs must be developed to overcome the critical water scarcity condition of the country.

Paper: **Trends in Levels of Disinfection by-Products in Drinking Waters of Twin Cities**

Author: Sidra Abbas, Dr. Imran Hashmi, Sajida Rashid and Romana Khan

Recommendation:

Further investigation is suggested for better understanding the formation of CDBPs. Further research involving the characterization and correlations of these critical water quality parameters is necessary to have better understanding of THMs formation and the associated risk to human health as a result of exposure to THMs. Water authorities need to review water treatment practices with view to improve the removal of organics form the water sources prior to disinfection, using alternative disinfectants and reducing water age in distribution system. More research is needed to determine the risk associated with DBPs.

As the DBPs issue is gaining momentum in Pakistan, the emphasis will be to minimize DBP formation whilst maintaining a microbiologically safe drinking water supplies.

Paper: **Recharging of Depleting Groundwater Aquifer in Punjab, Pakistan – A Case Study**

Author: Engr. Javed Munir, M. Mohsin Munir, Engr. Syed Abbas Ali

Recommendation:

1. The case study reveals that that there is much provision on the rivers in Punjab for small storages using inflatable rubber dams. The analysis concludes that twenty seven (27) sites as summarized in Table 5 are considered suitable for constructing inflatable dams in Pakistan.

2. Ground water recharge by the use of rubber inflatable dams can be successfully achieved having flexibility in operation of available flows during lean and flood period.

3. The study can be further extended by carrying out feasibility studies considering detailed aspects related to economic benefits for the potential sites presented in the paper.

Paper: **Groundwater Recharge Estimation in an Irrigated Area- A Case Study of Rechna Doab, Punjab, Pakistan**

Author: Ghulam Zakir Hassan, Abdullah Yasar, Saleem Akhtar, Faiz Raza Hassan

Recommendation:

Recharge to groundwater reservoir was estimated by groundwater balance method. Moreover, observed water levels were compared with groundwater levels calculated through specific yield method. In the specific yield method, the results depended on the observed water level and the aquifer specific yield. It was concluded that groundwater fluctuates with time and space markedly. Water level rises in wet seasons (after monsoon) and then drops in dry season (before monsoon). Rainfall and canal irrigation system are contributing significantly to groundwater recharge, with variation in time and space. Groundwater abstraction rate is more, especially in existing well field, than aquifer recharge rate due to which groundwater level is declining continuously. The average recharge from rainfall and canal irrigation system has been estimated to be in the range from 109 mm to 145 mm with an average value of 125 mm in Kharif season for the period from 2005 to 2011. Similarly recharge for Rabi season during year 2005 to 2011 is in the range from 59 mm to 77 mm with an average value of 65 mm. While estimated an average groundwater abstraction through public and private tubewells is 116 mm and 115 mm in kharif and Rabi season for year 2005 and it has reached 131mm and 128 mm in kharif and Rabi season of 2011 due to continuous increase in number of private tubewells. Groundwater level near old WASA well fields are going down continuously with average rate up to 0.9 m annually. Net average groundwater recharge for Kharif and Rabi season is negative except positive for kharif season in 2008, 2010 and 2011. The results from this study indicated that groundwater abstraction is greater than corresponding value of recharge. Therefore, aquifer is being depleted on regional basis with the passage of time.