Conjunctive Water Management for Sustainable Irrigated Agriculture in Rechna Doab: An Overview and Progress of Research Work

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BACKGROUND

The conjunctive water management project aimed to identify combinations of institutions and technical strategies to manage surface and groundwater at regional scale to promote environmental sustainability and maximize agricultural productivity of water ('crop per drop'). Two major semi-arid irrigated areas, Rechna Doab in Pakistan and Murrumbidgee Region in Australia are chosen for this study. Both areas have access to surface and groundwater supplies, but overall water is the limiting factor for agricultural production. Both areas lack in the availability of natural drainage due to flat topography, and the environmental consequences of irrigated agriculture (salinity and waterlogging) are also similar in these two regions. The project was started officially on January 1999 and would end by June 2002. This project is funded by ACIAR, and executed with the technical collaboration of CSIRO, Australia. The local collaborators in Pakistan are Pakistan Council for Research in Water Resource (PCRWR), Soil Salinity Research Institute (SSRI) and Ayub Agricultural Research Institute (AARI).

OBJECTIVES

The primary objectives of the project are to develop and test methods of controlling waterlogging and salinity through effective conjunctive management of surface and groundwater supplies. The components and specific objectives as per approved project are listed below:

PROJECT COMPONENTS AND PROGRESS

A: Identification of combinations of institutional and technical strategies that promote sustainable conjunctive water management at the regional scale:

Specific objectives of this component are to:

1. Identify combinations of technical strategies and institutional arrangements and rules that promote sustainable conjunctive water management in irrigated areas.
2. Identify institutional constraints in Rechna Doab that impede effective conjunctive water management.

Research Output:
Four country reports have already been published.

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B: Evaluation of the technical feasibility of providing irrigation water of acceptable quality from multiple sources in a timely manner across an irrigated region and their environmental and economic/financial consequences.

Objectives of this component:

1. Identify technical constraints in Rechna Doab and in Coleambally Irrigation Area (CIA) in the Murrumbidgee Region that impedes effective conjunctive water management.
2. Determine sustainable levels of groundwater and surface water use in Rechna Doab and CIA, Murrumbidgee Region.
3. Determine strategies to induce recharge in parts of Rechna Doab where groundwater levels are falling.
4. Evaluate effective drainage management strategies at the distributary level in Rechna Doab and farm level in the Murrumbidgee Irrigation Area (MIA), Murrumbidgee Region.
5. Identify technical solutions for encouraging effective conjunctive water in Rechna Doab and the Murrumbidgee Region.
6. Assess on-farm financial/economic effects of alternative technical solutions aimed at increasing optimal and sustainable conjunctive use of water in Rechna Doab.

C: Design and transfer of knowledge and technology to stakeholders in the CIA and in Rechna Doab

Objectives:

1. Design and communicate technical and institutional guidelines for policy makers and Area Water Boards within Rechna Doab.
2. Design and communicate technical guidelines for policy makers in the Murrumbidgee Region.

Research Activities

Research activities under component (A1) and (B1) are already finished and the output to that effect has been reported in the 1999 progress report. The description for activities under environmental and financial component (B2-B6) and design and transfer of knowledge to stakeholders (C) are provided against the specific objective.

B2: Determine sustainable levels of groundwater and surface water use in Rechna Doab and Identify technical solutions for encouraging effective conjunctive water in Rechna Doab

In the Rechna Doab, in order to formulate an optimal conjunctive water management system for irrigated agriculture in the area, nodal network water balance approach was used to access the available water resources and estimation of recharge to groundwater aquifer. The various activities, which were completed during the year 2001, were comprised of comprehensive data base development, water balance study, and conjunctive water management modeling study. The objective of the conjunctive water management model for Rechna Doab was to maximize utilization of surface supplies and the extraction from groundwater, which will be environmentally friendly. The constraints considered were: surface water availability, capacity of the surface water distribution system, water rights, groundwater levels, groundwater quality, water demands for ensuring environmentally sustainable conjunctive water management in Rechna Doab.

B3: Artificial/managed recharge basin siting strategy: A GIS based approach and Geophysical investigations

The objective of this activity was to prepare a framework for citing artificial recharge zones in Rechna Doab by evaluating soils, hydrogeology, water, land use and general conditions applying modern techniques of geographical information system. A set of criteria acceptable for sighting a recharge basin was established for transmitting layer and storing layer. The transmitting layer was the unsaturated soil profile in the basin area having conditions for infiltrating and conveying acceptable quality water to the aquifer system. Its evaluation was based on soil texture and salinity. The storing layer was the aquifer system having capability of storing percolated water and recovery by wells. This layer was evaluated on the basis of history of depth to water table, aquifer parameters and groundwater quality. It was proposed that a reach of the storm water drain traversing the potential recharge zone might be developed to fulfill the purpose of reducing, stopping, or even reversing declining levels of groundwater. The secondary information on storing layer was analyzed in terms of history of depth to water table, aquifer parameters and groundwater quality. Five areas were identified in lower Rechna Doab in the vicinity of Chenab and Ravi Rivers; from two to eleven thousand hectares in size have been delineated fulfilling the requirements. The availability of excessive water and conveyance to the delineated site were of prime consideration. A surface drainage network in Rechna Doab constructed to carry storm water runoff and canal escape water was superimposed. Four out of five sites were located close or within the course of a drain system. Two sites traversed by and close to reaches of main drains were proposed for potential development as an artificial recharge area. Geophysical investigation at two locations was carried out by PCRWR. For Geophysical investigations, sixteen and twelve Vertical Electrical Soundings (VES) were established in Kamalia and Mamun Kanjan areas of Rechna Doab respectively. Following conclusions were drawn from the geophysical investigations done at two sites:

- Generally sand formation was found in the area.
- Geophysical investigations support the findings of GIS.
- Depending upon the geophysical conditions of two sites, water spreading and pit techniques can be useful for artificial recharge in the Kamalia area site whereas dug well up to 10m depth can serve the purpose in Mamun Kanjan area.

B4: Evaluate effective drainage management strategies at the distributary level in Rechna Doab and farm level

A subsurface evaporation basin (SEB) trial as a combination of biological, engineering and agronomic measures was established in Rechna Doab under this activity in the year 2000. Monitoring and evaluation activities regarding depth to water table data, groundwater quality, soil salinity, climatic and hydrological data were continued during this year.

The objectives were:

- To apply an innovative approach for drainage and reclamation of land and redress the problem.
- To ensure tree growth and increase discharge from the water table due to transpiration.
- To encourage pre monsoonal plowing of abandoned land to increase infiltration of rainfall and to provide leaching.

ESTABLISHMENT OF SUBSURFACE EVAPORATION BASIN (SEB)

The SEB trial was established to reclaim the abandoned waterlogged and saline soils. The system relies upon groundwater flow into the SEB. Due to the drought conditions from 1998 to 2000, the water table went down about 1m below the bed depth of SEB in June 2001. Dr Shahbaz Khan and

Dr Evan Christen from CSIRO visited the SEB site during the first half of the year 2001. After discussing SEB with the CSIRO experts, following activities were carried out.

- Plantation of rice crop adjacent to SEB (southern and eastern side) to raise the water tables to normal levels. Full amendments were used in growing the rice crop.
- Depth to water table data were analyzed for hydraulic gradients along the north south and east west transects for monthly intervals.
- Water quality parameters were plotted over time for each piezometer. These piezometers then grouped from nearest to farthest from SEB.
- Piezometer levels were plotted against rainfall events.
- Spatial and temporal changes in soil salinity are plotted over time.
- A relief hole of 1.2m diameters and 0.9m deep was dug to penetrate into sandy layer below. This SEB site is a two-layer system. The top 2m layer is clay loam below which there is sand aquifer. Thus the lower layer is more transmissive and has more potential for water to move towards SEB. So to see the movement of water towards SEB, the relief well was dug.
- SEB Modeling exercise by using MODFLOW is completed. Different scenarios are developed to determine conditions under which SEB approach may be applicable.

B5: ***Identify technical solutions for encouraging effective conjunctive water in Rechna Doab and the Murrumbidgee Region.***

The discussions were held with stakeholders to finalize the modeling scenarios for conjunctive water management.

B6: ***Assess on farm financial/economic effects of alternative technical solutions aimed at increasing optimal and sustainable conjunctive use of water in Rechna Doab.***

The information was collected from the field by using pre-tested questionnaires. The primary data were collected from 544 farms on distribution of soils with in the farm, potential land uses, economic returns from potential land uses, farm land use practices / particular cropping intensity, optimum/ maximum economic return to farmer. The secondary data sources were used for the data on crop evaporative requirements, current irrigation practices, leaching requirements, annual rainfall, leakage to deep aquifer, depth to water table, capillary up flow from shallow water table, salt concentration of irrigation water and ground water, acceptable net recharge, acceptable gain of salt in root zone. The data were processed and analyzed by using the SWAGMAN Farm model developed by CSIRO. This model identified environmentally sustainable levels of irrigated agriculture and has been modified and adapted for 28 sub divisions within the Lower Rechna Doab. The initial results of the model were presented in the workshop during April 16-17, 2002 and the research report will be finalized with the help of Dr. Shahbaz Khan by June 2002.

C1: ***Design and communicate technical and institutional guidelines for policy makers and Area Water Boards within Rechna Doab.***

A workshop on Institutional Aspects of Conjunctive Water Management was held on July 6, 2000 in Lahore, Pakistan. All the stakeholders were invited to contribute in the workshop. The researchers from IWMI, PCRWR, University of Punjab Lahore, and other members from Steering Committee/PIDA/NDC/PDC participated in the meeting. The workshop provided important input for the institutional and legal aspects of water management in the Rechna Doab.