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FOR MEMBERS ONLY

Pakistan Engineering Congress is a prestigious professional body established in 1912 dedicated, interalia to technical advancement of Science & Engineering in the country

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PROFILE OF PRESIDENT
ENGR. NAJAM WAHEED

Engr. Najam Waheed obtained his Bachelor's Degree from University of Engineering & Technology, Lahore in Civil Engineering. He has over thirty years of multifaceted professional experience leading and pursuing development and engineering projects which includes planning, project management, preparation of technical reports and contract documents. He is well-versed in various national and international codes, regulations, quality standards and their implementation. He worked on various prestigious and technically complex projects.

Engr. Najam Waheed has been a Council Member of Pakistan Engineering Congress for more than two decades. He has been an active member of the Congress serving as Secretary, Joint Secretary, Treasurer, and Convener of all important Committees of the Congress, and was elected as the President of the Pakistan Engineering Congress in December 2021. His vision has been manifested in a digital transformation of the Congress's services and has laid a strong foundation for future growth and developments of Engineers Communities.

His dedication to engineering development and the Pakistan Engineering Congress played a significant role in developing effective synergies with important professional bodies in the country, which would significantly contribute to engineers professional competence in a challenging environment of disruptive technologies and sustainable development.



Engr. Najam Waheed
President
Pakistan Engineering Congress (77th Session)

EDITOR'S NOTE

World Environment Day is the United Nations' principal vehicle for encouraging worldwide awareness and action for the environment. Held annually since 1973, the Day has also become a vital platform for promoting progress on the environmental dimensions of the Sustainable Development Goals. With the United Nations Environment Programme (UNEP) at the helm, over 150 countries participate each year. Major corporations, non-governmental organizations, communities, governments and celebrities from across the world adopt the World Environment Day brand to champion environmental causes

This year's World Environment Day campaign focused on land restoration, desertification and drought resilience under the slogan "Our land. Our future. We are #GenerationRestoration".

According to the UN Convention to Combat Desertification, up to 40 per cent of the planet's land is degraded, directly affecting half of the world's population and threatening roughly half of global GDP (US$44 trillion). The number and duration of droughts has increased by 29 per cent since 2000 – without urgent action, droughts may affect over three-quarters of the world's population by 2050.

Land restoration is a key pillar of the UN Decade on Ecosystem Restoration (2021-2030), a rallying call for the protection and revival of ecosystems all around the world, which is critical to achieve the Sustainable Development Goals. 2024 will mark the 30th anniversary of the UN Convention to Combat Desertification. The sixteenth session of the Conference of the Parties (COP 16) to the United Nations Convention to Combat Desertification (UNCCD) will be held in the Saudi capital, Riyadh, from 2 to 13 December 2024. Saudi Arabia pledges to plant tens of billions of trees in the country and wider region to combat drought, desertification, and land degradation.

Here are seven ways to get involved in ecosystem restoration on World Environment Day as outlined in the practical guide.

i. Make agriculture sustainable
ii. Save the soil
iii. Protect the pollinators
iv. Restore freshwater ecosystems
v. Renew coastal and marine areas
vi. Bring nature back to cities
vii. Generate financing for restoration

Environment protection and conservations development program in Pakistan draws its inspiration from Stockholm Convention of 1972 held under the umbrella of United Nations. As environment protection ordinance was enacted in 1983 as a starting, followed by National Conservation Strategy (NCS) in 1992. The culmination came in 1997

with enactment of Pakistan Protection Environment Act specifying the National Environment Quality Control Standards as a Benchmark. In 2001 the Government of Pakistan formulated the National Action Plan to arrest the ever-increasing degradation of Environment mainly due to man made errors of Commission.

Pakistan, like many countries around the world, faces significant environmental challenges that threaten the health and well-being of our people and the sustainability of our natural resources. From air and water pollution to deforestation and habitat degradation, the stakes have never been higher.

As members of the engineering community, we have a moral obligation to lead by example and drive positive change in our society. Whether it's through sustainable infrastructure projects, renewable energy solutions, or innovative waste management practices, engineers have the power to make a tangible difference in the fight against environmental degradation.

It is well known saying that the trees are lungs of the Earth but human being depleted natural resources, cut down forests, led to pollution and global warming. It is high time that we turn to nature and start pursuing it. Every year World Environment Day is observed to raise awareness about climate change, global warming, deforestation and loss of biodiversity.

As Generation Restoration, we have a responsibility to act. Countries must fulfill their commitments to restore degraded ecosystems and land. We must use our national climate action plans to halt and reverse deforestation. We must significantly increase financial support for developing nations to adapt to extreme weather, protect nature, and promote sustainable development.

Remember, inaction is costly, but effective action makes economic sense. Every penny invested in ecosystem restoration yields up to thirty times in benefits. Let us work together to build a sustainable future for our land and humanity.

Let us commit ourselves to embracing innovation, collaboration, and solidarity in our efforts to restore our lands, enhance our resilience, and combat desertification. Together, we can make a meaningful difference and leave a positive legacy for the planet and future generations.

SUBJECT: <u>SEMINAR ON "EFFECTS OF CLIMATE CHANGE ON INFRASTRUCTURE DEVELOPMENT" HELD ON 17.02.2024</u>

1. Pakistan Engineering Congress organized a Seminar on 17.2.2024 on the above cited subject. The following papers were presented by the specialists of the Climate affairs:

i) "Climate Change and Geohazards"

ii) "Navigating Climate Change Impacts on Biodiversity in Upper Indus Basin Hydropower Development"

iii) "Challenges of Climate Change Adaptations in Northern Pakistan with Special Focus on Road Infrastructure and Agriculture"

In this connection the Recommendations proposed by the Specialists are as under:

i). <u>Mitigation:</u>

- Mitigation of Climate Change factors i.e. preventing / minimizing the Climate Change.
- Mitigation of geohazards occurring solely due to anthropogenic Climate Change or due to the hybrid effect of natural land anthropogenic Climate Change.
  (these include general Civil Engineering measures etc).

ii). <u>Adaptation Strategies:</u>

I. Install flood monitoring and early warning systems to provide advanced notice of potential flooding.

II. Construct barriers, levees, and floodwalls along rivers and coastlines to help contain flood waters

III. Raise the level of roads, bridges, buildings, and other critical infrastructure above expected flood levels.

IV. Make infrastructure water-resistant and able to withstand flooding

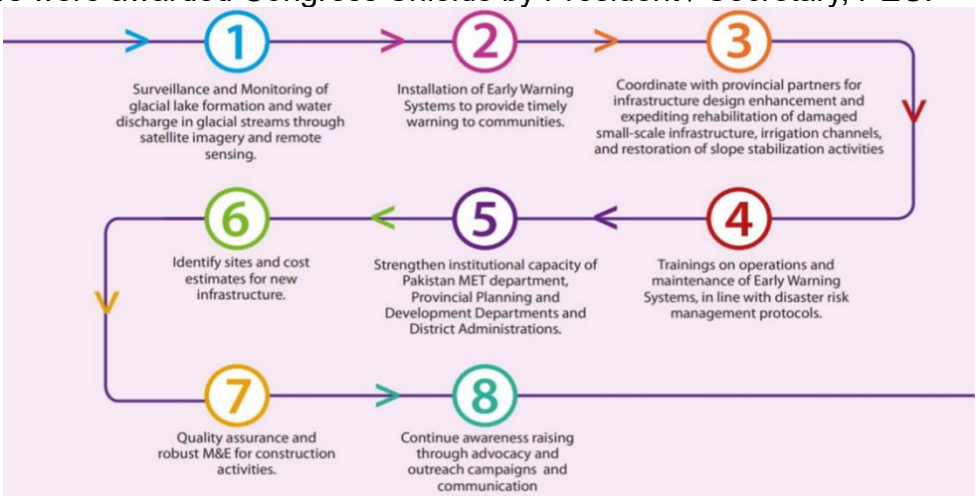
V. Upgrade storm drains, culverts, and ditches to increase drainage capacity.

VI. Construct holding ponds and retention areas to temporarily store flood waters.

VII. Educate communities on flood risks and preparedness

Mitigation of Climate Change factors i.e. preventing / minimizing the Climate Change.

2. It was a very well attended Meeting. After questions/answers Session, the Speakers were awarded Congress Shields by President / Secretary, PEC.



Seminar on Effects of Climate Change on Infrastructure Development Held at Pakistan Engineering Congress Headquarter on 17-02-2024



Engr. Nayyar Saeed, Secretary PEC Conducting the Proceedings



(From Left) Engr. Dr. Javed Iqbal, Chairman of the Session, Engr. Najam Waheed, President PEC, Engr. Nayyar Saeed Secretary PEC.

Glimpses of Audiences





Glimpses of Audiences





Glimpses of Audiences





Questions / Answers Session



Engr. Syed Imran Waheed



Engr. Sohail Kibria



Engr. Masood Ahmad



Engr. Capt. (R) M. Qadir Khan



Engr. Dr. Muhammad Riaz



Prof. Dr. Abdul Qadir



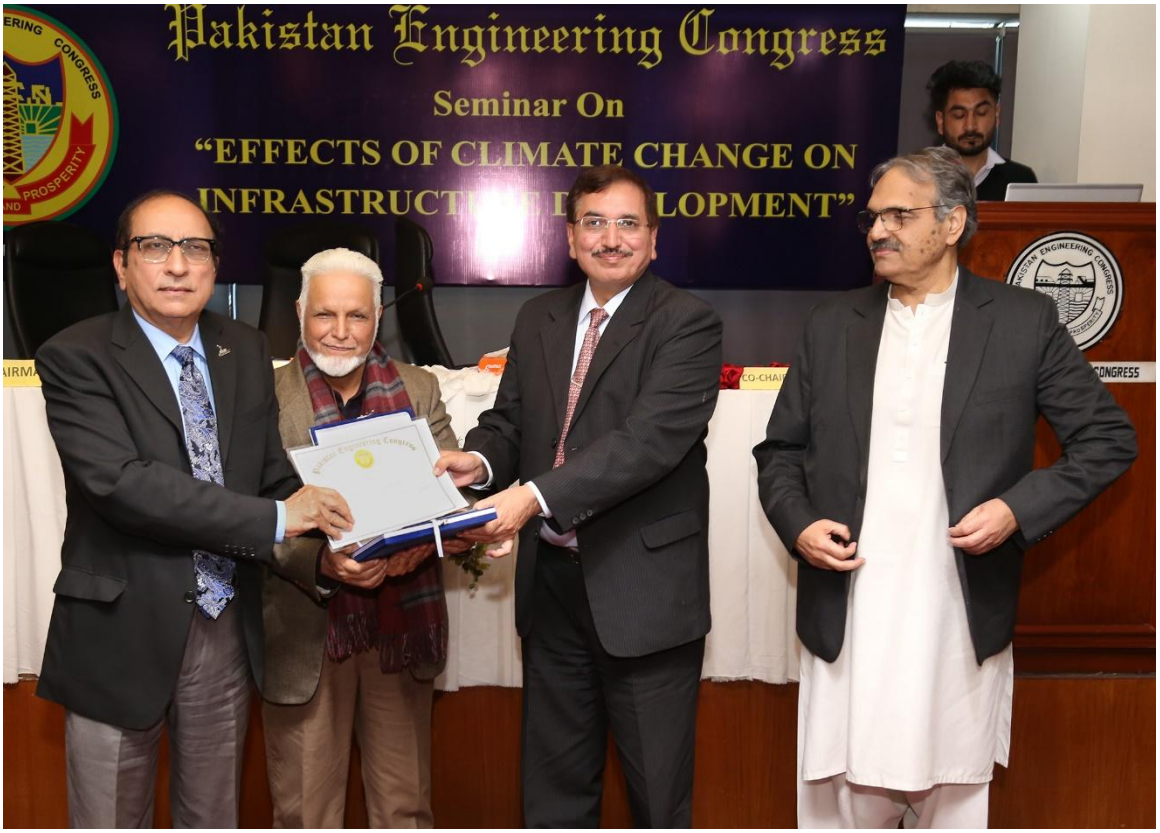
Engr. Riaz Nazir Tarar



Engr. Attique ur Rehman



Chairman of the Session Engr. Dr. Javed Iqbal Summing-up the Presentations by the Speakers



(From Right) Engr. Nayyar Saeed Secretary-PEC, Chairman of the Session Engr. Dr. Javed Iqbal and Engr. Capt. (R) M. Qadir Kham Vice President-PEC presenting Pakistan Engineering Congress Shield to Engr. Sohail Kibria for presenting his paper on the Topic of "Climate Change & Geohazards"



(From Left) Engr. Dr. Javed Iqbal Chairman of the Session and Engr. Nayyar Saeed Secretary-PEC presenting Pakistan Engineering Congress Shield to Mr. Usman Ahmad for presenting his paper on the Topic of “Navigating Climate Change Impacts on Biodiversity in Upper Indus Basin Hydropower Development”



(From Left) Engr. Capt. (R) M. Qadir Khan Vice President-PEC, Engr. Dr. Javed Iqbal Chairman of the Session and Engr. Nayyar Saeed Secretary-PEC presenting Pakistan Engineering Congress Shield to Ms. Tania Haider and Syeda Fizza-e-Batool for presenting their paper on the Topic of “Challenges of Climate Change Adaptations in Northern Pakistan With Special focus on Road Infrastructure and Agriculture”



(From Right) Engr. Nayyar Saeed Secretary-PEC presenting Congress Shield to Chairman of the Session Engr. Dr. Javed Iqbal with Engr. Capt. (R) M. Qadir Khan Vice President-PEC

SUBJECT: <u>VISIT OF PEC DELEGATION OF JALALPUR CANALS PROJECT ON MARCH 09, 2024</u>

1. A 16 (Sixteen) Members strong Delegation of Pakistan Engineering Congress led by Engr. Ch. Muhammad Aamir Ali, Vice President, Engr. M. Anwar Qaseem Qureshi, Honorary Joint Secretary and Engr. Dr. Muhammad Riaz, Member Executive Council/Chief Editor paid a Technical Visit to Jalalpur Canals Project on March 09, 2024. The delegation was welcomed by Engr. Javed Hassan, Chief Resident Engineer of the Project. The delegation was apprised of the salient features of the Project. After it the delegation was taken round the Project site, Siphon, cross Drainage structure etc. At the conclusion of the visit, Pakistan Engineering Congress Shield and Publications were presented to Engr. Javed Hassan, Chief Resident Engineer and as well as to Engr. Muhammad Zubair, Team Leader of the consultants. It was a very informative visit.

BRIEF OF JALALPUR IRRIGATION PROJECT (JIP)

1. Project Objective

- Sustainable agriculture to alleviate poverty in District Jhelum and Khushab.
- Construction of flood carrying channels (FCCs) to protect the area from the devastation of torrential flood water and reclamation of water-logged / saline area.
- 40 cusecs for water supply to 26 villages through 17 outlets at different locations.

2. Project Components

- Project Output 1**:** Construction of Main Canal, Distribution System and Flood Carrier Channels.
- Project Output 2**:** Improvement in Water-use Capacity in the Project Area.
- Project Output 3: Improvement in Farm Management Capacity in Project Area.

3. Project Salient Features

• Non-perennial Canal	=	April to October
• Design Discharge	=	1350 cusecs
• CCA	=	174,000 acres (118000+56000)
• Water Allowance	=	6.75 Cs/1000 Acres
• Length of Main Canal	=	115.7 km (380 RDs)
• Number of Distributaries & Minors	=	23 + 7
• Length of Distributaries & Minors	=	210 km (6+92+112)
• Length of Lined Main Canal	=	25 km
• Number of Flood Carrier Channels	=	16
• Length of Flood Carrier Channels	=	276 km (5+133+138)

4. Loan Salient Features

• Project Cost: reduce further	=	US$ 320.59 million expected to below US$ 300 million

= (**ADB:** US$ 234.63 m + **GoP:** US$ 85.96 m)

= (US$ 40 million loan cancelled)

- Financing Source: = Asian Development Bank-Loan No. 3599-PAK
- Project Approval by ECNEC: = 7th February 2018 (Rs. 32,721.46 million)
- Output 1 by Irrigation Department = Rs. 26,500 million (Works)
- Output 2 & 3 by Agriculture Deptt. = Rs. 3,900 million
- Loan Signing: = 13th April 2018
- Loan Effectiveness: = 31st May 2018
- Loan Closing Date: = 30th June 2024-

= Proposed extension to Dec 2027 due to initial; delay

- Loan Disbursement = US$ 74.30 Million (32%)

5. Overall Financial Progress: Rs. 17,742 million (54%)

6. Current Status (Overall Physical Progress: **55%**)

Package	Contract Amount (PKR m)	Contract Agreement	Letter of Commencement/ Completion Time	Possession of Site	Ongoing Activities	Physical Progress
Package-01 (RD 0+000 to RD 52+000)	7,619	4th December, 2019	17th February, 2020 /4 Years + 1 Year DNP*	• 21.85 KM of Main Canal and Distributary out of 21.85 KM (100%). • 1.52 KM of FCC out of 5.51 KM (28%).	Canal is ready for operation by June 2024 Some of the stone works - not relevant for operation will continue for few more months.	80%
Package-02 (RD 52+000 to RD 225+500)	10,797	17th June, 2021	2nd August, 2021 /4 Years + 1 Year DNP*	• 147.08 KM of Main Canal and Distributaries (100%) • 111.8 KM of FCC out of 134.42 KM (83%).	Construction of bridges, syphons, culverts and earthwork for Main Canal embankment from RD 52 to RD 225 is in process.	47%

Package-03 (RD 225+500 to RD 379+750)	8,100	30th September, 2020	27th May, 2021 /4 Years + 1 Year DNP*	• Main Canal & Distributaries out of 165.87 KM (100%). • FCC out of 122.1 KM (100%).	Construction of structures, depressed culverts and bridges of main canal from RD 225+500 to RD 379+750 is in process.	65%

* Defect Notification Period

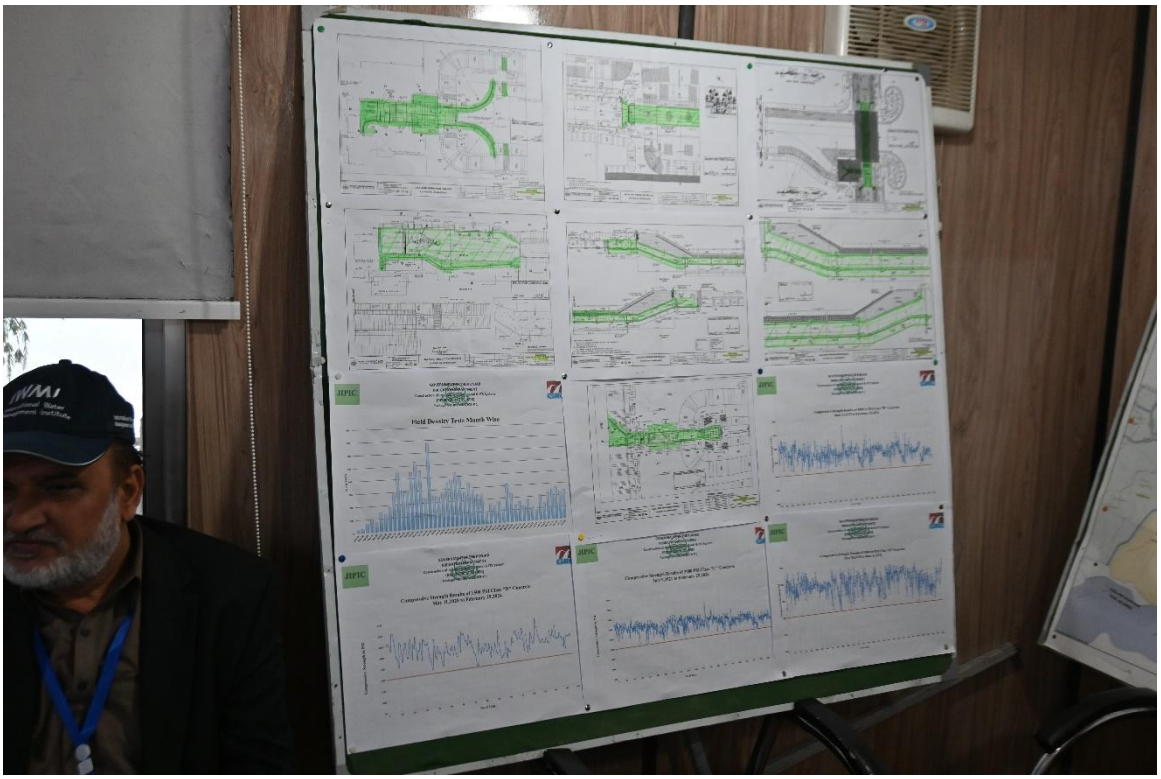
7. Disbursement Status and Project Rating

Loan Amount ($ M)	Disbursement up-to 30.06.23 ($ M)	Budget Estimate 2023-24 ($M)	Disbursement 2023-24 ($M)	Cumulative Disbursement till date ($M)	Ranking
Original: 274.63 Revised: 234.63 Cancelled: 40	55.44	26	24.08	79.52 (33.89%)	On Track

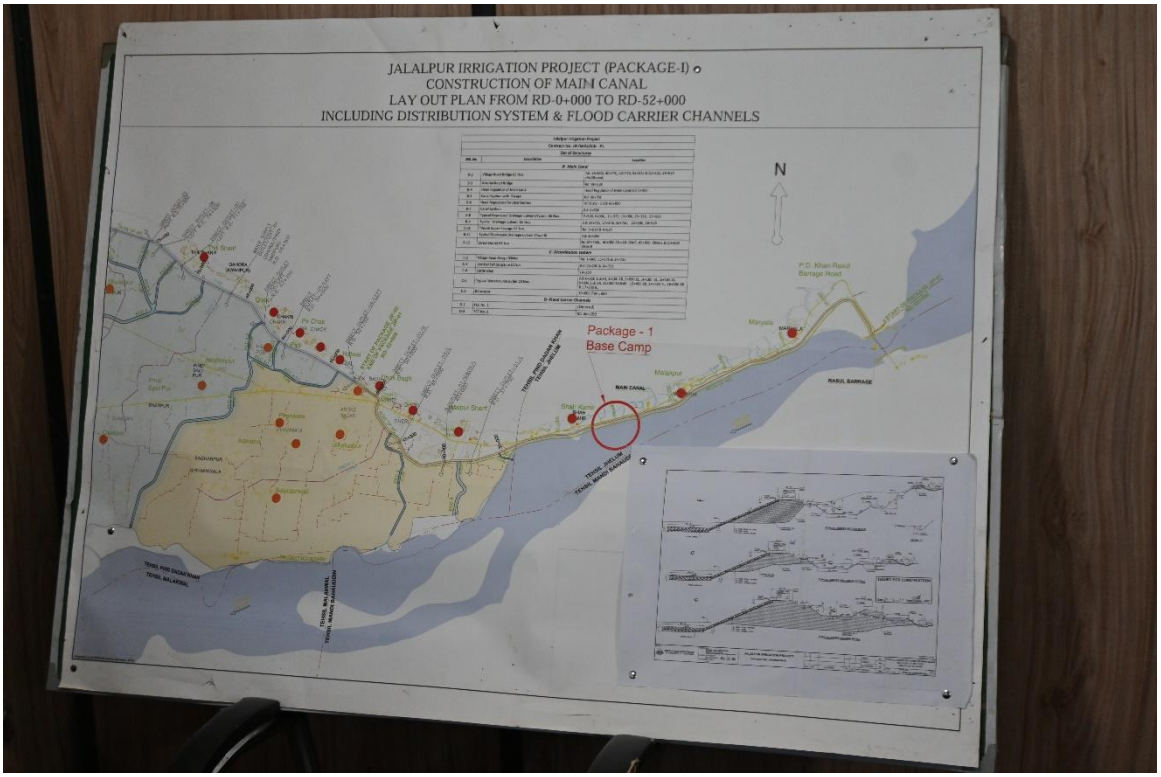
A Delegation of Pakistan Engineering Congress paid a Technical Visit of Jalalpur Irrigation Project on 9-03-2024



Engr. Javad Asad, Chief Resident Engineer Jalalpur Irrigation Project is Briefing the Delegation about the Project Salient Features and details of Design Components Project



Jalalpur Irrigation Project Detail of Features Design of Project various parts



Jalalpur Irrigation Project Detail of Features Design of Project various parts





Picture of Siphon of Jalalpur Irrigation Project



Cross Drainage Structure at Jalalpur Irrigation Project



Inauguration plaque at one of the Site of Command Area Development of Jalalpur Irrigation Project.



Formal Presentation at Camp Office by Engr. Javad Asad, Chief Resident Engineer Jilalpur Irrigation Project



Engr. Dr. Muhammad Riaz Member Executive Council Pakistan Engineering Congress along with Engr. Rana Muhammad Yamin Member Executive Council, Engr. Tahir Anjum Qureshi Members Executive Council, Engr. Dr. Muhammad Saeed Member Executive Council and Engr. Mian Muhammad Zubair presenting Pakistan Engineering Congress Shield to Engr. Javad Asad, Chief Resident Engineer Jalalpur Irrigation Project



Engr. Dr. Muhammad Riaz Member Executive Council Pakistan Engineering Congress presenting Research Publications of Pakistan Engineering Congress to Engr. Javad Asad, Chief Resident Engineer Jalalpur Irrigation Project



Engr. Dr. Muhammad Riaz Member Executive Council Pakistan Engineering Congress and Engr. Rana Muhammad Yamin Member Executive Council Pakistan Engineering Congress Presenting Pakistan Engineering Congress Shield to project consultant Jalalpur Irrigation Project



Engr. Dr. Muhammad Riaz Member Executive Council Pakistan Engineering Congress and Engr. Rana Muhammad Yamin Member Executive Council Pakistan Engineering Congress Presenting Research Publications of Pakistan Engineering Congress to Project Consultant Jalalpur Irrigation Project



Engr. Dr. Muhammad Riaz Member Executive Council Pakistan Engineering Congress along with Engr. Rana Muhammad Yamin Member Executive Council, Engr. Tahir Anjum Qureshi Members Executive Council, Engr. Dr. Muhammad Saeed Member Executive Council Presenting Research publications of Pakistan Engineering Congress to project Consultant Jalalpur Irrigation Project



A group Photo of Delegates with Jalapur Project Team



Pakistan Engineering Congress Delegates Visiting and discussing various Structures of Jalapur Irrigation Project

Welcome Address

By

Engr. Najam Waheed,

President Pakistan Engineering Congress

World Water Day, 2024

On the theme of "Leveraging Water for Peace"

On May 4, 2024

Distinguished Delegates,

Executive Council Members,

Fellow Engineers, Ladies & Gentlemen,

Assalam-o-Alaikum and Good Morning !

It is a matter of great honor and pleasure for me to welcome you all over here on the World Water Day. As we gather here today to commemorate World Water Day, we are reminded of the critical importance of water in our lives and the pressing need to leverage this precious resource for peace and prosperity. This year, the theme **"Leveraging Water for Peace"** calls upon us to recognize the transformative power of water in fostering cooperation, resolving conflicts, and building sustainable societies.

Ladies and Gentlemen!

Water is not merely a commodity; it is a fundamental human right and a cornerstone of development. Access to clean water and sanitation is essential for the health, dignity, and well-being of individuals and communities worldwide. Yet, millions of people still lack access to safe drinking water, while many more face the daily threat of water scarcity, pollution, and degradation.

In recognizing water as a shared resource, we must also acknowledge its potential to unite us across borders, cultures, and ideologies. Water knows no boundaries; rivers, lakes, and aquifers transcend geopolitical divides, connecting us in ways that go beyond politics and conflict. By embracing water as a catalyst for cooperation, we can overcome differences and work together towards common goals.

One of the most significant challenges we face in leveraging water for peace is the increasing competition for scarce water resources. As populations grow, economies expand, and climate change intensifies, the demand for water is rising, placing unprecedented pressure on freshwater ecosystems. In many regions, water scarcity has become a source of conflict, aggravating tensions and undermining stability.

However, water scarcity does not have to be a source of conflict; it can also be an opportunity for collaboration. Through dialogue, negotiation, and cooperation, riparian states can find mutually beneficial solutions to shared water challenges. By fostering trust, transparency, and goodwill, we can transform water from a potential source of conflict into a catalyst for peace.

Ladies and Gentlemen!

Investing in water infrastructure and management can yield significant dividends for peace and development. Sustainable water management practices, such as rainwater harvesting, wastewater recycling, and ecosystem restoration, can help alleviate water stress, enhance resilience, and promote social cohesion. By prioritizing investments in water and sanitation, we can address the root causes of poverty, inequality, and instability, laying the foundation for a more peaceful and prosperous future.

Moreover, water plays a crucial role in addressing some of the most pressing global challenges we face, including food security, public health, and environmental sustainability. By promoting sustainable agriculture, improving water efficiency, and protecting ecosystems, we can enhance food production, reduce poverty, and safeguard biodiversity. By ensuring access to clean water and sanitation, we can prevent disease, promote gender equality, and empower marginalized communities. By integrating water into climate change adaptation and mitigation strategies, we can build resilience, mitigate risks, and safeguard our planet for future generations.

Ladies and Gentlemen!

Leveraging water for peace requires a collective effort and a shared commitment to cooperation, sustainability, and justice. As we mark World Water Day, let us recommit ourselves to harnessing the transformative power of water for the benefit of all. Let us work together to ensure that water flows freely, nourishing communities, fostering cooperation, and paving the way for a more peaceful and prosperous world for generations to come.

I would like to thank you all once again for being with us.

Thank you.

-.-.-.- Pakistan Paindabad -.-.-.-

SUBJECT: **<u>WORLD WATER DAY, 2024 WAS HELD ON SATURDAY, MAY 04, 2024 ONTHE THEME OF "LEVERAGING WATER FOR PEACE" AT MASHHADI HALL OF CONGRESS HEAD-QUARTER.</u>**

1. Pakistan Engineering Congress is commemorating World Water Day along-with the World since 2005 and the papers presented at the event were published in 19-Volumes that have been distributed complimentary to Provincial/Federal Government Departments, Engineering fraternity etc. This year i.e.2024 the Theme is "Leveraging Water for Peace". For convenience of Speakers, following Sub-Themes were formulated:

   i), Climate Change-Water-Peace Nexus.

   ii). Transboundary Water Conflicts.

   iii). Climate Change and Transboundary Water Conflicts.

   iv). Water is Life; Water is blood for peace at the Global, regional and local level.

   v). Transboundary Water management (Shared River Basin Management).

   vi). Climate Change And urban Management.

   vii). Any other theme.

2. Engr. Mansoor Ali, General Manager/Head of Water and Agriculture Division, NESPAK was the Chairman and Dr. Khawar Munir, General Manager, WAPDA was Co-Chairman of the Technical Session. The proceedings started with Recitation of Verses from the Holy Quran. Engr. Nayyar Saeed, Secretary, Pakistan Engineering Congress presented Welcome address on behalf of President, Pakistan Engineering Congress.

3. Renowned specialists of Water resources affairs belonging to leading Institutions presented papers on the following Topics:

- "TRANSBOUNDARY WATER CONFLICTS INDO-PAKISTAN CONTEXT"
- "PROSPECTS IN WATER SECTOR DEVELOPMENT OF PAKISTAN"
- "ESTIMATION OF FUTURE DISCHARGES & IMPACT OF CLIMATE CHANGE ON THE HYDROPOWER GENERATION OF NALTAR IV HPP PAKISTAN"
- "CLIMATE CHANGE RESILIENCE AND URBAN WATER GOVERNANCE (A CASE STUDY OF PAKISTAN)
- "THREATS AND CHALLENGES TO WATER RESOURCES IN PAKISTAN: A COMPREHENSIVE ANALYSIS OF SALINITY, CLIMATE CHANGE, AND SOIL SALINIZATION"
- "DIVERTING FLOODWATER FOR SUSTAINABLE USE OF GROUNDWATER THROUGH MANAGED AQUIFER RECHARGE"
- "WATER REQUIREMENTS OF MAJOR CROPS IN THE CENTRAL PUNJAB: A LYSIMETRIC STUDY"
- "HYDRAULIC DESIGN GUIDELINES OF CULVERTS IN PLAIN AND HILLY AREAS"

- “TREATMENT OF HIGHLY TOXIC PHARMACEUTICAL EFFLUENT FOR THE CONSERVATION OF SURFACE WATER”

After the presentation of the papers, lively Questions/Answers Session ensued after which Shields of Pakistan Engineering Congress were presented to the Speakers by the Engr. Nayyar Saeed, Secretary, PEC/Capt. ® M. Qadir Khan, Vice President, PEC along-with Engr. Mansoor Ali Khan and Engr. Khawar Munir, Chairman/Co-Chairman of the Session. It was a largely attended event.

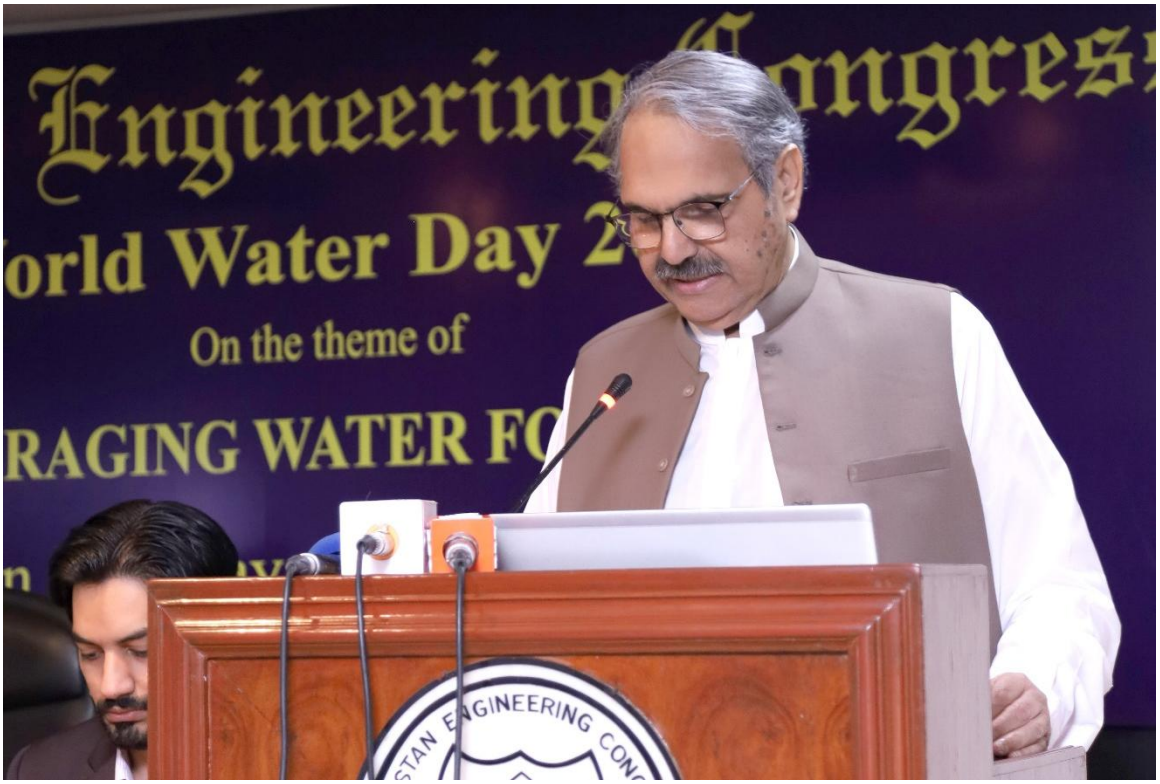
World Water Day 2024 on the theme of "Leveraging Water for Peace" Commemorated at Pakistan Engineering Congress Headquarter on Saturday May 4, 2024



Engr. Muhammad Ammar Member Executive Council Conducting the Proceedings



(From Left) Engr. Dr. Khawar Munir Co-Chairman of the Technical Session, Engr. Mansoor Ali Chairman of the Technical Session, Engr. Nayyar Saeed Secretary-PEC, Engr. Muhammad Ammar Publicity Secretary- PEC



Engr. Nayyar Saeed Secretary-PEC Presenting Welcome Address at the event on the behalf of President Pakistan Engineering Congress

Glimpses of Audiences



(From Left) Engr. Shahid Hameed G.M. WAPDA, Engr. Riaz Ahmad Khan Former President PEC, Engr. Husnain Ahmad V.P PEC, Engr. Iftikhar Ahmad Former President PEC, Engr. Jamil Ahmad Basra Treasurer PEC,
Engr. Ch. Ghulam Hussain Former President PEC with other respected Engineers



(From Left) Engr. Iftikhar Ahmad Former President PEC, Engr. Jamil Ahmad Basra Treasurer PEC, Engr. Ch. Ghulam Hussain Former President PEC





(From Right) Engr. Muhammad Ibrahim Malik Members PEC, Engr. Capt (R) M. Qadir Khan Vice President PEC, Engr. Syed Saleem Akhtar with other respected engineers.



In this picture Engr. Nayyar Saeed Secretary PEC, Engr. Husnain Ahmad V.P. PEC with other respected engineers

Questions / Answers Session



Engr. Syed Hammad Ali



Engr. Hammad Muzamal Kiani



Engr. Capt. (R) M. Qadir Khan Vice President Pakistan Engineering Congress



Engr. Muhammad Iqbal



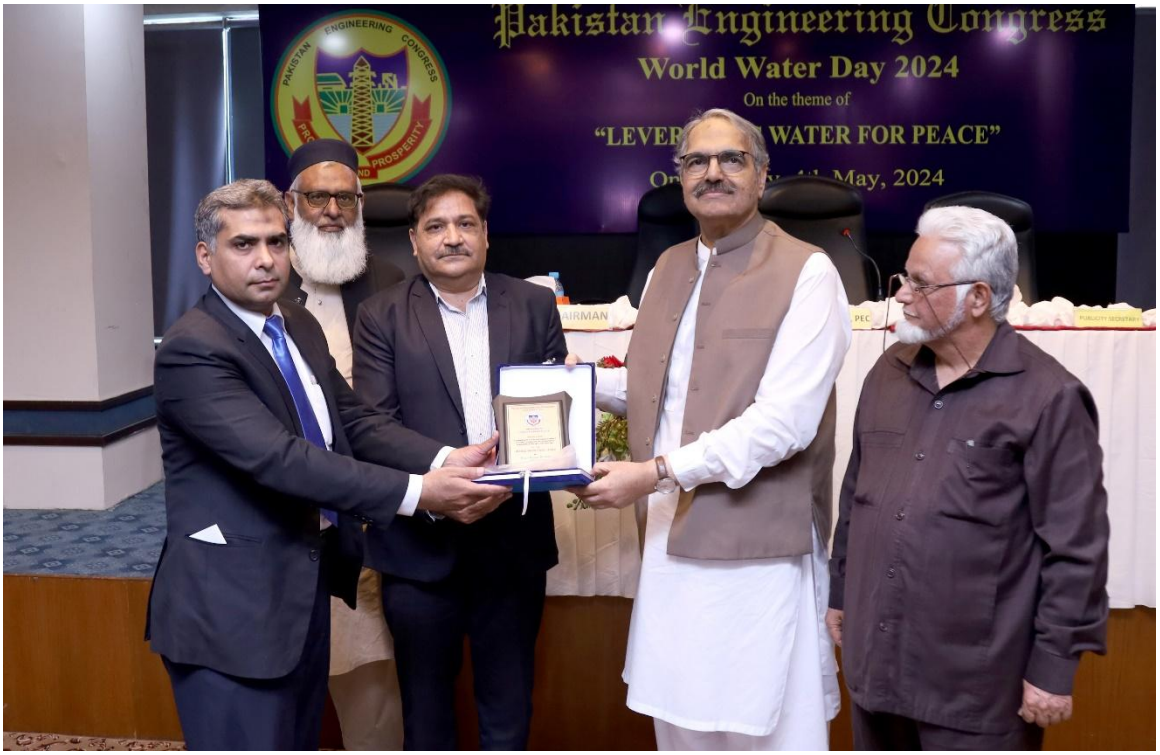
Engr. Muhammad Fida Hussain



Chairman of technical Session Engr. Mansoor Ali General Manager/Head of Water & Agriculture Division NESPAK, Summing-up the Presentations by the Speakers



(From Right) Engr. Capt. (R) M. Qadir Khan Vice President-PEC, Engr. Nayyar Saeed Secretary-PEC, Engr. Mansoor Ali Chairman of the Technical Session and Engr. Dr. Khawar Muir G.M WAPDA Co-Chairman of the Technical Session presenting Pakistan Engineering Congress Shield to Engr. Riaz Nazir Tarar for his paper on "Transboundary Water Conflicts Indo-Pakistan Context"



(From Right) Engr. Capt. (R) M. Qadir Khan Vice President-PEC, Engr. Nayyar Saeed Secretary-PEC, Engr. Dr. Khawar Munir G.M WAPDA Co-Chairman of the Technical Session and Engr. Mansoor Ali Chairman of the Technical Session presenting Pakistan Engineering Congress Shield to Engr. Syed Hammad Ali for his paper on “Estimation of Future Discharges & Impact of Climate Change on the hydropower Generation of Naltar IV HPP Pakistan”



(From Right) Engr. Capt. (R) M. Qadir Khan Vice President-PEC, Engr. Nayyar Saeed Secretary-PEC, Engr. Dr. Khawar Munir G.M WAPDA Co-Chairman of the Technical Session and Engr. Mansoor Ali Chairman of the Technical Session presenting Pakistan Engineering Congress Shield to Ms. Maryam Abid for her paper on “Climate Change Resilience and Urban Water Governance (A Case Study of Pakistan)



(From Right) Engr. Capt. (R) M. Qadir Khan Vice President-PEC, Engr. Nayyar Saeed Secretary-PEC, Engr. Dr. Khawar Munir G.M WAPDA Co-Chairman of the Session and Engr. Mansoor Ali Chairman of the Session presenting Pakistan Engineering Congress Shield to Ms. Amina Mukhtar for her paper on “Treatment of Highly Toxic Pharmaceutical Effluent for the Conservation of Surface Water”



(From Right) Engr. Capt. (R) M. Qadir Khan Vice President-PEC, Engr. Nayyar Saeed Secretary-PEC, Engr. Mansoor Ali Chairman of the Technical Session and Engr. Dr. Khawar Munir G.M WAPDA Co-Chairman of the Technical Session presenting Pakistan Engineering Congress Shield to Engr. Muhammad Hassan for his paper on “Water Requirements of Major Crops in the Central Punjab: A Lysimetric Study”



(From Right) Engr. Capt. (R) M. Qadir Khan Vice President-PEC, Engr. Nayyar Saeed Secretary-PEC presenting Pakistan Engineering Congress Shield to Chairman of the Technical Session Engr. Mansoor Ali Chairman of the Session With Engr. Dr. Khawar Munir Co-Chairman of the Technical Session



(From Right) Engr. Capt. (R) M. Qadir Khan Vice President-PEC, Engr. Nayyar Saeed Secretary-PEC and Engr. Mansoor Ali Chairman of the Technical Session presenting Pakistan Engineering Congress Shield to Engr. Dr. Khawar Munir Co-Chairman of the Technical Session



(From Right) Engr. Capt. (R) M. Qadir Khan Vice President-PEC, Engr. Nayyar Saeed Secretary-PEC presenting Pakistan Engineering Congress Shield to Guest of Honor Engr. Rana Muhammad Dawood With Engr. Mansoor Ali Chairman of the Technical Session and Engr. Dr. Khawar Munir Co-Chairman of the Technical Session

Media Coverage



Engr. Nayyar Saeed Secretary-PEC in Conversation with Media People



Engr. Riaz Nazir Tarar Associate NDC in Conversation with Media People



Engr. Shahid Hameed G.M WAPDA in Conversation with Media People

WELCOME ADDRESS

PRESIDENT PAKISTAN ENGINEERING CONGRESS

SYMPOSIUM ON

“PAVEMENT MANAGEMENT SYSTEM”

On May 11, 2024

Distinguished Delegates

Executive Council Members

Fellow Engineers

Ladies and Gentlemen!,

Assalamo Alaekum and Good Morning!

It is my privilege to extend a very warm welcome to all on behalf of Pakistan Engineering Congress to this important symposium on Pavement Management System. Considering the current situation of the road network, the importance of the topic becomes extremely relevant.

Roads, highways, and sidewalks are the arteries of our modern society, facilitating transportation, commerce, and connectivity. Yet, they are subject to wear and tear, weathering, and deterioration over time. This is where pavement management system steps in, offering a comprehensive approach to ensure the longevity, safety, and efficiency of our transportation infrastructure.

Ladies and Gentlemen!

At its core, a pavement management system is a strategic tool that helps authorities effectively manage and maintain road networks. It involves the systematic assessment, monitoring, and prioritization of maintenance and rehabilitation activities. By leveraging data-driven insights, engineers and planners can make informed decisions to optimize resources and enhance the performance of our roadways.

One of the key components of a pavement management system is condition assessment. Through advanced technologies such as pavement condition surveys, laser scanning, and satellite imagery, experts can evaluate the health of pavements, identifying issues like cracks, potholes, rutting, and surface distress. By quantifying these conditions, authorities can prioritize maintenance interventions based on urgency and cost-effectiveness.

Moreover, pavement management systems employ predictive modeling techniques to forecast the future deterioration of roadways. By analyzing historical data and factors like traffic loads, environmental conditions, and material properties, engineers can anticipate the rate of pavement degradation and plan proactive maintenance strategies. This proactive approach not only saves costs in the long run but also minimizes disruptions to traffic flow and ensures road safety.

Ladies and Gentlemen!

Furthermore, pavement management systems facilitate asset management by integrating various data sources into a centralized database. This enables authorities to track the performance of individual pavement sections, monitor maintenance activities, and allocate resources efficiently. With real-time access to comprehensive information, stakeholders can make well-informed decisions to optimize the lifecycle

of pavement assets and enhance the overall resilience of our transportation infrastructure.

However, implementing and maintaining a pavement management system requires collaboration and commitment from various stakeholders, including government agencies, transportation departments, engineering firms, and the public. It demands ongoing investment in infrastructure, human resources, and technology.

Ladies and Gentlemen!

Engineers have a diversified role in the society for the development of the economy of a country. Engineers can have significant influence on the infrastructure development, government policies, agricultural productivity, environmental sustainability, disaster management, ethical and social responsibilities and many other fields for socioeconomic progress of any country. One of the major challenges for the engineers is the utilization of indigenous resources for high-tech, innovations so that a society can develop a balanced economy based in its own resources.

In this regard, pavement management systems play a vital role in preserving the integrity and functionality of our road networks. By adopting a proactive and data-driven approach to pavement maintenance, we can ensure safer, smoother, and more sustainable transportation for generations to come.

Ladies and Gentlemen!

I am sure today you would benefit from the presentation of the learned speakers.

I thank the authors for preparing the papers and presenting them on the Pakistan Engineering Congress forum and thank you all for sparing time and being with us here today.

Pakistan Zindabad

SUBJECT: **SEMINAR ON "PAVEMENT INSPECTION AND DIAGNOSIS FOR EFFECTIVE PAVEMENT MANAGEMENT SYSTEM" (PMS) HELD ON SATURDAY MAY 11, 2024 AT MASHHDI HALL OF CONGRESS HEAD-QUARTER.**

It is apprised that communication & Works Department is developing Road Asset Management System (RAMS) in which Pavement Inspection and Diagnosis is an important input for monitoring and managing the road Infrastructures. Communication & Works Department recently formulated a Manual on Pavement Inspection and Diagnosis with the help of JICA. In this regard to create the awareness and feedback from practicing Engineers a Seminar was arranged on the above cited subject on May 11, 2024.

Proceedings started with recitation of verses from Holy Quran.

The following International/Domestic specialists of Pavement Management System presented papers on following Themes:

* "Asphalt Pavement Distresses, Identification and Corrective Measures with 2-Case Studies"
* "Measuring Characterizing and Reporting Pavement Roughness"
* "Pavement Functional Evaluation with Pavement Condition Index"
* "Introduction to the JICA Project Related to Pavement Management System (PMS)
* "Performance Monitoring Parameters of Pavement Under Management System (PMS)"

Proceedings started with recitation of verses from Holy Quran. After the presentation of Papers, a lively Questions/Answers Session comprising question raised by the participants and Answers conveyed by the Speakers ensued. Concluding Remarks were given by Engr. Nafasat Raza, Chairman Technical Session. Pakistan Engineering Congress Shields were presented to the Speakers by Engr. Najam Waheed, President, PEC and Chairman, Technical Session. It was a very informative and largely attended event.

Seminar on Pavement Inspection & Diagnosis for Effective Pavement Management System (PMS) Held at Pakistan Engineering Congress Headquarter on May 11, 2024



Engr. Ayyaz Ahmed Rasheed Member Executive Council-PEC Conducting the Proceedings



(From Left) Engr. Syed Nafasat Raza Chairman of Technical Session, Engr. Najam Waheed President-PEC, Engr. Ayyaz Ahmed Rasheed Member Executive Council-PEC



Engr. Najam Waheed President-PEC Presenting Welcome Address at the event

Glimpses of Audiences



1st Row (from Left) Mr. Shintaro MUTO, Engr. Muhammad Ammar Publicity Secretary-PEC, Engr. Dr. Waseem Mirza, Engr. Zubair Emran Khawaja.
2nd Row (From Left) Engr. Nayyar Saeed Secretary-PEC, Engr. Ch. Muhammad Arif Vice President-PEC



(From Left) Mr. Shintaro MUTO, Engr. Muhammad Ammar Publicity Secretary-PEC, Engr. Dr. Waseem Mirza, Engr. Riaz Ahmad Khan Former President-PEC.



(From Left) Engr. Amer Yaqoob, Engr. Dr. Javed Iqbal alongwith other respected Engineers



(From Left) Mr. Shintaro MUTO, Engr. Muhammad Ammar Publicity Secretary-PEC, Engr. Dr. Waseem Mirza, Engr. Riaz Ahmad Khan Former President-PEC. Engr. Capt. (R) M. Qadir Khan Vice President-PEC



Engr. Ch. Muhammad Arif Vice President-PEC, Engr. Capt. (R) M. Qadir Khan Vice President-PEC, Engr. Dr. Muhammad Saeed along with other Respected Engineers



Seen in the picture is Engr. Husnain Ahmad Vice President along with other respected Engineers



Chairman of the Technical Session Engr. Syed Nafasat Raza Member Executive Council-PEC Summing-up the Presentations by the Speakers



(From Right) Engr. Najam Waheed President-PEC and Chairman of the Technical Session Engr. Syed Nafasat Raza presenting Pakistan Engineering Congress Shield to Engr. Zubair Emran Khawaja for his paper on "Asphalt Pavement Distresses, Identification and Corrective Measures with 2 Case Studies"



(From Right) Chairman of the Technical Session Engr. Syed Nafasat Raza and Engr. Najam Waheed President-PEC presenting Pakistan Engineering Congress Shield to Engr. Dr. Wasim Mirza for his paper on “Measuring Characterizing and Reporting Pavement Roughness”



(From Right) Chairman of the Technical Session Engr. Syed Nafasat Raza and Engr. Najam Waheed President-PEC presenting Pakistan Engineering Congress Shield to Engr. Amer Yaqoob for his paper on “Pavement Functional Evaluation with Pavement Condition Index”



(From Right) Chairman of the Technical Session Engr. Syed Nafasat Raza and Engr. Najam Waheed President-PEC presenting Pakistan Engineering Congress Shield to Mr. Shintaro MUTO for his paper on “Introduction to the JICA Project Related to Pavement Management System (PMS)”



(From Right) Chairman of the Technical Session Engr. Syed Nafasat Raza and Engr. Najam Waheed President-PEC presenting Pakistan Engineering Congress Shield to Engr. Waleed Zafar for his paper on “Findings of Pilot Axle Load Survey in Punjab”

SUMMARY OF THE CHINIOT DAM PROJECT

MAY 13, 2024

The Chiniot Dam Project is located on Chenab River in Tehsil and District Chiniot, Faisalabad Division, Punjab at about 100 km downstream of Qadirabad Barrage & 5 km from the Chiniot city and about 100 meters upstream of existing Railway Bridge on Chenab River. The Project will comprise a 22 m high Earth Fill Dam that will create a reservoir with a gross storage volume of about 0.90 MAF. The total length of the Dykes is 83km and the crest width of 10m is proposed on the both side dykes.

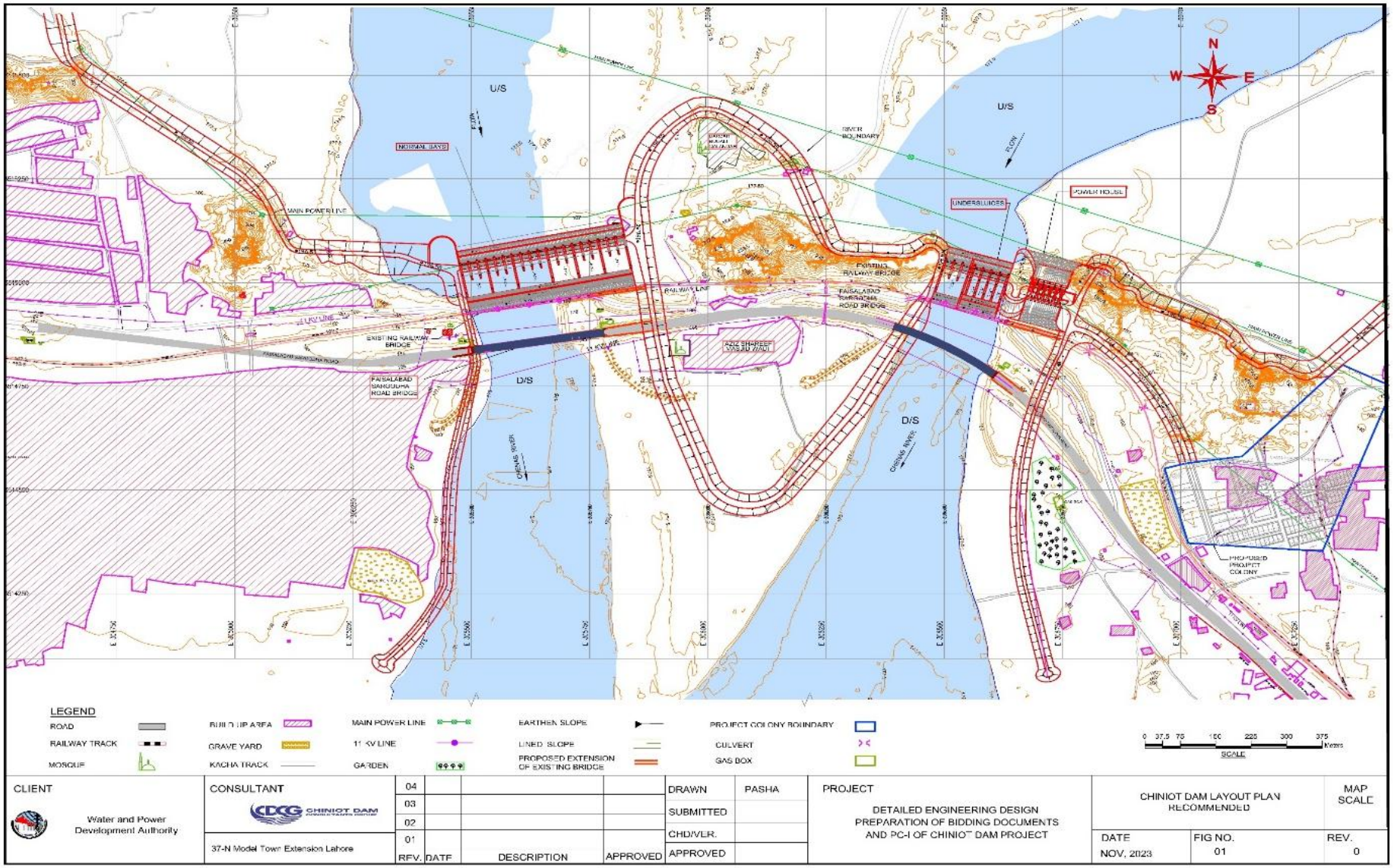
Salient Features	
Reservoir Length (km)	35
Dyke Length (km)	83
Gross Storage (MAF)	0.90
Dead Storage (MAF)	0.05
Installed Capacity (MW)	80
Riverbed Level	175 m.a.s.l
Normal Reservoir Level	190 m.a.s.l
No. of Gates	26 (04 in left & 22 in Right Gorge)
Capacity of Barrage/Spillway (Cumecs)	31,627
Irrigation Benefits during Low Flow Season equivalent to Command Area (Acre)	80000

The primary objective of Chiniot Dam project is to provide flood mitigation to the nearby areas of Chenab River. The project will also provide a water storage of 0.9 MAF to regulate existing downstream canal network that will be used in case of water shortages in the area.

Inflows in Chenab River at Marala during the months of November to February are very low. During this period India would have a capability to mal-operate the structures (existing and proposed Hydro-electric Dams) upstream of Marala Barrage and stop flows in Chenab River up to the tune of 168.3 Mm^3 (0.136 MAF) for 21 days. An alarming situation would arise at Marala in case of India taking advantage of its capability to mal-operate upstream structures. Development of storage sites on Chenab River will enable Pakistan to store additional water during flood seasons and utilize the same in the low flow seasons or in case of mal-operation by India.

Other than above, 80 MW of power will also be generated to meet the energy needs of the country. The project will provide sustainable and reliable water supply to nearby community and will result in ground water recharge. It will also result in recreation & socio-economic uplift.

Overall 45,500 acres of land will be acquired for the proposed dam project, out of which approximately 21,000 acres land is river plain and 24,700 acres is comprised of rich fertile agriculture land. The total cost of the project is expected to be **PKR 356 billion**. And the construction of the project will take approximately 6 years to complete. The layout of the proposed Chiniot Dam Project is as under:


U/S
D/S
N
W
E
S
NORMAL DAYS
MAIN POWER LINE
EXISTING RAILWAY BRIDGE
FAISALABAD SARGODHA ROAD BRIDGE
RAILWAY LINE
EXISTING RAILWAY BRIDGE
FAISALABAD SARGODHA ROAD BRIDGE
AZIZ SHAHEED FLYOVER ROAD
UNDERSLUICES
POWER HOUSE
PROPOSED PROJECT COLONY
CHENAB RIVER
LEGEND
ROAD
RAILWAY TRACK
MOSQUE
BUILT UP AREA
GRAVE YARD
KACHA TRACK
MAIN POWER LINE
11 KV LINE
GARDEN
EARTHEN SLOPE
LINED SLOPE
PROPOSED EXTENSION OF EXISTING BRIDGE
PROJECT COLONY BOUNDARY
CULVERT
GAS BOX
0 37.5 75 150 225 300 375 Meters
SCALE
CLIENT
Water and Power Development Authority
CONSULTANT
CHINIOT DAM
37-N Model Town Extension Lahore
04
03
02
01
REV. DATE
DESCRIPTION
APPROVED
DRAWN
PASHA
SUBMITTED
CHD/VER.
APPROVED
PROJECT
DETAILED ENGINEERING DESIGN PREPARATION OF BIDDING DOCUMENTS AND PC-I OF CHINIOT DAM PROJECT
CHINIOT DAM LAYOUT PLAN RECOMMENDED
MAP SCALE
DATE
NOV, 2023
FIG NO.
01
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Welcome Address

By

Engr. Najam Waheed,

President Pakistan Engineering Congress

World Environment Day, 2024

June 8, 2024

Honorable Chief Guest

Distinguished Delegates,

Executive Council Members,

Fellow Engineers, Ladies & Gentlemen!

Assalam-o-Alaikum and Good Morning!

It is a matter of great honor and pleasure for me to welcome you all over here on the World Environment Day 2024. This year's theme, "Accelerating Land Restoration, Drought Resilience & Desertification Progress," calls for urgent action to combat the degradation of our land and build resilience in the face of drought and desertification.

Ladies & Gentlemen!

The degradation of our lands, the increasing frequency and severity of droughts, and the relentless march of desertification threaten not only the health of our planet but also the well-being and livelihoods of millions of people around the world. As we gather here today, let us reaffirm our commitment to taking bold and decisive action to reverse these alarming trends and pave the way for a more sustainable and prosperous future for all. Land restoration is a cornerstone of our efforts to combat environmental degradation and promote sustainable development. The degradation of our lands through deforestation, overgrazing, unsustainable farming practices, and urbanization has far-reaching consequences for biodiversity, water resources, food security, and climate stability. Restoring degraded lands through reforestation, sustainable land management practices, and ecosystem restoration not only helps to mitigate climate change but also enhances soil fertility, water retention, and biodiversity.

Ladies & Gentlemen!

Drought resilience is another critical area that requires our immediate attention and action. The increasing frequency and intensity of droughts, aggravated by climate change and unsustainable water management practices, pose a significant threat to food security, water availability, and livelihoods around the world. Drought-prone regions are particularly vulnerable to the impacts of water scarcity, crop failures, and food insecurity, which can lead to widespread poverty, displacement, and social unrest. Building drought resilience requires a multifaceted approach that combines improved water management, climate-smart agriculture, early warning systems, and community-based adaptation measures.

Ladies & Gentlemen!

Desertification, the process of land degradation in arid, semi-arid, and dry sub-humid areas, is a global challenge that undermines the productivity of ecosystems, threatens biodiversity, and displaces communities. Desertification is driven by a combination of

factors, including unsustainable land use practices, overexploitation of natural resources, climate change, and population growth. The expansion of deserts and the degradation of drylands have severe consequences for food security, water availability, and ecosystem health, particularly in vulnerable regions of the world.

Ladies & Gentlemen!

Pakistan, like many countries around the world, faces significant environmental challenges that threaten the health and well-being of our people and the sustainability of our natural resources. From air and water pollution to deforestation and habitat degradation, the stakes have never been higher.

As members of the engineering community, we have a moral obligation to lead by example and drive positive change in our society. Whether it's through sustainable infrastructure projects, renewable energy solutions, or innovative waste management practices, engineers have the power to make a tangible difference in the fight against environmental degradation.

Let us commit ourselves to embracing innovation, collaboration, and solidarity in our efforts to restore our lands, enhance our resilience, and combat desertification. Together, we can make a meaningful difference and leave a positive legacy for the planet and future generations.

I would like to thank you all once again for being with us. May peace and blessings be upon you all.

Thank you.

-.-.-.- Pakistan Paindabad -.-.-.-

Inaugural Address

By

Engr. Syed Abdul Qadir Shah, Chief Guest

At the eve of

World Environment Day, 2024

Held on June 08, 2024

President Pakistan Engineering Congress!

Distinguished Guests!

Participants!

Ladies and gentlemen!

Assalam o Alaekum!

I feel immensely grateful to Pakistan Engineering Congress for giving me the opportunity to listen to the scholarly presentations on the theme of todays' event by eminent environmentalists, climatologists and experts. This year, we come together under the theme of "Land restoration, desertification, and drought resilience." Our planet's health depends on the vitality of its lands, yet we face significant challenges but we have to turn these challenges into opportunities.

Ladies & Gentlemen!

Environment protection and conservations development program in Pakistan draws its inspiration from Stockholm Convention of 1972 held under the umbrella of United Nations. As environment protection ordinance was enacted in 1983 as a starting, followed by National Conservation Strategy (NCS) in 1992. The culmination came in 1997 with enactment of Pakistan Protection Environment Act specifying the National Environment Quality Control Standards as a Benchmark.

In 2001 the Government of Pakistan formulated the National Action Plan to arrest the ever increasing degradation of Environment mainly due to man made errors of Commission.

Ladies & Gentlemen!

It is well known saying that the trees are lungs of the Earth but human being depleted natural resources, cut down forests, led to pollution and global warming. It is high time that we turn to nature and start pursuing it.

Every year World Environment Day is observed to raise awareness about climate change, global warming, deforestation and loss of bio-diversity.

As Generation Restoration, we have a responsibility to act. Countries must fulfill their commitments to restore degraded ecosystems and land. We must use our national climate action plans to halt and reverse deforestation. We must significantly increase financial support for developing nations to adapt to extreme weather, protect nature, and promote sustainable development.

Remember, inaction is costly, but effective action makes economic sense. Every penny invested in ecosystem restoration yields up to thirty times in benefits. Let us work together to build a sustainable future for our land and humanity.

We must embrace sustainable practices, invest in renewable energy, and foster a culture of conservation.

Let us pledge to leave a legacy of a healthier, greener, and more vibrant Earth for future generations. Together, we can forge a path towards a sustainable future, but it requires each one of us to actively participate in this global endeavor.

Ladies & Gentlemen!

In the end, I congratulate Pakistan Engineering Congress for arranging the seminar on such an important subject. I hope the recommendations of the seminar will provide us the way forward for land restoration and drought resilience. I hereby declare the seminar open.

Thank you all.

-.-.-.- Pakistan Paindabad -.-.-.-

SUBJECT: **WORLD ENVIRONMENT DAY, 2024 ACCELLERATING LAND RESTORATION, DROUGHT RESILIENCE AND DESERTIFICATION PROGRESS HELD ON SATURDAY 8TH JUN, 2024 AT CONGRESS HEAD-QUARTER.**

1. Between June and August, 2022 torrential rains and combination of riverine, urban and flash flooding led to an unprecedented disaster in Pakistan. According to the National Disaster Management Authority (NDMA) around 33-Million people that is, one in seven have been affected by the floods. Including nearly 8-Million, displaced. The floods have taken the lives of more than 1700 people, one third of which were children. Rain induced floods, accelerated glacial melt, and resulting Landslides devastated millions of homes and key infrastructure, submerging entire villages and destroying livelihoods. The estimated colossal loss was $ 46400 Million.

Sr. No.	Particulars	Rs. in Billion	$ in Million
1	Damages	3202	14906
2	Loss	3272	15233
	Sub Total	6474	30139
3	Needs	3493	16261
	TOTAL	9,967	46400

2. The Theme of World Environment Day, 2024 ”Accelerating Land Restoration, Drought Resilience and Desertification Progress” adopted World over is an apt Theme keeping in view the massive devastation being wrecked by Environmental disasters World over: The Government of Pakistan is undertaking numerous Projects to combat the colossal adverse effects of climate change etc.

i). **Accelerating Land Restoration”**

The on-going construction of Mohmand Dam Hydro Power Project with 0676 MAF of live storage is a major step for bringing more land under cultivation. It will bring huge Acares of Land under cultivation. The Govt. is also making efforts to cover Multipurpose Diamer Basha Dam Project under CPEC financing. The Asian Development Bank has pledged $100 Million for construction of “MAULONG Dam” Project in Baluchistan (to be constructed under supervision of WAPDA) and bring 47000 Acares of Land under cultivation. The KPK Govt. has also revived “Chashma Project” and allocated Rs.20 Billion in 2024-25 Budgets for its completion.

II). **Droughts Resilience.**

Shortage of Water Spells economic misery and food shortage. This calls for proper/equitable management of use of surface and under-ground-Water. As the consumption of ground Water has reduced the Level of aquifers, artificial recharge of Ground Water is on the anvil. Shortage of Water can also be solved by construction of under-ground Water Reservoirs for Storage of Flood/Rain Water. Rain harvesting is also being successfully accomplished in a number of Countries.

iii). **Desertification Progress.**

It requires afforestation of fellow Lands on a massive scale. Effort was made in the recent past for plantation of 10 Billion Trees. This effort should continue because only 5% Land of the Country is under forests viz-a-viz the minimum 25%. The salinity

and Water logging menace is turning huge Tracts of Land uncultivable WAPDA"s International Water and Salinity Research Institute (IWASRI) is mandated to check it alongwith other Institutions.

3. Inaugural address was delivered by the Chief Guest Engr. Abdul Qadir Shah, Welcome Address by Engr. Najam Waheed, President, PEC. Specialists of Land, Water and Environment affairs presented under mentioned papers:

"NAVIGATING CLIMATE CHALLENGES: THE MULTIFACETED IMPACT OF CLIMATE CHANGE ON PAKISTAN (REVIEW PAPER)"

"ASSESING THE ENVIRONMENTAL IMPACTS OF DROUGHTS AND DESERTIFICATION IN PAKISTAN CHALLENGES AND MITIGATION STRATEGIES"

"INNOVATIVE TREND ANALYSIS PRECIPITATION, TEMPERATURES AND SPI (STANDARD PRECIPITATION INDEX) DROUGHT INDEX OF LAHORE"

"ROLE OF SALINITY MAPPING IN CONTROL OF DESERTIFICATION PROGRESS AND ACCELERATING LAND RESTORATION"

"ROLE OF AFFORESTATION INITIATIVES IN RESTORATION AND SUSTAINABILITY OF LAND ECOSYSTEMS AND CLIMATE MITIGATION IN PAKISTAN"

"COMPREHENSIVE STRATEGIES FOR LAND RESTORATION, DROUGHT RESILIENCE, AND COMBATTING DESERTIFICATION IN PAKISTAN" (VIA ZOOM)

"REDUCED TILLAGE SYSTEM AS A CLIMATE SMART AGRICULTURE TECHNOLOGY FOR RAINFED AREAS" (VIA ZOOM)

"ACCELERATING LAND RECLAMATION AND COMBATING DESERTIFICATION: EXPLORING THE MICROBIAL WAY FORWARD" (VIA ZOOM)

"TEMPORAL ANALYSIS OF LAND DEGRADATION IN THE INDUS DELTA: IMPLICATIONS FOR ENVIRONMENTAL SUSTAINABILITY" (VIA ZOOM)

After presentation of papers the Chief Guest summed up the discussions and an overall assessment. After it a lively Questions/Answers Session ensued, At the end Pakistan Engineering Congress Shields were presented to the Speakers by the Chief Guest along-with President, PEC/Chairman of Technical Session. Pakistan Engineering Congress Shield was also presented to the Chief Guest Engr. Abdul Qadir Shah by Engr. Najam Waheed, President, PEC and Engr. Dr. Javed Iqbal Session Chairman.

World Environment Day 2024 on the theme of "Accelerating Land Restoration, Drought Resilience & Desertification Progress" Commemorated at Pakistan Engineering Congress Headquarter on Saturday June 8, 2024



Engr. Muhammad Ammar Member Executive Council Conducting the Proceedings



Engr. Najam Waheed President-PEC Presenting Welcome Address at the event



Chief Guest Engr. Syed Abdul Qadir Shah Speaking on the theme of Accelerating Land Restoration, Drought Resilience & Desertification Progress



(From Left) Engr. Dr. Javed Iqbal Chairman of the Technical Session, Engr. Najam Waheed President-PEC, Chief Guest Engr. Syed Abdul Qadir Shah, Engr. Muhammad Ammar Publicity Secretary- PEC

Glimpses of Audiences



(From Left in Front Row) Engr. Najam Waheed President-PEC, Engr. Husnain Ahmad Vice President-PEC, Engr. Syed Abdul Qadir Shah Former Chairman Pakistan Engineering Council Chief Guest, Engr. M. Anwar Qaseem Qureshi Joint Secretary-PEC, Engr. Riaz Ahmad Khan Former President-PEC, Engr. Riaz Nazir Tarar Associate NDC.



(From Left) Engr. Ch. Ghulam Hussain Former President-PEC, Engr. Dr. Javed Iqbal Member Executive Council-PEC, Engr. Sh. Mushtaq Ahmad, Engr. Syed Nafasat Raza Former Secretary-PEC, Engr. Dr. Muhammad Saeed Member Executive Council-PEC

Glimpses of Audiences



(From Right) Engr. Iftikhar Ahmad Former President-PEC, Engr. Muhammad Ibrahim Malik Member Executive Council-PEC, Engr. Syed Jawad Hussain Shah Member Pakistan Engineering Council, Engr. Muhammad Hassan



(From Left) Engr. Ch. Muhammad Arif Vice President-PEC, Engr. Zubair Emran Khawaja, Engr. Nayyar Saeed Secretary-PEC, Engr. M. Anwar Qaseem Qureshi Joint Secretary-PEC, Engr. Riaz Ahmad Khan Former President-PEC, Engr. Riaz Nazir Tarar Associate NDC.

Glimpses of Audiences





Glimpses of Audiences



From Left) Seen in Picture Engr. Syed Jawad Hussain Shah Member Pakistan Engineering Council, Engr. Muhammad Hassan, Engr. Syed Nafasat Raza Former Secretary-PEC, Engr. Nayyar Saeed Secretary-PEC, Engr. Muhammad Ibrahim Malik Member Executive Council, Engr. Iftikhar Ahmad Former President-PEC



(From Left) Engr. Ch. Muhammad Arif Vice President-PEC, Engr. Zubair Emran Khawaja, Engr. Nayyar Saeed Secretary-PEC, Engr. M. Anwar Qaseem Qureshi Joint Secretary-PEC, Engr. Riaz Ahmad Khan Former President-PEC, Engr. Riaz Nazir Tarar Associate NDC.

Glimpses of Audiences





(From Left) Engr. Ch. Ghulam Hussain Former President-PEC, Engr. Capt. (R) M. Qadir Khan Vice President-PEC, Engr. Sh. Mushtaq Ahmad, Engr. Dr. Muhammad Saeed Member Executive Council-PEC

Questions / Answers Session



Engr. Husnain Ahmad Vice President Pakistan Engineering Congress in deep Conversation with a Speaker in Context of Presentation



Mr. Kamran Zulfiqar

Questions / Answers Session



Engr. Capt. (R) M. Qadir Khan raising some Point with the Speaker



Chairman of the Session Engr. Dr. Javed Iqbal, Summing-up the Presentations by the Speakers



(From Right) Engr. Najam Waheed President-PEC, Engr. Syed Abdul Qadir Shah Chief Guest, and Engr. Dr. Javed Iqbal Chairman of the Session presenting Pakistan Engineering Congress Shield to Engr. Arslan Imtiaz Presenting paper on "Navigating Climate Challenges: the Multifaceted Impact of Climate Change on Pakistan (Review Paper)"



(From Right) Engr. Najam Waheed President-PEC, Engr. Syed Abdul Qadir Shah Chief Guest, and Engr. Dr. Javed Iqbal Chairman of the Session presenting Pakistan Engineering Congress Shield to Ms. Rimsha Azhar Presenting paper on "Assessing the Environmental Impacts of Droughts and Desertification in Pakistan Challenges and Mitigation Strategies"



(From Right) Engr. Najam Waheed President-PEC, Engr. Syed Abdul Qadir Shah Chief Guest, and Engr. Dr. Javed Iqbal Chairman of the Session presenting Pakistan Engineering Congress Shield to Mr. Hafiz Raziullah Presenting paper on "Innovative Trend Analysis Precipitation, Temperatures and SPI (Standard Precipitation Index) Drought Index of Lahore"



(From Right) Engr. Najam Waheed President-PEC, Engr. Syed Abdul Qadir Shah Chief Guest, and Engr. Dr. Javed Iqbal Chairman of the Session presenting Pakistan Engineering Congress Shield to Mr. Raheel Mustafa Presenting paper on "Role of Salinity Mapping in Control of Desertification Progress and Accelerating Land Restoration"



(From Right) Engr. Najam Waheed President-PEC, Chief Guest Engr. Syed Abdul Qadir Shah, Engr. Dr. Javed Iqbal Chairman of the Session presenting Pakistan Engineering Congress Shield to Ms. Khadija Aslam Presenting paper on "Role of Afforestation Initiatives in Restoration and Sustainability of Land Ecosystems and Climate Mitigation in Pakistan"



(From Right) Engr. Najam Waheed President-PEC, Chief Guest Engr. Syed Abdul Qadir Shah, Engr. Dr. Javed Iqbal Chairman of the Session presenting Pakistan Engineering Congress Shield to Ms. Nimra Ashraf Presenting paper on "Role of Afforestation Initiatives in Restoration and Sustainability of Land Ecosystems and Climate Mitigation in Pakistan"



(From Right) Engr. Najam Waheed President-PEC, Engr. Syed Abdul Qadir Shah presenting Pakistan Engineering Congress Shield to Engr. Dr. Javed Iqbal Chairman of the Technical Session



(From Right) Engr. Najam Waheed President-PEC, along with Engr. Dr. Javed Iqbal Chairman of the Technical Session presenting Pakistan Engineering Congress Shield to Chief Guest Engr. Syed Abdul Qadir Shah

SUPPLEMENT

Seminar on "Artificial Intelligence / Nano Technology" held on Saturday, February 18, 2023 at 10:0 A.M. at Mashhadi Hall of Pakistan Engineering Congress at 4th Floor, 97-A/D-1, Liberty Market, Gulberg III, Lahore

Chairman: Engr. Iftikhar-ul-Haq

Co-Chairman: Engr. Dr. Muhammad Riaz

Tilawate Quran-e-Pak:

The proceedings commenced with the recitation fo Verses from the Holy Quran.

The following papers were presented.

- Applications of Emerging Technology for Public Good
- Functional Nano Materials for Bio Medical Applications
- From Model to Data Driven A-I. A Case of Urdu Language Processing

After the presentation of the papers lively Questions / Answers Session ensued Engr. Iftkhar-ul-Haq, Chairman of Session summed-up and gave an overview thereof.

At the end Pakistan Engineering Congress shields were presented to speakers by Engr. Iftikhar-ul-Haq and Engr. Muhammad Riaz, Chairman / Co-Chairman of Technical Sesion respectively. Pakistan Engineering Congress Shields were also conferred by President, PEC on Chairman and Co-Chairman of the Technical Session. It was very well attended meeting.

NANOTECHNOLOGY; the art of controlling and engineering of materials at the nano-scale (typically 1 to 100 nanometers), has revolutionizing various areas of daily life from advanced machining to health sector by introducing new properties and capabilities. Unprecedented opportunities and properties have been discovered by reengineering existing products and devices at nano level. Nanotechnology holds immense potential to transform and improve the quality of life through advancements in healthcare, energy, electronics and materials science. It's importance is understood by its ability to create new economic opportunities, address global challenges, and drive scientific innovation.

Nanotechnology offers exceptional capabilities due to precise control at atomic level to improve various aspects of human life and environment using resources more efficiently. It's importance stems from its ability to enhance materials and devices by exploiting unique properties that emerge at the nanoscale such as surface area, quantum effects, and ability to interact with biological systems at the molecular level enabling innovations that were previously unattainable.

The glimpse of few current applications and future trends in nanotechnology are listed below.

- **Transformative impact across multiple industries**

Energy and Environment: nanomaterials quantum dots and nanowires enhance the efficiency of renewable energy devices. Nanotechnology provides advanced solutions for water purification, air filtration, soil remediation and capable to remove contaminants such as heavy metals, organic pollutants and pathogens at nano level.

Materials Science: the manipulation and engineering of materials at nanoscale enable to grow materials with superior and optimized properties such as strength,

durability, and thermal resistance. Another important aspect is the capability to develop self-healing materials that can repair themselves when damaged, extending their lifespan and reducing maintenance costs.

Electronics and Information Technology: The miniaturization, flexible and wearable electronics components and devices lead to more powerful, efficient and compact electronic devices. Nanotechnology is critical in the development of quantum computers and neuromorphic computing, that mimic neural networks, offering enhanced processing power and efficiency

Healthcare and Medicine: nano devices enables to detect disease biomarkers at very low concentrations and nanoscale targeted drug delivery system can deliver medicine medications directly to disease cells minimizing side effects and improving efficiency.

- **Economic and Societal Benefits:**

Economic Growth: Nanotechnology creates new markets and opportunities for innovation across industries driving economic growth. The global nanotechnology market is projected to grow significantly, with applications in healthcare, electronics energy and more.

Interdisciplinary Research: Nanotechnology fosters collaboration between different scientific disciplines including physics, biology, and engineering, leading to new insights and breakthroughs which contribute to fundamental discoveries about the behavior of materials at the nanoscale, providing insights into quantum mechanics and molecular interactions.

Seminar on the theme of "Artificial Intelligence / Nano Technology" Commemorated at Pakistan Engineering Congress Headquarter on Saturday February 18, 2023



Engr. Muhammad Ammar Member Executive Council Conducting the Proceedings



(From Left) Engr. Dr. Muhammad Riaz Co-Chairman of the Technical Session, Engr. Iftikhar ul Haq Chairman of the Technical Session, Engr. Najam Waheed President-PEC, Engr. Muhammad Ammar Publicity Secretary- PEC

Glimpses of Audiences





Glimpses of Audiences





Glimpses of Audiences





Questions / Answers Session



Engr. Riaz Nazir Tarar



Engr. Capt. (R) M. Qadir Khan

Questions / Answers Session





Ms. Fouzia

Questions / Answers Session



Ms. Shumaila



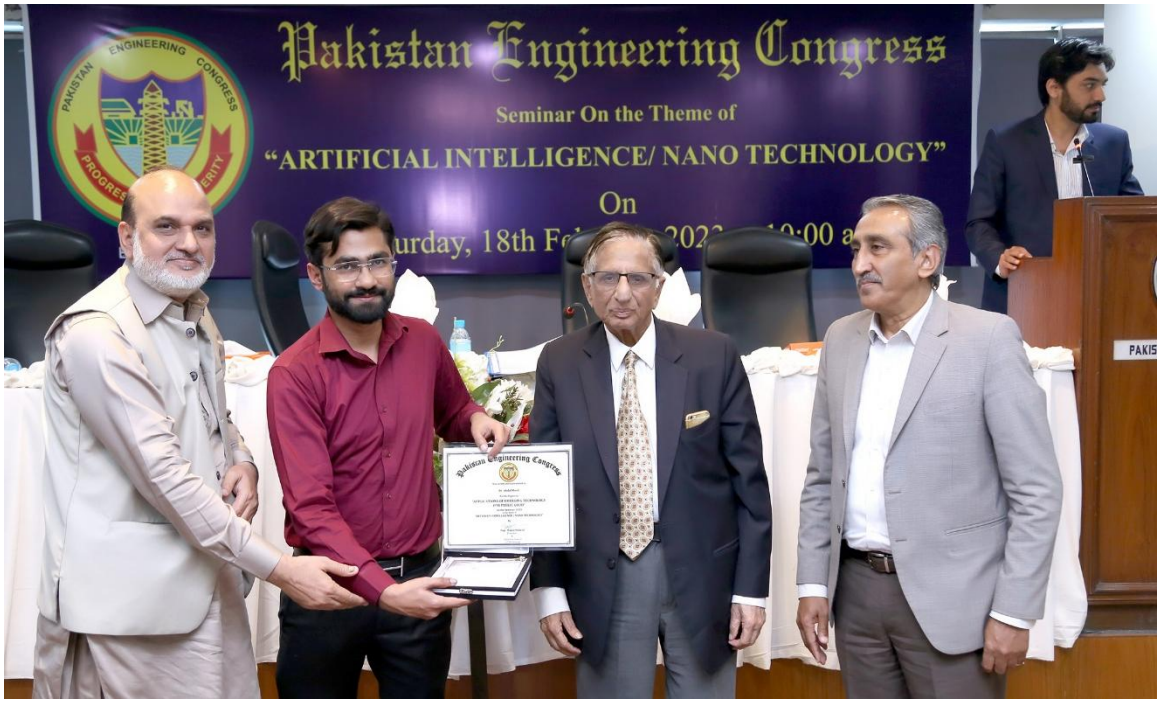
Engr. Amir Yaqoob



Co-Chairman of technical Session Engr. Dr. Muhammad Riaz, Summing-up the Presentations by the Speakers



Chairman of technical Session Engr. Iftikhar ul Haq, Summing-up the Presentations by the Speakers



(From Right) Engr. Najam Waheed President-PEC, Engr. Iftiikhar ul Haq Chairman of the Technical Session and Engr. Dr. Muhammad Riaz Co-Chairman of the Session presenting Pakistan Engineering Congress Shield to Mr. Akif Rehman for his paper on "The Role of Nano Technology in Clean Energy Devices"



(From Right) Engr. Najam Waheed President-PEC, Engr. Iftiikhar ul Haq Chairman of the Technical Session and Engr. Dr. Muhammad Riaz Co-Chairman of the Session presenting Pakistan Engineering Congress Shield to Prof. Dr. Irshad Hussain for his paper on "Functional Nano Materials for Bio Medical Applications"



(From Right) Engr. Najam Waheed President-PEC, Engr. Iftiikhar ul Haq Chairman of the Technical Session and Engr. Dr. Muhammad Riaz Co-Chairman of the Session presenting Pakistan Engineering Congress Shield to Prof Dr. Khurram Shahzad for his paper on "From Model to Data Driven A-I. A Case of Urdu Language Processing"



(From Right) Engr. Najam Waheed President-PEC, Engr. Iftiikhar ul Haq Chairman of the Technical Session and Engr. Dr. Muhammad Riaz Co-Chairman of the Session presenting Pakistan Engineering Congress Shield to Dr. Abdul Basit for his paper on "Applications of Emerging Technology for Public Good"



(From Right) Engr. Najam Waheed President-PEC presenting Pakistan Engineering Congress Shield to Engr. Dr. Muhammad Riaz Co-Chairman of the Technical Session



(From Right) Engr. Najam Waheed President-PEC presenting Pakistan Engineering Congress Shield to Engr. Iftikhar ul Haq Chairman of the Technical Session

MEMORIAL REFRERRENCE OF ENGR. MAHMOOD UL HASSAN SIDDIQUI HELD AT MASHHADI HALL OF PAKISTAN ENGINEERING CONGRESS HEAD-QUARTER ON 16.09.2023

SUBJECT: ENGR. MAHMOOD UL HASSAN SIDDIQUI – A VERTERAN ENGINEER, A LEGEND IN OWN LIFE TIME.

Engr. Mahmood ul Hassan Siddiqui, was born on 25th April, 1927 and passed away on 10-04-2023 in Service as Chief Engineer/Consultant to Govt. of Punjab Irrigation Department for following Cardinal Assignments:

- Implementation of Indus Water Treaty-1960
- Apportionment of the Water of Indus River System between Provinces of Pakistan.
- Irrigation problems of Punjab

The late Engr. Mahmood ul Hassan Siddiqui had an impressive record of Accomplishments:

i). BSc. (Civil Engineering) in First Division from Aligarh Muslim University (Aligarh-India) in 1946 with Distinction in the following subjects:

* Docks: Harbors and Water supply Engineering.
* Structural and Steel work design.

ii). Awarded “Tamgha-i-Imtiaz” by Govt. of Pakistan-2003

iii). Institution of Engineers (IEP) National Excellence Award, 2012.

iv). Conferred with the Title of Mohafiz-e-Aab in 2016 by “Punjab Kisan Boards & Progressive Farmers of Punjab” for meritorious Services”

v) Student Engineer Punjab PWD, Building and Road Branch received practical training in the Construction and Maintenance of Buildings, Roads and High-Ways.

vi). Lecturer in Building Construction and Drawings in Govt. School of Engineering, Rasul.

Apportionment of the Waters of the Indus River System between the Provinces of Pakistan:

21stMarch, 1991, will go down in the history of Pakistan as a pivotal breakthrough in its leap towards the 21st century and turning point in its march towards national consolidation. On that day was unraveled a dispute that had been festering in this part of the subcontinent for the past seventy years. As a follow-up to the meeting of the Chief Ministers at Lahore on March 3, 1991, a meeting of the representatives of the four provinces was held at Lahore on March 04, 1991. Another meeting was held at Karachi on March 16,, 1991. The list of participants is attached:

1. There was an agreement that the issue relating to Apportionment of the Waters of the Indus River System should be settled as quickly as possible.
2. In the light of the accepted water distributional principles the following

apportionment was agreed to:

PROVINCES	KHARIF	RABI	TOTAL
PUNJAB	37.07	18.87	55.94
SINDH	33.94	14.82	48.76
KHYBER PAKHTUNKHWA	3.48	2.30	5.78
(B) CIVIL CANALS	1.80	1.20	3.00
BALOCHISTAN	2.85	1.02	3.87
TOTAL	77.34 +1.20	37.01 +1.20	114.35 +3.00

*Including already sanctioned Urban and Industrial uses for Metropolitan Karachi.

**Un-gauged Civil Canals above the rim stations.

3. N.W.F.P. (Now KPK) /Baluchistan Projects which are under execution have been provided their authorized quota of water as existing uses.
4. Balance river supplies (including flood supplies and future storages) shall be distributed as below:

Punjab	Sindh	Baluchistan	KPK	TOTAL
37%	37%	12%	!4%	100%

5. Industrial and Urban Water supplies for Metropolitan City, for which there were sanctioned allocations will be accorded priority.
6. The need for storages, wherever feasible on the Indus and other rivers was admitted and recognized by the participants for planned future agricultural development.
7. The need for certain minimum escapage to sea, below Kotri to check sea intrusion was recognized. Sindh held the view, that the optimum level was 10 M.A.F., which was discussed at length, while other studies indicated lower/higher figures. It was, therefore, decided that further studies would be undertaken to establish the minimal escapage needs down stream Kotri.
8. There would be no restrictions on the Provinces to undertake new projects within their agreed shares.
9. No restrictions are placed on small schemes not exceeding 5000 acres above elevation of 1200 ft. SPD.
10. No restrictions are placed on developing irrigation uses in the Kurram/Gomal/Kohat basins, so long as these do not adversely affect the existing uses on these rivers.
11. There are no restrictions on Baluchistan, to develop the Water resources of the Indus right bank tributaries, flowing through its areas.
12. The requirements of Left Bank Out-Fall Drain (LBOD) will be met out of the flood supplies in accordance with the agreed sharing formula.
13. For the implementation of this accord, the need to establish an Indus River System Authority was recognized and accepted. It would have headquarters at Lahore (Now in Islamabad) and would have representation from all the four provinces.
14. The system-wise allocation will be worked out separately, on ten daily basis and will be attached with this agreement as part and parcel of it:

    a). The record of actual average system uses for the period 1977-82, would for the guide-line for developing a future regulation pattern. These ten daily uses would be adjusted pro-rata to correspond to the indicated seasonal

allocations of the different canal systems and would form the basis for sharing shortages and surpluses on all Pakistan basis.

b). The existing reservoirs would be operated with priority for the irrigation uses of the Provinces.

c). The Provinces will have the freedom within their allocations to modify system-wise and period-wise uses.

d). All efforts would be made to avoid wastages. Any surpluses may be used by another Province, but this would not establish any rights to such uses.

A large number of Distinguished Engineers (Annex-I) spoke on the meritorious contribution of the Late Engr. Mahmood ul Hassan Siddiqui spelling out the distinctive work. Guidelines imported spanning over the long period.(Now in Islamabad)

(Contributed by Engr. Dr. Mazhar Hussain Mahu of Punjab Government).

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Participants of Meeting of Indus River Waters in Provinces. March 04, 1991

List of Participants:

1. Mr. Ghulam Hyder Wyne	Chief Minister, Punjab
2. Mr. Jam Sadiq Ali	Chief Minister Sindh
3. M. Afzal Khan	Chief Minister, NWFP.
4. Mr. Mir Taj Muhammad Jamali. Baluchistan	Chief Minister
5. Mr. Shah Mahmood Qureshi.	Minister Finance Punjab.
6. Mr. Muzaffar Hussain Shah.	Minister Law Sindh
7. Mr. Mohsin Ali Khan.	Minister Finance, NWFP
8. Mr. Zulifqar Ali Magsi.	Minister Home, Baluchistan.
9. Mr. Fareed Khan Toofan. NWFP.	Minister for Irrigation Govt. of
10. Mr. Mazhar Ali	Advisor, Government of Punjab.
11. Mr. Muhammad Alam Baluch	ACS (I&P)/Advisor, Govt. of Sindh
12. Mr. Khalid Aziz	ACS(P&D), Govt. of NWFP
13. Mr. Muhammad Amin	Secretary (I&P) , Govt. of Baluchistan
14. Mr. Rana Khursheed Anwar	Secretary (I&P), Govt. of Punjab.
15. Mr. Perez Masud Punjab	Chief Secretary, Govt. of
16. Mr. M. H. Siddique	Director Regulation, Govt. of Punjab.
17. Mr. Abdul Aziz Shaikhj	Advisor (WD), Govt. of Sindh
18. Mr. Allah Bux Baloch	XEN: Govt. of NWFP
19. Mr. Muhammad Ibrahim	XEN Govt. of Baluchistan.
20. Mr. Faqir Ahmed Paracha NWFP	Secretary (I&P), Govt. of

MEMORIAL REFRERRENCE OF ENGR. MAHMOOD UL HASSAN SIDDIQUI

PROFILE OF ENGR.MAHMOOD-UL-HASSAN SIDDIQUI (LATE)

History is full of eminent scholars, scientists and engineers worldwide who have contributed for the welfare of nations and the humanity at large. As regards the subcontinent, considering India and Pakistan, the green revolution was brought by the British government while ruling this area. Although the fertile land with round the year following of rivers existed in pre British rule, however, it could not be benefited for the uplift of future growing needs of the population in the area. The massive irrigation system for the fertile land was developed with construction of many dams and gravity flow irrigation canals from the head works leading to minor canals and extended these into water courses to irrigate lands.

After the partition of Pakistan and India, the canal system was divided accordingly between Pakistan and India. Engineers in Pakistan worked dedicatedly and developed and operated not only the existing network but constructed replacement works under the Indus Water Treaty 1960, including major Dams and link Canals to feed the area which was deprived of irrigation flow due the result of Indus Waters Treaty, 1960.

Engineer Mahmood ul Hassasn Sidddiqui, born in Gujranwala and graduated from Aligarh Muslim Engineering College was one of our eminent engineers who started his career in Irrigation and Power Department of the Government of Punjab Pakistan in 1950. He did not only participated in construction of gigantic canals system but also achieved expertise in operation of these canals which was the most difficult task after replacing the flow from various rivers into the link canals and then into the feeder canals keeping in view the demand of the land with certain crop patterns. He proved to be an icon in the distribution and operation of canals and served the department till his last breath. He proved to be a matchless expert in his area of engineering. He trained hundreds of new engineers in the department and was titled as the Father/Baby Engineers.

In addition to his own important and delicate assignment, Mr. Mahmood ul Hassan Siddiqui was declared by his department as a permanent Advisor to the Pakistan Commissioner for Indus Water (PCIW) for implementation of the Indus Basin Treaty 1960. The Office of PCIW has been benefiting from his expertise and accordingly Mr. Mahmood ul Hassan Siddiqui, participated in almost one hundred meetings of the Permanent Indus Commission and Site Inspection in India, Occupied Jammu and Kashmir, AJK and Pakistan as a representative of the Government of the ,Punjab.

Mr. Mahmood ul Hassan Siddiqui also drafted the Government of Punjab's part of sharing of water of the Indus system of rivers in the Water Apportionment Accord signed between the four Provinces of Pakistan in 1991. He was nominated as a permanent Technical representative of the Government of Punjab in IRSA and served in this capacity till his last breath.

Mr. Mahmood ul Hassan Siddiqui due to his God gifted capabilities used to present his department as a Consultant and Advisor in dealing with NESPAK and other Provinces regarding construction, remodeling and operation of canal system. In reward to his expertise and services rendered to Pakistan, he was honored with Tamgha-e-Imtiaz in 2003 by the President of Islamic Republic of Pakistan. The Institute of Engineers Pakistan, extended their National Excellence Award to Engr. Mahmood

ul Hassan Siddiqui in 2012. He also achieved the Title of Mohafiz-e-Aab in 2016 on account of his meritorious services for Pakistan.

He enjoyed a very respectable and high ranking position in the Irrigation and Power Department of the Government of Punjab and at the same time was one of the most popular persons amongst his colleagues and friends. His personal and family life is also full of success. However, the day of 10th April, 2023 became very heavy on the engineering community in Pakistan and his family and friends when he passed away from this World very quietly (Inna Lillahe Wa Inna Elaihe Rajeun

INDUS BASIN TREATY 1960 CONTRIBUTION 0F ENGR. MAHMOOD UL HASSAN SIDDIQUI (LATE)

The world as well as the Civil Engineers of the country received the sad news of loss of Engr. Mahmood ul Hassan Siddiqui on 10th April, 2023 (Inna Lillahe Wa Inna Elaihe Rajweun)

No doubt the name of Engr. Mahmood ul Hassan Siddiqui needs no introduction in Governmental and private spheres of experts of Water Resources Engineering. After completing his B.Sc. (Civil Engineering Degree) from Aligarh Muslim University, Aligarh, he chose to devote his life for the development of newly created Pakistan by joining the Government services at Punjab Irrigation Department in 1950s. His distinguished experience and services in the fields of planning and design of Irrigation infrastructures, Head-works, Water management tasks of equitable supplies in canal systems, SCARP Tube-wells, small dams and Transboundary water issues have certainly been commendable.

His devoted services in finalizing Water Apportionment Accord 1991 were remarkable. In the matters pertaining to Transbundary waters with India Engr. Mahmood ul Hassan Siddiqui, with his vast knowledge of negotiations of the Indus Waters Treaty 1960, provided valuable input under the ambit of Treaty provisions and his extensive experience through the office of Pakistan Commissioner for Indus Water (PCIW).

At the level of Permanent Indus Commission, the name of Engr. Mahmood ul Hassan Siddiqui first surfaced as an adviser to PICW during 50th meeting held at Islamabad in June, 1980 when he was serving as Director Indus Water Treaty and Regulation in Punjab Irrigation Department, Lahore. With nothing less than exceptional he contributed to the Government Level Negotiations/Meetings along with his participation at the Commission Level Meetings/Negotiations in resolving the matters of design differences of various hydroelectric plants, for instance Wuller Barrage/Tulbul Navigation Project as well as the matters under resolution at third forum i.e. Baglihar HEP case, Kishenganga Arbitration case etc. Due to his vast institutional memory and technical expertise the Government of the Punjab continued to hire his services even after retirement as Consultant, Punjab Irrigation Department till his last breath. Since 1980 till 2015 Engr. Mahmood ul Hassan Siddiqui took part in various significant Meetings of the Permanent Indus Commission. He attended his last meeting of the Commission, i.e. 115th PIC Meeting, in August 2018 at Lahore.



For the smooth conduct of Tours of Inspection of Permanent Indus Commission to barrages and other irrigation works regulated under Punjab Irrigation Department he spearheaded elaborate arrangements and sound technical briefings up to the level, which was appreciated even by the Indian side.



Just like his professional skills the words don't fall as easily avoidable for saying something about his extra-ordinary personal attributes. He was very affectionate, polite, soft-hearted and always ready to help and wisely guide/advise anytime anywhere both professionally and otherwise. Whoever met him never felt that it's his first meeting with him.



As a bearer of Tamgha-e-Imtiaz in 2003 by the President of Pakistan, The IEP National Excellence Award in 2012 and a most coveted of all the titles of Mohafiz-e-Aab in 2016 on account of his meritorious services for Pakistan, his name would be remembered among water resources engineers and in the history safeguarding water rights of Pakistan.

Memorial reference of Engr. Mahmood ul Hassan Siddiqui on 16-09-2023



Engr. Amjad Saeed Former President Pakistan Engineering Congress, Presently Member IRSA Punjab.



Engr. Najam Waheed President Pakistan Engineering Congress



Mr. Muhammad Adeel Anjum



Engr. Suleman Najib



Mr. Faisal Hassan



Mr. Munawar Hassan



Engr. Habib Ullah



Engr. Dr. Muhammad Abid Bodla Member Infrastructure Development (P&D) Punjab



Engr. Riaz Ahmad Khan Former President Pakistan Engineering Congress



Dr. Ahmed Javed



Capt. (R) Saif Anjum



Dr. Arif Mahmood Siddiqui Son of Engr. Mahmood ul Hassan Siddiqui

Glimpses of Audiences



(From Left) Dr. Arif Mahmood Siddiqui Son of Engr. Mahmood ul Hassan Siddiqui, Engr. Riaz Ahmad Kham Former President Pakistan Engineering Congress, Engr. Najam Waheed President Pakistan Engineering Congress



Family of Late Engr. Mahmood ul Hassan Siddiqui

Glimpses of Audiences





Glimpses of Audiences





Engr. Najam Waheed President Pakistan Engineering Congress Presenting Congress Shield to Dr. Arif Mahmood Siddiqui Son of Engr. Mahmood ul Hassan Siddiqui

IMF GRILLS PAKISTAN ON POWER RATES

By

Shahbaz Rana

ISLAMABAD: As consumers prepare to face three major electric shocks in July, the International Monetary Fund (IMF) has advised Pakistan to finalise the next increase in power tariffs based on further rupee devaluation instead of assuming the current stable value of the local currency.

The IMF's 'advice' could further compound the problems of electricity consumers because the government has worked out next year's up to Rs7 per unit electricity increase in rates based on a stable exchange rate, according to energy ministry sources.

The IMF raised the issue of exchange rate devaluation during a meeting with the National Electric Power Regulatory Authority (NEPRA), said the sources.

They stated that the IMF also questioned the incorrect electricity consumption assumptions used for the current fiscal year's annual power tariff adjustments. The higher consumption estimates, subsequently proven wrong, resulted in a hefty increase in electricity bills due to monthly and quarterly tariff adjustments.

The sources said that Pakistani authorities apprised that the upcoming increases in electricity prices would overburden consumers due to multiple increases on account of monthly fuel adjustments, quarterly adjustments, and the upcoming big annual base tariff increase.

Pakistan has informed the IMF that electricity prices may skyrocket in July due to simultaneous adjustments on account of monthly, quarterly, and annual increases in tariffs.

NEPRA has also scheduled a hearing on the coming Thursday to determine the annual base tariff adjustment. The IMF team is in town until May 23rd to gauge the government's readiness to undertake tough measures and approve the next budget before presenting it to the federal cabinet and Parliament.

Domestic consumers are already paying up to Rs62 per unit for electricity, significantly contributing to suppressed demand and shifting to alternate energy sources.

The sources said the Ministry of Energy faced tough questions over its incorrect and unrealistic estimates of electricity consumption during this fiscal year. It was also revealed during these discussions that NEPRA did not have any in-house capacity to work out assumptions and had to rely on whatever the Ministry of Energy shared with it.

It had assumed a 7% increase in electricity consumption for this fiscal year, which in fact dropped compared to the previous year. The wrong estimates led to a lesser increase in the annual base tariff in July last year but caused heavy increases in prices due to monthly and quarterly adjustments, said the sources. The sources said Pakistani authorities admitted before the IMF that the 7% demand growth assumptions were unrealistic. They assured that for the next year, demand would be projected around 3% to avoid a higher-than-anticipated increase in prices during the fiscal year.

The sources said the IMF viewed consumers as 'worse off' because of wrong estimates by the Ministry of Energy.

The issue of the applicable exchange rate for working out prices also surfaced during Pakistan-IMF meetings. The IMF advised Pakistan to consider the average depreciation in the value of the rupee for working out next year's annual base tariffs instead of reflecting a stable value.

The IMF assumed the rupee would be devalued to Rs329 to a dollar or 18% by June next year. It is not clear what value of the rupee it has recommended for working out the next base price increase.

The IMF was also inquisitive about a lag in passing on the impact of the increase in electricity prices due to quarterly adjustments.

The sources said that due to incorrect estimates coupled with systemic inefficiencies, the circular debt may end up at least at Rs2.450 trillion, as against the target of Rs2.310 trillion. They said Pakistani authorities admitted before the IMF that the circular debt reduction target would be missed by a margin of Rs138 billion.

However, they assured that efforts would be made to recover Rs20 billion of the quarterly adjustment within this fiscal year to keep the circular debt around Rs2.430 trillion. Missing the circular debt reduction target is a serious issue that highlights the mismanagement of the energy ministry.

The sources said NEPRA would provide realistic numbers of electricity demand and exchange rate to the IMF, which will be used for working out electricity price increase calculations.

Energy and taxation emerged as the two contentious topics of discussion during the past one-week IMF negotiations. However, it seems neither the IMF nor the government were learning their lessons and would repeat the same mistakes in the shape of further increasing taxes and electricity prices.

Courtesy: Published in The Express Tribune, May 18th, 2024.

BANK FINANCING HITS RECORD HIGH

By

Salman Siddiqui

KARACHI: Pakistan's commercial banks have continued to freely lend to the cash-strapped government at elevated rates of return, taking their financing to a record high of 93% of total deposits in January 2024.

According to data compiled and shared by Optimus Capital Management (OCM), banks' credit to the private sector, however, remained stagnant at the eight-month low at 44% of deposits in January. Higher inflation and interest rates did not allow businesses to expand their production lines and also set up new factories.

Bank deposits ticked down to Rs27.54 trillion in January compared to Rs27.84 trillion in December 2023, as "rich depositors apparently withdrew cash that they had deposited in December on the request of banks to allow financial institutions to maintain their books with good numbers," Arif Habib Limited (AHL) economist Sana Tawfik said while talking to The Express Tribune.

She said the government's reliance on domestic debt was on the rise due to lesser foreign loan inflows for quite a long time.

Data suggests that banks invested Rs25.60 trillion in government debt securities like T-bills, Pakistan Investment Bonds (PIBs) and Sukuk out of the total deposits of Rs27.54 trillion. This led to a rise in the investment-to-deposit ratio (IDR) to the all-time high of 93% in January.

The IDR stood at 85% a year ago in January 2023 and at 91% in December 2023. Government borrowing from domestic banks is on the rise to finance the fiscal deficit widening primarily due to a significantly high interest cost on debt. The record high policy rate of 22% is estimated to push interest payments beyond Rs8 trillion in this fiscal year.

A one-percentage-point rise in interest rate increases interest cost by around Rs200-250 billion a year. The central bank cumulatively jacked up its key policy rate by 15% between September 2021 and June 2023.

Financial markets hope that the central bank will start slashing the policy rate in March or April this year, which will result in a reduction in interest payments and will encourage private businesses to borrow from banks for their existing and new investment projects.

The government has continued to increase borrowing from commercial banks since the International Monetary Fund (IMF) barred it from taking loans from the State Bank of Pakistan (SBP) in mid-2019. It is believed that central bank lending triggers inflation in the economy.

Credit to private sector

Credit flow to the private sector remained stagnant at Rs12.09 trillion in January 2024 out of the total deposits of Rs27.54 trillion, as a result of which the advances-to-deposit ratio (ADR) stood at 44% for the second consecutive month.

The ADR had been on the wane in the prior eight months and reached 44% in December 2023 compared to 52% in April 2023.

AHL's Tawfik said the ADR dropped also due to the change in banks' strategy to accept maximum deposits in the past one year compared to their reluctance to receive more deposits in December 2022.

She recalled that the government had imposed a tax on those banks whose ADR was lower than 50% in 2022. Therefore, the banks increased the ratio through lowering their deposit levels. Later, the government suspended the tax.

Market talk suggested that the tax may be imposed again this year on lower ADR to encourage financial institutions to lend maximum funds to the private sector to ramp up economic activities, she said.

Bank deposits

Customer deposits at banks ticked down in January compared to December 2023. They, however, grew 21% in the past one year to Rs27.54 trillion in January 2024 compared to Rs22.75 trillion in the same month of last year.

Tawfik said bank deposits grew for two major reasons – conversion of workers' remittances into Pakistani rupees and soaring government debt taken from local banks. Both the transactions are shown in deposits. The local relatives of overseas Pakistanis who send funds back home deposit them in banks.

She pointed out that the government borrowed from banks for deficit financing but the money continued to remain parked in banks, which inflated the deposit size.

Negative return

The excessive lending to the government is sometimes made through bank borrowing from the central bank.

Sometimes banks make expensive borrowing from the central bank at over 22% and lend to the government at a rate less than 22%, taking a hit on their returns, which become slightly negative.

However, banks made most of the lending through deposits and partially meet the government financing requirement through borrowing from the central bank.

Tawfik said banks were doing so on expectation that the central bank would soon cut interest rate, which would turn margins positive.

Courtesy: Published in The Express Tribune, February 27th, 2024.

INCOME TAX FILERS DROP 35%

By

Shahbaz Rana

ISLAMABAD: The interim government has failed to broaden the tax base, with the number of income tax return filers shrinking 35% to just under 3.9 million compared to last year, amid challenges to achieve monthly tax collection targets.

The caretaker government, whose rule has now effectively ended with the oath of the new National Assembly, also remained unable to tax retailers, neither was it able to suspend the mobile phone connections of non-filers of income tax returns. There was hope that, unlike politicians, technocrats would move against powerful retailers.

Sources told The Express Tribune that, contrary to the hype created around bringing reforms in the Federal Board of Revenue (FBR), the figures of income tax return filers have significantly dropped.

This is the second consecutive month in which the government has missed the monthly tax collection target. However, due to better collection in the previous months, the FBR has somehow managed to achieve the eight-month tax target of Rs5.83 trillion.

The FBR, whose performance remained exceptionally good during the first half of the fiscal year, started facing problems from January this year. This coincided with the interim finance minister's attempts to restructure the tax machinery despite opposition from some cabinet members and questions over the mandate of the caretakers. The Election Commission of Pakistan also advised the interim government against restructuring the tax machinery.

Shrinking Tax Base

In November last year, Pakistan had shared a plan with the International Monetary Fund (IMF) to increase the number of income tax return filers to 6.5 million by June 2024. The interim government decided to set up district tax offices to expand the base by shifting half of the tax force in the regional tax offices to these new offices.

The Special Investment Facilitation Council (SIFC) had also given the interim government the target to increase the tax base by at least one million during the current fiscal year over last year's figure. When these targets were set, about 5 million people had filed tax returns for the last year.

As of the end of February, sources said, the total income tax returns received by the FBR stood at just 3.88 million – a number that was 2.1 million or 35% short compared to tax year 2022. The government faced a reduction in the number of filers across all four categories: companies, associations of persons, business individuals, and the salaried class.

However, senior FBR officials hope that the figure will see a sharp jump in March after the publication of the Active Taxpayers List on Monday. All non-filers' names will be omitted from the new list, which will double the rate of withholding taxes on their transactions.

Details showed that compared to 92,704 associations that filed returns in the previous year, this year the figure has so far remained at 91,135. Similarly, in the last tax year, about 77,600 firms had filed their returns, which have now dropped to less than 72,000, showing a decline of about 8%.

The major reduction in the number of filers was in the case of business individuals, as about 1.6 million or 43% fewer persons filed their income tax returns this year, said the sources. In the last tax year, about 3.8 million business individuals filed returns, which have now shrunk to 2.2 million.

Similarly, about 22% or 435,000 fewer salaried persons filed their returns this year. As against nearly 2 million salaried persons who filed returns last year, only 1.55 submitted their annual statements of wealth and income this year.

The FBR had sent a proposal to the finance minister to impose tax on retailers, but she left the matter for the next government, according to the sources. Similarly, a committee was also constituted to suspend the mobile phone connections of non-filers, but no order was issued in this regard.

A senior FBR official said that despite the low number of filers, there were about 840,000 new filers this year, which showed the efforts of the tax machinery. Out of this, the big number was business individuals, as 510,000 business persons became return filers for the first time.

Nearly 11 million individuals and companies are registered with the FBR, but less than 7 million did not file their annual returns.

Tax Collection

The FBR has managed to achieve its eight-month tax collection target of Rs5.829 trillion, thanks to better performance in the first six months of the fiscal year. A timely decision by the Supreme Court of Pakistan in the super tax case also helped the FBR get Rs6 billion on the last day, which in return became the reason to achieve the eight-month target.

The FBR, for the second time in this fiscal year, missed the monthly target by a margin of Rs33 billion or 4.6%. Under an arrangement with the IMF, Pakistan may have to kick in a mini-budget if the monthly collection falls short of the target by more than 1%.

The tax authorities attribute the shortfall in the monthly collections to the interim finance minister's drive to restructure the FBR and the increased number of holidays in February.

The provisional collection figures showed that the FBR has so far collected Rs5.83 trillion, showing an increase of Rs1.34 trillion or 30% over the collection made during the same period of the previous fiscal year.

Till December, the FBR's management was confident of achieving the Rs9.415 trillion annual target despite a slump in imports. Income tax collection amounted to Rs2.76 trillion, up over Rs800 billion, or 41%, during the first eight months of this fiscal year.

Sales tax and customs duties remained the weakest areas. Sales tax collection reached over Rs2 trillion, which was Rs316 billion, or 19%, more than the last fiscal year. The FBR collected Rs352 billion in FED, and the collection of customs duty stood at Rs710 billion.

Details showed that as against February's target of Rs714 billion, the FBR could provisionally pool Rs.681 billion – a shortfall of Rs33 billion. But there was an increase of Rs162 billion or 32% in collection compared to the same month of the last fiscal year.

Courtesy: Published in The Express Tribune, March 1st, 2024.

AGRI-REVOLUTION VIA CHINA'S EXPERTISE

By

Gohar Ali Khan

KARACHI: China's agricultural modernisation has been remarkable, ensuring food security for its billion-plus population. Pakistan can leverage Chinese expertise to revitalise its agricultural sector, a cornerstone of its economy.

In Pakistan-China collaboration, both countries benefit from diverse environmental conditions conducive to crop cultivation and livestock rearing.

"Effective management of postharvest losses and enhancing the value of fruits and vegetables through research and development (R&D) collaboration with China is crucial. With Pakistan producing 20 types of fruits and 40 types of vegetables, the high postharvest losses of about 40% in the supply chain result in significant waste, limiting consumer access," said Prof Dr Zahir Ahmed Zahir, from the University of Agriculture Faisalabad's Institute of Soil and Environmental Sciences, also serving as President of the Soil Science Society of Pakistan (SSSP).

"Currently, Pakistan's export of fruits and vegetables stands at $600 million, a figure that could potentially reach $2 billion by improving postharvest practices, reducing losses, and fostering value-added products and industries," he said.

China's staple food is rice, while Pakistan relies heavily on wheat. China made rice yield scaling a priority. In 1964, Chinese Scientist Dr Yuan Longping, recognised as the father of hybrid rice, dedicated himself to this task, achieving success in 1972 with the development of a high-yield hybrid rice variety, increasing yield by 20%.

Presently, China boasts hundreds of hybrid varieties, effectively meeting local demand and bolstering food security.

"We are harnessing China's hybrid varieties as well. In Sindh, we cultivate rice on two million acres, with half of this land dedicated to hybrid varieties imported from China," said Dr Nihaluddin Marri, Agriculture Research Sindh Director Technical-I.

"To ensure food security, we must focus on three key areas: enhancing high-yield hybrid wheat, optimising storage systems, and managing population growth to halt the conversion of agricultural land into housing schemes. With a rising population and diminishing agricultural land due to expanding housing societies across the country, these measures are imperative," he added.

Professor Zhou Chang Ming from Xinjiang Agriculture University in China highlighted the current robust state of China's agricultural production. As the world's leading producer of wheat, rice, and corn, China also cultivates significant quantities of soybean, cotton, sugar, and other agricultural products. This abundance not only sustains domestic needs but also fuels international markets.

The agricultural landscape in China is evolving, transitioning from a focus solely on food cultivation to a diversified portfolio including vegetables, fruits, livestock, and poultry farming. This diversification enhances resilience within the agricultural sector, mitigating risks associated with reliance on a single industry.

"China's 14th Five-Year Plan for Agricultural and Rural Modernisation aims to advance rural farming practices, thereby boosting the income growth of rural residents. With significant investments in agricultural research, development, innovation, and mechanisation, China has significantly enhanced the quality and profitability of its

agriculture sector. Serving as a model for other developing nations, China's agricultural modernisation efforts offer invaluable lessons. Notably, the China Maps centres by Syngenta exemplify innovation in the sector, providing comprehensive solutions for farming needs and leading to unprecedented yield improvements," highlighted Zeeshan Baig, General Manager of Syngenta Pakistan, an esteemed figure in agricultural technology.

Pakistan stands to gain significantly from China's agricultural modernisation on multiple fronts. Firstly, by enhancing cooperation with China through the China-Pakistan Economic Corridor (CPEC), Pakistan can access opportunities for infrastructure development, trade facilitation, and technology transfer within the agricultural sector.

Secondly, drawing insights from China's successful agricultural policies, planning, and management practices can aid Pakistan in overhauling its agricultural productivity, efficiency, and sustainability.

Thirdly, by tapping into China's vast market potential and demand for agricultural products, particularly high-value and niche items like fruits and vegetables, Pakistan can bolster its export revenue.

Lastly, Pakistan can leverage China's support and assistance to address various challenges confronting its agriculture sector, including climate change, water scarcity, pests and diseases, and food safety concerns.

Utilising state-of-the-art machinery and cutting-edge components can produce high-quality seeds and breeds developed through biotechnology, genetic engineering, and hybridisation. These advancements result in crops with higher yields, increased resistance, and enhanced adaptability. Embracing digital agriculture, including satellite imaging and Internet of Things (IoT) sensors, offers valuable data for improved decision-making, pest management, and soil and water crop management.

Additionally, prioritising research and development in biotechnology can lead to the creation of high-yielding and climate-resilient crop varieties tailored to Pakistan's unique agro-climatic conditions. Smart and precision agriculture utilise big data, Artificial Intelligence (AI), IoT, drones, sensors, and satellites to monitor and optimise agricultural production and management.

Meanwhile, modern agricultural machinery and equipment, such as tractors, harvesters, planters, sprayers, irrigation systems, and storage facilities, enhance the mechanisation and automation of agricultural operations.

"China has placed a significant emphasis on value addition, concurrently reducing losses to a mere 2%, by enhancing the production, packing, and marketing of value-added products domestically and internationally. It is imperative for us to adopt and adapt to Chinese technologies in this regard. Currently, we suffer from substantial losses, particularly in horticulture, with approximately 40% of food and vegetables going to waste. Moreover, China's proactive promotion of sustainable agriculture practices, including organic farming and conservation efforts, underscores its commitment to addressing environmental concerns and ensuring long-term sustainability. The journey of China's agricultural modernisation exemplifies its dedication to transforming its agrarian economy into a technologically advanced and sustainable sector capable of navigating future challenges," remarked Prof Dr Muhammad Ismail Kumbhar, a renowned Researcher and Sustainable Development

Expert from the Department of Agricultural Education Extension at Sindh Agriculture University (SAU).

Key areas to address to reduce postharvest losses and enhance value addition in fruits and vegetables include:

1. Capacity building in postharvest technology and value addition through collaboration with Chinese experts.
2. Introduction and technology transfer of modern tools, equipment, and machinery for harvest, postharvest management, and packaging of fruits and vegetables.
3. Development of value-added products and processing technology for fruits and vegetables.
4. Exchange of promising cultivars of fruits and vegetable crops to improve yield and quality.
5. Automation of nursery technology for horticultural crops through collaboration with Chinese R&D counterparts.
6. Implementation of quality seed production and processing technology, especially for hybrid seeds.
7. Establishment of food processing zones near CPEC to enhance value-added products, thus stimulating economic growth through agricultural export-led strategies.

China's expertise can play a crucial role in capacitating Pakistani experts and attracting investors to these processing zones, fostering collaboration and innovation in the agricultural sector.

Courtesy: Published in The Express Tribune, March 4th, 2024.

EUROBONDS SKYROCKET ON IMF TALKS

By

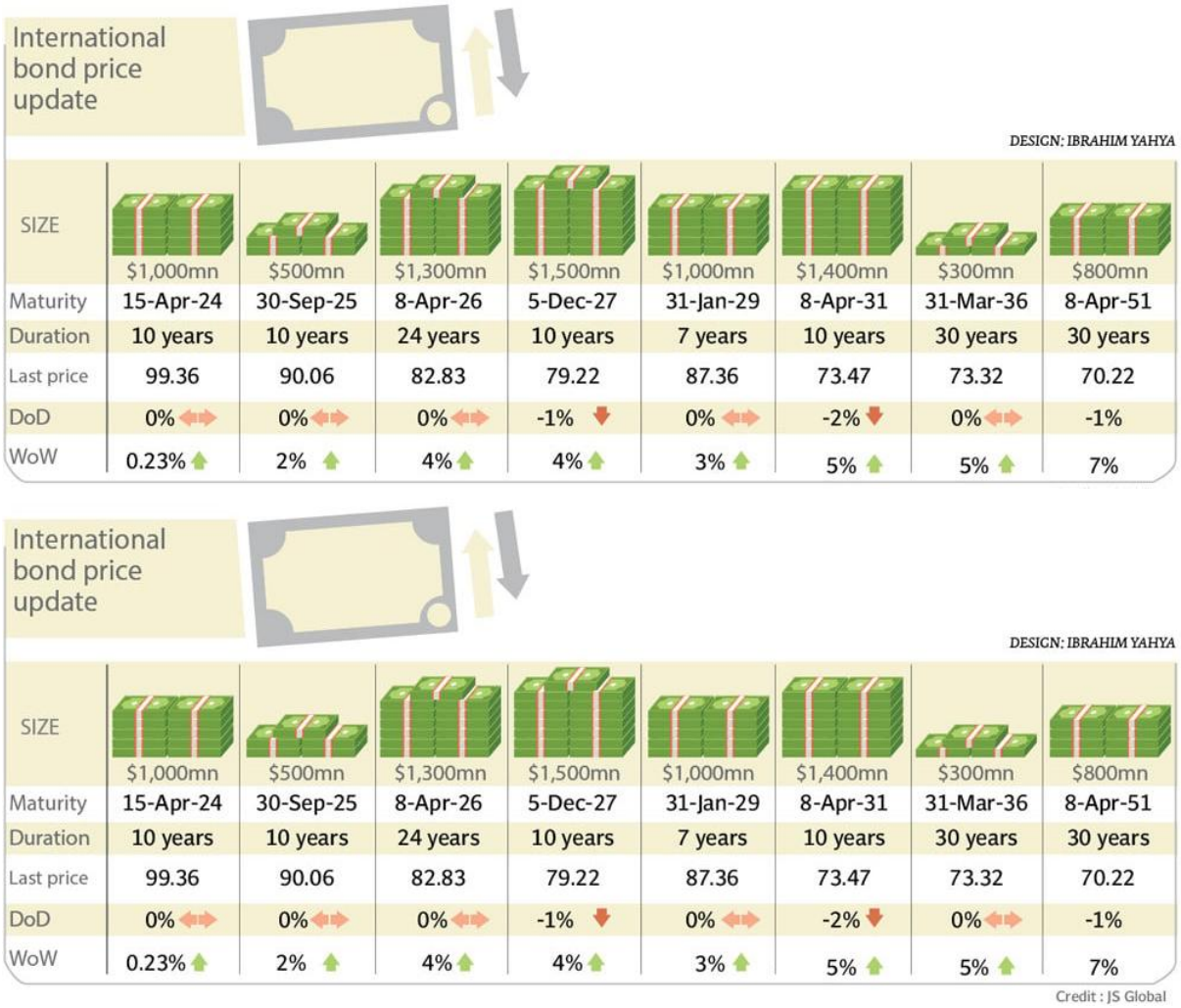
Salman Siddiqui

KARACHI: Pakistan's US dollar-denominated Eurobonds hit a record high price in the global market following an informal invitation from the newly elected government of Prime Minister Shehbaz Sharif to the International Monetary Fund (IMF) for talks on the last loan tranche of $1.1 billion and a new loan programme.

The development spurred global investors, encouraging them to take new positions in rising foreign bonds on the belief that the nation would successfully meet all future foreign debt repayments, including the $1 billion Eurobond maturing in April 2024.

According to JS Global Research, the 2024 Eurobond reached a new record high price of 99.36 cents each, followed by the 2025 notes soaring to a record high of 90.06 cents each.

The bonds had previously dropped by around 5% due to inconclusive general election results held on February 8 in the country. Prior to securing the current $3 billion loan programme ending in March-April 2024, they were trading at less than 50 cents.



The research house reported that Pakistani foreign bonds, along with others, surged by up to 7% in the week ending Tuesday, marking an outstanding rally amid the

formation of the Pakistan Muslim League-Nawaz (PML-N) led coalition government in the centre.

A total of eight Pakistani Eurobonds and Sukuk are listed in global debt markets, totalling $7.80 billion. They are set to mature between April 2024 and April 2051.

Data further suggests that the bonds have gained value by up to 10% in the span of a month and by up to 17% in the first two months and one week of 2024.

Speaking to The Express Tribune, Tahir Abbas, Head of Research at Arif Habib Limited, stated that PM Shehbaz Sharif's decision to initiate talks for a new IMF loan programme has boosted global investor confidence in Pakistan's economy, attracting them to purchase new lots of the country's global bonds.

In his inaugural speech after assuming the post of PM on Sunday, Sharif stressed the urgent need for a new loan programme, stating that the government is prepared to take tough decisions in this regard.

Investors took new positions in foreign Eurobonds based on the belief that the nation has a solid plan to repay existing debt. The new package would also provide time for the government to implement necessary economic reforms and boost economic activities and growth.

Abbas noted that the bonds continued to gain traction with political clarity in the country, attracting extended buying since the PML-N and Pakistan Peoples' Party (PPP) formed a coalition government in the centre.

Subsequently, the election for the national assembly's speaker and deputy speaker, along with the poll for the prime minister's post, paved the way for the coalition government to make tough economic decisions to navigate the economy out of crisis.

Abbas projected that the size of the IMF's new loan programme may vary between $5-8 billion and could span a period of two to three years.

He added that the caretaker government had made significant improvements in economic indicators such as inflation and the current account deficit, which could facilitate Pakistan in securing the new loan package on favourable terms.

Earlier in late January 2024, State Bank of Pakistan's (SBP) Governor, Jameel Ahmad, remarked that economic indicators had improved significantly, providing a conducive environment for negotiating a new loan programme with the IMF.

The upcoming political government is expected to secure a new programme as the current $3 billion program is set to conclude in March 2024.

Ahmad noted that foreign exchange reserves had increased to $8.3 billion in January from $4 billion six to seven months earlier in June 2023. The current account deficit remained low at 0.7% of GDP (or $800 million), compared to significantly higher levels last year. The inflation rate is expected to sharply decrease in the second half (Jan-Jun) of the current fiscal year 2023-24. The current account deficit is estimated to remain contained at 0.5-1.5% of GDP in FY24. Export earnings and workers' remittances are on the rise, and the primary fiscal deficit is improving.

Abbas further stated that the new IMF loan programme would create fiscal space for the government to ramp up economic activities.

The new programme may require the government to take measures to increase the number of taxpayers, enhance revenue collection through taxes, sell off loss-making state-owned entities, and initiate reforms in the energy sector to make power and gas affordable for households and businesses.

Courtesy: Published in The Express Tribune, March 6th, 2024.

FOOD SECURITY UNDER THREAT

By

Gohar Ali Khan

KARACHI: Experts have warned that salinity in soil and groundwater is taking a heavy toll on agricultural production in the country, which is causing losses to farmers and putting food security at risk.

The warning comes at a time when the fast changing climate globally has wreaked havoc in the shape of floods, droughts and heat waves in Pakistan and elsewhere, damaging crops and destroying livelihoods of many people.

The experts said salinity in soil and groundwater could indeed have detrimental effects on farm production as it could hinder plant growth and reduce crop yields.

They said in Sindh, where agriculture was a significant part of the economy, addressing salinity issues was crucial for sustaining crop productivity and ensuring food security.

These experts were sharing their views at a one-day training programme for farmers organised at the Sindh Agriculture University (SAU) under the aegis of Australian Research Council.

The objective of the event was to provide technical training to saline-affected farmers in the Indus Basin region of Sindh under the “Adapting to Salinity in the Indus Basin Project.”

The experts emphasised that measures such as improved irrigation practices, drainage systems and soil management techniques could help mitigate the impact of salinity in the region.

They suggested that the promotion of salt-tolerant crop varieties and implementation of policies to conserve water resources could also be useful and beneficial for combating the salinity challenges.

SAU Vice Chancellor Professor Dr Jan Muhammad Marri stated that negative impacts on agricultural production were being observed in Sindh due to salinity in soil and groundwater.

He stressed the importance of farmers’ training to make such land cultivable and cope with salinity. In terms of salinity, he added, Sindh was the most affected province of Pakistan.

Marri said the Australian project “Adapting to Salinity in the Indus Basin” would not only make farmlands cultivable through research and recommendations from agricultural and water experts but also enable all stakeholders to play an important role in rehabilitating severely saline-impacted lands and making them productive.

SAU Dean Faculty of Crop Production Dr Inayatullah Rajper said the effects of salinity existed in soil and water in all four provinces, particularly because of the use of non-prescribed fertilisers, thus necessitating technical assistance for the affected farmers.

Later on, during the technical session and training, various eminent agricultural experts including Dr Muneer Ahmed Mangrio, Dr Muharram Ali, Dr Jawed Umrani, Bhawani Shankar and others imparted training to a large number of farmers, who hailed from various districts of Sindh including Hyderabad, Tando Muhammad Khan, Jamshoro, Matiari, Sanghar, Badin and Tando Allahyar.

Courtesy: Published in The Express Tribune, March 9th, 2024.

AURANGZEB FORESEES $10B RESERVES WITH IMF NOD

By

Shahbaz Rana

Finance Minister Muhammad Aurangzeb stated on Tuesday that Pakistan's gross official foreign exchange reserves would increase to $10 billion in two months, as the International Monetary Fund is set to approve the $1.1 billion final loan tranche on Monday.



The minister also unveiled his strategy to avoid any future International Monetary Fund (IMF) programmes but only after obtaining a new "large and longer" 24th programme. His strategy revolves around enhancing exports, foreign direct investment (FDI), and raising debt from global markets – the three pillars that every finance minister has been attempting to implement during the past 16 years with varying degrees of success.

The finance minister also took a jab at his predecessor, stating that "no one can imagine a plan B with only 15 days of reserves" – in a veiled reference to former Finance Minister Ishaq Dar's mention of Plan B in 2023 when the country was struggling to secure the IMF bailout package.

Aurangzeb spoke at the inaugural session of the 7th Edition of the "Leaders in Islamabad Business Summit" (LIIBS).

This edition of the summit has been jointly hosted by Nutshell Group and Unity Foods Limited, in collaboration with OICCI (Overseas Investors Chamber of Commerce and Industry), with Faysal Bank Limited as the Platinum partner, and InfraZamin Pakistan as the strategic partner. The theme of the event this year is 'Collaborating for Growth.'

Aurangzeb stated that the $3 billion Stand-By Arrangement (SBA) was absolutely critical for Pakistan, and the IMF has now commended the country for successfully completing the programme.

The Fund has already disbursed $1.9 billion under the SBA, and its executive board is set to approve the last loan tranche of $1.1 billion on April 29th, according to Ministry of Finance officials.

Aurangzeb mentioned that the last loan tranche is expected to be disbursed next week, and the country is also anticipated to secure more inflows in June. This would help increase the foreign exchange reserves to the $10 billion mark, he added.

Reserves held by the central bank are currently just over $8 billion. A major reason for sustaining the reserves at their current levels is the massive buying of US dollars from the local markets by the State Bank of Pakistan, according to central bank sources.

They stated that the purchases from the market have already exceeded the size of the current IMF programme.

While the massive purchases have helped sustain the foreign exchange reserves at the current level of $8 billion, they have also contributed to keeping the rupee-dollar prices higher at Rs279 to a dollar.

The finance minister mentioned that an IMF mission would visit Pakistan by mid-May to negotiate the new deal.

However, he stated that the size and duration of the programme were not known at this stage. He hoped to reach a staff-level agreement by the end of June or early July.

The minister stated, “We had a very good discussion with the IMF in Washington, with a view that we go for a larger and a longer programme. We will start discussions on the contours of the programme when the IMF mission visits Pakistan in the middle of May, and we are hoping that if all goes well, and we agree on privatisation, we can get into a staff-level agreement by the end of June or early July, so that we could move on.”

He mentioned that the new IMF programme was needed to bring permanency to economic stability and the execution of structural reforms.

Aurangzeb highlighted three areas for the future IMF programme, which included increasing the tax-to-GDP ratio and broadening the tax base, fixing the energy sector, and accelerating the privatisation programme.

The federal minister stated that the government intends to bring the untaxed and under-taxed sectors into the net, for which it will collaborate with the provinces. “So that we start moving towards a 13-14% tax-to-GDP, a more sustainable range, in the next 3-4 years.”

He stated that the textile and information technology sectors were critical for enhancing the country’s exports. He hoped that the interest rates would go down due to a slowdown of the inflation rate.

The finance minister mentioned that during a meeting between Crown Prince Mohammed Bin Salman and Prime Minister Shehbaz Sharif, Saudi Arabia showed an appetite for a $5 billion investment in Pakistan. “It is now up to us to offer them bankable projects for bringing in the $5 billion investment,” he added.

The minister hoped that the country would be able to attract new foreign commercial loans from the next fiscal year, as the rating agencies were looking for the sustainability of the current economic stability.

“Our roadmap is exports, FDI, and debt to take the country forward,” said Aurangzeb.

It is unusual that external debt is made part of the strategy for the economic well-being of any country.

The finance minister stated that the privatisation of Pakistan International Airlines is in progress. “The Expression of Interest for the PIA privatisation has been submitted, and we expect the bids to come in,” he said. “We are also seeing interest in the Islamabad Airport, but the government wants to accelerate the privatisation agenda as we go forward,” he added.

He mentioned that the economic situation was showing improvement. “There was a primary budget surplus, and the country also had a current account surplus of $619 million last month,” said Aurangzeb.

Welcoming the delegates to the summit, former Minister for Investment, Muhammad Azfar Ahsan emphasised the need for collaboration between the private, public, and military sectors. “Pakistan is at a crossroads, but I am optimistic that the finance team under the dynamic leadership of Finance Minister Muhammad Aurangzeb will collaborate and do the needful. To progress as a country, we need competent teams in four main stakeholder domains: political government, bureaucracy, business leadership, and the business community.”

Courtesy: Published in The Express Tribune, April 24th, 2024.

ADB, DONORS PLEDGE $5B IN GRANTS

By

Salman Siddiqui

KARACHI: The Asian Development Bank (ADB) and donors have pledged $5 billion in grants for member countries to combat vulnerabilities like climate change, natural disasters, poverty, and gender gaps over the next four years, enabling nations including Pakistan to focus on growth, development, and regional connectivity.

In a statement on Friday, the ADB said, “Donors and ADB have agreed to replenish $5 billion for ADB’s Asian Development Fund (ADF) 14 and Technical Assistance Special Fund (TASF) 8. The commitment was made during ADB’s 57th Annual Meeting.”

According to the bank, ADB President Masatsugu Asakawa said at a press conference, “This remarkable replenishment marks the largest ever commitment to ADF’s grant operations. It demonstrates ADF donors’ continued partnership with ADB to address the pressing development challenges of those most in need.”

The ADF is ADB’s largest source of grants for operations in its poorest and most vulnerable developing member countries and is replenished every four years. ADF 14, marking the 13th replenishment since the fund’s establishment, will support grant operations during 2025–2028.

The ADF 14 replenishment is about 22% higher than the $4.1 billion available in ADF 13 and will provide eligible ADB members with the largest-ever volume of ADF grants. TASF 8 will provide grants that help prepare projects, build capacity, and provide technical or policy advice.

Pakistan remains a top vulnerable country to climate change worldwide despite its less than 1% contribution to greenhouse gas emissions globally. It faced its worst situation in 30 years during the Summer 2022 floods, affecting 33 million people and inflicting more than $30 billion in damages and economic losses on the nation.

Pakistan would receive eligible grants through transformative projects among other initiatives. Additionally, Islamabad may also secure concessional loans, as the regional bank intends to provide $16.7 billion at very low interest rates over long repayment periods.

ADB President Masatsugu Asakawa further said, “Grants are more important than ever as our poorest and most vulnerable members seek to reverse recent development setbacks and take urgent action to combat the climate crisis.”

ADF 14 prioritises dedicated assistance to small island developing states that are particularly vulnerable, especially to climate change, and to countries in fragile and conflict-affected situations.

ADF 14 will continue to play a critical role in supporting climate change adaptation and disaster risk reduction. It will enable expanded assistance for regional cooperation and regional public goods, and for transformative gender action. It will also provide agile assistance in the event of emergencies through its crisis response window.

More than $2.5 billion, or 51%, of the replenishment will be funded by contributions from donors, including two new countries: Armenia and Georgia. ADB will significantly increase its net income transfers to ADF, from just under $1.2 billion in ADF 13 to almost $1.6 billion in ADF 14, an increase of 35%. The remaining $0.9 billion will comprise transfers from earlier ADF cycles and income from liquidity investments.

In parallel, ADB intends to provide $16.7 billion in concessional loans, which have very low interest rates over long repayment periods, during the ADF 14 period. Overall, ADB will be able to provide more than $8 in grants and concessional loans for every $1 in donor contributions.

ADB is committed to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific, while sustaining its efforts to eradicate extreme poverty. Established in 1966, it is owned by 68 members, 49 from the region.

The following donors announced contributions to ADF 14: Armenia; Australia; Austria; Canada; Denmark; Finland; France; Georgia; Germany; Hong Kong, China; India; Indonesia; Ireland; Italy; Japan; Luxembourg; Malaysia; Netherlands; New Zealand; Norway; People's Republic of China; Philippines; Portugal; Republic of Korea; Spain; Sweden; Switzerland; Taipei, China; Türkiye; United Kingdom; and United States.

The following developing member countries are the primary recipients of grants from ADF 14: Federated States of Micronesia; Kiribati; Kyrgyz Republic; Maldives; Marshall Islands; Nauru; Samoa; Solomon Islands; Tajikistan; Tonga; Tuvalu; and Vanuatu. Grants will also be available to support the people of Afghanistan and Myanmar, and for transformative projects in Bangladesh; Bhutan; Cambodia; Cook Islands; Fiji; Lao People's Democratic Republic; Mongolia; Nepal; Niue; Pakistan; Palau; Papua New Guinea; Sri Lanka; Timor-Leste; and Uzbekistan.

Addressing a press conference, ADB President Masatsugu Asakawa said, "We meet amidst multiple challenges that impact human and economic development, where progress has stalled for many. It is incumbent on us to intensify efforts to address the climate crisis, eradicate poverty, and foster inclusive socioeconomic development. The Asian Development Bank, alongside other multilateral development banks, plays a pivotal role in these efforts."

"With this in mind, I am pleased to announce that yesterday we concluded the pledging session for the Asian Development Fund 14, or ADF 14. I am very grateful for the generous pledges from donors, which helped to deliver a replenishment of $5 billion."

ADF 14 focuses on climate change adaptation, disaster risk reduction, promoting gender equality, and driving forward regional cooperation and integration, including regional public goods, he said.

ADF 14 remains ready to respond to disasters, health emergencies, and large cross-border displacements in a flexible manner.

"Our efforts will pave the way for a resilient, inclusive, and sustainable region, ensuring that the Asian Development Fund remains a powerful tool for change."

Courtesy: Published in The Express Tribune, May 4th, 2024.

POOR RATING MARS $3.5B DEBT PLAN

GOVT NEEDS FUNDS FOR BASHA DAM, ONCE AGAIN WANTS TO INCLUDE IT IN CPEC

By

Shahbaz Rana

ISLAMABAD: As Pakistan's junk credit rating becomes a hurdle in the way of acquiring $3.5 billion in debt for the Diamer Bhasha dam project, the government has decided to simultaneously try to sell its stake in another power project and convince Beijing to make the scheme part of the China-Pakistan Economic Corridor (CPEC).

The Water and Power Development Authority (Wapda) – the sponsor of the Diamer Basha dam project – has requested Islamabad to pitch the project as a "big-ticket item" to Beijing during next week's visit of Prime Minister Shehbaz Sharif, according to government sources.

The authority told the government that its options were limited due to no response from various multilateral creditors.

Among the available options are to sell a stake in the 1,450-megawatt Ghazi Barotha hydropower project to Kuwait and once again persuade Beijing to make the Diamer Basha project part of CPEC, according to the recommendation made by Wapda to the federal government.

During last week's meeting of the CPEC Joint Cooperation Committee (JCC), Pakistan requested China to consider the Diamer Basha project for inclusion in CPEC. PM Shehbaz may now request the Chinese government to sign a framework agreement to review the possibility of including the project in CPEC, they added.

The government requires $4 billion for the power generation component of the project but it has so far been able to borrow only $500 million through the sale of Eurobond. It is in search of $3.5 billion to construct the 4,500MW powerhouse of the project.

Wapda has informed the federal government that its capacity to borrow from the international capital and financial markets is constrained owing to the low sovereign credit rating and Pakistan's economic vulnerabilities.

International credit rating agencies have assigned junk rating to Pakistan, describing the country's debt as highly risky. This has now become the biggest stumbling block in the way of acquiring new foreign commercial loans and floating sovereign bonds.

The United States has offered to provide debt for the Reko Diq mining project, subject to the condition that Pakistan grants US Exim Bank the status of a preferred creditor.

Pakistan had hoped that the last standby arrangement of the International Monetary Fund (IMF) would help it win improved ratings but it did not happen due to the high external financing requirement.

In November last year, Pakistan signed a memorandum of understanding (MoU) with Kuwait for selling its equity in the Ghazi Barotha hydropower project. The understanding had been reached between Pakistan and the Kuwait Investment Authority for undertaking the process through the latter's subsidiary Enertech.

Sources said that due to the limited financing options, it had been decided to fast-track the hiring of a financial adviser to sell the equity stake to Kuwait. After the hiring, the government will expedite the process to sell its shares to Kuwait.

Following lukewarm response from the Asian Development Bank and the World Bank, Pakistan had begun construction of the dam, with a storage capacity of 6.4 million acre feet of water, from its own resources. It hoped that it would be able to raise commercial financing for the 4,500MW power house.

The federal government approved the generation component of the project at a cost of Rs1.42 trillion two years ago.

It was struggling to find an anchor financier for the project and tried to convince the Saudi Fund for Development, Islamic Development Bank, Asian Development Bank and Asian Infrastructure Investment Bank to fund the project but so far no breakthrough could be achieved, Wapda informed the federal government.

The government has also attempted to enter into an investment-debt arrangement with Saudi Arabia. Last month, Pakistan offered the Diamer Basha project to Saudi Arabia for equity partnership, seeking $1.2 billion in equity investment and $2.3 billion in debt for 10 years.

Pakistani authorities were hopeful that Saudi Arabia would pick the project as part of its $5 billion investment plan. However, the government has not yet formally received any response from the Saudi authorities, said a senior government official.

The Diamer Basha project is being constructed with a ratio of 30% equity and 70% debt. The dam will generate around 18 billion units of electricity annually.

Pakistan has described it as a critical project for restoring the energy sector’s viability and reducing the carbon footprint.

PM Shehbaz has instructed the Ministry of Planning to make Diamer Basha dam part of CPEC. This is the second time in seven years when Pakistan has decided to include the project in CPEC.

Courtesy: Published in The Express Tribune, May 31st, 2024.

SUBJECT: PAVEMENT INSPECTION AND DIAGNOSIS FOR EFFECTIVE PAVEMENT MANAGEMENT SYSTEM (PMS)

It is apprised that Communication and Works Department is developing “Road Asset Management System” (RAMS) in which Pavement Inspection and Diagnosis is an important input from monitoring and managing road infrastructures. Communication and Works Department recently formulated a Manual of on Pavement Inspection and Diagnosis with the help of JICA. In this regard to create the awareness and feedback from practicing engineers a Seminar was arranged on the above cited subject on May 11, 2024. Summary of papers presented is given below:

PAVEMENT ROUGHNESS

In its broadest sense, pavement roughness has been defined as “the deviations of a surface from a true planar surface with characteristic dimensions that affect vehicle dynamics, ride quality, dynamic loads, and drainage” (Sayers 1985). A more general definition of roughness is “distortions of the road surface that contribute to an undesirable, unsafe, uneconomical, or uncomfortable ride” (Hudson 1981). Roughness can be divided into longitudinal variations and transverse variations with longitudinal roughness having by far the greatest effect on undesirable vehicle forces (Hudson 1981).

Roughness is measured in terms of International Roughness Index (IRI). IRI is a ratio of the accumulated suspension motion to the distance traveled obtained from a mathematical model of a standard quarter car traversing a measured profile at a speed of 80 km/h (50 mph). Expressed in units of meters per kilometer (inches per mile), the IRI summarizes the longitudinal surface profile in a wheelpath. The computation of IRI from longitudinal profile measurements is defined in ASTM Standard E 1926 (ASTM 1999e).

The presentation details the measuring, characterizing & reporting pavement roughness. Major topic include:

- Definition and importance of measuring roughness
- Measurement techniques
- Reporting and roughness specifications
- Factors affecting road pavement roughness

ONE PAGE PRESENTATION BRIEF BY ZUBAIR EMRAN KHAWAJA, MD, AZEA (May 11, 2024)

Durability and lifecycle performance of asphalt pavements, largely are dependent upon quality of its predominant components and bitumen in asphalt mix. In Punjab Pakistan, Sargodha (Pull 11) and Margalla quarries for aggregates and National Refinery & Parco for bitumen supplies are time tested sources. Engineer show ever may through R & D come up with alternate combinations to save our precious mineral resources for generations to come.

Asphalt Mix Design for non-restricted axle loads operating on our roads is a great challenge for pavement designers. The Punjab Highway Department for decades has accepted responsibility of asphalt mix design by entrusting to Roads Research and Material Testing Institute (RR&MTI) Lahore. On other hand FIDIC Condition of Contract categorially assigns this responsibility to contractor(s)and the Engineer(s) approved the asphalt mix design within the design limits.

During last three (03) decades or so, philosophy of asphalt mix design for hot tropical climate has changed from dense graded to open graded mixes, of course rich in air voids, at reduced effective bitumen content. No doubt stone to stone contact provides greater stability and shear resistance against heavy axle load. However, same time reduced effective bitumen content in asphalt mix poses challenges of early ordination. Research has proved that minimum bitumen film thickness of 8-micron on surface of aggregates provides adequate safety against raveling. It is also recommended that for hot weather conditions softening point of the asphalt mix may be kept between points 75°C and 85°C for low and high-volume traffic roads respectively. Stability and flow quotient values 3.8(BBC) and 4.7(BWC) by adjusting bitumen filler ratio helps in achieving stable and durable pavements.

Strict quality control and supervision of asphalt plant operations and then at the stage of laying of asphalt, inspector (s)either in dump trucks and paver hooper can identifying common production flaws e.g. over-heated, over sanded, lower/ over bitumen content and segregation etc. Pavement thickness and compaction control are few of essential tasks for enhancing useful life of the pavement. Use of di-electric profiling system (DPS) is right to measure density during asphalt laying. Pavers' screed and correct rolling pattern play a vital role in obtaining smooth pavement finish.

"No matter how well a pavement is designed and built, no matter how long that pavement lasts, roadway users will tend to call it "GOOD" or "BAD" based on smoothness and Safety of the ride."

Like any manufactured product, pavements are subjected to different kind of distresses like UV Rays, Air, Rain, Oil spills and heavy axle load etc. All of them individually or in combination adversely affect the design life of the pavement.

It is important to safe our assets through much cheaper preventive and maintenance operations. Best possible method is regular inspection by trained inspectors e.g. best time for the observations of cracks is immediate after rain as water in cracks changes pavements color.

We may for this purpose develop asset management manuals helping field staff for knowledgeable inspections. Asphalt institute pavement condition index (PCI) is a handy method for determining pavement condition.

Early maintenance employing emulsified bitumen routines such as fog seal, sand seal, slurry seal, cape seal, single and double surface treatment coats are helpful in extending can extend 3-5 years pavement life at only 10% of rehabilitation cost. Seal coats are also very handy in treating raveling loss of fine aggregates etc.

Maintenance Engineer must be able to identify cracks, distortions and pavement disintegrations. Generally, cracks in pavements are non-structural "top-down" whereas, fatigue cracks classically are "bottom-up". Identification and early repair of defects is an important task of Maintenance Engineer.

Jhang~Shorkot Road case study-1described top-down cracks in the pavements. Deflection measurements and Benkelman beam study revealed that pavement structurally was sound, therefore, fog seal and chip coat was recommended by RR&MTI. Whereas occasional potholes were recommended to be corrected by excavating deep into lower pavement layers.

Case study-2 revealed that heavy axle load operating from Damam to Riydh and dense asphalt mix design were major culprits which led to early pavement

distress in form of rutting in slow lane of left carriageway. Contractor(s) was made responsible for milling and overlay. Axle load restrictions were quickly enforced which was effective measure against rutting.

JICA PROJECT：Project for Strengthening of Road Asset Management System in Punjab Province

Japan International Cooperation Agency (JICA) has been cooperating in technical cooperation projects to establish efficient and effective maintenance and management systems in countries around the world by utilizing Japanese maintenance, renewal and management technologies.

This project is one of these JICA projects to provide technical assistance for capacity building of road and bridge maintenance and management systems, with "PACIFIC CONSULTANTS CO. (PCKK) as the prime consultant, "EIGHT-JAPAN ENGINEERING CONSULTANTS INC." (EJEC) and "HANSHIN EXPRESSWAY COMPANY LIMITED." (HEX) as the JVs to implementing the project with counterpart RAMS team.

The project will contribute to the following in Punjab.

1) Promoting understanding of the PDCA cycle-based maintenance of road and bridge maintenance in CWD.
2) Establishment of a system and improvement of inspection and diagnostic capability
3) Realization of the selection of repair areas and prioritization of routes for road and bridge maintenance management within the allocated budget by CWD
4) Realizing maintenance of road and bridge facilities in Punjab based on appropriate priority order.

Pavement Functional Evaluation with Pavement Condition Index

Pavement performance is widely categorized as structural performance and functional performance. Structural performance includes deflection measurement and pavement thickness measurement. On the other hand, functional performance includes Pavement Condition Index (PCI), Roughness Measurement (IRI) and Skid Resistance Measurement.

The Pavement Condition Index PCI for roads and parking lots was developed by the U.S. Army Corps of Engineers. ASTM D 6433-20 Standard Practice for Roads and Parking lots Pavement Condition Index Surveys and ASTM D 5340-20 Standard Test Method for Airport Pavement Condition Index Surveys. 20 types of pavement distresses are recorded during field survey for evaluation of PCI value for asphalt surfaced road.

Pavement Condition Index (PCI) is an, illustration how the condition of a pavement changes over time based on periodic assessments. Time is used to track the progression of pavement condition assessments over multiple inspection periods. The Pavement Condition Index (PCI), is a numerical rating used to quantify the overall condition of the pavement. PCI values range from 0 to 100, where a higher PCI indicates better pavement condition and vice versa. As the pavement ages and is subjected to traffic, weather, and other factors, it may experience deterioration such as cracking, rutting, roughness, and loss of structural integrity. This deterioration leads to a decrease in PCI values over successive inspections.

In some cases, the PCI trend may include thresholds representing intervention points or triggers. These thresholds indicate critical PCI levels where specific maintenance or rehabilitation actions should be considered to prevent further deterioration or restore pavement condition.

The presentation details Pavement Functional Evaluation with Pavement Condition Index. Major topic include:

- Introduction to Pavement Performance.
- Pavement Condition Index.
- Types of Pavement Distresses.
- Case Study of Punjab.

FINDINGS OF PILOT AXLE LAD SURVEY IN PUNJAB

Traffic is one of the most important parameters when it comes to the pavements. It is therefore essential to know its composition in terms of volume, axle load, axle configuration, contact pressure and repetitions. Among these, axle load carries significant importance as any deviation in it can drastically change pavement and design pavement life. The importance of axle load is explained by the famous engineering law that the "*degree of pavement damage caused by an axle load is proportional to approximately the fourth power of the axle load*". This simple law shows that doubling the axle load will not simply double the damage, but the damage would be many times more. In other words, doubling the axle load will increase the damaging effect almost 22 times. Therefore, it is essential to carry out axle load surveys to assess the actual load moving on the pavements and hence use this information to take necessary actions.

With the help of JICA, RAMS carried out a pilot axle load survey at two locations in Punjab. Mobile weighing pads were used to weigh vehicles. The results of the survey showed that loaded vehicles were severely overloaded, causing serious damage to the pavements. The results were analyzed using both AASHTO guide 1993 and Mechanistic Approach. The analysis by both approaches depicted that the design life of the pavement would decrease by approximately 66% due to overloading. It also showed that the original load factors used during the design procedure do not accurately reflect the actual axle loads moving on the pavements.

The presentation consists of following topics:

1) Introduction

i) Need for Axle load survey

ii) Scope of Axle load survey

2) Damage to Pavement due to Overloading

3) Methodology

4) Findings and Analysis

i) AASHTO design Guide 1993 Approach

ii) Mechanistic Empirical Approach

5) Conclusion

APPLICATION OF FOURTH INDUSTRIAL REVOLUTION (4IR) IN ENVIRONMENTAL SCIENCES

Ramsha Mazhar[1] and Zahiruddin Khan[2]

ABSTRCT

The man-kind has faced countless changes since its birth on the planet. These changes were both natural as well as man-made. Historically, man has acquired most of the knowledge through experience and through trial and error. The pace of knowledge dispersion has raised exponentially in the recent era and in most cases this knowledge is being transmitted into machine so that it can think and make rapid and precise decisions based upon accumulated data. The world has seen four industrial revolutions so far and is entering into the fifth one. This paper reviews the on-going transition from men to machine based bio-digital world where machines are going to take control and guide man on how to respond to the given situation. Special focus of this review is the environmental science arena as issues like global warming, acid rain and other global environmental issues would direct the way we live and plan our life style. Technologies of 4th Industrial revolution that have emerged just in last decade and would digitally connect the world have been explored briefly.

Key words: Biophysical world; Digital revolution, Data power; AI, IOT, Machine Learning

The first Industrial Revolution introduced a mammoth change in how things were produced and operated. It shifted man from hands-based working to mechanized operations. It completely changed how people worked and lived, thus transforming society as a whole. It all started in Britain around the 1700s and then spread to other parts of the world. Originally, the term "Industrial Revolution" was coined by an English historian named Arnold Toynbee in the 1800s. He used it to talk about how Britain's economy changed between 1760 and 1840. But now, we use this term more broadly to describe any big changes in how economies work, not just in one specific time or place.

Characteristics of Industrial Revolution:

The Industrial Revolution was a massive shift that brought about significant changes across various aspects of society. These changes shaped the world in profound ways, altering how people lived, worked, communicated, traveled and viewed their place in society and the natural world. These changes were broadly classified six types of technological changes as briefed below;

Technological Changes:

- ➔ **New Materials:** Iron and steel became primary materials for tools and vehicles
- ➔ **New Energy Sources:** Coal, steam power, electricity, petroleum, and internal combustion engines were utilized.
- ➔ **Inventions:** Machines like the spinning jenny and power loom increased production while reducing the need for human effort.
- ➔ **Factory System:** Work shifted to factories, leading to increased specialization and division of labor.

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- ➔ **Advancements in Transportation and Communication:** Steam locomotives, steamships, automobiles, airplanes, telegraph, and radio revolutionized transportation and communication.
- ➔ **Application of Science:** Science started playing a bigger role in industry.

Non-Industrial Developments:

- ➔ **Agricultural Improvements:** Mechanized farming methods supported a larger non-agricultural population.
- ➔ **Economic Changes:** Wealth distribution changed, with land losing significance as industrial production rose, and international trade expanded.
- ➔ **Political Shifts:** Economic power changes led to new state policies suited for industrial societies.
- ➔ **Social Changes:** Cities grew, working-class movements emerged, and new forms of authority developed.
- ➔ **Cultural Transformations:** A broad societal change occurred.
- ➔ **Worker Changes:** Workers transitioned from craftsmen using hand tools to machine operators in factories, leading to a shift in skills and work relationships [1].

The industrial revolutions are typically categorized into four main phases:

1. **The first Industrial Revolution (1IR)** marked a huge shift from agriculture to industry. It brought about mechanization, changes in crop patterns and the manufacturing of goods on a large scale. This period saw the discovery and widespread extraction of coal, alongside the invention of the steam engine and advancements in metal forging. These changes completely revolutionized how products were made and traded. New inventions like spinning machines and fabric looms emerged, transforming textile production. Additionally, canal based navigation augmented traditional transport via wagons and mules. Overall, it was a time of massive change, introducing technology that transformed the way things were produced and moved from one place to another.
2. **The Second Industrial Revolution (2IR),** which emerged around the late 19th and early 20th century, marked the discovery and utilization of electricity, gas, and oil as key energy sources. The combustion engine played a pivotal role, complementing these new fuel sources. This period witnessed the introduction of steel and chemical-based products into the market place. Communication technology experienced significant advancements with the telegraph and, later on, the telephone, setting the stage for improved global connectivity. Transportation took a massive leap forward with the invention of both airplanes and automobiles. Mass production techniques revolutionized mechanical production, enhancing the speed and efficiencyof manufacturing processes [2].
3. **The Third Industrial Revolution (3IR)**, which unfolded in the latter half of the 20th century, introduced significant advancements in technology and energy sources. Nuclear energy emerged as a notable and previously untapped source of power during this era. This revolution was characterized by the rapid growth of electronics, telecommunications, and the widespread adoption of computers. It also paved the way for significant developments in space exploration, research, and the field of biotechnology, all made possible through these new technologies. In industrial

sectors, two key inventions, Programmable Logic Controllers (PLCs) and Robots, played crucial roles in ushering in an era of high-level automation. These innovations revolutionized industrial processes, enabling greater efficiency and precision in manufacturing and production [3].

Throughout history, people have relied on different forms of technology, even though it might not resemble what we have today. Each era had its own technological advancements that were significant for their time, aiding people in making their lives easier and striving to improve upon those inventions. The concept of the industrial revolution emerged from this continual cycle of using available technology to enhance life and advance further. We're currently in the midst of the fourth industrial revolution, also known as Industry 4.0. This era is witnessing the ascent of technology and web design companies, among other advancements.

The Industrial Revolutions have been defined by the dominant technologies of their times: steam for the first, electricity for the second, preliminary automation for the third, and now, cyber physical systems and intelligent computers are at the forefront of the Fourth Industrial Revolution (4IR). Before 2014, the term "Industry 4.0" was hardly used in Google searches. However, by 2019, a McKinsey global survey [4] found that 68 percent of respondents considered Industry 4.0 a top strategic priority. Seventy percent stated that their companies were already testing or implementing new technologies associated with Industry 4.0. The Fourth Industrial Revolution builds upon the inventions of the Third Industrial Revolution, also known as the digital revolution, spanning from the 1950s to the early 2000s. This period introduced computers, various electronics, the Internet, and more. Industry 4.0 takes these inventions beyond previous limits, utilizing four key types of disruptive technologies [4]:

1. **Connectivity, Data, and Computational Power:** This involves technologies like cloud computing, the Internet, block chain, and sensors that enable data gathering and processing across networks.
2. **Analytics and Intelligence**: Advanced analytics, machine learning, and artificial intelligence (AI) are employed to extract insights and make predictions from vast amounts of data.
3. **Human-Machine Interaction**: Technologies such as virtual reality, augmented reality,, robotics, automation, and autonomous guided vehicles redefine how humans interact with machines, enhancing efficiency and capabilities.
4. **Advanced Engineering:** This includes additive manufacturing (like 3-D printing), renewable energy, and nanoparticles, pushing the boundaries of production, energy sources, and materials.

Technologies of 4th Industrial Revolution:

The Fourth Industrial Revolution, as coined by Klaus Schwab and introduced through the World Economic Forum (2016), refers to a period characterized by the fusion of technologies, blurring the lines between the physical, digital, and biological spheres. This era encompasses advancements like robotics, artificial intelligence, nanotechnology, quantum computing, biotechnology, and internet of things, 3D printing, and more. Schwab's vision includes these innovations reshaping industries, connectivity, and communication. Industry 4.0 describes the growing trend towards automation and data exchange in technology and processes within the manufacturing

industry, including:

1. **Quantum Computing**: Advanced computation technology that leverages quantum-mechanical phenomena to process information more efficiently than classical computers. Quantum computing has the potential to solve problems that are currently infeasible for classical computers, such as breaking encryption codes and simulating complex chemical reactions. It has potential applications in areas such as drug discovery, finance and machine learning [5].

2. **Internet of Things (IoT):** A network of interconnected devices that communicate and exchange data to perform tasks and improve efficiency. IoT sensors gather environmental data remotely and transmit it wirelessly to a central interface. It eliminates the need for researchers to physically travel to various locations for data retrieval. Data is securely stored in the cloud, enabling easy access and retrieval. It also provides insights into various environmental aspects such as soil quality and air pollution levels. It allows researchers to use analytics software to track trends and compare differences across multiple locations and big data platforms process vast amounts of information rapidly, aiding researchers in quick analysis.

3. **Industrial Internet of Things (IIoT):** Similar to IoT but specifically focused on enhancing industrial processes and manufacturing. The industrial internet of things, or IIoT, involves using smart sensors, actuators, and devices like Radio Frequency Identification (RFID) tags to improve how things are made in industries. These devices connect and share information, allowing for data collection, analysis, and better decision-making. It helps industries like manufacturing, energy, utilities, and oil and gas be more efficient and reliable by providing valuable insights from the gathered data [6].

4. **Cyber-Physical Systems (CPS):** Digital systems blending computational and physical capabilities, interacting with humans and the environment. Cyber-physical systems are like super smart setups that blend the real world with the digital world. They use sensors to collect real-life data and gadgets (called actuators) to actually do things in the physical world based on that data. These systems don't just collect info; they actively work with both the real and digital worlds, using the internet to connect globally and share information. They have special ways for people to interact with them, and they're creating tons of cool solutions that are changing how we live every day [7].

5. **Smart Manufacturing:** Utilizing advanced technologies for automated and optimized manufacturing processes. Smart manufacturing emphasizes adaptability and flexibility in production systems. Machines and processes can be adjusted rapidly and efficiently in response to changing demands or market conditions, allowing for agile and responsive manufacturing operations.

6. **Smart Factories:** Manufacturing facilities employing IoT, AI, and automation to enhance productivity and decision-making. In smart factories, IoT devices play a crucial role by linking machines and computers to gather real-time data about the manufacturing processes. This comprehensive data is then processed using AI and machine learning techniques to extract meaningful and actionable insights from the vast amounts of information collected. This integration of IoT, AI, and machine learning enhances efficiency, predictive maintenance, and overall optimization within the manufacturing environment [8].

7. **Cloud Computing**: Delivery of computing services like storage, databases, and software over the internet to offer scalability and flexibility. Cloud computing is like a super powerful computer system that can help run smart programs like AI and machine learning. These programs analyze and understand the information collected by devices like smart sensors in real-time. This helps make better decisions about when machines might need fixing before they break down, and it also helps come up with new and better things to make or do based on all that information. Ultimately, it's about using these technologies together to make smarter choices and create new and improved products and services [9].

8. **Cognitive Computing:** AI systems that mimic human thought processes, enabling tasks like problem-solving, pattern recognition, and decision-making. Cognitive computing is like making super smart computers that work a lot like human brains. These computers can solve tricky problems, recognize patterns in big amounts of information, and make smart decisions just like humans do. They learn from their experiences, get better over time, and can even understand and talk with people using normal language. They're used in many areas like healthcare, finance, and customer service to do really complex tasks that need a lot of brainpower to figure out.

9. **Artificial Intelligence (AI):** Machines simulating human intelligence, performing tasks such as learning, reasoning, and problem-solving. Artificial Intelligence refers to machines designed to do things that usually need human intelligence. These smart machines can learn from data, make decisions, solve problems, and understand things like humans do. They use algorithms and advanced techniques to imitate human thinking and perform tasks ranging from recognizing patterns to making decisions, essentially mimicking human intelligence in various ways.

10. **Genomics & Gene Editing**: Advancements in studying and editing genes, revolutionizing healthcare and biotechnology. Genomics is like reading and understanding the instruction book of life—the genes. It helps us learn how our genes work and what they mean for our health. Gene editing, on the other hand, is like using a special tool to make changes in these instructions. Scientists can fix problems or even make enhancements in these instructions, potentially helping to cure diseases or make things better for our health. These advancements open doors to customizing treatments based on each person's unique genetic makeup and hold the promise of major breakthroughs in healthcare and biology.

11. **5G Network:** The fifth generation of cellular network technology, offering faster speeds and reduced latency to support various applications. The 5G network represents the latest and most advanced evolution of internet connectivity for your devices. As the fifth generation of this technology, it brings exceptional speed and reduced lag times, significantly enhancing the browsing and usage experience on phones and other gadgets. Its remarkable speed capabilities allow for quicker loading of content and reduced delays during usage. This upgrade unlocks the potential for various high-speed applications and services, resulting in a smoother and faster user experience for everyone connected to it.

12. **Autonomous Vehicles:** Self-driving vehicles using AI and sensors to navigate without human intervention. Autonomous vehicles are like smart cars that drive themselves without needing a person to steer. They use clever technology like artificial intelligence and sensors to understand their surroundings and move around without

human control. These vehicles can sense what's happening on the road, make decisions, and drive safely from one place to another, all on their own.

13. **Robots & Cobots:** Robotics technology assisting in various tasks, with collaborative robots (cobots) designed to work alongside humans. Robots are like machines built to help with different jobs, from assembling things to handling repetitive tasks. They use advanced technology to work efficiently and independently. On the other hand, cobots, short for collaborative robots, are designed to team up with humans. These special robots are made to work alongside people, assisting them in tasks where their combined efforts can achieve better results, making work easier and more efficient.

14. **Block Chains:** Distributed and secure digital ledgers that enable secure and transparent transactions. Block chains are like super secure digital records that keep track of transactions or information. Unlike traditional databases, Block chains are spread across many computers, making them extremely secure and hard to tamper with. They store information in blocks that are linked together in a chain, creating a transparent and unchangeable record of transactions or data. This technology ensures trust and security in various types of transactions, allowing people to exchange information or assets in a safe and transparent way without needing a central authority overseeing the process.

15. **Big Data**: Large volumes of data collected and analyzed to derive insights and make informed decisions across industries. Big Data refers to huge amounts of information gathered from various sources, like smartphones, sensors, or online activities. This information is then analyzed to uncover patterns, trends, or insights that can help companies or organizations make better decisions. It's like having a massive library of data that's studied and used to understand trends or behaviors, allowing businesses to improve their strategies, products, or services based on this valuable information [10].

Application of 4th Industrial Revolution on environmental sciences:

The application of the Fourth Industrial Revolution (4IR) in environmental sciences is multifaceted and impactful, offering both challenges and opportunities:

1. **Environmental Monitoring:** AI, IoT, and machine learning empower advanced sensors and monitoring systems. These technologies facilitate real-time data collection, analysis, and predictive modeling for environmental parameters like air quality, water quality, and biodiversity. This aids in early detection of environmental threats and enables proactive intervention.
2. **Resource Management:** 4IR technologies optimize resource utilization through smart grids, IoT-enabled agriculture (precision farming), and water management systems. AI-driven predictive analytics enhance efficiency in resource allocation, minimizing waste and conserving natural resources.
3. **Resource Monitoring through IoT:** Internet-connected sensors track water and electricity usage, providing valuable data to identify inefficiencies and reduce waste, ultimately benefiting the planet.
4. **Integration of IoT into Machinery:** Providers assist by retrofitting old machines or installing new equipment to leverage IoT capabilities. These upgraded machines often have better environmental performance than older models, reducing carbon footprints.

5. **Adoption of Sustainable Manufacturing Methods:** Lean manufacturing, aimed at waste reduction, goes beyond minimizing product waste. It focuses on eliminating any activity that doesn't add value for consumers. This approach also helps in reducing travel distances for products or employees, thereby decreasing environmental impacts.

Overall, the integration of IoT technologies, the transition to more sustainable manufacturing methods like lean manufacturing, and the adoption of eco-friendly equipment are leading the charge towards greener and more efficient manufacturing practices. These changes not only benefit the environment but also enhance the competitiveness and efficiency of manufacturing operations.

6. **Sustainable Infrastructure:** Innovations in smart infrastructure development leverage 4IR technologies for sustainable urban planning, energy-efficient buildings, and transportation systems. This includes the implementation of IoT-based smart cities to reduce carbon footprints and enhance overall sustainability.
7. **Climate Change Mitigation:** The application of AI and machine learning supports climate modeling, predictive analysis, and simulation for assessing climate change impacts. This aids in developing strategies for mitigation and adaptation to changing environmental conditions.
8. **Renewable Energy Integration:** 4IR facilitates the integration and management of renewable energy sources like solar and wind power through smart grids and IoT-enabled energy systems. This contributes to reducing dependency on fossil fuels and mitigating greenhouse gas emissions.
9. **Waste Management:** Advanced technologies enable more efficient waste management processes through AI-powered recycling and waste sorting systems. IoT devices aid in tracking waste flows, optimizing collection routes, and minimizing environmental pollution.
10. **Conservation and Biodiversity:** 4IR supports biodiversity conservation efforts through remote sensing, AI-based analysis of ecological data, and IoT-enabled monitoring of wildlife habitats. This enhances understanding and protection of ecosystems.
11. **Environmental Policy and Decision-Making:** Big data analytics and AI assist policymakers in making informed decisions by analyzing vast amounts of environmental data. This aids in formulating effective environmental policies and regulations.

Moreover, the development of more advanced robotics and innovative technologies associated with the Fourth Industrial Revolution is expected to lower the cost of CO_2 capture, storage, or utilization, thereby expanding the market and making it more accessible. The application of **IoT technology** could allow for global monitoring of CO_2 levels, enabling strategic efforts to capture CO_2 more effectively where it's most abundant and potentially linking various initiatives for greater impact [11] .

Following examples illustrate how 4IR technologies are already being deployed to address environmental challenges, offering improved monitoring, personalized advice, and innovative solutions to tackle issues related to air pollution and global warming.

1. **Enhanced Environmental Monitoring:** Leveraging the **Internet of Things (IoT)** allows for more comprehensive and real-time monitoring of environmental factors such as air pollution, which includes innovative methods like using mobile network

data in Brazil and the Array ofThings (AoT) in Chicago.

2. **Cost-Effective Solutions:** Technologies like **Low Power Wide Area Networks** (LPWANs) offer cost-effective, portable, and always-connected sensors to monitor various aspects of the environment, such as air quality, without excessive expenses.
3. **Personalized Pollution Advice:** Utilizing **IoT data,** platforms like UK Air provide personalized air quality forecasts and advice, allowing individuals to access health recommendations and takeappropriate actions based on air quality levels in their specific locations.
4. **Innovative Solutions for Air Quality:** Innovations like **'Robotic Trees'** in Mexico that use microalgae to clean CO2 from the air and 'Parasitic Drones' in Hong Kong designed to absorb carbon emissions from billboards, showcase creative approaches to combat air pollution and reduce greenhouse gasses[12].

Future Trends:

Despite the groundbreaking potential of 4IR technologies, it's acknowledged that the revolution is in its infancy. This presents an opportunity to ensure that this industrial revolution is founded on sustainability unlike its predecessors. While some game-changing 4IR solutions are yet to be developed, certain trends are expected to dominate the next 20-30 years. Venture capitalists are eyeing seven key trends, anticipating them to shape the companies that will lead the way in addressing global challenges. These trends include innovations in AI, IoT, self-driving vehicles, biotech, and nanotechnology.

1. Proliferation of AI- AI's widespread adoption, driven by its convergence with big data and hardware advancements, marks a pivotal transformation from theory to practical application in our daily lives. This shift characterizes the Fourth Industrial Revolution as a significant leap in intelligence and productivity. As AI becomes increasingly integrated into various facets of society each year, its capabilities continue to advance. This progress allows AI not only to optimize resource usage, such as materials and energy but also to revolutionize entire systems ranging from energy grids and transportation to city infrastructures and industrial processes. The goal isn't just for AI to work faster than humans but to think differently, fostering collaboration between humans and AI to solve complex scientific problems. This collaboration holds immense potential, particularly in predicting weather patterns, understanding natural disasters, and advancing clean energy through biomimicry and innovative materials. In essence, AI's evolution empowers us to address these critical challenges more effectively.

2. Roll out of automation- Automation is set to take over many tasks we do today and introduce new ones we'll soon rely on. For the environment, this means better, cleaner ways to move around and more efficient use of energy and resources in industries. But we have to be careful—while automation boosts productivity, it could also lead to problems like more traffic or unsustainable use of natural resources, like using AI-powered drones for fishing, causing unintended harm. We need to balance the benefits of automation with making sure it doesn't harm the environment.

3. More Decentralization- The convergence of Fourth Industrial Revolution (4IR) technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), Block Chain, and 3D printing has the potential to drive decentralization across various sectors, offering considerable environmental and inclusivity advantages. For instance,

peer-to-peer renewable energy grids powered by IoT sensors and AI algorithms can create intelligent virtual power plants. These systems enable efficient distribution of locally generated renewable energy, reducing reliance on centralized power grids and minimizing transmission losses. This not only lowers carbon emissions but also promotes community involvement in sustainable energy production. Decentralized manufacturing using 3D printing can revolutionize production by allowing goods to be made on-site or closer to the point of use. This reduces the need for extensive transportation and distribution networks, cutting down greenhouse gas emissions associated with long-distance shipping.

Moreover, decentralized manufacturing empowers local communities and businesses, fostering inclusivity and economic growth. Block Chain technology plays a crucial role in enabling trust and transparency in decentralized systems. Its use in supply chains can ensure ethical sourcing, reduce waste, and enable fair compensation for participants, thereby promoting sustainability and inclusivity. In short, leveraging these 4IR technologies for decentralization can indeed lead to innovative solutions that not only benefit the environment by reducing carbon footprints but also foster inclusivity by empowering communities and individuals in various sectors.

4. More Collaboration- To focus this collaborative potential on environmental goals, we can strategically harness technological advancements and collaborative frameworks:

- ➔ **Open APIs and Open Source Movements:** Encourage the development of open APIs and open-source tools specifically tailored for environmental data sharing and analysis. These can facilitate collaboration among diverse groups, enabling seamless sharing of information, innovative solutions, and collective problem-solving.
- ➔ **Block Chain for Transparency and Trust:** Utilize Block chain to create transparent and secure platforms for environmental initiatives. Smart contracts and decentralized ledgers can ensure accountability in carbon trading, supply chain transparency for sustainable sourcing, and efficient management of resources among collaborating entities.
- ➔ **Digital Platforms for Collaboration:** Develop digital platforms that connect experts, communities, and environmental movements. These platforms can facilitate communication, knowledge-sharing, and coordination of efforts, allowing diverse groups to collaborate on local and global environmental issues.
- ➔ **Crowdsourcing and Citizen Science:** Leverage technology to engage communities in environmental monitoring and problem-solving. Mobile apps, IoT devices, and crowdsourcing platforms can empower citizens to collect data, report environmental issues, and participate actively in local conservation efforts.
- ➔ **Data-driven Decision Making:** Emphasize the use of data analytics and AI to derive actionable insights from environmental data. Collaborative efforts can employ these technologies to identify patterns, predict environmental trends, and optimize resource allocation for maximum impact.
- ➔ **Education and Awareness:** Use technology to spread awareness and educate the masses about environmental issues. Social media, virtual reality experiences, and interactive educational tools can mobilize broader support for environmental causes.

➔ **Incentivizing Collaboration:** Develop incentive structures, possibly through Block chain-based reward systems, that encourage individuals and organizations to collaborate on environmental initiatives. This could involve rewarding carbon footprint reductions, sustainable practices, or active participation in community environmental projects [13].

Challenges:

The challenges in implementing Industry 4.0 span economic, social, political, and organizational realms:

1. **Economic Challenges:**

➔ **High Economic Cost:** Initial investment in new technologies and infrastructure can be prohibitively expensive.

➔ **Business Model Adaptation:** Adapting existing business models to integrate Industry 4.0 technologies requires substantial changes, which might be costly and challenging.

➔ **Unclear Economic Benefits:** Assessing and quantifying the return on investment can be complex, leading to uncertainty and excessive investment in unproven technologies.

2. **Social Challenges:**

➔ **Privacy Concerns:** Increased data collection raises concerns about individual privacy and data security.

➔ **Job Displacement:** Automation and AI-driven processes can lead to job losses, especially for blue-collar workers, contributing to social and economic disparities.

➔ **Reluctance to Change:** Stakeholders may be resistant to adopting new technologies due to fear of job loss, lack of understanding, or traditional practices.

3. **Political Challenges:**

➔ **Lack of Regulation:** The absence of clear regulations and standards for new technologies creates uncertainty and hampers effective governance.

➔ **Legal Issues and Data Security:** Unclear legal frameworks and data security concerns hinder the smooth adoption of Industry 4.0.

4. **Organizational Challenges:**

➔ **IT Security Concerns:** The need to open up production shops for connectivity raises significant IT security issues, exposing systems to cyber threats.

➔ **Reliability for Machine-to-Machine Communication (M2M)**: Ensuring stable and rapid communication between machines is crucial for operational integrity.

➔ **Maintaining Process Integrity:** Ensuring the integrity of production processes is challenging with increased automation and connectivity.

➔ **Avoiding IT Snags:** Any disruptions in IT systems can lead to expensive production outages and downtime.

➔ **Protection of Industrial Know-How:** Securing control files for industrial automation to prevent intellectual property theft is critical.

- ➔ **Skills Gap:** There's a shortage of skilled workers proficient in the technologies needed for Industry 4.0, hindering smooth transitions.
- ➔ **Low Management Commitment:** Lack of support and commitment from top management can impede the adoption of new technologies.
- ➔ **Employee Qualifications:** Insufficient qualifications and training among employees may slow down the transition to Industry 4.0 [14].

Key points regarding improper device disposal and its impact on the environment:

- **Schwab's Insight:** The Fourth Industrial Revolution has benefits but also drawbacks. Prioritizing people and collaboration while understanding that new technologies are developed by and for people is crucial.
- **E-Waste Concerns:** Incorrect disposal of devices leads to electronic waste (e-waste), posing significant threats to human health and the environment.
- **UN Report:** The United Nations warns about the dangers of e-waste, projecting global e-waste to reach 52.2 metric tons by 2021.
- **Retailer Initiatives:** Many electronics retailers offer disposal drop-off points, promoting responsible disposal practices.
- **Educating Consumers:** Continuously educating consumers about responsible electronics disposal is essential. Disposing of electronics like regular household trash can lead to chemical leakage into groundwater and soil, posing environmental risks [15].

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Proposed Study - Soil Salinity Mapping of Indus Plain for Spatio-temporal Variation Assessment Using Remote Sensing and GIS

By

Muhammad Basharat[1], Raheel Mustafa Gondal[2], Shakeel Ahmad[3], and Muhammad Masood Ahmed Soomro[4]

ABSTRACT

The importance of salinity monitoring is beyond doubt. The Indus River and its tributaries bring about 31.6 million metric tons (Mt) of salts annually. The whole irrigated area in Pakistan would be surveyed by IWASRI, MREP and LIM. Four categories namely, non-saline (S1), slightly saline (S2), moderately saline (S3), and strongly saline (S4) will be mapped for surface salinity. The whole irrigated area of IBIS will be surveyed at the resolution of one auger bore log @ 1 sq.km for Lower Indus for profile salinity, analyzed in the laboratory and results computerized afterwards, however for Punjnad Barrage and Muzzafagarh canal commands it would be about @ 1.5 sq.km and for rest of the Punjab and KPK it would be 2 sq.km for one observation.

Salinity is wide spread in Lower Indus part of IBIS. Nearness to Arabian Sea is the real issue. The previous surveys indicate that areas under S2 and S3 in irrigated areas of Lower Indus has increased from 1979-81 to 2001-03. That is, the non-saline area has decreased from 54% in the previous survey to 49% in 2001-03. Thus, in Lower Indus deterioration has taken place in almost all categories of surface salinity in previous survey.

1. Introduction

Saline soils (without Sodium salts) and Sodic soils (called ‘alkali soils) are most wide spread in irrigated areas in arid and semi-arid regions, but also occur in the more humid climates, especially in coastal areas. The salts (other than sodium) or exchangeable sodium in saline and sodic soils hinder crop growth. For efficient crop production, these salts must be leached from the root zone (Ritzema, 1994). But, in water scarce-regions, the leaching is difficult due to a shortage of fresh water. It is true that waterlogging and salinity is still a serious issue in all of IBIS.

1.1 Literature review

Salinity refers to the accumulation of salts in the root zone that results in adverse effects on plant growth when plant transpires water but leaves most of the salts in the salt solution suppressing plant growth (Kahlown *et al.,* 1998). Concentration of soluble salts plays a critical role in the formation of salt-affected soils particularly in such irrigated areas where evaporation exceeds precipitation (Daba and Qureshi, 2021). Physically saline soil is recognized by the visible white crust of salt on soil surface. Soluble salt content controls the osmotic pressure of the soil solution (Sadiq, 1992). Chemically, if the conductivity of saturated soil extract exceeds 4 dS/m at room

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temperature and exchangeable sodium percentage (ESP) is less than 15, the soil is regarded as affected from salinity. Likewise, a soil is considered sodic when it contains sufficient exchangeable sodium ion that affects the growth of most plants. In sodic soil, electrical conductivity of sodic soil is generally less than 4 dS/m, pH is as high as 10, and ESP is greater than 15. Sodicity impacts the physical characteristics of soil reducing permeability of water and air through the soil (Sadiq, 1992).

Pakistan is predominantly an agricultural country where irrigated agriculture is mainly practiced. The prevailing arid and semi- arid conditions over vast areas of Indus Plain provide critical situation for the development of soil salinity. Continuous seepage and deep percolation to the adjoining lands from the unlined irrigation canals network, improper field irrigation practices, unleveled fields, flat topography and lack of natural drainage, have all contributed in the development of waterlogging over vast areas of IBIS especially Sindh province. To cope with the problem of waterlogging and salinity, government implemented a number of Salinity Control & Reclamation Projects (SCARPs) all over the country, about 61 in number. The importance of salinity monitoring is beyond doubt. This not only helps in the evaluation of the impact and effectiveness of the projects but also help future planning. A number of organizations were established for monitoring of these projects. A substantial volume of data on the parameters such as watertable, salinity status and profile salinity, landform and climate, etc. had been collected in the past.

Researchers have highlighted three sources of salinity in the basin:

(i) Soil salinity is inherent in the Indus Basin due to its flat topography, aridity and diversion of natural river courses for the expansion of the irrigation system (Tarar, 2002). It is further increased with depth (Iqbal *et al.*, 2020).

(ii) The Indus River and its tributaries bring about 31.6 million metric tons (Mt) of salts annually. Out of the total salts, about 19.95 Mt are deposited in the canal commands at the rate of 1.25 tons per hectare. About 8.81 Mt of salts are drained below Kotri. The remaining 2.8 Mt of salts are retained in either wetlands or join the underlying aquifer through seepage (Saiqa *et al.*, 2022). This massive addition of salt across the Indus Basin is a direct result of the Indus Basin Irrigation System, which diverts water through canals and distributaries onto lands across the Indus Basin.

(iii) Another source of salts in the Indus Basin is the use of groundwater. In Sindh, the groundwater quality is generally worse but groundwater use for irrigation is considerably lower than in Punjab (Ahmad *et al.,* 1998; Young *et al*., 2019). With more pumping of groundwater, there are more chances of salinity build-up in the soil (Ashraf and Saeed, 2006). Irrigating with low or marginal quality groundwater exacerbates the accumulation of salts in the soil profile and plant root zone, causing secondary salinization, land degradation, and reducing agricultural production (Ali, 2018). As a result, it was estimated in the late 1990s that about 6.2 Mha (35–40% of the total irrigated area) was affected due to the twin problems of waterlogging and salinity (Government of Pakistan, 1997; Ali, 2018), while in 1989, based on research that was current at the time, WAPDA estimated that about 40,000 ha was being abandoned annually because of the presence of shallow and saline groundwater (WAPDA, 1989; Qureshi and Perry, 2021). More recent data from the 2000s suggest that 4.5 Mha across the Indus Basin is affected by salinity (WAPDA, 2007). This variation in

estimates emphasizes a desperate need for updated and regular assessment of the presence of salinity across the basin.

The highest concentration of saline area is in the Sindh province, where nearly half of the land is affected by soil salinity. The efforts have reduced the saline area from 35% of the total area in 1980 to 28% in 2007. Due to deeper groundwater depths and leaching through monsoonal rains, much of the salt added by the groundwater in Punjab is washed away. This is the reason that the saline area in Punjab is low compared with Sindh. In the Sindh province, groundwater is shallow and of inferior quality, restricting leaching even in monsoon months particularly due to absence of root-zone drainage. A recent assessment of soil profile of 0-5 m in the southern Indus Basin showed that 28% of the surveyed region is saline and 20% is saline-sodic. The process of soil salinization and sodification intensifies in lower parts of Sindh (Iqbal *et al*., 2020).

In the particular case of the lower Indus plains, which have a flat gradient, poor drainage is another reason for waterlogging and salinity. Almost 50% of the cultivable command area in Lower Indus does not have drainage facilities (Steenburgen *et al*., 2015). Drainage facilities, though on a limited scale, brought immediate good results over 2.3 Mha of land after the implementation of 18 different drainage projects consisting of surface (open) and sub-surface (tile) drainage (World Bank, 1997).

In 2006, an investigation by the National Drainage Program identified that the 1999 cyclones and 2003 floods and afterwards exaggerated the issues of waterlogging and salinity due to the incapacity of Left Bank Outfall Drain (LBOD) and tidal link (World Bank, 2006). The combined effect of poor drainage and climate change induced rising sea levels in the coastal areas has resulted in an increased risk of coastal flooding, inundation of wetlands and other ecosystems (Ali, 2018). IWMI has done an intensive and extensive research regarding salinity management in the IBIS and produced a series of reports. Aslam M. (1998) has concluded that secondary salinization in the Indus Basin is associated with the shallow groundwater table and use of marginal to poor quality groundwater for irrigation. Amongst the preventive and curative approaches, the preventive salinity measures pay rich dividends at a much less cost and effort. The aforementioned approach is especially true for the Lower Indus, thus part of the salinity can be managed by lowering watertable with proper water management and that is only possible with drainage.

1.2 Previous Salinity Surveys of IBIS

In this regard a number of efforts were made to assess the salinity situation. Various survey programs were arranged and carried out during last 70 years. Activities carried out under these programs are briefly described below:

A countrywide reconnaissance survey of Landforms, Soils and Land Use was conducted under the umbrella of Colombo Plan during 1952-54 mainly through photo interpretation generalized information regarding landforms, soils and land use. Only the severely salt-affected lands were shown on the maps of landforms and soils. The results of the survey were published in the report titled “Landforms, Soils and Land use of the Indus Plain, West Pakistan” 1958.

Land Reclamation Directorate of Punjab conducted annual appraisal of surface salinity only in Punjab through a"*Thur Gurdawari*" monitoring program during winter months. The field work was carried out by Patwaris and surface salinity was mapped in the field as: *Thur Kohna (*inherent salinity), *Thur Panjsala* (saline for last five years), *Thur Nau* (new salinity), *Thur Jazvi* (partially saline) and *Thur Tirk* (total saline). (Salman, 2000)

Water and Soil Investigation Division (WASID) of WAPDA carried out semi-detailed soil survey during 1962-65 with the help of chak plans and photo enlargements (1:15,840) of 1:40,000 scale contact prints, taken during 1952-54.

Soil Survey of Pakistan carried out reconnaissance soil survey of the area in 1968 with an average density of 2 auger holes per square mile. Aerial photographs of 1:40,000 scales taken in 1952-54 were used as base maps and soils were examined up to 150 cm depth. Delineations of the salt-affected areas in terms of slight, moderate and strong salinity were made.

Master Planning and Review Division, WAPDA, in collaboration with International Bank for Reconstruction and Development (IBRD) conducted comprehensive surveys of: surface salinity, profile salinity/sodicity, soil textural classification, water table depth, shallow water quality and land use for irrigated areas of Indus Plain comprising of 41.3 million acres during 1976-79 and presented in the form of Salinity Atlas.

IWASRI in collaboration with SMO conducted the latest survey in 2001-03 in all of the IBIS.

1.3 Need for the proposed research study

Recently (March-2022) PCRWR carried out a study titled: "*Adapting to Salinity in the Southern Indus Basin (ASSIB)*" in collaboration with Australian Centre for International Agricultural Research (ACIAR) and other Pakistani as well as international organizations with the key objective to review the policies and strategies relevant to salinity management in the southern Indus Basin. It was one of the recommendations of consortium that there was a need to conduct regular surveys to determine the extent of waterlogging and salinity, particularly for the southern Indus Basin, with detailed survey to be conducted at 10-year intervals, now about 20 years have passed that no salinity survey could be conducted.

As such, following study was designed to aim at fresh soil salinity mapping of the whole Indus Basin to know current situation of salinity in the Indus plain, employing advanced remote sensing techniques, GIS and machine-learning algorithms etc. The results of this study will help planning for implementing a long-term salinity management strategy facilitating for educating farmers living with the salinity and will act as a ready reference for all the R&D organizations for future planning as well.

1.4 Objectives

The proposed study is designed to achieve the following objectives.

- To check the current status of soil (surface & profile) salinity in the irrigated areas of IBIS;

- To assess the spatial and temporal changes in soil salinity in comparison with the last surveys; and
- To classify irrigated areas of whole IBIS based on the severity of soil salinity for remedial measures, and recommending appropriate land use options.

1.5 Study Area

The study area would be entire irrigated canal command areas of IBIS, to be surveyed by IWASRI, MREP Bhalwal and LIM Project Hyderabad for the respective areas falling under IBIS, as shown in Figure 1. If needed personnel's from other WAPDA departments can be taken for field survey e.g. SMO.

1.6 Study output

Several maps will be produced particularly the watertable depth, water quality, surface salinity and profile salinity etc. In addition a study report will also be produced detailing about the methodology followed and results obtained.

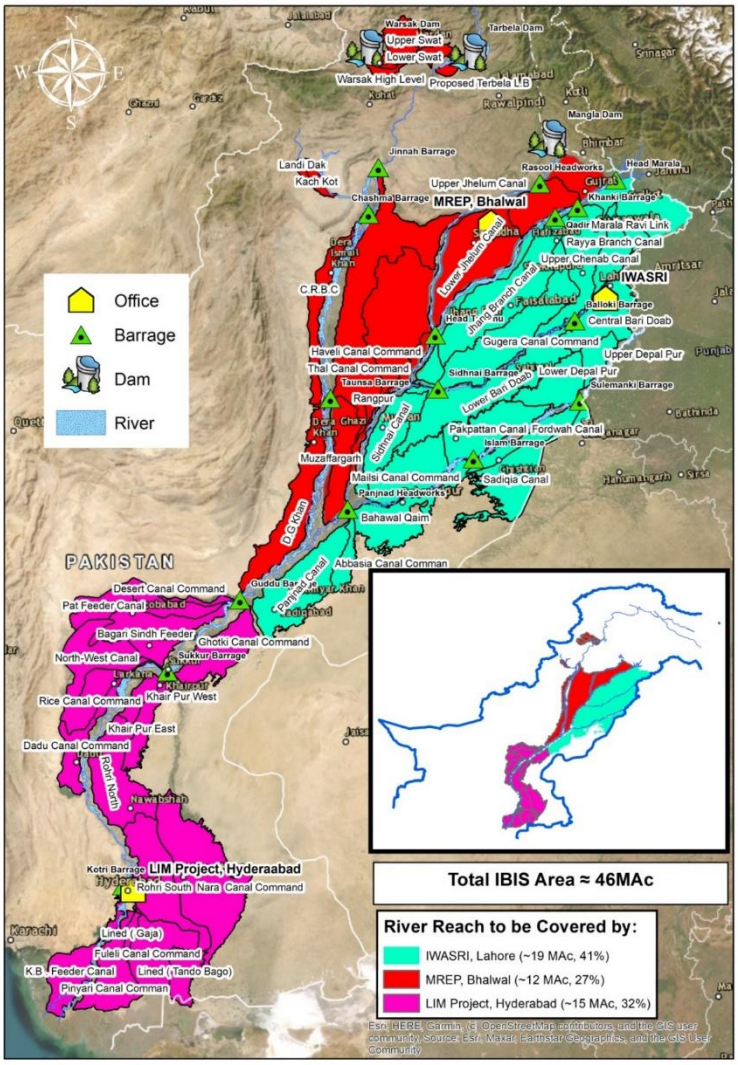


Figure-1: *Delineation of Canal Command Areas of IBIS to be surveyed by IWASRI and its Field Offices.*

2. Methodology

In the beginning literature will be reviewed for all the past studies on soil salinity carried out during different time periods in Pakistan and other countries in the world especially South Asian countries, viz; India, Bangladesh, and Iran having irrigation system similar to Pakistan. Sampling technique will be sought from literature for latest technology and methods for surface salinity measurement and profile salinity sampling. The next phase will consist of extensive field survey for data collection. The whole irrigated area of IBIS (~ 46MAc) will be surveyed at the resolution of one auger bore log @ 1 sq.km for Lower Indus (will also include Kachhi Plain) for profile salinity, analyzed in the laboratory and results computerized afterwards, however for Punjnad Barrage and Muzzafagarh canal commands it would be about @ 1.5 sq.km and for rest of the Punjab and KP it would be @ 2 sq.km for one observation for profile salinity.

2.1 Criteria for Surface Salinity Mapping

Four categories namely, non-saline (S1), slightly saline (S2), moderately saline (S3), and strongly saline (S4) will be mapped. The criteria for classification of surface salinity categories are based on the Soil Survey Manual Agriculture Handbook No.18 (1993) of USDA as quoted in WAPDA (2001).

2.2 Use of Machine Learning Tools (MLT) for Surface Salinity Mapping

Advancement in remote sensing techniques & machine-learning algorithms has started contributing to fast & large-scale monitoring & mapping of soil salinization throughout the modern world. In this research, satellite imageries from Landsat-8 OLI, Sentinel-2A and Dynamic World will be acquired to be processed on Google Earth Engine (GEE) platform. The training dataset in the form of field survey will be fed to the modelling environment. Classification and Regression Trees (CART), Random Forest (RF), and Support Vector Regression (SVR) methods will be implemented to create a correlation between ground measurements and satellite-derived environmental variables or spectral indices. The reason for selecting above mentioned satellite imageries is that they are free source and are available at high resolution with low return period. After selecting the optimum variables including wetness band, four soil salinity indices, and one vegetation index; soil salinity maps will be generated in three machine-learning algorithms. Or otherwise satellite images/maps would be printed (at about 1:40,000 scale) in GIS and handed over to field teams for salinity assessment with naked eye and classified accordingly. The data will be marked in GIS software in the office and maps prepared accordingly.

2.3 Grid Size Selection - Criteria for Profile Salinity Mapping

Salts keep on fluctuating from surface to groundwater and vice versa through the soil profile, depending upon rainfall, canal water and groundwater usage and quality. Soils can be highly variable, even over short distances. Because of this variability, it is often insufficient to collect soil at just one location. Instead, it is preferable to collect composite samples. By combining multiple sub-samples into a single composite sample, we can minimize the effects of soil variability by averaging the soil properties over larger areas. It is therefore necessary to select a suitable grid

size for profile salinity survey of whole IBIS therein considering two major constraints namely cost & time.

Selection of optimized grid size is very important in order to obtain quality results of survey for which data of historically carried out soil salinity surveys can be used as initial guideline. Soil Survey of Pakistan carried out reconnaissance soil survey of the area in 1968 with an average density of 2 auger holes per square mile. Aerial photographs of 1:40,000 scales taken in 1952-54 were used as base maps and soils were examined up to 150 cm depth. Similarly, Master Planning and Review Division, WAPDA, in collaboration with International Bank for Reconstruction and Development (IBRD) conducted comprehensive surveys of: surface salinity, profile salinity/sodicity, soil textural classification, watertable depth, shallow water quality and land use for irrigated areas of Indus Plain comprising of 41.3 million acres during 1976-79 @ 1Km X 1Km and presented in the form of Salinity Atlas. During 2001-03 SMO in collaboration with IWASRI carried out basin wide salinity survey @ 2Km X 2Km under NDP and updated soil salinity Atlas.

In this proposed study different parts of IBIS can be surveyed considering different grid sizes @ 1Km, 2Km, 5Km & 10Km (however the later two categories become too course) impact of its variation on quality of results will be checked. Table 1 (PC-II, 2024), as given below also, represents number of sites, samples and time required for survey with a particular grid size. However, in Punjab and Lower Indus the grid would be 2Km x 2Km and 1Km x 1Km, respectively.

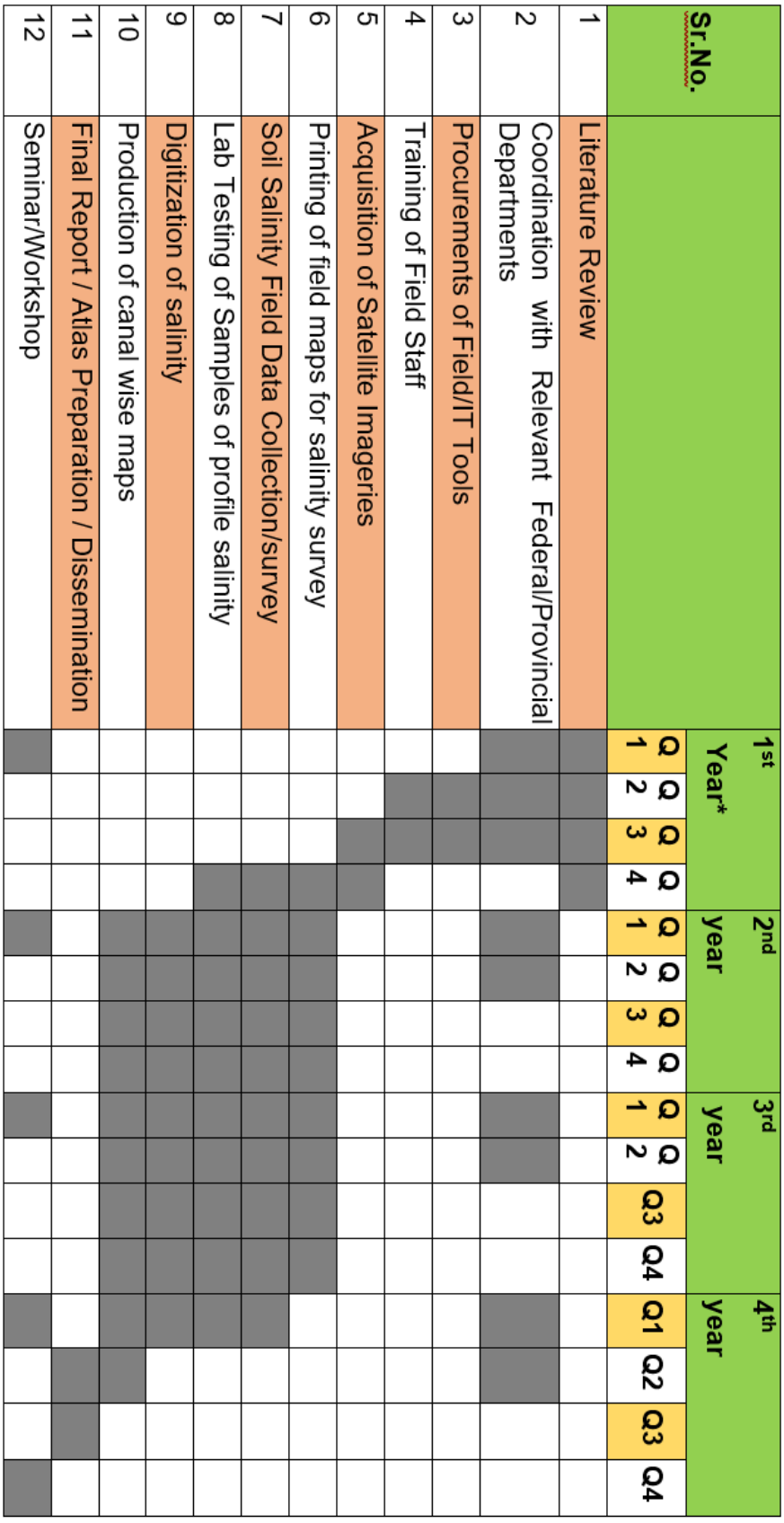
Table-1 Statistics of Samples & Duration for Salinity Survey Using Different Grid Sizes

Sr. No.		Grid Size	Samples		Duration
			Sites	No	
1		1Km x 1Km	188643	754572	3Y 10M
2		2Km x 2Km	94322	377286	1Y 11M
3		5Km x 5Km	37729	150914	0Y 9M
4		10Km x 10Km	18864	75457	0Y 4M

In order to study the distribution of salts and sodic conditions in the soil profiles, one auger hole per Cell will be made up to 180 cm depth or to the sloughing material whichever is shallower. Soil samples will be collected in four sectional depths viz. 0 to 15, 15 to 45, 45 to 90 and 90 to 180 cm as per USDA Manual. These samples will be tested for pH, ECe and SAR in the laboratory for classification of soil profiles. Moreover; as USDA derived relationship between SAR/ESP based on USA's soil, similarly, SAR-ESP relationship will be derived from soil samples based on Pakistan's soil and climatic conditions. The soil samples will be classified according to the criteria laid down in USDA Handbook No.60. Location of each bore site will be determined using Global Positioning System (GPS) by the field party. This will facilitate and ensure location of observation point for GIS maps production.

2.4 Schedule of activities

Following schedule of activities is planned keeping in view of the activities and area to be surveyed



2 Analysis of Previous Surveys

This section is limited to the analysis and comparison of surface salinity survey 2001-2003 of the four provinces, with the previous survey conducted in 1976-79. The surface salinity has been categorized into four classes S1, S2, S3 and S4, according to level of salinity. The comparison of the two surveys shows a remarkable improvement in S2, S3 and S4 categories in Punjab Pakistan, which have been converted into non-saline, i.e. non-saline areas increased from 86% in 1976-79 to 93% in 2001-03, as shown in Figures 2 and 3. This is quite logical, the reason being that after completion of Tarbela reservoir in 1976-77, the canal head withdrawals in the Indus increased to 124.6 BCM just after the Tarbela Dam and reached the peak of 133.2 BCM in 1979. Thereafter, canal withdrawals then stagnated at this level up to 1989-90 and have now declined to around 125.8 BCM due to reduction in reservoir capacities (4.37 MAF, 28%, by the year 2012) caused by progressive sedimentation (Ahmad et al., 2012). That is why there is about 30% reduction in Rabi supplies to Punjab, during 2001-09 due to online storage loss and Low River flows during drought period (Basharat et al., 2014a). Increased fresh water supply to agricultural lands is a major factor, in leaching down the salts or otherwise salinity build up. Therefore, it is hypothesized (in the absence of fresh survey and reduced canal supplies during last many years) that profile salinity has also increased in Punjab. Therefore, leaching of salts is now an emerging issue in many of the areas in Punjab.

On the other hand in Lower Indus part of the IBIS, the non-saline area has decreased from 54% in the previous survey to 49% in 2002-03 survey. Thus, in Lower Indus part deterioration has been noticed in almost all categories, and the salt affected area has increased. One of the most obvious reasons for this contrasting behavior, in changes in surface salinity, in Punjab and Lower Indus, is lowering of watertable in Punjab. On the other hand, increased waterlogging conditions in Lower Indus, particularly after the provision of higher canal supplies after commissioning of Mangla and Tarbela Dams, and the absence of conjunctive use of canal and groundwater leading to lack of drainage in the root zone, had been the major factors for increase in surface salinity. The map of latest available surface salinity survey (2002-03) carried out by WAPDA, for the IBIS, is shown in Figure-4.

Table-2: Surface salinity status of IBIS surveyed by WAPDA

AREA SURVEYED 1976-79 (millions hectare)					
Province	**Non-Saline**	**Slightly Saline**	**Moderately Saline**	**Strongly Saline**	**Area**
NWFP (now KP)	0.526	0.040	0.000	0.000	0.607
Punjab	8.704	0.729	0.445	0.283	10.162
Lower Indus	3.239	1.093	0.607	1.012	5.951
Total	12.510	1.862	1.053	1.336	16.721
AREA SURVEYED 2001-03 (millions hectare)					
NWFP (KP)	1.1	0.01	0.02	0.01	1.14
Punjab	9.789	0.385	0.186	0.162	10.522
Lower Indus	2.964	1.231	0.603	1.247	6.049
Total	13.202	1.619	0.794	1.413	17.032

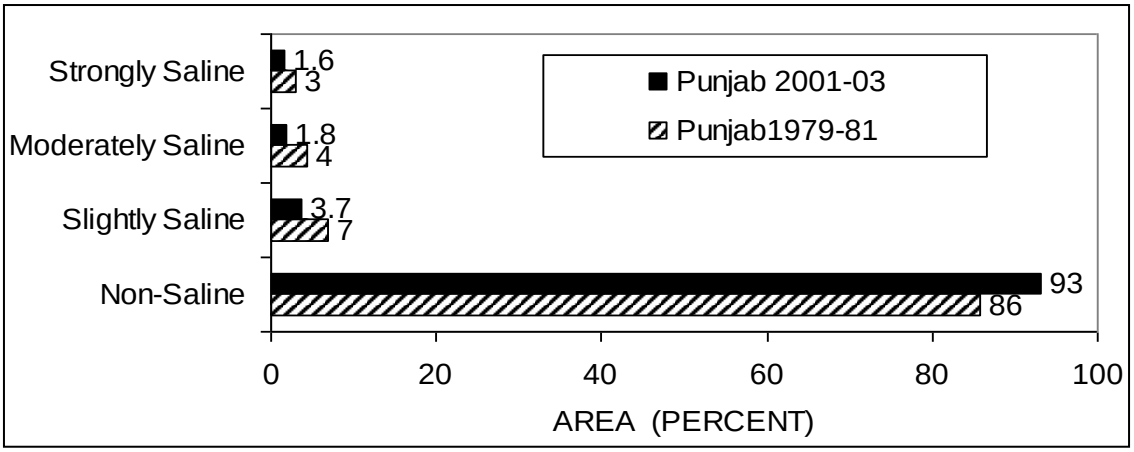


Figure-2: Comparison of surface salinity in Punjab for the periods: 1979-81 and 2001-03

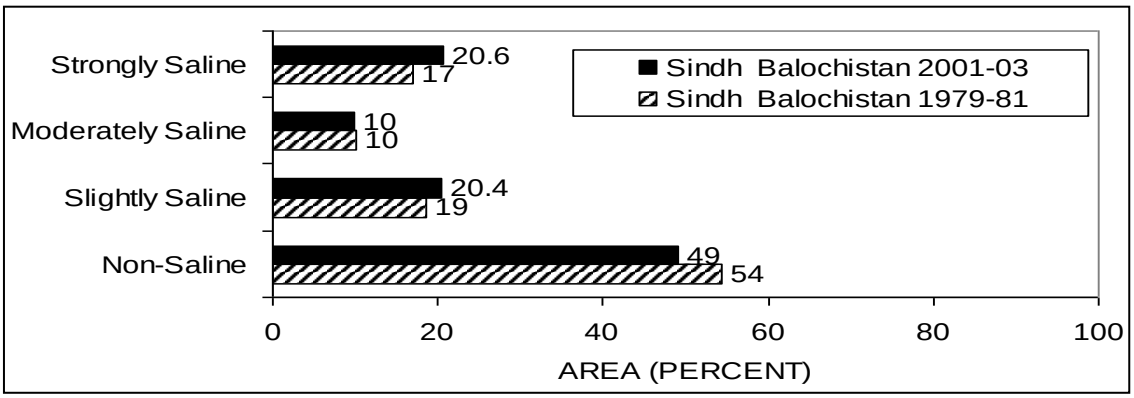


Figure-3: Comparison of surface salinity in Lower Indus for the periods: 1979-81 and 2001-03.

On the other hand, areas under S2 and S3 in irrigated areas of Lower Indus (Sindh and Baluchistan) has increased from 1979-81 to 2001-03. That is, the non-saline area has decreased from 54% in the previous survey to 49% in 2001-03. Thus, in Lower Indus deterioration has been taken place in almost all categories of surface salinity, and the salt affected area has increased. One of the most probable reasons for this contrasting behavior, in changes in surface salinity, in Punjab and Lower Indus, is lowering of watertable in Punjab. On the other hand, increased waterlogging conditions in Lower Indus, particularly after the provision of higher canal supplies after commissioning of Mangla and Tarbela Dams, and the absence of conjunctive use of canal and groundwater leading to lack of drainage in the root zone, had been the major factors for increase in surface salinity.

IWMI has done an intensive and extensive research regarding salinity management in the IBIS and produced a series of reports. Aslam M. (1998) has concluded that secondary salinization in the Indus Basin is associated with the shallow groundwater table and use of marginal to poor quality groundwater for irrigation. Amongst the preventive and curative approaches, the preventive salinity measures pay rich dividends at a much less cost and effort. The aforementioned approach is especially true for the Lower Indus, thus part of the salinity can be managed by lowering watertable with proper water management.

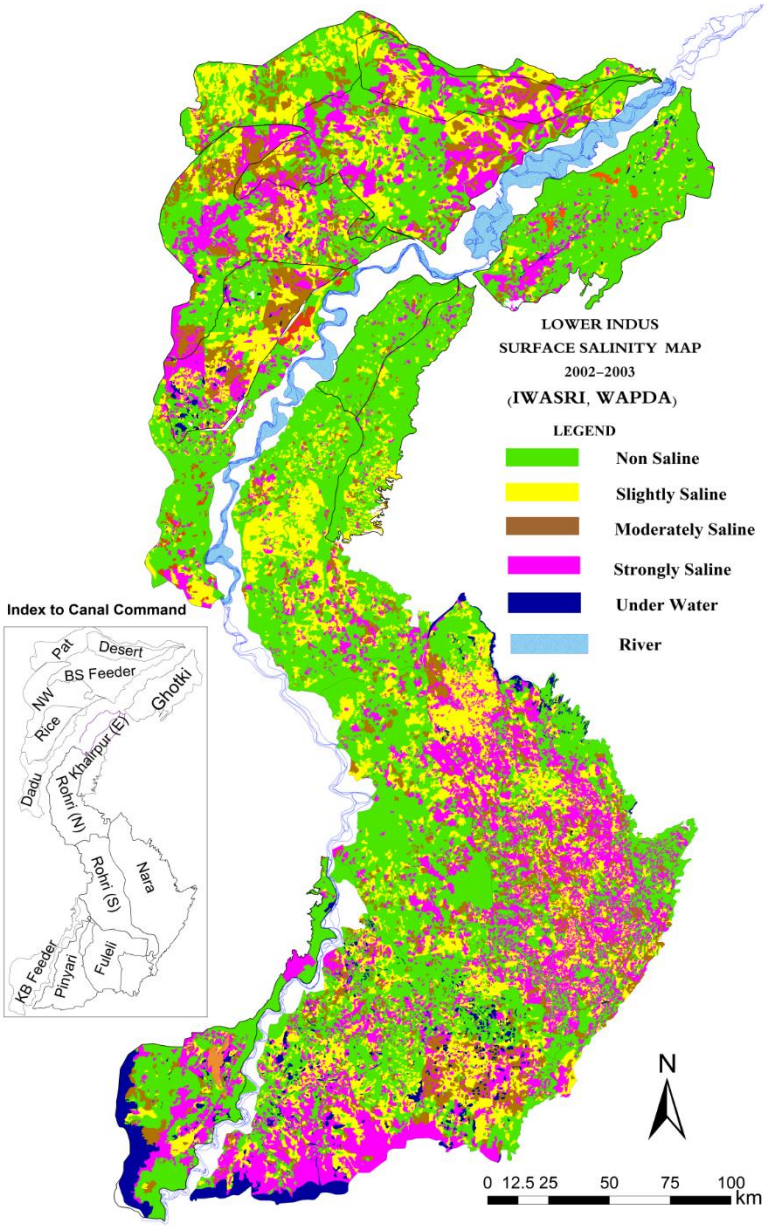


Figure-4: Surface salinity in Lower Indus, as observed during 2002-03 (Basharat et al., 2014b).

4 Expected Outcomes

1. The expected outcome of this study would be the fresh/current status of surface/profile soil salinity in the canal command areas of IBIS.
2. The results of this study will help comparing the last survey findings (2001-03 by IWASRI); highlight the severity of soil salinity in different canal-command areas w.r.t. spatio-temporal variation on account of prevalent climate change scenario. This information can also be utilized for the zoning of whole Indus Plain based on soil salinity.
3. The results of this study will be helpful for developing policy guidelines for sustainability and planning for implementing a long-term salinity management

strategy, translating manifold economic implications benefitting to national economy.

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Role of Irrigation & Water Resources Research in the Economic Development of Nation

By

Adnan Hassan[1]

Summary

One of the main causes of prosperity of developed nations is the extensive application of science and technology in almost the entire fabric of their economy. The developing countries have lately come to realize the importance of research as vital ingredient of economic growth and consequently are endeavoring to mobilize their indigenous resources to boost up their developmental activities with the assistance of modern technology. But, by and large, the Research and Development activity in the Water Resources sector, a very essential element for systematic growth of infra structure is however still very much neglected. The investment in Irrigation and Water Resources research has been universally recognized as capable of appreciable reduction in the overall cost of management of water resources in addition to boosting-up technological capabilities of the man-power and developing new techniques/innovations.

This article, apart from discussing the need for establishing Irrigation Research Institute, their part in effecting/exercising quality control through sustained testing in major developing works to meet the diversified needs of the ever-growing technological age. It also briefly outlines the activities of the Irrigation Research Institute, Lahore; its past achievements and future programs.

Introduction

Constant flow of scientific and technical knowledge, is an essential pre-requisite for the economic growth of any nation specially the so called under developed ones- Its mass scale use by developed countries is a continuous process which has remarkably resulted in their existing prosperity. Research and Development effort is considered critical in solution of these problems and attaining the goals set in all the sectors including construction. The conspicuous absence or scarce utilization of this resource of universal recognition is, however, an obvious drag on the pace of economic development in all the under developed countries.

The technology has, of necessity, to be based on peculiar resource endowment of a country and to be ultimately woven into the fabric of its social and cultural complex. Therefore, it becomes essential for each country to have its own source of technological innovation and improvement. But it is the fact that a major portion of the budget is consumed and steadily increased every year in the water resource development sector whereas the important R and D activity is found to be more than neglected. Investment on this aspect has not kept pace with development being undertaken even when it is an established fact that it enhances the technical acumen of local talent to infuse the much-needed confidence for self-reliant economy.

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The Importance and Need for Research in the Irrigation and Water Resources Management Field

Research plays a pivotal role of a brain in an engineering department, serving as a driving force for innovation, progress, and advancement. It is through research that departments discover groundbreaking solutions to complex problems. The importance of research in an engineering department cannot be overstated, as it enables engineers to stay at the forefront of technology, develop new methodologies, and push the boundaries of what is possible. By conducting research, gaps in existing knowledge can be identified, alternative approaches can be explored, and existing systems can be improved and processedd. Additionally, research fosters collaboration, both within the department and with external partners, facilitating the exchange of ideas and fostering a culture of continuous learning. Ultimately, research in an engineering department enables the development of cutting-edge technologies, drives innovation, and ensures that engineers are equipped to tackle the challenges of tomorrow.

The need today everywhere in the world, is to develop the resources and minimize the cost factor. This need can only be fulfilled if sufficient knowledge is available to all technologists, engineers and practitioners engaged in the Irrigation and water resource management activity so that the limited financial resources are stretched to give optimum benefit to the most and to cut down wasteful tendencies, if any. The large vacuum between actual practice and knowledge can only be bridged and future problems/needs can only be served through adequate research and development facilities. A well organized and equipped Research Organization can play a vital role and meet the diversified needs of various water resource managers, through the efforts of scientists, engineers, planners, by carefully and specially studying each and every item and operation so that saving in one may not be drowned by overspending in others.

Researchers investigate hydrological processes, water quality parameters, and the impacts of human activities on water resources. These studies provide valuable insights for policymakers, water managers, and industries to make informed decisions regarding water allocation, conservation, and pollution prevention. It involves implementing innovative technologies, infrastructure development, and efficient management practices to optimize water use, reduce losses, and protect water resources.

Research findings consequently have a cumulative effect. A small saving even in one item of work may well pay off for the entire research- expenditure in many instances. Investment in Irrigation Research has, therefore, always been recognized to be quite profitable and fully justified. Most of the countries in world have established national research Organizations directly or indirectly concerned with the science of Irrigation and Water resource management which continue to expand to suit the changing pattern of demands. It is estimated that at least about 300 institutes in about 57 countries of the world exist in the field of Irrigation research.

Brief History of Irrigation Research Institute:

The phenomenal place of development of irrigation out-standing the technical horizon then existing, leaving behind in its wake number of technical problems which have progressively been springing-up and confronting the engineers. Founding of major irrigation structure on alluvium presented highly intricate and complex technical

problems. The construction of so many control points on the rivers crated flood problems of a colossal magnitude. This situation high-lighted the necessity of a central institute where all such problems could be tackled. This began in a small way in 1924, when a small laboratory was set-up in a wing of Punjab University Chemical Department at Lahore.

IRI Laboratories and Model Trays at Lahore:

Soon the problems spilled out of the laboratory at Lahore and a field station was established in 1925 at Malikpur (now in India) where investigation of river problems on large scale models becomes possible. The laboratory at Punjab University Lahore had to be expanded very soon and a Chemical and Physics Section setups were added at Library Road, Old Anrakali Lahore and named as Irrigation Research Institute, Lahore. In 1931, Hydraulics Section which was destined to play a major role in future was opened in the same premises. The institute progressively built-up its reputation over this period and was recognized as one of the premier research institutes in the East and was internationally known, as it was dealing with a range of problems both specific and basic covering a wide area of realm of science majorly focusing on water resources and hydraulics.

Hydraulic Research Station Nandipur For Hydraulics Modelling in Hydraulics Wing of Irrigation Research Institute:

Due to partition of province in 1947, the field station of Malikpur went over to India and a new field station was opened in 1952 at Nandipur about 80 km from Lahore, covering an area of 100 acres by the side of Upper Chenab Canal, where a gravity fall of 20' was available. The area is served with the circulation of 500 cusecs discharge which is fed back into the irrigation canal. With these facilities, about 2 dozen field scale experiments can be conducted simultaneously. The availability of continuous discharge of this magnitude and a gravity fall of 20' with such a large field area is a unique which is not available even in most sophisticated laboratories of the West.

Hydraulics wing of IRI deals with hydraulic modelling carried out before any intervention or construction of any hydraulic structure. Mainly these model studies are carried out at Hydraulics Research Station Gujranwala.

Experimental Research Station, Niazbeg Lahore of Physics Wing of Irrigation Research Institute:

This was followed in 1954 by another field station at Niazbeg (16 km from Lahore) covering an area of 50 acres for the study of problems conduced with canal lining, tubewells, evapotranspiration and other aspects of soil physics. A radio isotope center for determination of seepage losses from irrigation channels has also been established there.

In early 60s, as a result conclusion of **Water Treaty** with India, the implementation stage of Indus Basin Project works began. These works were of magnitude unprecedented in the technical history of the world and the top most Engineers and Consultants of the world joined their heads and took up this challenge under the good offices of the World Bank. This called for the highest standards of laboratory testing of the models. The institute was successful in making such a mark as regards its technical competence, resourcefulness and economy that the entire model testing of the Indus Basin Project (I.B.P.) works where entrusted to this institute. Since then, the institute has been catering to the needs of WPDA and with the disaster

at Tarbela Dam since 1974, all the models testing for devising solution to the highly complex and intricate hydraulic problems have been entrusted to this institute. It may be observed that with the unique facilities available in this institute it was possible to construct a combined model of the two spillways of Tarbela Dam (prototype height 476' and a combined max discharge of 1.5 million cusecs) on as a large scale so that even the model discharge in this case was of the order of 85 cusecs.

With the recognition of the physical and technical capabilities of this institute, the entire model study work of various components of different dams has been entrusted to the Irrigation Research Institute. A special cell headed by a chief Research Officer has been created for these studies. Out of a number of models constructed for Kalabagh Dam, the comprehensive model of the dam comprising all the features i.e. two spillways, low level out-lets works and the Power Tunnels has been constructed. In this process, the institute was equipped with Sedimentation section, Electronic Instrumentation Section and sophisticated Publication Section. The international experts connected with Tarbela Dam Project make a bee-line for this institute when the model testing is going on.

Field Research Station, Babakwal, District Sheikhupura:

With the curtailment of experimental research station, Naizbeg due to construction of canal colony and WASA inftrastructures, it was felt as need of time to establish another field station where experiments at field and semi field conditions may be carried out. In the year 2014 a new research station was established at Kala Khatai Road, Babakwal, Tehsil Ferozwala, District Sheikhupura 20 km away from IRI, Lahore.

With above all capacities and capabilities , the institute is capable of and is catering to the needs of Irrigation Department in R&D sector including all the provinces of the country and the Federal Government in such departments as Communication and works, WAPDA, Highway, Railway, Irrigation etc.

Basic & Applied Research, Testing and Quality Control in Physics Wing of Irrigation Research Institute:

Physics wing of IRI is in place with the objectives to deal with multifarious water sector issues by basic and applied research at field and semi field levels. The factors are basic and applied research which play essential roles in irrigation research, ensuring the development and implementation of effective and sustainable irrigation practices. Basic research focuses on understanding the fundamental principles and processes of irrigation, such as water movement in soils, and training works-water interactions. This knowledge forms the foundation for applied research, which aims to translate scientific findings into practical solutions and technologies for improved irrigation management by application of same scenarios in field and semi-field conditions. Testing and quality control are crucial aspects of irrigation research, involving the evaluation and validation of new irrigation methods, technologies, and products. Testing ensures that these innovations meet performance standards, water-use efficiency, and environmental sustainability criteria. Quality control measures help maintain consistent and reliable irrigation systems, ensuring that components of system including hydraulic structures meet specified standards and performance expectations. Through these interconnected processes, basic and applied research, testing, and quality control contribute to advancing irrigation practices, optimizing water use, and enhancing agricultural productivity while minimizing environmental impacts. The technical sectors are becoming test oriented to maintain their standards.

The field formation / engineers rely on tests as basis for making many important decisions. Testing of materials essentially involves knowledge of accepted methods of testing, training in methods of observation, appreciation of the significance of data derived from tests, knowledge of standards and specifications, acquaintance with the technical periodical literature and other sources of recorded data on properties of materials, and practices in preparing giving the results of investigations /studies. The extensive use of experimental studies is well-recognized features of any technical development. The Government which spends a great part of its budget in one form or another on water resource management activity has obviously to be interested in obtaining value for the money invested by ensuring the desired efficiency of the whole process from inception to satisfactory completion of the finished unit. IRI Physics wing has been planning and has to play its due role in carrying out of the testing to ensure the desired quality control of construction materials to be used.

Special Achievements/Work done by Irrigation Research Institute, Lahore:

The work done by the Institute is disseminated through printed reports and online through e-library of IRI and published papers at National and International level to encourage use of the research results in actual practice. A brief resume of the special works done and remarkable achievements so far by this Institute may be of some interest in this context, has been presented below.

- In the country, every significant flood protection works or hydraulic structure, whether it is a dam, highway bridge, railway bridge, or barrage across a river, undergoes thorough model testing in the institute. The design and layout features of these structures are meticulously developed and refined through this testing process, ensuring that they meet the required standards and receive the institute's stamp of approval.

- Model Studies of Mangla Dam, Tarbela Dam, Bhasha Diamer Dam, Detail Design of Kalabagh Dam, Kotri Barrage & U/S training works, Taunsa Barrage & U/S training works, Guddu Barrage & U/S training works

- Models of tunnel No. 3, 4 & 5 of Terbela Dam tested; failed at International Lab during first operation, re-tested at Nandipur, performing satisfactorily.

- Terbela spillways with flip bucket tested at an International Laboratory. Failed at site. Re-tested at Nandipur and performing properly.

- Evaluation on mix-ratio analysis methods published in Pakistan Engg Congress, 1987 and was awarded **Gold medal**

- A new method for proportioning of concrete mix published in the institute of Civil Engg London,1982 and was awarded **Governor Medal**

- Structural investigation of Sukkur Barrage Arches, published in the proceeding West Pakistan Engg Congress, Vol-one and was awarded **Gold Medal** by W.P.E.C

- Optimum moisture content for compacting soils, one point method published in Journal of Irrigation & Drainage, England, 1983 and was awarded **Governor award.**

- A number of technical papers published on the basis of research work done for the use in the field conditions at local and global levels.

- Similarly, a new technique for determining micro velocities in sub-soil flow has been developed for which the instrument has been designed and constructed in the institute. This technique is being successfully employed to monitor the performance of

tubewells as regards incrustation, not only of strainers, but also the surrounding shrouding material. The technique is also enabling us to determine the rate of seepage flow for various reaches of canal, which information will be source of great economy in tackling the seepage from the canals, as the reaches requiring remedial measures would be singled out.

The institute has done pioneer work in determining and tackling seepage losses from water courses (field irrigation channels of small discharges). In the same context, a device for accurate determination of the discharge of a water course has been designed and construed in the institute which is based upon an entirely new concept. The institute is also catering to the needs of soil mechanics of Government Department as well private enterprise. Design of foundation of structure according to local conditions of soil profile and water table are under taken for various agencies. Similarly, the advice on slot size of strainer in tubewells in particular local soil strata is also rendered. Similarly, the experiments to prevent corrosion and incrustation of strainers of tubewells (caused by the electrolytic processes around the strainer) by neutralizing the electric generated in the soil strata by imposing a counter current from outside have been carried out.

Technology of protection against river erosion, which is a common feature on excessively controlled rivers have been developed which are being very successfully employed in the field. Different geometries f spurs have been tested modified with the result that geometries for highly efficient and effective spurs have been now evolved.

Similarly Research studies on Artificial Recharge of Aquifer in Punjab, Impact Assessment on canal lining in Punjab , Geotechnical investigations of flood bunds in Punjab , Sediment study for management of hill torrents in DG Khan, Impact of plastic pollution on water resources, Groundwater Monitoring, Modelling and Management , Groundwater-depletion (Faisalabad Airport), Identification of corrosion, incrustation and other problems of choked tube-wells and their renovation by economical methods, Canal seepage measurement, Development of Integrated Water Resource Management (IWRM) Framework,Excessive Entry of unwanted floating material (Aquatic Plants) in Pakpattan Canal, National seminars and field workshops for awareness and consultation, Testing the Quality of stones ,Development and up dation of digital maps of Punjab Irrigation Network.

Future Vision

To cope with the growing challenges and opportunities in the field of irrigation and water resource management the Institute's effectiveness and maintain its leadership in irrigation research may be enhanced. This can be achieved by introduction of innovative research disciplines to cope with the current and future emerging water scarcity challenges like climate changes (floods, droughts), water quality concerns, fresh and saline water intrusion, hill torrents management, sediment transport modeling, river morphology changes, secondary salinization, drainage water managements, use of hydro-informatics in IWRM, groundwater flow and solute transport modeling; managed aquifer recharge, rainfall harvesting, Bio-remediation for remediation of effluents, constructed and floating wetlands, plastic pollution and water resources, watershed management for control of sedimentation, canal lining materials and seepage control. The following proposals may be considered to achieve the above-mentioned milestone:

i. **Maintain the leadership of IRI:** This is need of time that every such problem, where any brainstorming is involved or where there is any policy reform or technological reform in the operations are involved, may be referred to IRI. It can also enhance the institute's effectiveness and bring it into the mainstream.

ii. **Proud to be the intellect property of department**: When the employee is recognized as intellectual property, they will experience a sense of pride, leading to an enhancement in their efficiency.

iii. **Equal Opportunity Employer/ Employee Well-being:** Investing in employee well-being through improved infrastructure, equal incentivization, perks and privileges like all other similar position employees, reducing disparity and discriminative behavior, equal level opportunities including the international trainings, courses, logistic facilities, recreational spaces, and flexible work arrangements will boost morale and productivity.

iv. **Technological Advancements:** Upgrading research facilities with cutting-edge technology can enable researchers to conduct more precise experiments, analyse data faster, and stay at the forefront of innovations.

v. **Skill Development:** Organizing regular training sessions (local and international), workshops, and seminars can enhance skills and keep the researchers updated on the latest irrigation techniques and methodologies

vi. **Collaborative Environment:** Creating collaborative spaces can encourage interdisciplinary research within the Institute and foster partnerships with other research institutions, thus promoting knowledge exchange and collective problem-solving.

vii. **Enhanced Reputation:** A modernized facility can attract renowned researchers, professors, and students, thereby elevating the researcher's reputation on a global scale.

viii. **Increased Funding:** Upgraded infrastructure and advanced research capabilities can attract more funding from governmental bodies, private organizations, and grants.

ix. **Research Output:** With improved resources, the researchers can produce higher-quality research, leading to patents, publications, and practical solutions for real-world irrigation challenges.

x. **Industry Collaboration:** Industry partnerships can flourish, allowing researchers to work closely with irrigation equipment manufacturers, agricultural companies, and other stakeholders, facilitating the practical application of research findings.

xi. **Technological Advancement:** The upgrade can position the research institute as a hub for cutting-edge research, which will attract global attention and contribute to solving pressing water resource management issues.

xii. **Economic Impact:** The Institute's research can lead to more efficient irrigation methods, reducing water wastage and benefiting local communities, farmers, and the environment

xiii. **Collaboration:** Collaborations with other research institutions and industries can enhance knowledge dissemination, accelerate innovation, and address irrigation challenges comprehensively

xiv. **Educational Opportunities:** Upgraded facilities can offer enhanced learning experiences for students, researchers, and professionals, driving knowledge dissemination and skill development in the field of irrigation.

In conclusion, the importance and need of research in irrigation and water resources management in the development of a nation has a high place when it comes to priorities and stands to benefit all stakeholders involved.

RAINWATER HARVESTING APPROACH: COST-EFFECTIVE TREATMENT FOR REUSE AND GROUNDWATER RECHARGE

By

Hira Nissar[8], Rameesha Tanveer[1], Abdullah Yasar[1]*,
Amtul Bari Tabinda[1]

Abstract

Rainwater harvesting is an effective technology for urban water conservation and sustainable water management. The present study focuses on the design of a novel horizontal filtration system integrated within a rainwater harvesting system. This study indicates the linkage between groundwater and gross domestic production (GDP). Moreover, it sheds light on the primary components, environmental factors, resistivity with respect to geological aspects in slow sand filtration and rainwater harvesting system. The hydro-geological characteristics in terms of efficiency are summarized to determine the depth of the aquifer, groundwater quality, aquifer drawdown, and the characteristics of soil-bed. This process is effective in removing 60-90% turbidity, 70-80% COD, and 80-90% BOD. The potential of a rainwater harvesting system to capture the rainwater and use it for direct groundwater recharge has been discussed in the context of Pakistan. The proper policies and regulatory institutional framework are also formulated in this study. This study is incorporated the potential alternative of a rainwater harvesting system for preventing groundwater deterioration. Thus, this system facilitates in mitigating the urban stormwater flooding during monsoon, depleting aquifer problems, and groundwater quality deterioration.

Keywords: Rainwater Harvesting; Slow-Sand Filter; Groundwater recharge; Sustainability

1. Introduction

Groundwater is the largest unfrozen freshwater resource that maintains the aquatic and land ecologies. These characteristics make it more prone to exploitation to fulfill agricultural, domestic, and commercial needs (Naser et al., 2017). Groundwater depletion and surface water contamination are the biggest concerns of government and the public globally. About 55% of people live in urban areas, and the number is continuously increasing. It is expected to be increased up to 68% of the urban population of the world by 2050.

Slow-Sand Filtration is a cost-effective and sustainable technology that integrates physiochemical and biological treatment processes. This process is effective in removing 60-90% turbidity, 70-80% COD, and 80-90% BOD. The combination of fine and coarse sand particles removes bacterial pathogens from the influent water (Venudevan et al., 2019). The system has proved successful in the treatment of bacterial pathogens, dissolved and suspended solids, BOD, COD, and other water pollutants (Li et al., 2019). The % removal efficiency of slow sand filter system for Arsenic, Lead, Chromium, Copper, and Cadmium is 95%, 100%, 97%, 100%, and 97%, respectively (Venudevan et al., 2019). Slow sand filtration does not require chemical addition and additional power for groundwater recharge. The system is self-operating, easy to install, and prevents contamination. Rapid urbanization, anthropogenic activities, and seepage of wastewater into the underground aquifer

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have caused the contamination of groundwater (Jalees et al., 2021). Although soil is a natural filter, continuous seepage of pollutants causes saturation of soil matrix, which eventually contaminates the groundwater (Jalees et al., 2021).

Previous studies in Punjab aimed at planning strategies for mitigating the problem of high volumes of stormwater during monsoon, groundwater depletion, low water accessibility, and rainwater harvesting potential of the city. Siddiqui et al. (2020) and Sahar et al. (2021) utilized GIS technique for mapping of the potential rainwater harvesting sites in Lahore. Ali et al. (2021) investigated the impact of rainfall fluctuations on storage performance of rainwater harvesting systems. In another study, managed aquifer recharge (MAR) approach was carried out at four sites in Lahore to mitigate the depleting aquifer problem (Ashiq et al., 2020). Hasnain S.A. (2018) and Hameed et al. (2021) assessed the feasibility, efficiency, and social acceptability of installing RWH system on rooftops of residential buildings. Ameen et al. (2020) proposed different WSUD (water sensitive urban designs) approaches for maximizing rainwater storage and groundwater recharge in Gulberg, Lahore. Ali et al. (2020) assessed the economic and environmental feasibility of rainwater harvesting systems in eight cities of Punjab. The groundwater quality (Shahzad et al., 2020; Hussain et al., 2017; Deeba et al., 2019; Farid et al., 2018; Ashraf et al., 2021), and aquifer characteristics (Hasan et al., 2017; Awan, 2019; Jabeen et al., 2020; Bibi et al., 2021) in Punjab, have been characterized by various studies.

The rainwater harvesting system capture the excess water during monsoon season and use it for groundwater recharge. The main focus of this study is treated groundwater recharge, that has been carried out only once by Hussain et al. (2019), but under different site conditions. Thus, in addition to mitigating the stormwater stagnation and depleting aquifer problems, the system also facilitates quality maintenance of the underground aquifer. Slow sand Filtration system has been integrated with the rainwater harvesting system for the treatment of influent stormwater. Moreover, plantation of salinity tolerant plants and grasses was done for additional decontamination of stormwater. The integration of slow sand filtration with rainwater harvesting system is a cost-effective approach with low operational and regular maintenance requirements. This study provides a potential and promising solution to a real-time problem, which can be implemented on large-scale to solve the problem of stormwater drainage, aquifer depletion, and deteriorating groundwater quality issues in urban environments. This study aims to facilitate treated groundwater recharge for preventing aquifer contamination and will provide a sustainable solution of water conservation for community awareness and mitigation of stormwater drainage issues.

2. Groundwater and GDP

Natural water aquifer present underground is the largest and most abundant resource of quality water available for the global population. It is easily accessible and less prone to degradation and desiccation from pollutants and drought. This resource supplies 36%, 27%, and 42% water for domestic, industrial, and agricultural purposes, globally (Mitra, 2015). This water also restores the base flow of water into wetlands, lakes, and rivers when there is no or insufficient rainfall. The industrial uses of groundwater are inconsiderate when compared with agricultural uses of water. However, industrial consumption constitutes larger groundwater use. A strong relationship exists between the GDP and groundwater use in megacities of the world.

As population and economic development increase, groundwater use is also increased (Chanapathi et al., 2019). The Asian region is blessed with excessive water supply through monsoon rains, wide river channels, and glaciers. The main issue is increased demand and decreasing quality of potable groundwater resources. The sustainability of groundwater resources in some Asian cities including Bangkok (Thailand), Lahore (Pakistan), Ho Chi Minh (Vietnam), Yangon (Myanmar), and Hyderabad (India) was determined using the FGSI model in a research study. The results of this study indicate moderate sustainability of groundwater resources, and lower sustainability of policy-making in this sector (Shrestha and Pandey, 2016). The groundwater resource of a particular area has its advantages which can be maintained if the aquifer is adequately managed and replenished. The sustainable development of water also demands strategic schemes that fulfill the needs of the current generation without depleting water for future needs. Such technologies should also be efficient to cope with population increase, climate change impacts, and rapid industrialization (Hassan et al., 2016).

3. Rainwater Harvesting

Rainwater Harvesting is a part of Low Impact Development approaches for effective water management (Fletcher et al., 2015). Rainwater harvesting is considered as most viable, cost-efficient, and sustainable method to fulfill water demand. Rainwater harvesting is a method that involves the collection of water from different catchment areas such as roads, ponds, rooftops, etc. when rainfall occurs. This water is stored in storage tanks to serve as an alternative to tap water for consumption or non-consumption purposes (Zhang et al., 2020). Rainwater serves as the most feasible source in metropolitan areas where demand is high, but the supply is limited. This shall help in minimizing stress on the underground aquifer. Rainwater harvesting also assists in managing urban stormwater management issues and in the rehabilitation of the natural water cycle (Vialle et al., 2015). The expanding metropolitan cities of Pakistan can gather various advantages by this method in various ways. The advantages include runoff control of stormwater; cost-efficiency; water demand is fulfilled and minimum efforts required for stormwater management during the monsoon season (Campisano and Modica, 2015; Palla et al., 2017; Jing et al., 2018).

Rainwater harvesting systems installed in 23 USA cities were assessed for their efficiency in stormwater management in semiarid areas. The study reported 20% reduction in stormwater runoff (Steffen et al., 2013). RWH systems are found to be more efficient for stormwater runoff control and water supply under humid environments, with larger tank sizes, and large catchments to capture a sufficient amount of harvestable rainfall (Ali et al., 2020). Another study reported that rainwater-harvesting systems considerably reduced pressure on the municipal water supply systems (Santos & Farias, 2017). Rainwater harvesting for augmentation of groundwater and water conservation fulfills 71% of demand in the drought-prone area of Bangladesh (Rahaman et al.,2019).

4. Components of RWH system

A conventional RWH system consists of the main storage tank that facilitates collection and storage of rainwater. The catchment surface can be any impervious surface that is connected to the main storage tank. When rainfall occurs, the water received by the catchment surface runs off to the storage tank through collection systems that may be pipes, downspouts, etc. The purpose of the installation of a rainwater harvesting system defines the final destination of water. Either the water can be stored in the tank

for use by nearby buildings or it can be made to infiltrate into the underground aquifer for groundwater recharge.

Pumps are usually installed to supply water to taps in nearby buildings from the RWH system. The quality control system consists of debris screens, flush diverters, or screens (Abbasi and Abbasi, 2011; Campisano et al., 2017). Quality control is necessary to maintain the quality of rainfall water for further use. Raingardens are a good source of managing stormwater quality. Water from RWH is mainly utilized for non-potable purposes around the world, but with effective disinfection, it can be made suitable for drinking purposes as well. The size of storage tank is one of the critical factors for RWH system efficacy. Size is designed based upon the demand and location. A large-sized storage tank provides better water harvesting benefits, but its installation into a small space decreases the benefits (GhaffarianHoseini et al., 2016).

The majority of RWH systems comprise of following main parts:

1. Catchment Area: Area for rainwater capture. It captures direct rainfall or runoff rainfall water. It can be a rooftop, pavement, or rocky area varying in size according to water requirement and rainfall pattern of site (Alim et al., 2020).
2. Storage Tank: The tank for storage of rainwater after it is harvested in the catchment area. Rainwater is stored until its usage for any purpose. The storage facility may be ponds (above surface) or cisterns (formed beneath the surface) (Alim et al., 2020)
3. Target: The final point of water usage. The target may be a domestic facility, cropping purpose, landscaping, or any other purpose for which the system has been installed (Alim et al., 2020).

5. Factors to consider for a successful RWH system

A review on literature carried out to determine the factors that influence installation and efficiency of RWH systems concluded that factors like rainfall (56%), slope (83%), soil type (75%), landuse (75%), and socioeconomic criteria (25%) were considered in the studies (Ammar et al. 2016). The factors include rainfall, topography, land use, hydrology, soil texture, ecology, environment, socio-economic data Optimal tank size constitutes the most significant consideration while designing the RWH plant. Size determines the water storage and maximum supply and is optimized depending upon the available area and local climate. Ideal tank size ensures long-term sustainability of the system (Alim et al., 2020).

6. Techniques for replenishing aquifer using rainwater harvesting

Different techniques and designs are utilized to restore groundwater level. The most effective ones are those that utilize inverted wells, green belts, and soakways.

6.1 Inverted wells

Inverted wells are the reverse pumped wells designed to recharge groundwater level. They are suitable in areas with high land values such as metropolitan cities where aquifer is confined and deep below the ground. Vegetation is necessary in the catchment area to prevent clogging of wells from large, suspended particles (Ahmed et al. 2019).

6.2 Soakways

Soakways involve development of permeable layer below the ground to prevent runoff of rainwater. Permeable layer can be in the form of vegetation, paving blocks with gaps

or vertical voids, and graveled. Soakways filter silt and sedimentary particles to purify the inflowing water. Diversion channels are developed in catchment area to direct rainwater towards inverted wells and soakways developed for groundwater recharge. Soakways require regular cleaning to prevent clogging and over-pollution (Ahmed et al. 2019).

6.3 Green belts

Green belts are specialized catchment areas for groundwater capture. About 300-600 ft. wide green belt, having natural depressions, built across the road, efficiently captures the rainwater. 100,000m3/km green belt stores 4977 MG rainwater. Green belts are found in various regions in metropolitan areas of Pakistan, which can serve as areas for groundwater capture (Ahmed et al. 2019).

6.4 Permeable Pavement

A typical permeable pavement consists of a strong and pervious paved surface, storage bed of aggregates, and underdrain system (Lee et al., 2015). Permeable pavement system decreases runoff by facilitating water infiltration through pervious layer to the layer of aggregated and finally recharges the underground aquifer (Kamali et al., 2017). The impervious urban surfaces can be converted into permeable surfaces. A study was conducted in Haidian, Beijing to assess the impact of green infrastructures on urban flood reduction. It showed that 50% of impervious surfaces converted to permeable pavement reduced peak flows from 37.9% to 35.7% and runoff volumes from 46.2% to 42% within 1, 2, 5, and 10 years of storm events. The reduction rate can decrease further by 59.6% and 51.0%, if the impervious surfaces are entirely converted to permeable pavements (Liu et al., 2014c). Another study evaluated the hydrological performance of three partially permeable pavements in Canada, Vaughan, and Ontario for 22 months. The results reported that the permeable pavement system captured most of the rainfall that was <7 mm deep. It also reported a 43% and 50% reduction in runoff volume and peak flows, respectively (Drake et al. 2014). Results of such studies support that permeable pavement system facilitate sustainable management of urban stormwater in variety of geographical locations (Imran et al., 2013). Implementation of green infrastructure to reduce urban flooding for achieving economic and environmental benefits has gained significance over the years (Li et al., 2019).

6.5 Retention ponds

Retention system consists of filter media, vegetation, storage system, and underdrain arranged in layers. Retention pond is a designed depression that receives stormwater runoff from impermeable surface (Liu et al., 2014a). The activities of plants and microbes treat stormwater through different physical and biological processes in a bioretention cell, thus reducing the runoff volume and peak flow. The biological organisms increase the lag time and evapotranspiration to facilitate water uptake by vegetation and soil infiltration (Lucke et al., 2017). Stormwater runoff infiltrates through vegetation layer, soil layer, and finally the storage layer. This water is stored in the storage layer for some time, and then it is either discharged downstream or infiltrated (Mangangka et al., 2015). Runoff processes can be reduced by increasing soil infiltration through increased vegetative interception and evapotranspiration, using bio-retention systems (Li et al., 2019).

6.6 Infiltration Trenches

Infiltration trenches are the green urban infrastructures that facilitate stormwater runoff control and treatment received from the local roads. These trenches are more efficient as compared to the Austin sand filters with 75% reduction in cost (Kang et al., 2021). An infiltration trench is a storage tank, which is filled with lattice structures or aggregates, with geotextile filter lining. These structures are built to control the stormwater runoff temporarily to avoid flooding (TRCA and CVCA, 2010). Large sized storage space in the infiltration trench controls more stormwater runoff (Wang & Guo, 2020).

6.7 Bio-swales

Grass swales are the part of LID practices for urban stormwater management, which facilitate aesthetic advantages along with mimicking the natural hydrological characteristics of vegetation such as evapotranspiration, reduced runoff, and infiltration (Dietz, 2007). Swales are the substitutes for traditional drainage system, due to their beneficial source-control characteristics such as pollutants removal and lowering flow velocity (Willis et al., 2013). cost of maintenance of bio-swales is greater than the traditional drainage systems. However, swales are built with lower initial costs. In addition, urban landscapes with green infrastructure provide environmental, economic and health benefits (Li et al., 2017). Grass swales are utilized for stormwater management for several years (Luell et al., 2021). The design strategies still rely on anecdotal information related to infiltration capacity, stormwater transport, and water quality (Fardel et al., 2019).

7. Influence of hydrogeological conditions on rainwater harvesting

Site selection significantly influences the efficiency of rainwater harvesting system (Ammar et al., 2016). In addition, hydro-geological conditions and socio-economic conditions are also essential for achieving maximum benefits from rainwater harvesting (Wu et al., 2018). Algorithms based analysis such as GIS (Tiwari et al., 2018; Singhai et al., 2019), hierarchical analytical method (Balkhair and Ur Rahman, 2019; Shadeed et al., 2019), and multi-criteria analyses (Grum et al., 2016; Singh et al., 2017) are used for determination of suitable sites for capturing the rainwater. Modelling of site characteristics using suitability maps provides an estimation of efficiency and costs of the system (Terêncio et al., 2017). Curve number (CN) values used in this study are given in Table 1.

Table-1: CN Values of different Soil Groups.

Land cover	Hydrological Soil Group			
	A	B	C	D
Grass	49	69	79	84
Crops	67	78	85	89
Forests	36	60	73	79
Impervious surfaces	98	98	98	98
Water-proof geotextiles	98	98	98	98

(Source: Márquez et al., 2021)

According to different researches land slope values between 5%-10% (Wu et al., 2018; Jamali and Ghorbani, 2020) and between 2%-8% (Mahmoud and Alazba, 2015) are

suitable for harvesting rainwater. Rainwater harvesting efficiency of sloped systems is higher than the vertical systems. (Şahin et al., 2019). Soil pits for water storage in a rainwater harvesting system improve soil moisture content, promote root growth, and enhance the efficiency of rainwater use for irrigation purposes (Song et al., 2017; Meng et al., 2019). The collection, infiltration and seepage of rainwater in the soil matrix increases soil moisture content and benefits fine root system by 24% and 11.7% within <200cm of soil depth in a hilly apple orchard (Guo et al., 2021). Additionally, the rainwater harvesting techniques combined with 36m2 micro-catchment and straw mulching improves plant physiology and morphology, and increases the moisture content of soil, thus facilitating the pistachio trees (Tadros et al., 2021). Rainwater harvesting techniques promote soil infiltration capacity significantly for better root growth (Suo et al., 2019). Rainwater seepage improves soil moisture in the top 60cm of soil layer but has no significant effect on the deeper layers of soil (Ding et al., 2021). The water use patterns significantly influence the hydrology of a river basin as compared to land use change that has minor impacts. The similar impacts were observed for the influence of land use and water use change on rainwater harvesting (Wambura et al., 2018). The infiltration capacity of soil is significant for the groundwater recharge through harvested rainwater. The infiltration coefficient values for different surfaces are given in Table-2.

Table-2: Infiltration Co-efficient of different land cover types.

Land Cover	Infiltration co-efficient (Ic) %
Built-up (without RWH)	5
Asphalt	5
Pavement	20
Woody Vegetation	25
Meadows & Pastures	35
Arable Lands	40
Bare-soil	50
Built-Up (with RWH)	80

(Source: Nachshon et al., 2016)

Urbanized surfaces have reduced the potential of rainwater infiltration as compared to vegetated surfaces (Farswan et al., 2019). Artificial aquifer recharge is an effective method to maintain the sustainability of the aquifer Permeability of soil matrix is an important factor that influences the aquifer recharge capacity. Sand and Gravel stones have the highest permeability, and therefore, are preferred for aquifer recharge. Rain infiltration improves the ecological environment by contributing to base flows and groundwater recharge. Infiltration-based LID technologies can have significant potential for reducing runoff and groundwater recharge (Bonneau et al., 2017). Green stormwater management systems such as filter strips and swales are sustainable solutions with low infrastructure costs. Improvement in the systems can facilitate higher benefits and reduced disadvantages (Brudler et al., 2019). Treated recharge of groundwater through integrated stormwater filtration and rainwater harvesting system, will facilitate in sustainable water conservation while fulfilling this water demand.

8. Rainwater Quality

Currently, there are no studies carried out to evaluate the quality of rainwater at Sheikhupura. However, few studies have analyzed the characteristics of rainwater in Lahore. The results of these studies are given in Table 15. A total 16 rain water samples, two samples from each selected area were collected. Different areas of Lahore city (Wapda Town, Nishter Road, Model Town, Walton Cantonment, Baghbanpura, Daroghawala and Wagha Border) and its surroundings (Sheikhupura) were selected for collection of rain water samples. Rainwater Quality is influenced by atmospheric pollutants. High concentrations of particulate matter in air of Lahore and Sheikhupura contribute to higher total suspended solids in rain. The release of harmful contaminants through vehicular emissions and other sources are the cause of low pH (acidity) in rainwater (Yaqub et al., 2019).

Hussain et al. (2019) reported the concentration of different parameters at the ponding site in Gaddafi stadium as Chloride (24 mg/l), Sulphate (7 mg/l), TDS (78 mg/l), BOD (78 mg/l), Cu (0.13 mg/l), As (5.65 mg/l), Fluoride (0.20 mg/l), Total coliform (96 MPN/100 ml), and Fecal coliform (21 MPN/100 ml) (Hussain et al., 2019). The results of analysis from all the above-mentioned studies reveal that direct rainwater is a freshwater resource on earth. The concentration of all parameters in rainwater, is within the permissible limits defined by WHO for drinking water quality. However, bacterial contamination has been reported in rainwater collected from rooftops. The quality of stormwater that is runoff after urban rain events is also reported to be polluted with high concentrations of metals and turbidity (Wang et al., 2018: Gavrić et al., 2019). The analysis of stormwater quality from the study site given in Table 3 indicates the high concentration of different pollutants in stormwater, which require treatment.

Table-3: Rainwater Quality in Lahore and Sheikhupura

Cities	pH	Electrical Conductivity	Turbidity	TSS	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	F^-	NO_3^-	SO_4^{2-}
		µS/cm	(NTU)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Sheikhupura	5.58	485	9.53	1100	1054	0.166	80	48	3550	21.8	49.39	1.09
Wapda Town	5.66	101.45	8.62	500	130	0.082	240	48	5300	10.29	41.7	1.95
Nishter Road	5.4	81.25	11.845	4000	245	0.103	1600	960	3550	11.16	36.79	1.31
Model Town	5.87	107.65	23.685	4500	176	0.042	304	76.8	5300	14.31	54.45	1.005
Walton Cantonment	5.54	84.7	10.67	1500	137	0.018	64	24	3550	17.4	48.95	1.52

Baghbanpura	5.15	134.3	8.905	500	109	0.134	40	48	5300	21.12	59.66	1.02
Daroghawala	6.04	114.35	8.02	4000	185	0.028	160	42	3550	15.30	47.67	1.68
Wagha Border	5.44	135.1	7.57	4500	301	0.018	80	48	7100	22.79	48.165	2.05
Mean ± SD Value	(5.4870 ± 0.323)	(143.135 ± 122.409)	(12.267 ± 5.933)	(2410 ± 1654.25)	(257.85 ± 286.75)	(0.0702 ± 0.0506)	(420 ± 628.14)	(143.10 ± 289.48)	(4785 ± 1458.32)	(16.44 ± 4.52)	(52.35 ±12.11)	(1.396 ± 0.384)

(Source: Yaqub et al., 2019)

9. Relationship of Electrical Resistivity with Geological Data

Vertical Electric Sounding determines the groundwater depth, vertical extent of groundwater contamination, soil bed mapping, detection of salt water mixing into the groundwater, landfill thickness, subsurface hydrogeology, map stratigraphy, and depth of the bedrock (Mayange et al., 2018). Resistivity mapping for geological surveys is based upon the specific resistivity of different types of rocks, minerals, and soils. The standard resistivity values are given in Table. The igneous and metamorphic rocks have lower degree of fracturing as well as lower percentage of groundwater-filled fractures; therefore, they have high resistivity values. Sedimentary rocks are more porous and possess high water content, thus have lower resistivity values. Similarly, groundwater and wet soils also have lower values for electrical resistivity. Thus, the resistivity of sandy soil is higher than the clayey soils. The resistivity values for some soils and rocks overlaps. The reason for this is porosity of particles, water retention, and salt concentration. The resistivity of groundwater (10-100Ωm) is higher than the seawater (0.2Ωm), because of greater salts concentration in the seawater than groundwater. This distinction enables the delineation of coastal interfaces of fresh and saline environments.

The resistivity of metals is also high because of their toxicity. The addition of toxic metals into the groundwater lowers groundwater resistivity value indicating metal pollution. Strong electrolytes such as KCl and NaCl lower the electrical resistivity of groundwater to <1Ωm. The influence of weak electrolytes on groundwater resistivity is relatively smaller. The hydrocarbons have very high values for electrical resistivity. Electrical Resistivity Method proves values in a larger range in contrast to other methods of geological mapping used for estimating physical quantities. The magnitude of variations in rocks and soils in a single survey may vary. Thus, geological analysis through electromagnetic and electric methods are very reliable and versatile. Resistivity of common soils and rocks are given in Table-4.

Table-4: Electrical Resistivity Values of Soil, Rocks, and Water bodies

Materials	Resistivity (Ωm)
Clay (wet – moist)	1.5 - 3.0
Silty-clay/Silty soil (wet – moist)	3-15
Silty & Sandy soil (moist - dry)	15-150
Bedrock (well-fractured - slight fractured) and (damp soil filled cracks)	150-300
Sand & gravel - with silt	About 300
Sand & gravel - with silt layers	300 - 2400
Bedrock (slight fractured having dry Soil filled cracks)	300 - 2400
Sand & gravel deposits (coarse and dry)	> 2400
Bedrock (massive and hard)	> 2400
Freshwater	20-70
Seawater	0.18-0.24

(Source: Mustafa et al., 2015)

Under business as usual' scenario, the quality of groundwater may get highly polluted and can be a source of serious health concerns in Lahore. The development at local and national level requires mitigation and management for the prevention of groundwater quality deterioration. Rainwater harvesting system for groundwater recharge through was designed, considering the factors involving that design must be suitable for the available space and location. Drawdown of water from underground aquifer must be fast. The system must prevent impurities to mix with the groundwater (Hussain et al., 2019).

The main characteristic that influences the infiltration characteristics of soil-bed and aquifer recharge is its permeability (Dong et al., 2018). Infiltration rate is influenced by soil texture, bulk density of soil, land use characteristics, rainfall intensity, and land slope (Singh, 2018). Silty-clay soils layer, that forms the surface of land at the project site, has low permeability and poor drainage (Rahmati et al., 2018), thus lowering the groundwater recharge.

10. Efficiency of Slow Sand Filtration and Groundwater Recharge

According to the formula used by Siddiqui and Siddiqui (2018), the total estimated RWH Potential of the site is 15,078 m3, after 300 mm (0.3 m) of rainfall. This rainfall generates 19.95 inches (507 mm) of stormwater, which is received by the rainwater harvesting system. The harvested water is recharged to the groundwater after complete treatment from the stormwater filtration system. Thus, the system efficiently prevents urban flooding and wastage of rainwater. About 85% of tube wells in Pakistan are located in Punjab. Pumping of excess water for irrigation and consumption has caused water-table depletion by 6 meters, and deterioration of water quality. Consequently, pumping costs of groundwater have increased along with the requirement for the installation of treatment plants. The Indus basin has the storage capacity of 820 mm/ha/year, that meets the demand of irrigation and consumption throughout the year. About 70% rainfall is received in Punjab during the monsoon season each year. The evapotranspiration rate is higher because of semi-arid environment. About 190 bm3 water is supplied to the country through Indus river and its tributaries. 50 bm3 flows directly into the sea, while 10 bm3 is lost through evapotranspiration. The absence of dams and sustainable water management facilities cause loss of rainwater and the flood water every year (Qureshi, 2020). The

water quality parameters for direct rain and treated water from filtration assembly of rainwater harvesting system are within the permissible limits of WHO. In addition, the vegetation bed also contributed to the filtration of influent stormwater.

The filtration efficiency of slow sand filtration system is in consistent with the 95% total pollution removal efficiency achieved by Liu et al. (2015). The slow sand filtration system used by Thomas and Kani (2018) contributed to 86% and 77% removal efficiency of turbidity and electrical conductivity, respectively. Slow-sand filtration system is effective for the removal of 99% of turbidity, pathogens, and suspended contaminants. These filters are resistant to fluctuations in pH and metals concentration. Slow-sand filtration is a combination of chemical and physical treatment processes. Fine-grained sand and gravel stones are most effective in filtration of wastewater, and influence the efficiency of slow-sand filters (Verma et al., 2017). The infiltration of stormwater occurs because of head difference, which makes the rates of inflow and recharge, equal to each other. The arrangement of this design enables rapid groundwater recharge without energy utilization (Hussain et al., 2019). Thus, this horizontal slow sand filtration assembly is efficient for stormwater decontamination and treated groundwater recharge.

11. Rainwater Harvesting Systems in Pakistan

Rainwater Harvesting Systems have been installed in Pakistan. The details of the installed systems and their limitations, are given in Table 5.

Table-5: Rainwater Harvesting Systems in Pakistan

Source	Areas	Purpose	Specification
PCRWR (2010)	Cholistan – by PCRWR.	To overcome the issues of water scarcity in the desert.	Installation of 110 reservoirs, and 20 tube wells for rainwater harvesting and storage
Source	Areas	Purpose	Specification
Walton B. (2010)	Islamabad (at Faisal Mosque) – by Capital Development Authority in collaboration with UNDP and PCRWR.	To recharge the groundwater.	First Urban RWH System. The system will recharge groundwater to meet the needs of 1 million people in the capital city.
Jamal S. (2020)	Lahore (Near Lawrence Road) – by WASA.	To overcome urban flooding issues during monsoon.	Underground water storage system installed with a catchment area of 30 acres, and storage capacity of 1.4 million gallons.

Most of the recent studies in Pakistan were focused on the evaluation of rainwater harvesting potential of different areas through the use of modeling techniques and data analysis. The details of some of these studies are given in Table-6.

Table-6: Comparative Studies

Studies	Objectives/Aims	Methods	Results	Limitations	Recommendations
Ahmed et al. (2018)	To evaluate RWH potential of rain barrels for controlling stormwater runoff in Quaid-e-Azam Apparel park, Sheikhupura. To quantify the efficiency and economic feasibility of rain barrels in 2, 3, and 4 year return period.	Use of SWMM V 5.0 modelling method for quantification of results.	There was 24% reduction in flow-rate in 2, 3, and 4 years return period. There was 9% reduction in flooding of drainage pipelines. The operational and maintenance cost was lowered by 26% through RWH.	SWMM software does not assist in design of RWH infrastructure. Rain barrels were not useful for 4 and 5 year return period, because of limited size. Increasing the size may have cost implications.	Quality of harvested water must be analyzed prior to its usage.
Rashid et al. (2018)	To evaluate the potential of rainwater harvesting system in meeting household water demand in Islamabad.	Calculation of RWH Potential and household water demand. Analysis of results to determine the potential of RWH in fulfilling domestic water needs.	An accommodation of four people has rooftop RWH potential of 326,880 L, that is 22% higher than the 72, 154 L of water demand of that household.	Harvested rainwater cannot fulfill the drinking and cooking demand of water at household level.	The results cannot be applied on larger scales because of difference in sizes of households.
Siddiqui and Siddiqui (2019)	To assess the RWH potential of rooftops in Model town Lahore using ArcMap. To propose a model for domestic RWH systems.	Calculation of RWH potential using ArcMap, and development of theoretical model for Domestic RWH system.	RWH Potential of rooftops in Model Town is 535,756 m^3.	The quality of water from rooftops is not analyzed.	Government should make laws that enforce domestic RWH systems. Pilot-projects should be installed in different urban areas for sustainable water management
Hussain et al. (2019)	Construction of inverted tube wells for groundwater recharge and to mitigate the urban flooding problem in Gaddafi stadium	Identification of ponding sites. Collection of data to evaluate RWH potential. Construction of Recharge wells.	The study evaluated that every monsoon, urban flood of 305 acre/ft. volume is generated, which shows high RWH	The groundwater recharge efficiency was declared as satisfactory. The system is not cost-efficient, and required	Use of bio-retention basins and grassed drains are recommended to be installed around the inverted well to achieve

		Analysis of water quality	potential. The system removed the contamination from stormwater by 29-30%. The cost of system was 0.738 million with satisfactory groundwater recharge performance.	regular maintenance.	better water treatment efficiency.
Ali et al. (2020)	To develop hydro-economic model and analyze the efficiency of water conservation and stormwater capture, and economic feasibility of RWH systems in five climatic regions in Pakistan.	Use of mathematical formulas to quantify time-reliability, benefit-cost ratio, water conservation efficiency, stormwater storage efficiency, and daily water balance under different climatic regions.	Stormwater capture efficiency was highest in regions with low rainfall, larger tank size, and greater water supply. Water conservation efficiency was highest in humid regions, large tank size, and lower water supply. Benefit-cost ratio in semi-arid and desert climates is <1.0.	Model does not provide guidelines for construction of RWH system.	-
Ashiq et al. (2020)	To analyze the efficiency of managed aquifer recharge consisting of 4 recharge wells in reducing aquifer depletion in Lahore.	Four recharge wells were dug. Flow meters were installed in recharge wells to observe groundwater discharge and recharge rate.	The study concluded that 4 recharge wells can reduce the aquifer depletion by 16%, while 10 recharge wells can reduce the aquifer depletion by 32%.	The designed recharge wells were expensive, complicated to clean, and small in diameter. The study was conducted for a small time-period.	Long-term study and efficient design of recharge wells having larger diameter is required for increased efficiency. The filter should be installed outside so that it can be easily cleaned.
Hameed et al. (2021)	To analyze the applicability of LDA enforced law	Interview of professionals and locals. Data analysis	Many people were unaware about this regulation,	Only middle-income group, at a single locality	Alternative uses of RWH during non-rainy season

	regarding installation of RWH system in domestic buildings. To analyze the willingness and awareness of locals regarding installation of RWH system.	through chi-square and Cramer's V tests.	and only 4% had installed RWH system as a part of this regulatory requirement. Incentives, Penalties, and Awareness is required to drive people's willingness towards adoption of RWH system.	was targeted for this study.	should be explored. Study should be conducted on lower and higher income groups as well.

Water Laws in Pakistan

The regulatory system of Pakistan does not enforce installation of rainwater harvesting system currently. However, some of the laws that are relevant to water conservation and allow use of technologies for decontamination of water are given in Table-7.

Table-7: Regulations that support installation of Rainwater Harvesting Systems in Pakistan

Laws	Provisions
Constitution of Pakistan 1973	Article 9 provides the right to safe and adequate water supply to the citizens of Pakistan.
Pakistan Environment Protection Act (1997) (Amended in 2012)	The federal and provincial environmental act promote sustainable development and prevention and control of pollution to the environmental resources. The sustainable management and conservation of groundwater to ensure adequate and safe water supply fall under the provisions of this act
National Water Policy, 2018	The national water policy promotes the implementation of rainwater harvesting system to mitigate water scarcity issues in the country.
National Environment Policy, 2005	The policy requires the adoption of technologies for harvesting rainwater at both rural and urban scales
Punjab Water Act, 2019	Clause-19 of this act defines the duty of authority to ensure sufficient and adequate quality water supply
Punjab Canal and Drainage Act, 1873	Under this act, the provincial management van undertakes all steps to prevent aquifer contamination and depletion
WAPDA Act (Amended 1954)	Under this act, WAPDA can initiate any scheme to mitigate flooding and water scarcity problems

Moreover, the Capital Development Authority and Lahore Development Authority require all home owners to install domestic rainwater harvesting systems in Islamabad and Lahore, respectively. The system can be replicated on large-scale, by increasing the reservoir capacity and by installing advanced water treatment technologies to achieve additional water filtration efficiency. The system can be installed in every community park in urban areas to mitigate urban flooding and groundwater depletion issues. Treated groundwater recharge through sustainable methods is cost-efficient as compared to installing water treatment plants. The system provides long-term

solutions to aquifer depletion problems. Thus, this study fills the gap of all previous studies, providing a holistic solution to urban flooding issues.

Conclusion

The rainwater harvesting system provides an on-ground solution to water impermeability issues at the site. The situation will be worsened by future developments and unsustainable groundwater use. This study highlights the link between groundwater and gross domestic production. Moreover, it shed light on the primary components, environmental factors, resistivity with respect to geological aspects in slow sand filtration and rainwater harvesting system. The hydro-geological characteristics in terms of efficiency are summarized to determine the depth of the aquifer, groundwater quality, aquifer drawdown, and the characteristics of soil-bed. The potential of a rainwater harvesting system to capture the rainwater and use it for direct groundwater recharge has been discussed.

The rainwater harvesting system with integrated slow-sand filtration assembly is an efficient and feasible option for treating groundwater recharge with improved groundwater quality, mitigating groundwater depletion and urban flooding issues, which also meet the sustainable development goals (SDGs). The system can be replicated on large-scale, by increasing the reservoir capacity and by installing advanced water treatment technologies to achieve additional water filtration efficiency. The system can be installed in every community park in urban areas to mitigate urban flooding and groundwater depletion issues. Treated groundwater recharge through sustainable method is cost-efficient as compared to installing water treatment plants. The system provides long-term solutions to aquifer depletion problems. Thus, this study fills the gap of all previous studies, providing a holistic solution to urban flooding issues

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