

Concept Note

Title: Water Budgeting and Agricultural Productivity Assessment in the Indus Basin Irrigation System: Focus on Irrigation Water Management and Groundwater Sustainability

Introduction

Efficient water management is critical for sustaining agricultural productivity and ensuring the long-term viability of water resources, particularly in water-scarce regions such as the Indus Basin Irrigation System (IBIS). As the largest contiguous irrigation network in the world, IBIS underpins Pakistan's agricultural sector and plays a pivotal role in national food and economic security. The system operates through a three-tiered canal structure: primary canals with perennial flows, secondary canals with rotational flows, and tertiary canals with sequential flows each with distinct operational challenges.

However, this vast and complex infrastructure is under mounting pressure. Climate change is altering water availability, cropping intensities are rising, and groundwater abstraction particularly through solar tubewells has reached unsustainable levels. These trends are intensifying water scarcity and undermining the long-term sustainability of irrigated agriculture. Given Pakistan's dependence on both surface water and groundwater, improving water productivity has become a critical national priority.

This study, focused with particular attention on Bahawalnagar and Bahawalpur districts, will analyze the interplay between agroclimatic suitability, irrigation water availability, groundwater sustainability, and crop water productivity. It will also examine groundwater abstraction patterns, especially the role of solar tubewell pumping in selected canal commands. Leveraging remote sensing datasets such as WaPOR¹ and aligning with the Punjab Agriculture Policy² (2018) and the Punjab Irrigation, Drainage, and River Act³ (PIDRA) 2023, the study seeks to generate actionable insights for evidence-based water governance and the sustainable management of agricultural water resources.

Objectives

1. Map and classify crop types using remote sensing, quantify their water requirements across agro-ecological zones, and assess spatial variations in crop water productivity.
2. Evaluate the adequacy, equity, and efficiency of canal water delivery, and analyze the conjunctive use and sustainability of surface and groundwater resources.
3. Identify solar tubewells and assess their impact on groundwater abstraction using remote sensing within a selected canal command.
4. Develop a decision-support framework to guide evidence-based agricultural water management and enhance water productivity.

Proposed Study Area

- Bahawalnagar District
- Bahawalpur District

¹<https://data.apps.fao.org/wapor/?lang=en> FAO's portal to monitor Water Productivity through Open access of Remotely sensed data.

² <https://agripunjab.gov.pk/system/files/Punjab%20Agriculture%20Policy.pdf>

³ <https://punjablaws.punjab.gov.pk/uploads/articles/punjab-irrigation-drainage-and-rivers-act-2023-pdf.pdf>. Clause 5(i) promotes integrated and sustainable management of both surface and groundwater resources. Clause 28 supports the scientific regulation of groundwater abstraction through advanced technologies].

Implementation Modalities

The study will be jointly implemented by FAO, Punjab Agriculture Department, Punjab Irrigation Department, and academic partners (MNSUA and IHE Delft, Netherlands) through the establishment of a Technical Working Group (TWG). The TWG, comprising nominated sectoral experts (Agronomists, Soil Scientists, Groundwater Specialists, RS & GIS Experts, Irrigation Engineers, IT Experts, and Researchers), will guide study design and oversee execution. Specialized sub-working groups will deliver targeted outputs, with quarterly progress reviews in TWG meetings.

Capacity development will be central, including targeted training, workshops, field visits, and mutual learning. The study will begin with an inception workshop, followed by midterm and final review workshops. Output will be disseminated through reports, stakeholder workshops, and policy briefs. A sustainability plan will ensure the integration of findings into institutional workflows for long-term adoption.

The initiative will be funded under the WaPOR project, administered by FAO Pakistan.

Proposed Workplan

The proposed workplan for the study activities is presented below, with timelines to be finalized in consultation with the TWG.

No.	Activities	Responsibility	Support By	Nov 2025 – Jan 2026	Feb – Apr 2026	May – Jul 2026	Aug – Oct 2026
1	Nomination of Focal Point & Kickstart Meeting	FAO, PID, PAD, & MNSUA					
2	Inception Workshop	FAO					
3	Nomination of Sectoral Experts	FAO, IHE, PID, PAD, & MNSUA					
4	Formation of Technical Working Group (TWG) and Subgroups	FAO, PID, PAD, & MNSUA					
5	Training of Trainers (ToT) on WaPOR	IHE	FAO				
6	Data Collection (Command area boundaries, canal discharge, groundwater level, groundwater quality, soil characteristics, tubewells information, climate)	PID, PAD, MNSUA, FAO					
7	Data Analysis and Modelling	MNSUA, FAO, PID,	IHE				
7.1	Crop Type Mapping and calculating water requirements	MNSUA, PID, PAD,	IHE, FAO				
7.2	Crop water productivity assessment	MNSUA, PID	IHE, FAO				
7.3	Irrigation performance assessment	PID, MNSUA	IHE, FAO				
7.4	Groundwater sustainability mapping	FAO, PID, MNSUA					
8	Quarterly Progress Meetings	FAO, IHE, MNSUA	IHE				
9	Mid term and final review	FAO, MNSUA	IHE				
10	Decision Support Framework Development	FAO, PID, PAD, & MNSUA					

Expected Outcomes

- Strengthened institutional capacity to apply remote sensing tools such as WaPOR for water productivity enhancement.
- Evidence-based improvements in irrigation performance, crop water productivity, and resource allocation.
- Insights into sustainable groundwater management amid solar pump expansion and declining aquifers.
- Contributions to broader goals of climate resilience, food security, and sustainable water governance in the Indus Basin.