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Report of Policy Lab on Bridging Gaps in Agriculture Development Policies and their Implementation in Pakistan

پاکستان میں زرعی ترقی کی پالیسیوں کے اطلاق میں حائل رکاوٹوں کا خاتمہ

Policy Analysis & Recommendations- Part-6 of 11

Promoting Water Conservation

Addressed the critical issue of water scarcity by proposing conservation techniques and policy interventions for sustainable irrigation.

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بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

إِنَّ اللّٰه لَا يُغَيِّرُ مَا بِقَوْمٍ حَتَّىٰ يُغَيِّرُوا مَا بِأَنفُسِهِمْ

(سورة الرعد 13:11)

بے شک، اللہ کسی قوم کی حالت نہیں بدلتا جب تک وہ خود اپنی حالت کو نہ بدلے۔

Indeed, Allah does not change the condition of a people
until they change what is in themselves.
(Surah Ar-Ra'd 13:11)

ظَهَرَ الْفَسَادُ فِي الْبَرِّ وَالْبَحْرِ بِمَا كَسَبَتْ أَيْدِي النَّاسِ لِيُذِيقَهُمْ بَعْضَ الَّذِي عَمِلُوا لَعَلَّهُمْ يَرْجِعُونَ

(سورة الروم 30:41)

خشکی اور تری میں فساد ظاہر ہو گیا ہے، لوگوں کے اپنے ہاتھوں کے کیے ہوئے اعمال کی وجہ سے، تاکہ اللہ انہیں ان کے کچھ اعمال کا مزہ چکھائے، شاید کہ وہ باز آ جائیں۔

Corruption has appeared on land and sea because of
what the hands of people have earned, so that
He may let them taste part of what they have done,
that perhaps they will return (to righteousness).
(Surah Ar-Rum 30:41)

Promoting Water Conservation in Agricultural Practices

Addressed the critical issue of water scarcity by proposing conservation techniques and policy interventions for sustainable irrigation.

Research Group

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PREFACE

Agriculture remains the backbone of Pakistan's economy, providing livelihoods to a significant portion of the population and contributing substantially to the nation's GDP. However, despite its potential, the sector faces persistent challenges related to productivity, resource management, and international trade. In response to these pressing issues, a ***Policy Lab*** simulation exercise titled **"Empowering Agriculture for Food Security and Economic Growth: Implementation Strategies in Pakistan"** was conceived, designed, and mentored by **Dr. Muqeem Islam Soharwardy**. This Policy Lab initiative aimed to generate actionable policy recommendations through an intensive, research-based simulation exercise complemented by a two-day seminar.

The ***Policy Lab*** research exercise, conducted between **14th and 18th February 2024**, involved nine specialized research groups, each focusing on critical aspects of agricultural policy. These groups simulated high-level policy interventions, functioning as dedicated task forces and committees under the guidance of subject matter experts. Their work culminated in a comprehensive set of recommendations aimed at addressing structural inefficiencies and unlocking new growth avenues in Pakistan's agricultural sector.

The a Policy Lab research groups were structured as follows:

1. **Expanding Trade Opportunities by Unleashing Pakistan's Milk Export Potential** – Focused on identifying barriers to dairy exports and proposing strategic interventions to enhance Pakistan's competitiveness in the global dairy market.
2. **Development of Pakistan's Fisheries Sector** – Examined strategies to modernize fisheries, improve sustainability, and enhance exports.
3. **Increasing Pakistan's Share in International Halal Meat Export** – Explored pathways to leverage Pakistan's strength in halal meat production for greater penetration in international markets.
4. **Provision of Quality Fertilizer to Enhance Productivity** – Investigated fertilizer supply chain challenges and policy measures to ensure the availability of high-quality inputs for farmers.
5. **Provision of Quality Seeds to Enhance Productivity** – Assessed Pakistan's seed industry, highlighting reforms needed to boost agricultural yields through high-quality seeds.
6. **Promoting Water Conservation in Agricultural Practices** – Addressed the critical issue of water scarcity by proposing conservation techniques and policy interventions for sustainable irrigation.
7. **Increasing Pakistan's Share of Fruit Exports** – Focused on expanding Pakistan's footprint in the global fruit market through improved production, value addition, and trade facilitation.

8. **Evaluation of Implementation Strategies of Food Security in Pakistan** – Analyzed the effectiveness of existing food security policies and proposed comprehensive strategies for improved implementation.
9. **Increasing Availability of Agricultural Credit** – Examined the role of financial institutions in supporting farmers and proposed mechanisms to enhance access to agricultural financing.
10. **Climate-Smart Agriculture**, Food Security, and Sustainable Land & Water Management explored innovative solutions for sustainable agriculture and resource management
11. **Agricultural Mechanization & Innovation –** Promoting modernized agriculture through mechanization, crop diversification, and precision farming.

Through rigorous research and a ***Policy Lab*** simulation, this exercise sought to foster a deeper understanding of the challenges and opportunities in Pakistan's agricultural sector. The insights and recommendations derived from these working groups will serve as a valuable resource for policymakers, stakeholders, and researchers striving to enhance agricultural productivity, food security, and economic growth in Pakistan.

We extend our gratitude to all participants, researchers, and experts who contributed to this initiative. Their dedication and intellectual rigor have resulted in a policy framework that holds the potential to transform Pakistan's agricultural landscape and position the country as a leading player in global agricultural markets.

We extend our gratitude to all participants, researchers, and experts who contributed to this initiative. Their dedication and intellectual rigor have resulted in a policy framework that holds the potential to transform Pakistan's agricultural landscape and position the country as a leading player in global agricultural markets.

It is hoped that the recommendations and findings herein will contribute to **evidence-based policymaking, institutional capacity-building, and long-term agricultural growth**, ultimately fostering **national food security and economic stability**. انشاءالله.

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February 23, 2024

Executive Summary

Water security in Pakistan is a rapidly growing issue that impacts multiple sectors, extending beyond just the water industry to economic development, national security, and agricultural sustainability. Despite the vast availability of water resources, Pakistan's agricultural sector, which uses the majority of the water, continues to face inefficiencies that hinder overall economic productivity. A significant opportunity exists to improve water use through the adoption of modern irrigation technologies and better management practices. This executive summary outlines the current challenges, potential solutions, and strategic plan to address water wastage in Pakistan's agricultural sector over the next decade.

Key Challenges in Water Usage

- **Inefficient Water Use in Agriculture:** Pakistan's agricultural sector consumes around 91.6% of the nation's total water resources, yet it only generates about 5% of the GDP. Major crops like wheat, rice, cotton, and sugarcane consume up to 80% of water resources but contribute less than 5% to the national economy.
- **Traditional Irrigation Practices:** The reliance on outdated methods of irrigation, such as furrow, basin, and border irrigation, leads to high water losses. These methods are inefficient, with conveyance losses estimated at 60% and irrigation efficiency as low as 50% on many farms.
- **Groundwater Overdraft:** Increasing dependence on groundwater extraction has led to a significant drop in the water table, particularly in areas like Sindh and Punjab. Over-extraction contributes to land salinization and threatens long-term water availability.
- **Environmental Degradation:** The excessive use of water, especially for traditional flood irrigation, contributes to waterlogging and salinization, further reducing land productivity and threatening the ecological health of water bodies.

Current Water Conservation Challenges

- **Limited Adoption of High-Efficiency Irrigation Systems (HEIS):** Despite the clear benefits of modern irrigation systems like Drip and Sprinkler, adoption has been limited due to financial and technical barriers. HEIS has proven to save significant amounts of water and increase crop productivity but has not yet been scaled up across the country.
- **Lack of Technology Penetration:** Inadequate dissemination of technology and insufficient infrastructure for modern water management practices are key factors inhibiting water use efficiency.
- **Financial Constraints for Farmers:** The financial capacity of many small-scale farmers is limited, making it difficult for them to invest in water-efficient irrigation technologies and adopt improved farming practices.

- **Fragmented Land Holdings:** The prevalence of small farms (often less than five hectares) limits the effectiveness of water-efficient irrigation systems and prevents economies of scale that would make advanced irrigation systems more accessible.

Proposed Solutions and Strategic Plan

To address the growing challenges of water wastage and inefficiency in agriculture, the following solutions and strategies are proposed:

1. **Adopt High-Efficiency Irrigation Systems (HEIS)**
    - **Drip and Sprinkler Systems:** Promote the widespread use of HEIS like drip and sprinkler systems, which significantly reduce water wastage by delivering water directly to the root zone, minimizing evaporation and runoff.
    - **Incentivize Adoption:** Provide financial incentives, subsidies, and low-interest loans to farmers to make HEIS more affordable and accessible.
2. **Modernize Irrigation Infrastructure**
    - **Upgrade Irrigation Networks:** Modernize the existing canal and pipeline systems to reduce conveyance losses, improve water delivery, and increase overall efficiency.
    - **Precision Irrigation:** Introduce advanced irrigation technologies, such as sensor-based irrigation systems, to ensure water is applied only when necessary and in the right amounts.
3. **Training and Capacity Building for Farmers**
    - **Awareness Campaigns:** Launch national and local campaigns to raise awareness about the importance of water conservation and the benefits of modern irrigation systems.
    - **Farmer Training:** Provide comprehensive training to farmers on efficient water management techniques, crop diversification, and the use of HEIS.
4. **Encourage Crop Diversification**
    - **Shift to High-Value, Water-Efficient Crops:** Promote the cultivation of crops that require less water but provide higher economic returns, such as fruits, vegetables, and other drought-resistant crops.
    - **Government Support:** Offer subsidies and technical support for farmers to transition from water-intensive crops like sugarcane and cotton to more sustainable alternatives.
5. **Strengthen Institutional and Policy Frameworks**
    - **Implement the National Water Policy (2018):** Enforce the implementation of the National Water Policy, which focuses on more efficient water use through modern irrigation, equity in water distribution, and enhanced management of groundwater resources.
    - **Policy Enforcement:** Ensure strict monitoring and enforcement of policies related to equitable water distribution, and incentivize provinces to adopt water-efficient practices.

6. **Encourage Public-Private Partnerships (PPP)**
    - **Public-Private Collaboration:** Leverage public-private partnerships to fund large-scale irrigation projects and technology adoption programs. Involve private sector players in the development of water-efficient solutions for farmers.
    - **Access to Credit:** Improve access to financial products tailored to small farmers, enabling them to invest in efficient irrigation systems and other water-saving technologies.

Global Best Practices

- **Israel's Drip Irrigation:** Israel has successfully implemented drip irrigation across large areas of its agricultural sector. With its limited water resources, Israel has been able to increase agricultural productivity while conserving water. Pakistan can learn from Israel's approach by encouraging large-scale implementation of drip irrigation systems, particularly in water-scarce regions.
- **Australia's Water Trading System:** Australia has introduced a water trading system that allows farmers to buy and sell water rights. This market-driven approach has helped optimize water allocation and usage, ensuring that water is directed towards its most productive use. Pakistan could explore similar mechanisms to incentivize water conservation and ensure equitable water distribution.

Water security remains a critical and growing challenge for Pakistan, influencing various aspects of economic, social, and national development. The current management of water resources, especially in the agricultural sector, is inefficient, leading to significant water wastage and posing risks to long-term sustainability. This executive summary aims to highlight the key issues related to water use in Pakistan's agriculture, propose strategies for better water conservation, and outline actionable recommendations for enhancing water management practices.

Agricultural Water Use in Pakistan

Agriculture is the backbone of Pakistan's economy, contributing around one-fifth of the national GDP. However, the majority of water use in agriculture is devoted to irrigation, which contributes only a fraction to the economic output of water-intensive crops like wheat, rice, cotton, and sugarcane. Despite significant investments in irrigation infrastructure, the country suffers from excessive water losses and inefficient water use practices. Traditional irrigation methods dominate the agricultural landscape, resulting in conveyance losses and poor water productivity. The lack of modern irrigation technologies, such as High Efficiency Irrigation Systems (HEIS), exacerbates the problem.

The primary crops that consume the most water—wheat, rice, cotton, and sugarcane—yield relatively low economic returns. As a result, the country's agricultural practices are not only unsustainable but also suboptimal in terms of generating value. Pakistan's agricultural water productivity lags behind global standards, with inefficiencies in both water use and crop selection. The focus on traditional crops, combined with ineffective irrigation systems, limits the potential for maximizing water resources in agriculture.

Challenges in Current Water Management

A key issue facing Pakistan's agricultural sector is the over-reliance on traditional irrigation systems, such as furrow, basin, and border irrigation. These systems result in high water losses through deep drainage, leading to waterlogging and soil salinity, which further degrade agricultural land and reduce crop productivity. Furthermore, the limited adoption of more efficient methods, like drip and sprinkler irrigation, continues to undermine efforts for sustainable water use.

Other critical challenges include groundwater over-extraction, leading to falling water tables and the salinization of large areas of land. Small farm sizes exacerbate these issues, as poorer farmers often lack access to modern irrigation technologies and are unable to make investments in water-efficient solutions. Furthermore, the financial performance of irrigation services is poor, and there is a lack of long-term sustainability in the water distribution infrastructure, especially in the southern regions of Pakistan like Sindh.

Additionally, the impact of climate change is intensifying the pressure on water resources. Droughts, floods, and unpredictable rainfall patterns are becoming more frequent, further stressing the need for improved water management strategies that can withstand environmental changes.

Proposed Solutions for Efficient Water Use

To address these issues, the focus should shift towards adopting modern water management techniques, particularly High Efficiency Irrigation Systems (HEIS), which have been proven to significantly reduce water wastage and improve crop yields. The National Water Policy, 2018, is a step in the right direction, but its implementation is hindered by financial constraints, inadequate governmental support, and a lack of effective policy enforcement.

1. **Adopting HEIS**: The widespread adoption of technologies like drip and sprinkler irrigation can drastically improve water use efficiency in agriculture. These systems target water directly at the plant roots, minimizing wastage and ensuring optimal water distribution. In addition, the government needs to provide financial support to farmers, through subsidies or low-interest loans, to facilitate the transition from traditional to modern irrigation systems.
2. **Diversification of Crops**: Pakistan's agricultural sector needs to move away from water-intensive crops, such as rice and cotton, towards more water-efficient, high-value crops. Shifting to drought-resistant and low-water-demand crops will help conserve water resources while increasing agricultural productivity.
3. **Improved Water Governance**: Strengthening the governance of water resources is critical for ensuring that water use is optimized. This includes enhancing the legislative framework to enforce water conservation practices in agriculture and ensuring equitable distribution of water across all sectors. Furthermore, the establishment of water user associations (WUAs) at the local level, alongside community participation models, can help foster collective action and improve water management at the grassroots level.

4. **Strengthening Research and Development**: Investment in research and development (R&D) is essential for developing climate-resilient crop varieties and improving water conservation technologies. A national water information platform can play a pivotal role in gathering data, sharing best practices, and promoting efficient water management strategies across the country.
5. **Capacity Building and Awareness**: Educating farmers about the benefits of efficient irrigation systems and water conservation techniques is crucial for ensuring the successful adoption of modern technologies. Training programs, awareness campaigns, and workshops can help farmers better understand the long-term economic benefits of adopting HEIS.

Policy Recommendations

To achieve substantial improvements in water efficiency in Pakistan's agricultural sector, the following key policy measures are recommended:

- **Enhance Legislative Support**: The 2018 National Water Policy should be updated to prioritize the adoption of High Efficiency Irrigation Systems (HEIS) in agriculture. Furthermore, a legal framework should be drafted to enforce water conservation measures and regulate water use in agricultural practices.
- **Strengthen Water Governance**: Provinces should be encouraged to set specific water conservation targets, in coordination with the Pakistan Council of Research in Water Resources (PCRWR), and ensure the achievement of these targets through oversight by a national water council. Additionally, the existing river basin commissions should be strengthened to improve coordination and implementation of water management practices.
- **Invest in Infrastructure and Financing**: The public sector must allocate adequate resources toward the modernization of irrigation infrastructure and the promotion of HEIS adoption. Public-private partnerships (PPP) can also be explored to finance the widespread adoption of water-efficient technologies.
- **Support Agricultural Diversification**: Policies should incentivize farmers to shift towards high-revenue, low-water-demand crops. Financial assistance, market access, and knowledge transfer are crucial to facilitate this transition.
- **Improve Climate Resilience**: Pakistan should focus on developing drought-resistant crops and strengthening resilience to climate-related shocks. This will help safeguard water resources and ensure food security in the face of increasing climate variability.

Operational Plan for Water Conservation

A clear operational plan is necessary to translate these recommendations into actionable outcomes. The plan should include setting clear targets for the adoption of HEIS, establishing a monitoring and evaluation framework to assess progress, and ensuring that adequate resources are allocated to support these initiatives.

The goals of the plan include improving water productivity, reducing water wastage, and ensuring a sustainable water supply for future generations. Key activities in the first year should include awareness campaigns for farmers, the provision of credit facilities for adopting HEIS, and the setup of training programs. The expected outputs of the plan

are increased crop yields, improved quality of crops, and a higher contribution to the national GDP from water-efficient agricultural practices.

In terms of risks, the project may face challenges such as farmer resistance to change, complicated banking procedures for credit facilities, and the broader impacts of climate change. To mitigate these risks, continuous monitoring and feedback from stakeholders, including Water User Associations (WUAs), will be essential to adapt and refine the plan as needed.

Conclusion

Improving water efficiency in agriculture is not only essential for Pakistan's economic stability but also for ensuring food security and sustainable development. By adopting modern irrigation technologies, diversifying crop production, strengthening water governance, and increasing investments in water management, Pakistan can address its water crisis and lay the foundation for a more water-efficient future. The recommended policies and operational plans are designed to facilitate this transition and ensure the long-term sustainability of the country’s agricultural sector.

Introduction

Pakistan struggles to optimize its water resources, as evidenced by research (Young, et al., 2019). The country's water usage is predominantly agricultural, contributing approximately one-fifth of the national GDP, yet less than half of this stems from irrigated farming. Irrigation itself adds about US$22 billion annually to the GDP (Brioscoe & Qamar, 2005). However, the primary crops, namely wheat, rice, sugarcane, and cotton, which account for nearly 80 percent of water consumption, generate only around 5 percent of GDP, equivalent to roughly US$14 billion per year (Brioscoe & Qamar, 2005). Figure 1 illustrates the proportions of water usage and the agricultural GDP dependent on water. The agricultural sector consumes approximately 91.6 percent of the total annual water usage in the country (UNDP & zuriarrain, 2016).

Pakistan has seen improvements in water productivity within agriculture, attributed to increased fertilizer application, additional labor, and a substantial rise in groundwater extraction. However, there has been little progress in enhancing water use efficiency or transitioning to higher-value crops. Pakistan's agricultural water productivity trails behind that of many other nations (Ahmad, Iftikhar, & Chaudry, 2007).

Various methods, both traditional (e.g., Furrow irrigation, Basin irrigation, Border irrigation) and modern (e.g., Sprinkler irrigation, Drip irrigation), exist for applying water to fields. However, in Pakistan, due to limited technology penetration and financial constraints, traditional methods dominate irrigation practices, leading to water losses.

Term of Reference

To evaluate how Pakistan can reduce water wastage in ten years by resorting to modern efficient technologies.

To undertake a situational analysis of current irrigation methods and their wastage, determine the extent to which certain conservation techniques are being currently used, highlight the issues faced by the farmers in accessing resources and support provided by government agencies

Analyze the existing government usage of these techniques, discuss relevant organizational structures and their technical and resource capacities, role play organizations associated with agriculture, their organizational challenges faced, provision of loans/credit on easy terms with awareness/education/training for farmers

Formulate a Plan to meet its objective. The Plan’s special focus should be on implementation and sustainability.

Analyze at least two international best practices.

Discuss why the earlier steps, if any, in this direction failed and why the proposed plan can work.

Statement of Problem

The growing water demand, coupled with the impact of climate change has intensified the need for effective water conservation strategies. However, the prevalence of traditional irrigation systems in Pakistan is a threat to water conservation due to the inherent inefficient water utilization of these practices. Thus, there is a pressing need to research and identify innovative, context-specific approaches to conserve water in agriculture practices in Pakistan effectively.

Scope and Significance

i. The scope of the research is to assess the efficacy of water conservation policies in the realm of agriculture practices in Pakistan.
ii. To analyze the on-farm water management practices in vogue
iii. Suggest adoption of policies and efficient irrigation techniques based on international best practices.
iv. The study is significant because it undertakes a critical analysis of the current practices and policies of water conservation in agricultural practices and suggest improvements to the existing mechanisms and policies.

Methodology

i. A mix of Primary and Secondary Data
    a. Primary data includes interviews and a survey
    b. Secondary data includes research reports, publications, project reports and government-issued policy frameworks
ii. Situational Analysis of current water conservation policies, irrigation practices, institutional frameworks, irrigation infrastructure, water course improvement program
iii. Gap Analysis of current water conservation strategies and practices
iv. Gap Analysis of technological challenges related to the implementation of water conservation in agriculture practices
v. Cause and Effect Analysis—Adoption of HEIS
vi. SWOT Analysis of IRSA and On-farm Water Management Department, KP
vii. Stakeholder analysis of National Water Policy, 2018

Situational Analysis

Present Situation of water efficiency in agriculture

Currently, in Pakistan, we are facing close to 60% conveyance losses in the irrigation system (Young, et al., 2019). Irrigation services are not financially sustainable and financial performance is declining (Brioscoe & Qamar, 2005). Poor operational performance in irrigation continues to exacerbate waterlogging and salinization, especially in Sindh. Despite large-scale reclamation efforts, high water withdrawals and poor drainage mean salt continue to accumulate in soils and groundwater in the lower Indus Basin, affecting agricultural productivity (Young, et al., 2019).

We lose more than two-thirds of our available water resources due to poor management. For instance, there is around 25-40% water losses during irrigation application, which not only tends to exacerbate the waterlogging and salinity issues but has also significantly reduced the water productivity of major crops compared with the world average in general and neighboring countries in particular (Young, et al., 2019). Excessive deep drainage losses inherent to conventional flooding or level basin irrigation systems are one of the main reasons for low water productivity. Adoption of border and furrow irrigation systems, relatively efficient irrigation methods, are low on Pakistani farms. Although furrow irrigation is practiced for a few row crops and vegetables in Pakistan their current management has caused irrigation efficiencies down to 50% on farms (Akbar, Ahmad, Ghafoor, & khan, 2016).

A study was conducted to evaluate the irrigation efficiencies of different surface irrigation systems on farms in Pakistan which showed excessive irrigation application of 49% to furrow bed, 63% to border, and 79% to furrow bed fields. The excess irrigation applications

were lost as deep drainage because all fields were blocked at the tail ends and there was no tail drain runoff (WB, 2017).

Issues of Traditional Agricultural Practices in Pakistan

Reduced Efficiency due to Flood Irrigation

In traditional Pakistani irrigation systems, water flow to the field is controlled by temporary earthen dams that are removed to release water and then rebuilt. This constant destruction and reconstruction have weakened watercourse walls, decreased efficiency of water delivery, and required considerable time and labor.

Problem of uneven fields

When a field is uneven, farmers overwater to cover the high areas; this leads to waterlogging of the lower areas, possible increased soil salinity, and uneven crop growth.

Groundwater overdraft

The surface water scarcity has forced the farmers to abstract and even overdraw groundwater. According to a survey, 0.8 million water pumps are operating in Pakistan (Qureshi et al., 2008). The increasing number of water pumps and over extraction of groundwater has led to the salinization of almost 4.5 million ha of land, half of which lies in the irrigated lands of the Indus Basin. Due to inappropriate practices of irrigation and waterlogging from canal seepage, nearly 1 million ha of irrigated land is also affected (Qureshi et al., 2008). In the canal command areas of both Sindh and Punjab, there is a severe decline in the water table due to the overexploitation of groundwater (Bhutta & Smedema, 2007).

Small Farm Size

Farm size affects the productivity of the major crops in Pakistan (Ahmad et al. 2014a). It influences the extent to which practices are adopted and the system-scale effectiveness of these practices in terms of overall water use. Farm sizes in Pakistan are mostly less than 5 hectares. Farmers of smaller holdings tend to have less access to machinery, and being poorer, are typically less likely to be able to invest in water efficient irrigation technologies.

Present Policies for water conservation in agriculture

The major policy document in Pakistan that provides a framework for efficient utilization of water usage in Pakistan is the National Water Policy, 2018 issued by the Ministry of Water Resources. The key highlights of the policy framework are given below.

- The concept of "More Crop Per Drop" shall be pursued.
- Modernization of irrigation network
- The concept of participatory management of irrigation.
- Groundwater table shall be so managed that it does not impede crop growth or causes land salinity or underground saltwater intrusion.
- The Water Apportionment Accord of 1991. IRSA has to implement the Accord in letter and spirit as per provincial share stipulated in the Accord.
- Equity of water distribution between head and tail reaches shall be ensured.
- Use of treated sewage shall be promoted for non-edible crops
- Irrigation facilities shall be extended to new culturable command areas.
- Rain-fed areas where groundwater is available at relatively shallow level, will be given preference for solar pumping.
- Provincial governments would be encouraged to prepare large scale programs of rain water harvest ponds and mini dam construction in rain-fed areas

Legal Frameworks

i. The PCRWR Act (2007) outlines a clear national mandate for water research and analysis.
ii. Water Apportionment Accord (WAA) was signed amongst the Provinces on 16.03.1991 and IRSA was established for regulating and monitoring the distribution of water sources of Indus Rivers in accordance with the Accord

Institutional Framework

i. At the Primary Level in Pakistan, Ministry of Water Resources works on the development of water resources in the country and manages Indus Water Treaty, WAPDA, the Indus River System Authority (IRSA), and transboundary water organizations. WAPDA is responsible for construction of dams as well as the main canals from dams.
ii. At the Secondary Level in Provinces, the respective irrigation departments are responsible for management of secondary canals and construction of small dams
iii. At the tertiary level On Farm Water Management Departments in the Provinces are responsible for water course management and conveyance of water from canals to fields.

Critical Analysis and Evaluation of Existing Policies and Policy Documents

Involvement of Stakeholders

The NWP has little to say about the operational functions of WAPDA and IRSA, except to note the need to revitalize WAPDA and strengthen IRSA's role in real-time monitoring. The policy highlights the importance of financial sustainability for provincial irrigation operations and the role of technology to improve operational efficiency and effectiveness.

Design of Implementation Strategies

Pakistan's policies regarding water conservation in agriculture is facing the issue of implementation because the subject has been devolved to the provinces. Water resources are not included in the enumerated federal list of the 1973 Constitution of Pakistan; water management is largely, therefore, the purview of the provinces. Two areas fall within federal jurisdiction: interstate water disputes and policy setting for water and power development, as originally covered by the Water and Power Development Authority Act (1958). Article 155 of the Constitution includes a dedicated procedure in case of water allocation disputes. Disputes may be referred to the Council of Common Interests for decision, and it is the legal duty of federal and provincial governments to honor the council's decision. This provision was used for the approval of the 1991 Water Apportionment Accord. The Water Apportionment Accord was signed in 1991, and in 1992 the Indus River System Authority (IRSA) was established by federal legislation to implement the accord. Although the accord was a major step in interprovincial water sharing, little progress has been made since in resolving important ambiguities, particularly concerning the initial conditions.

Critical Analysis of Existing Implementation Strategies

Issues with Federal PSDP Allocation Towards Water Management

i. Comparison of the Federal PSDP allocations over two decades (Fig 2) indicate that allocation saw a 21% increase in the second decade. This 21% increase appears to be small and incompatible with the scale of interventions required for upgrading existing and constructing new irrigation water infrastructure for meeting targets of the National

Water Policy, 2018. (FAO, 2018)

ii. No consistent pattern of yearly allocation is observed over two decades in the Federal PSDP (Fig 3). The observed increasing and decreasing trend in the federal PSDP allocations is inconsistent and based on short term planning, driven by urgent needs to revive projects of national importance such as raising and extension of major reservoirs (Mangla and Tarbela dams), construction of Diamer Bhasha, and Mohmand dams and construction, upgradation and remodeling of large canals.

iii. Weak institutional set up for implementation of national water policy and insufficient financing of the major infrastructure projects are two major barriers to implement targets of the national water policy. This is evident by the fact that within the last three years only a single meeting of the National Water council is held. Furthermore, the nomination of five private (technical) members of the council are still pending

iv. After approval of the National Water policy in 2018, the funds allocation for large, medium and small dams have been increased substantially from 10.5 billion in 2017-18 to 84.14 billion in 2019-20. The statement is true that National Water Policy has been instrumental to a great extent towards increased allocation for new storages. Overall, at the national level, Canal extension and improvement is the highest National water priority and received PR 396 billion 43% of national agriculture water allocation, from the combined federal and provincial allocations

v. An allocation of PKR 282 billion to the agriculture on farm water management, is giant step to improve water efficiency at the National Scale. However, there is little evidence that benefits of the investment on lining of water courses outweigh the cost.

vi. The On-Farm Water Management Program is highly inclined towards lining of water courses. This is debatable whether the investment on lining of water courses can substantially result in water savings. Seepage losses are controlled but studies show that that in Pakistan almost 43.5% of the water losses still occur in lined watercourses and 66% in unlined water course. In addition to that research studies on economic productivity of water in various agroecological zones are needed, to harness full benefits of agriculture water.

Stakeholder Involvement, Impact and Engagement in Policy Design

The National Water Policy 2018 provides for the formation of two bodies incorporating the major stakeholders involved in conservation of water in agricultural practices.

National Water Council

A national body named as "National Water Council" (NWC) shall be established with the following composition:

1	Prime Minister of Pakistan	Chairman
2	Federal Minister for Water Resources	Member
3	Federal Minister for Power	Member
4	Federal Minister for Finance	Member
5	Federal Minister for Planning, Development & Reform	Member
6	Chief Ministers of Provinces	Members
7	5 Private sector members from water related disciplines	Members
8	Secretary, Ministry of Water Resources	Secretary

Steering Committee

A Steering Committee on water will assist the NWC by ensuring inter-provincial coordination and reviewing policy papers and monitoring reports before submission to NWC. The composition of the Steering Committee will be as follows:

Lack of Involvement of Farmers

1	Federal Minister for Water Resources	Secretary
2	Secretary Ministry of Water Resources	Member
3	Secretary, Ministry of Power Secretary	Member
4	Secretary Ministry of PD & Reform Secretary	Member
5	Secretary Ministry of Finance	Member
6	Chairman WAPDA	Member
7	Chief Engineering Advisor	Member/Secretary
8	Chairman NDMA	Member
9	Surveyor General of Pakistan	Member
10	Chairman Pakistan Engineering Council	Member
11	Provincial Irrigation Secretaries	Member
12	Secretary (Works), PWD, Govt. of Gilgit-Baltistan ACS Fata Secretariat	Member
13	ACS FATA Secretariat	Member
14	Secretary, (Irrigation & Small Dams), Govt. of AJ&K	Member

Lack of Involvement of Farmers

These two committees cover almost all the major stakeholders related to water conservation in agricultural practices. However, the absence of representation of farmers and land holders who ultimately execute the water conservation strategies at the farm level are absent from these committees. Therefore, even if policies are made for on ground execution to conserve water in agricultural practices, due to the absence of farmers and their input, such policies may not find adoptability at practical stage.

Performance of Institutional Frameworks for Implementation

To implement the policy of conservation of water in agricultural practices two major implementation strategies have been adopted by the Agricultural Departments of the Provinces

National Program from Improvement of Water Courses- Phase II

The Project aims to replicate the success achieved in National Program for the Improvement of Watercourses Phase-I and to enhance the agriculture growth in Pakistan. The broad objectives of the proposed project (NPIWC-II) are the social mobilization through capacity building of Water User Associations (WUAs), minimize the water conveyance and on farm water application losses, reduction in water logging and salinity, equity in water distribution, reduction in water distribution disputes, reduce the poverty through employment generation in agriculture sector and to increase the crops yield.

Project Components

1. Organization of Water Users Associations
2. Improvement of Watercourses
3. Construction of Water Storage Tanks
4. Provision of Laser Land Levelers

Project Outputs

1. Mobilization through capacity building of Water Users Associations.
2. Reconstruction/renovation and remodeling of 47,278 watercourses, involving complete earthen renovation, partial lining of critical reaches and installation of water control structures.
3. Construction of 14,932 water storage tanks with 60% subsidy,
4. Provision of 11,610 Laser Land Levelers at 50% cost sharing, with the expectation to save about 50% of irrigation water for wheat and about 68% of irrigation water for paddy.
5. The impacts of the project are given in Table 4,5 and 6

Critical Analysis

- Involvement of Water User Associations as stakeholders to encourage community participation
- Due to the 80:20 sharing model, the project encourages ownership of the infrastructure by the farmers
- Lack of interest of upstream farm owners
- Extra pressure from tail end users of water ways for improvement
- Major focus of improvement is at the tertiary level. However, it is more convenient and easier to focus on improvement at the secondary level to reduce conveyance losses
- Returns to investment on improvement on water ways vis-à-vis improvement in crop productivity is debatable
- Total Cost of the Project is 46.2 Billion whereas the total economic benefit from water saving was estimated at 2.3 Billion

Provision of High Efficiency Irrigation Systems (HEIS) on Cost Sharing (Subsidy)

Punjab

Under these arrangements, the government offers a subsidy of 60 percent of the installation cost for HEIS on up to 15 acres of land. The remaining costs are then covered by the beneficiary farmers. In addition to the system installation subsidy, the government also provides a subsidy of 60 percent of the scheme cost for constructing a water storage pond, if it is deemed necessary based on site-specific technical requirements. The decision to construct a water storage pond considers factors such as water availability, topography, and irrigation needs.

Khyber Pakhtunkhwa

The On Farm Water Management Department KP is providing subsidy to farmers for installation of HEIS with the help of World Bank Funding. The project supports installation of HEIS's such as drip, trickle, bubbler or sprinkler irrigation systems, primarily for high-value crops. These systems will be installed by a service provider on a shared-cost basis to crowd in private investment in these technologies. Farmers would provide 40 percent and the project 60 percent. Drip units would include a pumping unit, fertilizer tank, delivery fittings, filters, underground main pipeline, and delivery lines, etc. HEIS would be installed on at least 10,000 acres on a first-come-first served basis.

Sindh

The project that is being funded by the World Bank supports installation of HEIS drippers and bubblers for growing high value crops on irrigated and irrigable land; provide technical assistance packages to farmers on operations and maintenance of HEIS; and provide

additional training and assistance to farmers in the use of HEIS by specialists and consultants. Approximately 2,600 HEISs will be installed on 14,300 ha (35,000 acres) of irrigated and irrigable land. HEIS' will be provided (on demand) to the farmers on a 40 percent cost sharing basis. They will be installed by Sales, Supply and Service companies (SSCs) who will also provide a technical assistance package for the farmers in operation and maintenance of the system. Additional training and assistance will also be provided by the HEIS specialist in the field teams assisted by the technical assistance and training (TAT) consultants. Directorate General Agriculture Engineering &Water Management will have the overall responsibility for implementing the project.

Balochistan

An incentives methodology implemented in which the construction of a storage tank will be provided (as a grant under the project) in return for the installation of HEIS over the maximum productive command area. Farmers will also be encouraged to allow installation of water meters to demonstrate water saving with no depletion in growth rates or yields.

The project will require beneficiaries to contribute to the capital costs and to the operation and maintenance (O&M) costs of all development works. Whilst beneficiaries would contribute 100 percent of all O&M costs, they would contribute 10 percent towards scheme costs, comprising cash equivalent to 2 percent of the capital cost, contribution in the form of labor at 8 percent of the capital cost. The FO Contract will be overall 25 percent (value) of the capital cost. Overal1, this will be equivalent to 25 percent of the scheme development costs.

Critical Analysis

- Despite provision of subsidy, the HEIS systems are still expensive for farmers to afford
- Due to lack of technological knowledge at the farmer level, the systems are difficult to operate
- After installation services and O&M services of these systems make it unaffordable for the farmers at later stages
- Due to lack of technical knowledge of line departments involved, the O&M services are outsourced to private firms which inflates the cost for the farmer
- There is a need for capacity building of line department staff to offer services which can reduce the maintenance cost for the farmers

Monitoring Report of Promotion of High Value Agriculture Through Solarization of Drip & Sprinkler Irrigation Systems (Revised)

Project Objectives

i. Reduce the operational cost of high efficiency irrigation system
ii. Enhance crop and water productivity by through optimal use of water and non-water inputs by application of modern climate smart technologies
iii. Promote use of solar energy on in agriculture for promoting irrigated agriculture in remote areas
iv. Build farmers' capability at grassroots level for growing high value crops to get higher farm returns for alleviating poverty.
v. Create job opportunities in rural areas through introduction of climate smart technologies for high value irrigated agriculture

Observations

i. Promotion of High Value Agriculture Through Solarization Of Drip & Sprinkler Irrigation Systems (Revised) is a project that has been completed as far as the physical progress is concerned so its evaluation should be planned and department should submit its PC-IV.
ii. Agriculture Extension department may have played an important part in the sustainability of this project but there is a lack of coordination between Agriculture extension and Water Management Department
iii. Data Management of the Projects was not up to the mark and there were several anomalies found during analysis of Data which may not be according to the Farmer Criteria.
iv. Impact calculation of the project was not done neither a mechanism is devised for that process
v. Feedback from famers was not included in the project. A survey or the criteria may need to establish.
vi. Focus on Training & Development part was not included in this project which may lead to the sustainability challenges of the project.
vii. The quality control plans, quality check lists and methodologies were not available.

SWOT Analysis (on Farm Water Management Department, Punjab)

Strengths

Close proximity to Farmers and end users: The OFWM comes into close contact with farmers through WAUs which allows them to have feedback and propose solutions that are rooted in application

Government Support: The OFWM operates under the Agriculture Department of Punjab, benefiting from strong government backing and policy support. The Punjab government has allocated significant funds for water management projects in agriculture, such as the construction of watercourses and farm ponds. Out of total National Allocation for Agriculture Water Management, 31% share goes to on farm water management.

Technical Expertise: The wing has access to a pool of agricultural experts and engineers who provide valuable technical guidance and support to farmers. The Agriculture Department conducts regular training programs and workshops for farmers on modern irrigation techniques and water-saving practices.

Research and Development: The wing conducted research studies to explore innovative water management strategies and technologies suitable for local farming conditions.

Weaknesses

Data Unavailability: Insufficient data on water usage and agricultural practices may hinder evidence-based decision-making and program evaluation. There is a lack of comprehensive data on water usage patterns and crop water requirements, making it challenging to formulate targeted water management strategies.

Dependence on Foreign Funded Projects: Most of the HEIS projects are funded by World Bank and Asian Development Bank and hence there is a dependence on foreign loans which can become hindrances once these loans are not available.

Opportunities

High Percentage of conveyance losses in water courses: At present, Pakistan's tertiary level water courses suffer from a high-level of conveyance losses. This provides an opportunity to the organization to intervene and improve efficiency of water in agriculture

Low permeation of HEIS among farmers: At present, farmers in Pakistan are mostly deploying traditional irrigational methods. This is an opportunity for the organization to promote the use of HEIS among farmers to improve water conservation in agricultural services.

Government adopting the policy of More Crop Per Drop: The government through its NWP, 2018 puts emphasis on the policy of More Crop Per Drop which is an opportunity to improve water use efficiency in agriculture.

Decreasing Water Availability: Per Capita water availability in Pakistan is declining which makes it vital for the organization to intervene and allow the farmers to adopt efficient irrigation systems.

Threats

High Cost of HEIS: Adoption of HEIS is extremely important to improve water conservation in agriculture. However, the technology is expensive which is a threat to adoption

Low Technological understanding of farmer: Generally, farmers in Pakistan have a low technological know-how. This is a threat to the objectives of the organization to improve water conservation through adoption of HEIS.

Technological Challenges Related to Implementation

Electricity Availability

Study analysis showed high influence (31.51%) of this factor. Pakistan is facing severe electric power crises. Available and affordable power is basic need to operate this technology. During survey, adopters of this technology explained that they had installed the system but unfortunately, due to lack of electric power they were unable to operate it. They further pointed out that other power sources like diesel engine and tractors etc. cannot be used because of their high operational cost. If government offers proportional electricity price to farmers then adoption of high efficiency irrigation system can be enhanced (Kumar, 2005).

Technical Assistance

Training facilitates farmers to use technology more efficiently, training of water conserving Irrigation positively associated with adoption (Ribeiro Fabiana et,al, 2015). Field survey showed that respondents were disappointed due to lack of technical knowledge which is very important to operate a newly introduced technology. Technology users also claimed that right after the project installation government and supply & services companies should provide adequate training so that.

Cost

Average land holding in Pakistan is 6.4 acres (Economic Survey of Pakistan). Average farmers have very small land size and limited financial resources. Farmers with larger land holdings do not have financial issues so they can easily adopt high efficiency irrigation system (Putler and Zilberman 1984). Due to high initial cost many small farmers are powerless to afford such kind of projects. During survey, farmers showed up this factor with 16.73% effect. The average cost per acre for installation of sprinkle irrigation is Rs.

200,000 compared to Rs. 30-40,000 for traditional irrigation methods.

Area/Farm Based Subsidy

Subsidy is financial support to any economic sector (department/institutions/individual) to promote policies (Myers, N.; Kent, J. (2001). During study data collection farmers communicated that government should provide area/farm size-based subsidy. If one farmer had 25 acres of agriculture land, then he should give low subsidy as compared to a farmer owned 5-acre land because of small farmers' low financial resources.

Lack of Reliable Information

During the survey at district level, author came to know that many farmers don't know about this technology. Newly introduced technology adoption depends on farmer's specific time information towards this technology (Besley and Case 1993; Foster and Rosenzweig 1995; Conley and Udry 2010). No doubt, government of Pakistan is contributing in cost of project in form of subsidy but there is a huge need to market this project.

In Competencies of Supply & Services Companies

Farmers and other technology adopters also claimed that project execution team needs to improve their technology designing and installation expertise as farmers faced problems just after the installation of project. Not only is this but mostly project team members were unable to troubleshoot the problem. Timely irrigation to crops is very important for better production but due to late/delay in technology installation crop sowing time is greatly affected, ultimately leads to low production.

Non-Availability of Spare Parts

Farmers highlighted that advanced irrigation system consisted of many small parts. In case of a little fault/change of drippers they are unable to buy these parts because of their non-availability in local markets. This leads to delay in field irrigation.

Comparative Efficacy Analysis of Different Irrigation Techniques in Pakistan

Irrigation System	**Crop**	**Results**	**Reference**
Sprinkler vs. surface irrigation	Rice and wheat	Sprinkler was better (Rice produced 18% more yield)	Kahlown et al., (2007)
Rain gun sprinkler vs. surface irrigation	Corn fodder	Rain gun was better (34.52% of water saving)	Iqbal (1994)
Furrow vs. sprinkler vs. drip irrigation	Cotton	Cotton yields, Drip (4380 kg/ha) furrow (3630 kg/ha) sprinkler (3380 kg/ha) Drip irrigation produced 21% more seed cotton than the furrow method and 30% more than the sprinkler method.	Cetin (2002)
Furrow (conventional) vs. Drip.	Corn	Water used for irrigation Furrow irrigation (547- 629 mm/ year) Drip irrigation (371- 428 mm/ year)	Nazirbay et al., (2005)
Drip and furrow irrigation.	Tomato	Water savings Drip irrigation (56.4%) 22% more yield than furrow irrigation	Tagar et al., (2012)
Drip irrigation vs. furrow irrigation	Cotton	Increased seed cotton yield, yield components, water saving (53.3%) and water use efficiency (7.9 kg ha-1 mm-1)	Muhammad et al., (2010)

		was obtained under drip irrigation system as compared to furrow irrigation system.	
Under plastic tunnel drip and furrow systems.	Tomato, cucumber and bell pepper	The average water use efficiency in drip irrigation was Tomato (250%) Cucumber (274%) Bell pepper (245%)	Musa et al., (2014)
Line planting under basin irrigation, Ridge planting and planting under furrow irrigation.	Maize	Ridge planting was superior to furrow irrigation and basin irrigation with regard to average water use efficiency	Kori et al., (2017)
Comparison between Trickle irrigation, Rain gun sprinkler, Border irrigation and Furrow irrigation were made.	Cotton	Water saved under furrow. Rain gun sprinkler (14.26%) and trickle irrigation (34%) compared with border irrigation method.	Waheed-uzZaman et al., (2000)
Basin, furrow and rain gun sprinkler systems.	Sunflower	Using rain gun sprinkler irrigation system, 30.8% and 28.3% higher water use efficiency and 21.1% and 9.0% more water application efficiency was achieved as compared to basin and furrow irrigation system, respectively	Rana et al., (2006)
• Precision land levelling • Bed planting • Drip irrigation	Wheat, rice and cotton	Crop sown on precisely levelled land resulted in saving of 2768.1 million m3 and 3699.3 million m3 of irrigation water Drip irrigation enhanced the yields by 30- 40%.	Rizwan et al., (2018)
Furrow irrigation system vs. flood irrigation system.	Kinnow mandarin	Furrow irrigation average water saving (46.14%) and water use efficiency (4.58 kg m3) flood irrigation WUE (2.34 kg m-3)	Raza et al., (2021)

Economic and Financial Analysis

Category-wise PSDP Allocation for Agriculture Water Management

The category wise analysis reveals that (Fig 7), overall, at the national level, Canal extension and improvement is the highest national water spending priority (43% of national agriculture water allocation), followed by on-Farm Water Management (31% of national water allocation) and lastly construction of dams (26% of national water allocation).

Economic Impact of Cropping Pattern in Water Conservation

Given the crop irrigation demands and areas typically grown, rice consumes around 32 percent of the water, wheat and cotton both consume around 25 percent and sugarcane 18 percent. Around half of the rice crop (and 5 percent to 10 percent of the sugarcane crop) is exported, thus presenting a very significant virtual water export. Growing low productivity paddy rice for export in an arid, water scarce country does not make good economic sense. Reforms and investment are required to move this water to higher-value crops (fruit and vegetables) for export and to meet the growing domestic demand.

While a diverse mix of crops is grown in Pakistan, around three-quarters of the area and two-thirds of the value comes from two food crops (wheat and rice) and two cash crops (sugarcane and cotton) (Ahmad, Iftikhar, & Chaudry, 2007).

Cotton

The blue water footprint of cotton in Pakistan is around double the global average; conversely its blue water productively (weight produced for given volume of irrigation water) is around half the global average. Around a quarter of the groundwater depletion in Pakistan is associated with agricultural exports, of which cotton represents a significant fraction.

Wheat and Sugarcane

Mekonnen and Hoekstra (2011) review agricultural water footprints by country. They show the blue water footprints for wheat and sugarcane (raw sugar equivalent) in Pakistan are around four times the world average, Pakistan ranks second highest in the world for the blue water footprints for wheat and sugarcane (raw sugar equivalent), and seventh highest for rice.

Rice

Mekonnen and Hoekstra (2011) show that blue water footprints for rice is more than six times the world average. Pakistan ranks seventh highest in the world for the blue water footprints for rice.

Ultimately, while both cotton and rice are major export earners for Pakistan, the water performance of these crops is very poor compared to that of other countries; combined, they account for well over half the total irrigation water use of Pakistan. For a water scarce country, directing over half of the water used to water-intensive crops that are not essential for domestic food security and that deliver comparatively poor economic return is not a good long-term option.

Comparison with International Best Practices

North China Plain Water Conservation Project (2008) (Bank, 2008)

Outcomes:

Increased water productivity and reduced consumptive use.

i. The value of agricultural production per unit of water consumed increased in the range of 60 to 80 percent throughout the project area;
ii. non-beneficial water consumption was reduced by a sixth.
iii. Agricultural production tripled and farmer per capita incomes increased between 10 to 554 percent.
iv. About 360,000 households were among the project's beneficiaries.
v. Annual water savings averaged 1,200 m3/ hectare.
vi. More sustainable groundwater use.
vii. Across most of the project area, groundwater depletion was reduced to negligible levels or eliminated.
viii. Adaptable institutional arrangements supported groundwater recovery, with priority given to providing farmers with incentive packages linked to reductions in water consumption. County-level groundwater management plans were piloted in four counties.
ix. Strengthened institutional arrangements for irrigation system operation and maintenance. The original project target was 100 water user associations (WUAs),

but more than 500 were established, covering about two-thirds of the project area. Women's participation was estimated at 30 to 40 percent, and they were regularly elected to association committee posts. For the first time on this scale in China, WUAs assumed responsibility for both financing and operating irrigation systems.

x. Water charges. Volumetric water charges were initiated for about 62,000 hectares, 110 percent greater than the target area. Progressive increases in water charges typically rose from the relatively low pre-project baseline by a multiple of three to four times above appraisal targets.

xi. High benefits. The economic analysis suggested that the project achieved an overall rate of return of 24 percent, higher than the appraisal estimates of 21 percent.

Lessons Learned

The project successfully focused on new approaches to finding an appropriate mix of technical and institutional changes that reduced agricultural water consumption while at the same time benefiting the agricultural sector. Among the lessons are:

i. Development of WUAs. The success of the WUAs stemmed from two organizing principles: (a) democratic self-organized associations based on hydraulic boundaries, and (b) water measuring, with corresponding water charges on a volumetric basis.

ii. a flexible approach and adaptation to local conditions; the inclusion of farmers from the beginning in sub-project design; transference of control for water structures to WUAs; and the active support of both the Ministry of Water Resources and local governments.

iii. Importance of economic incentives. Approaches to water savings in agriculture are more likely to succeed if appropriate incentives are given to farmers to modify their practices.

iv. Monitoring and evaluation for technical innovations. Appropriate monitoring and evaluation system are necessary to verify the efficacy and efficiency of integrated water-saving measures in agriculture, and to share the information with water user associations.

Egypt Case

Different examples of water conservation campaigns in Egypt.

a. Volunteers clear the banks of the Nile River of plastic waste.
b. Conversation with public inhabitants about water conservation importance in Delta villages.
c. Spreading awareness among young students through artwork.
d. National Competition for Water Conservation for Primary Schools organized by the Ministry of Education and Technical Education and the Ministry of Housing, Utilities, and Urban Communities represented at the Holding Company for Water and Wastewater in cooperation with the European Union in Egypt.
e. Capacity building session for farmers to enhance their efficiency by utilizing the best practices in modern irrigation to ration water consumption, funded by the European Union in Egypt.
f. National Competition for Water Conservation for Farmers applying modern irrigation systems organized by the Ministry of Water Resources & Irrigation in cooperation with the European Union in Egypt.
g. Previous campaigns in lacked the concept of public participation in planning strategies and led to landscape degradation and detachment of inhabitants from the waterways'

surrounding environment.

h. Therefore, creative planning of water conservation campaigns in Egypt, along with sustainable water management, urban planning, and landscape design supporting the implementation of different SDGs, is vital for decreasing the continuous degradation of waterways in Egypt. (Sara S. Fouad a b, 2023)

Israel Case

Innovating Drip Irrigation

Israel has developed several systems to save water. The drip irrigation system, invented in Israel, that has become known worldwide, is responsible for 90% of agricultural irrigation (Staff, 2024). Today, 80% of Israel`s wastewater is treated and reused for agricultural irrigation. The goal is to reach 90% in five years, representing 400 million cubic meters a year from wastewater alone. Another 150 million cubic meters of mainly salty water is pumped out from faulty aquifers. Rainwater is caught and stored in reservoirs in winter and used in the summer for irrigation (Staff, 2024). Desalination is yet another facet of Israel's water strategy. More than 360 million cubic meters of water a year are desalinated in Israel, representing about 50% of the municipal drinking water in use.

Gap Analysis

Sr.#	Current	Intervention	Desired
1	Low irrigation efficiency causes water logging and salinity problems that decreases cultivable area	Decrease conveyance and application losses through HEIST	Efficient irrigation system with minimum seepage.
2	Pakistan irrigation system is not self-sustainable due to irrational pricing system where only 20% of the operational and maintenance cost is recovered through abyana.	Rationalizing abyana	A sustainable irrigation system that is at least on break even stage. Pricing must be based on water usage on volumetric basis
3	Negligible number of water logging and salinity resistant variety development for water logged areas	Strong Liaison with agri research system	A range of variety development for different regions in various crops to use the water-logged area in agriculture production.
4	Equipment for water efficient technology are not locally assembled/produced	Training of On Farm Water Management Department regarding installation of equipment	All equipment to be assembled locally to increase its affordability.
5	Current conveyance and application losses accounts for 60 % losses	Improvements in water courses and water application techniques	Decreases all types of losses to minimal
6	No treatment plant employed for recycling of drainage water to be reused in irrigation system	Installation of drainage water treatment plants	Recycling of drainage water for re-use in irrigation
7	Flood irrigation techniques	Provision of Agri-credit to farmers Public awareness Demonstration plots	High Efficiency Irrigation System

8	No regulatory frame work for underground water utilization which results in underground water depletion.	Government to draw legal framework	Ground water extraction to be regulated to ensure water table at respectable levels.
9	80% of water is used by four water intensive crops that contributes to 5% of GDP.	Increasing cropping intensity New cropping patterns	Efficiently utilization water resources to increase their contribution to GDP.
10	Limited availability of water reservoirs in rain-fed areas	Provision of Agri-credit facility to land owners of barani land	Construction of numerous small reservoirs/dams to ensure water conservation and availability for irrigation

Issues and Challenges in conservation of water in agricultural practices

1. Cropping pattern of Pakistan is dependent on high water consuming crops which are not essential for domestic food security and that deliver comparatively poor economic returns.
2. There is little attention given to development of drought resistant and salinity resistant crop varieties.
3. Almost 60% of Pakistan's agricultural water is lost in the canals and water ways during conveyance to the field
4. The current irrigation practices employed by the farmers have high water wastage and low yield.
5. HEIS are expensive to deploy which discourages the farmers from adopting them.
6. Farm sizes in Pakistan are small which also poses a challenge to adoption of HEIS.
7. The staff at On Farm Water Management Departments are not trained to provide operation and maintenance services for HEIS to the farmers.
8. Government is directing most of its budget to improvement of water ways and there is little focus on subsidizing HEIS.
9. The surface water scarcity has forced the farmers to abstract and even overdraw groundwater which is causing salinity issue.
10. The farmers in Pakistan do not have sufficient knowledge of technology utilization to adopt HEIS and promote water conservation.
11. Issue of electricity availability is a hindrance in adoption of water conserving technologies at the farm level
12. Less focus on impact analysis of projects of water conservation which reduces the efficacy of future planning.
13. There is no representation of farmers in the NWP, 2018 National Water Council
14. Federal PSDP allocation is not enough to meet the objectives on NWP, 2018.
15. The observed increasing and decreasing trend in the federal PSDP allocations is inconsistent and based on short term planning
16. There is little coordination among Primary, Secondary and Tertiary Level government agencies dealing with water conservation.

Conclusions

1. Although the National Water Policy, 2018 announced by the government is a step in the right direction, it faces a big challenge to its implementation due to the financial constraints as well as the misdirected priorities of the government which needs to focus on adoption of HEIS
2. While Pakistan's major agricultural export revenue is from cotton and rice, pursuing this policy of export is not necessarily water efficient and it delivers comparatively poor economic returns.
3. Involvement of Water User Associations and community participation model adopted by the government has lead to positive outcomes in improvement of water ways. the same model can be adopted for improving HEIS usage among farmers.

Recommendations

Enhance the legislative foundation for water governance

a. Update the 2018 Water Policy to include HEIS in agri as a priority
b. Drafting a legal framework to enforce water conservation in agri practices

Strengthen national and basin water governance

a. Target setting for water conservation by provinces in liaison with
b. PCRWR
c. Achievement of targets to be ensured by a national water council.
c. Strengthen existing river basin commissions.

Improve and optimize economic policy instruments

d. a. Adequate allocation in PSD towards agriculture water management
d. b. Diversion of resources towards the adoption of HEIS

Strengthen adaptive capacity to climate and environmental change

a. Strengthen resilience to floods.
e. Development of drought-resistant crop varieties

Improve data collection and information sharing

a. Enhance the R&D capacity of PCRWR and OFWM
b. Create a National Water Information Sharing Platform.
c. Strengthen the role of public awareness and participation

Diversification of Pakistan's cropping pattern

a. Shift towards high revenue-yielding crop varieties
b. Focus on less water-intensive crops

Operational Plan

	Project Summary	**Indicators**	**Verification**	**Risks**
Goal	Achieving Significant Conservation of water in Agricultural Practices within 3 years	Degree of increase in installation of modern irrigation techniques	Local manufacturing of equipment for HEIS	Upfront investments
Outcome	1. Improved water table 2. Reduced water wastage	3. Reduced water scarcity for other sectors	PCRWR Reports	1. Climate Change 2. Population Explosion
Output	Increase in CCA	1. High yield per acre 2. Improved quality of yield	3. Increased Net Production 4. Increased GDP contribution	5. Drought spell 6. Soil degradation
Activities	1. Awareness among farmers about the efficient irrigation systems in 1st year 2. Arrangement of Farm Credit for adoption of HEIS	3. Number of sessions conducted by authorities 4. Volume of Credit disbursed	1. Feedback & demand from WUAs to OFWM 2. Feedback from SBP regarding credit facility	1。Farmer`s resistance to Change 2. Complicated Procedures of Banks

Appendix

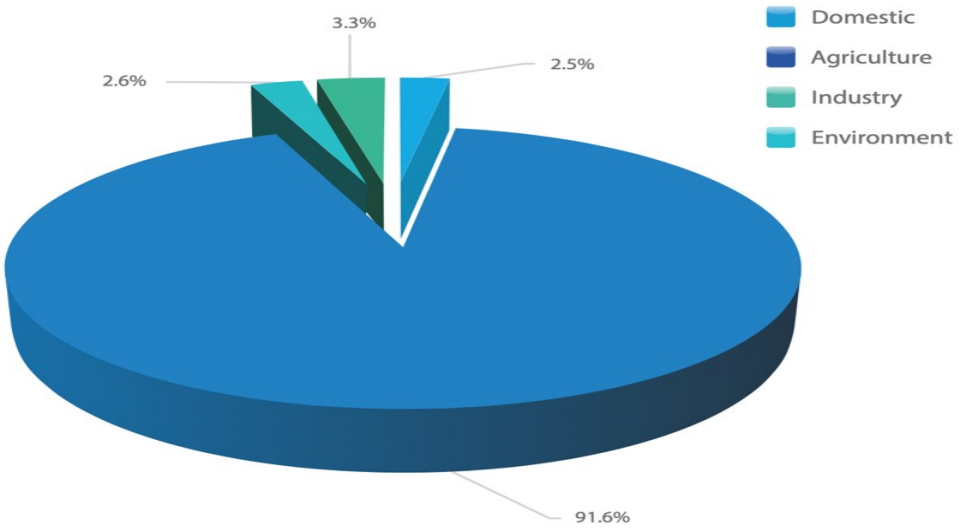
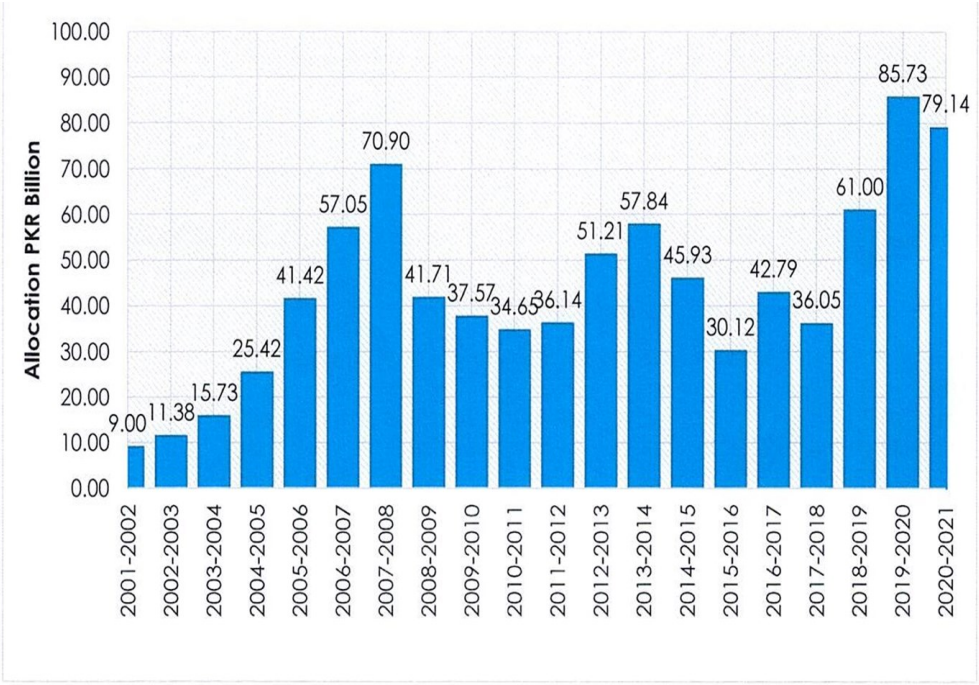


Figure 1: Water used by sub-sectors (2016). Source: UNDP



Data Source: Ministry of Water Resources, and Ministry of Planning Development and Special

Figure 2: Federal PSDP Allocation Towards Water Management

Table 3.1 Analysis of Federal PSDP Allocation over 20 Years

	Year	Allocation PKR Billion	Difference in Federal Water Allocation from the preceding Year (PKR Billion)	5 year Total Allocation PKR Billion	5 year Average PKR Billion
Funding Cycle 1	2001-2002	9.00	-10%		
	2002-2003	11.38	26%		
	2003-2004	15.73	38%	102.95	20.59
	2004-2005	25.42	62%		
	2005-2006	41.42	63%		
Funding Cycle 2	2006-2007	57.05	38%		
	2007-2008	70.90	24%		
	2008-2009	41.71	-41%	241.88	48.38
	2009-2010	37.57	-10%		
	2010-2011	34.65	-8%		
Funding Cycle 3	2011-2012	36.14	4%		
	2012-2013	51.21	42%		
	2013-2014	57.84	13%	221.24	44.25
	2014-2015	45.93	-21%		
	2015-2016	30.12	-34%		
Funding Cycle 1	2016-2017	42.79	42%		
	2017-2018	36.05	-16%		
	2018-2019	61.00	69%	304.71	60.94
	2019-2020	85.73	41%		
	2020-2021	79.14	-8%		

Data Source: Ministry of Water Resources, and Ministry of Planning Development and Special Initiatives[19]

Figure 3: Trend of Federal PSDP Allocation vis-à-vis previous year allocation towards water management

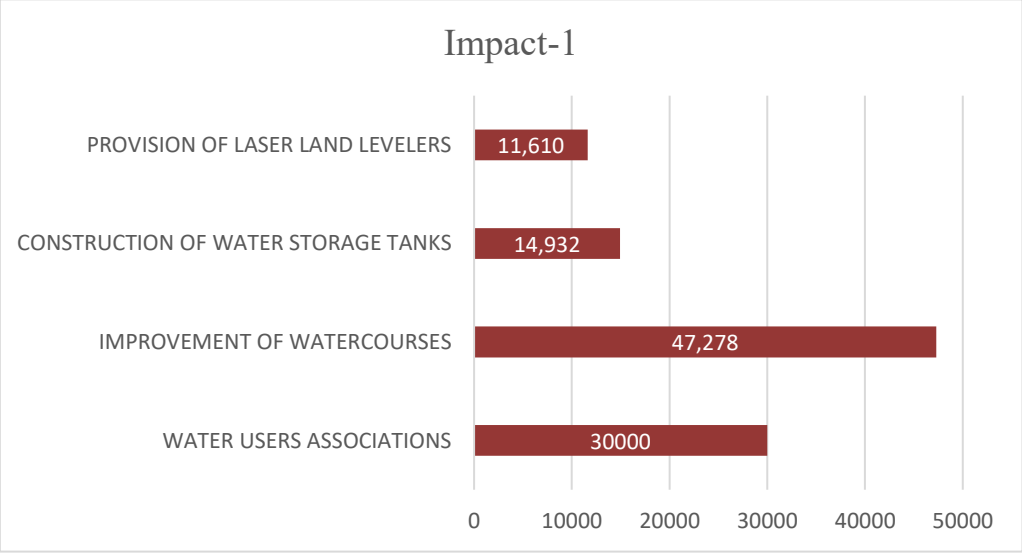


Figure-4: Impact of National Program from Improvement of Water Courses- Phase II (Achievements)

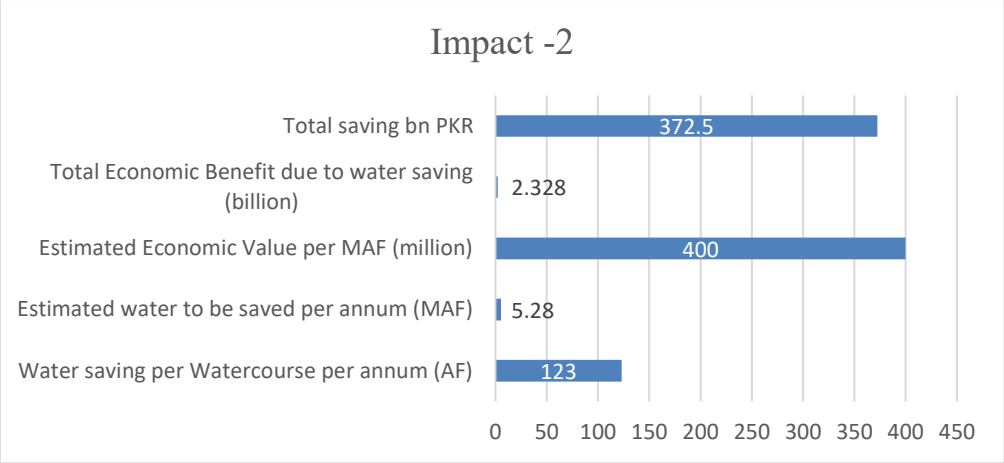


Figure-5: Impact of National Program from Improvement of Water Courses- Phase II (Economic Benefits)

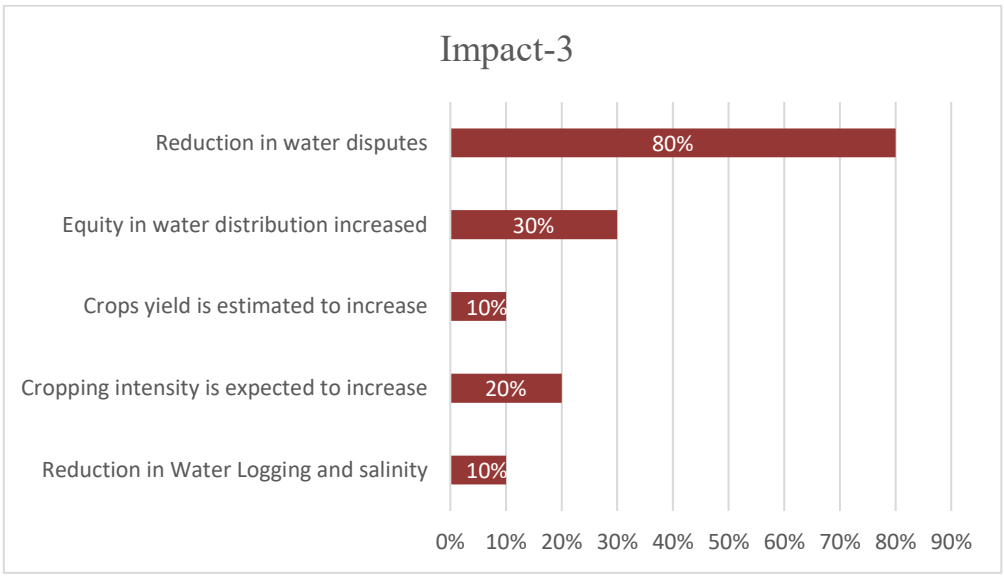


Figure 6: Impact of National Program from Improvement of Water Courses- Phase II (Improvement in water usage and crop productivity)

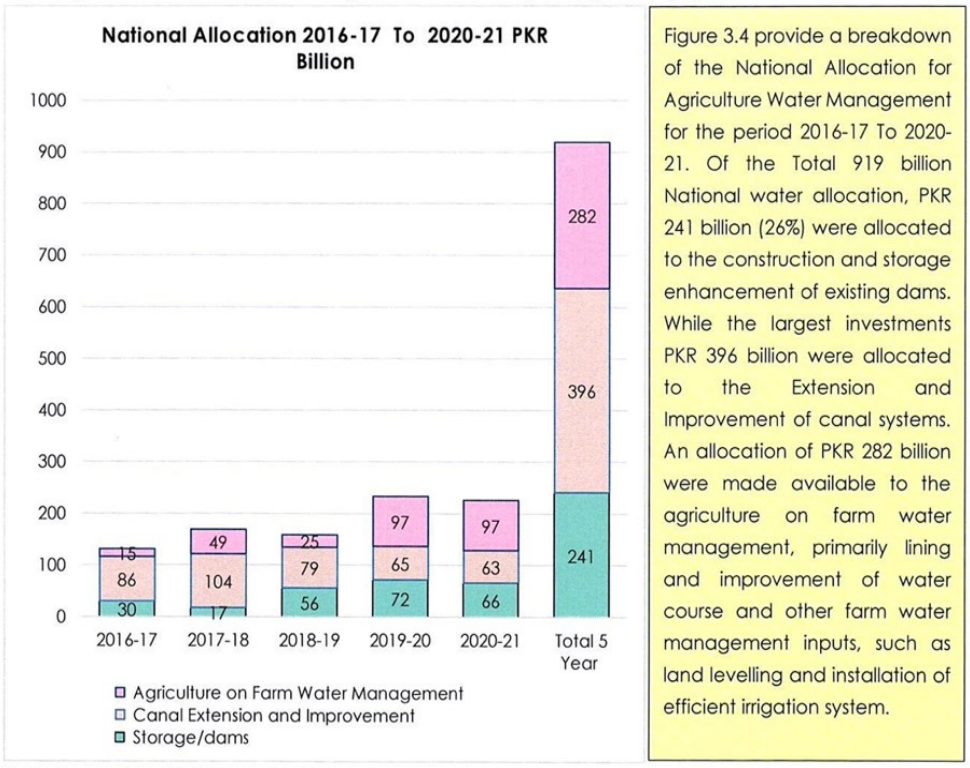


Figure 7: Breakdown of National Allocation for Agriculture Water Management

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