Annual report

Project

Optimising Canal and Groundwater Management to Assist Water User Associations in Maximizing Crop Production and Managing Salinisation in Australia and Pakistan

project number

LWR/2005/144

period of report

October 1, 2008 - May 31, 2009

date due

May 31, 2009

date submitted

May 31, 2009

prepared by

Mohsin Hafeez

co-authors/contributors/collaborators

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approved by

Mohsin Hafeez
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1 Progress summary

This project officially commenced in January 2008. However, because of the changes in management due to the departure of some key personnel, the project activities effectively commenced from October 1 2008. Therefore, the Project Leader from Charles Sturt University (CSU) requested timeline variation for Project Agreement from ACIAR and the new mutually agreed project completion date is December 31, 2012. This variation caused some delays, but the project team in Australia and PC has worked intensively and as a result the project remains on track in terms of its overall activities and achievement of the milestones in the first eight months for year-1, as reported in this document.

The project builds on the strong track record of different federal and provincial organizations in participatory irrigation management, particularly, the current initiatives by Government of Punjab through Punjab Irrigation and Drainage Authority (PIDA), Punjab-Pakistan, who is working closely with the Farmer organisations (FO) under the ongoing institutional reforms in the command area of Lower Chenab Canal (LCC) in Pakistan. This project thus link to different federal and provincial organizations responsible for irrigation management, and the extension services for participatory demonstration, evaluation and exploration of adoption pathways regarding promising on-farm water saving technologies already developed (e.g. laser-levelling; raised beds; zero-till planting etc.) elsewhere by the project team.

This project will develop and use, for the first time in the history of canal and groundwater management in Pakistan, the hydrologic-economic modelling tools capable of scenario analysis of water distribution as a function of crop-groundwater-soil mix at farm and "distributary" and "minor" canal levels both in the LCC and Coleambally Irrigation Area (CIA). More importantly, the project will couple Remote Sensing tools and hydrological data with socioeconomic data for developing the surface and ground water supply and demand management options at various spatial scales, for tailoring water sectors adaptations to climate change.

Currently PIDA is involved with 85 FOs for demonstrating improved irrigation practices in the LCC. In some areas of LCC groundwater is fresh and can be used for irrigation by the farmers, while in some other areas especially in the tail reaches of the irrigation system, the groundwater is saline and unsuitable for irrigation. Conjunctive use of surface and groundwater is common in areas with good quality groundwater. The tail-end and farmers often get less water due to inequity in access to surface water; they also have poor quality groundwater, such that the use of poor quality groundwater alone for irrigation reduces crop yield and production, causes salinity and thus have serious socioeconomic and environmental implications. These farmers need scientific information for "conjunctive use" of surface and groundwater for optimising their productivity and returns to limited land and water resources.

This project will deliver decision making tools to PIDA for rationalising surface water allocation. PIDA will also benefit from capacity building and training activities of the project. As PIDA is the key agency responsible for the implementation of water policy and the allocation of surface water resources in the study area, the scientific insights of this project will enable PIDA to improve its decision making regarding the "conjunctive management" of surface and groundwater resources. This will have major implications. For instance, reallocation of more surface water to tail-end areas with saline groundwater will improve agricultural productivity, enhance food security, and will have favourable economic, social and environmental impacts. What is needed is strong political will and commitment. This project will create new scientific knowledge and empower PIDA and FOs for more rational management and use of water resources.
### 2 Achievements against activities and outputs/milestones

**Objective 1: To develop tools capable of analysing hydrological and economic water management trade-off scenarios using spatial crop, soil, water availability and water quality data.**

<table>
<thead>
<tr>
<th>No.</th>
<th>Activity</th>
<th>Outputs/milestones</th>
<th>Completion date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2</td>
<td>Collect and synthesise facts and figures from existing data sources and available reports for the LCC and CIA.</td>
<td>Preliminary report drafted</td>
<td>May 2009</td>
<td>CIA component has been completed, and CSU team is working on the LCC component</td>
</tr>
</tbody>
</table>
1.3 Develop database of irrigated crops, water distribution, groundwater uses, soil physiography, aquifer characteristics, and cropping pattern in the LCC and CIA.  

<table>
<thead>
<tr>
<th>No.</th>
<th>Activity</th>
<th>Outputs/milestones</th>
<th>Completion date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Conduct separate interviews and workshops with community participants and groups of ‘experts’ to better clarify the major issues in canal and groundwater management.</td>
<td>Interviews and workshops involving discussions with community participants and groups of ‘experts’ were held in CIA and LCC.</td>
<td>July 2009</td>
<td>This activity has been partially achieved. A/Prof. Mohsin Hafeez and Munir A. Hanjra visited the project area and held interviews and workshops involving discussions with community participants and groups of ‘experts’ (see photograph below). During a follow up visit by the project team led by A/Prof. Mohsin Hafeez also held further discussion with key experts. In October 2008, the project leader met with key group of experts working within the water management sector in Pakistan to brief them about the ACIAR project, to learn about other ongoing projects and to get better clarification in canal and groundwater management projects. Project leader had a discussion with the expert groups including Dr. Zafar Altaf (Chairman Pakistan Agricultural Research Council ‘PARC’), Dr. Shahid Ahmad (Member, Natural Resources Management, PARC), Dr. Madar Samad (Director, International Water Management Institute (IWMI) South Asia), Mr. Hakeem Khan (Director, IWMI Pakistan), Mr Tsutomu Shimuzu (Japan Bank of International Cooperation “JICA”), Shafiq Ahmed (Director, Space and Upper Atmosphere Research Organization “SUPARCO”), Mr. Raza Mahmood Farrukh (Asian Development Bank), Prof. Dr. Zulfiqar Ahmad (Chairman, Department of Earth Sciences, Quaid-e-Azam University), Dr. Zahid Hussain (Ministry of Food, Agriculture and Livestock “MINFAL”), and Mohammad Abid Bodla (Member, Planning and Development Commission, Punjab). These discussion helped project team to understand the real issues in canal and groundwater management for LCC. Further in-person interviews with groups of ‘experts’ and local community leaders (PC) will be conducted in July 2009 through a questionnaire module specifically designed for this purpose, called Retrospective Module.</td>
</tr>
</tbody>
</table>

PC = partner country, A = Australia

**Objective 3:** To support PIDA and Farmer Organisations in the implementation of more equitable, economically efficient and hydrologically sustainable canal and groundwater management options in the study areas.
To better clarify the major issues in canal and groundwater management, and impact assessment at the completion of the project, panel data from 720 households (PC), mainly farmers but also non-farm households, on socioeconomic factors will be collected twice a year, throughout the project period, using a detailed questionnaire having the following modules:

1. Retrospective Questions Module  
2. Basic Information Module  
3. Irrigation Infrastructure Module  
4. Agricultural Production Module  
5. Income and Expenditure Module  
6. Credit Module  
7. Groundwater and Energy Module  
8. Climate Change Module  

This data on baseline socioeconomic conditions and end-of-project conditions will enable impact assessment for the project, to successfully demonstrate, evaluate and explore adoption pathways regarding promising on-farm canal and groundwater management strategies, and water saving technologies.

<table>
<thead>
<tr>
<th>3.2</th>
<th>Organise a joint year-end workshop to resolve differences between the ‘experts’ and farmers</th>
<th>Report prepared on the stakeholders’ perceptions regarding the major issues in canal and groundwater management</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>This activity has been partially achieved. Findings from previous interviews and workshops have been used to re-select one irrigation distributory as project site (PC) and better plan the year-end workshop. For assessing the stakeholders’ perceptions regarding the major issues in canal and groundwater management, a joint year-end workshop has been planned for Oct 2009 (PC).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.3</th>
<th>Analyse and synthesise findings from interviews and workshops.</th>
<th>Report prepared on the findings from interviews and workshops.</th>
<th>This activity has been partially achieved. Findings from previous interviews and workshops have been synthesised. Findings from a joint year-end workshop, and survey data from 720 households will be synthesised.</th>
</tr>
</thead>
</table>

*PC = partner country, A = Australia*

Photograph: Interviews and workshop involving discussions with community participants and groups of ‘experts’ held in LCC, March 2008 (Visible are Mohsin Hafee and Munir A. Hanjra, CSU team; and Niaz A. Rai - PC team) and October 2008 consultation in the study area.
3 Impacts

3.1 Scientific impacts

This project will develop and use, for the first time in the history of canal and groundwater management in Pakistan, the hydrologic-economic modelling tools capable of scenario analysis of water distribution as a function of crop-groundwater-soil mix at farm and "distributary" and "minor" canal levels both in the LCC and CIA. More importantly, the project will couple Remote Sensing tools and hydrological data with socioeconomic data for developing the surface and ground water supply and demand management options at various spatial scales, for tailoring water sectors adaptations to climate change.

Using participatory approaches, the project will also assist Farmers Organizations and PIDA staff for demonstrating and evaluating adoption pathways as listed below:

(i) promising on-farm canal and groundwater management strategies that would ensure more equitable, economically efficient and hydrologically sustainable distribution; and

(ii) on-farm water saving technologies already developed elsewhere (e.g. laser-levelling; raised beds; zero-till planting etc.).

This project has the potential to highlight the tradeoffs in canal and groundwater management in terms of the impacts on resource quality, income and livelihoods, socioeconomic impacts as well as "energy footprint" and "carbon footprint" in addition to the "water footprint". This will need incorporation of Remote Sensing data with baseline socioeconomic data, to be collected through in-person interviews using a detailed questionnaire having 8 Modules as noted above.

The project will also make use of the existing models i.e. SWAGMAN and MODFLOW/MT3D to develop on-farm water and salt balance linked with the regional groundwater flow and capacity. These two models have been handed over to the CSU project team by the previous project team. The SWAGMAN Farm model is a farm scale Salt, Water and Groundwater Management model. The CSU team is updating this model to "SWAGMAN Conjunctive" model linked with economics at farm level. This project will use this customised version called SWAGMAN Conjunctive model for optimising land and water management decisions at farm level.

MODFLOW/MT3D is a modular 3-dimensional ground water flow model and is capable of modelling groundwater flow and salt movement at the farm and canal command level. MODFLOW will be used for modelling the sub-regional supply (canal) surface and groundwater interactions. Data from extensive piezometric networks will be used to monitor water levels under each land use to calculate drainage values (mm/day) for each hydro-geologic unit in the LCC and CIA. Simulations will be carried out for all land uses within each land management unit.

3.2 Capacity impacts

CSU team has provided training to PC team on the use of GPS for the collection of georeferenced data and the ground truthing of Remote Sending and satellite data, as well on the use of Electrical Conductivity (EC) meters for collecting data on water quality. CSU team is taking lead on the development of questionnaire for the collection of socioeconomic data, and will take the lead to provide training to PC staff in Pakistan, and will also lead the data collection campaign in July 2009.

The PC team leaders from PIDA and UAF led by the Vice Chancellor UAF had meetings with ACIAR officials and also visited the CIA project area in Australia in May 2009. During this visit they presented initial findings through three seminars held at CSU on:
A number of students have been linked with the project as listed below:

Mr Amir Saeed - PhD thesis on Economics of Water Sector Adaptations to Climate Change in the Murray-Darling and Indus Basin

Mr Umar Draz - MSc thesis on Pathways to Reduce the Energy and Greenhouse Footprints in Large Irrigation Systems in Australia and Pakistan

TBA - MSc thesis on Economics of Conjunctive Use of Surface and Groundwater in Response to Climate Change

Ms Lubna Anjum - PhD on Remote Sensing for Water Accounting and Water Productivity Modelling at Watercourse to Canal Command and Catchment Scale

Ms Sadaf Majeed - PhD thesis on Remote Sensing for Actual Evapotranspiration Modelling

Mr M Adnan - PhD thesis on Remote Sensing for Land Use and Land Cover Classification

Mr A Waqas - MSc thesis on Assessing the Performance of Large Irrigation System through Remote Sensing and Participatory Approaches

3.3 Community impacts

Increasing water scarcity threatens the sustainability of irrigated agriculture and hence the food security. Groundwater development has contributed significantly to food security and reduction in poverty in Pakistan. Due to rapid population growth there has been a dramatic increase in the intensity of groundwater exploitation leading to declining groundwater tables and deteriorating groundwater quality. In such prevailing conditions, the hydrogeologic and economic assessment of escalating groundwater exploitation have become of paramount importance. Keeping this in view modelling conjunctive use of surface-ground water to assess future groundwater trends in the Indus River Basin, Pakistan is of paramount importance.

The Murray-Darling Basin is experiencing worst drought since the records began. Water scarcity has become a core issue, important to the wellbeing of rural communities and irrigated agriculture. How irrigation and cropping technologies respond to the water scarcity and what are the costs of adaptation to climate change is another aspect that affects both the cost of on farm water management decisions as well the costs and potential benefits of water management. The profitability of farming and the value or market price of water into the future remains uncertain. This project aims to develop a science-based information base for understanding the impacts of changes in irrigation technology and cropping decisions.

3.3.1 Economic impacts

In Pakistan, the economic payoffs of applying optimising canal and groundwater management options will accrue from three main pathways:

Firstly, where economic optimisation is an implicit outcome, the aggregate value of crop production is likely to be higher than the current aggregate production. On an individual farmer basis, this might result in a few privileged farmers close to the canal not necessarily making gains or even losing some of their productivity and income, but proportionally more farmers standing to benefit through increased crop productivity and hence incomes further away from the canal - improved equity.

The second mechanism by which economic gains will be generated is by enabling a better return on the Government of Pakistan's current investment in infrastructure rehabilitation and the lining of watercourses, as the improved delivery of water can be coupled to increased crop water productivity.
Thirdly, as the improved distribution of water is also explicitly designed to address the issue of salinisation, economic benefits are also likely to accrue through cost reductions arising out of a reduced need to rehabilitate or reclaim salt-affect irrigation lands. The order of magnitude of these economic benefits will be determined by comparing the "before Project" condition with "after Project" situation by using the socioeconomic panel data collected through household level survey, twice every year through the project life.

### 3.3.2 Social impacts

The key community impacts will be reduced social tensions among different stakeholder through equitable water distribution and reduced impacts on the environment. This will result in improved irrigator behaviour towards efficient irrigation management. The more rational, flexible and equitable distribution of water within farmers’ organisations is also expected to increase overall food production in the command area, thus increasing food security. Improved management and supply and demand coordination for surface water supplies can reduce inequity in water distribution between head- and tail-reaches of the system, and contribute to improved social relations and reduced litigation among water users in Pakistan.

The key Australian economic benefit will be reduced third party salinity costs due to rational augmentation of surface and ground water. The policy options developed under the project could lead to a better mix of perennial and annual crops leading to optimisation of economic returns from limited surface and ground water supplies, while improving the environmental quality.

### 3.3.3 Environmental impacts

The environmental impacts of this research in both countries are anticipated to be reduced incidence of land and water salinisation and the potential to rehabilitate salinity-affected areas in the longer term, as well improved equity in terms access to water particularly in Pakistan. The more efficient use of water and land resources is also likely to reduce adverse downstream impacts due to enhanced quality of return flows. Conjunctive use of surface and canal water can minimise the adverse impacts on the environment due to escalating ground water demand in Pakistan.

### 3.4 Communication and dissemination activities

The project activities and outcomes are being communicated widely among the stakeholders through FOs field days and demonstration and training components of the project, as well as workshops, conferences, briefing, technical notes, public seminars. For instance, PC team members were interviewed by radio and TV channels during their visit to CSU in May 2009. During this visit, the PC team members also gave seminar on:

Prof Dr Iqrar A. Khan, Vice Chancellor, University of Agriculture, Faisalabad, Pakistan, on "Precision Agriculture for Food Security".

Prof Dr Niaz Ahmad Rai, Director, Water Management Research Centre, University of Agriculture, Faisalabad, Pakistan on "Present Water Scenario in Pakistan and Interventions for its Sustainable Use".

Mr. Habib Ullah Bodla, Director Gauges, Irrigation and Power Department Government of the Punjab, gave two presentations:

1. Irrigation Sector Overview: Challenges and Strategies in the Indus Basin System
2. Channel Operation and Monitoring of Canal Flow in the Indus Basin System

These presentations were also attended by the members of a visiting delegation from Hohai University, China whereby they also held discussions on areas of mutual scientific interest and agreed on tri-angular working arrangements to be led by CSU team.
4 Training activities

Key training activities conducted by the CSU team under this project include:

1. Training to PC team on the use of GPS for the collection of geo-referenced data and the ground truthing of Remote Sensing and satellite data.

2. Training on the use of Electrical Conductivity (EC) meters for collecting data on water quality.

3. The development of questionnaire for the collection of socioeconomic data, and training to PC staff in Pakistan on data collection, collation, and analysis. The CSU team will also lead the data collection campaign in July 2009 to provide on-job training to the PC field team.

4. Training on the SWAGMAN Conjunctive model to PC team leaders during their visit to Australia in May 2009.

5. Training on the protocol and format for database development and sharing the project data among the team members in PC and Australia.

As noted earlier, the two visiting parties from China and Pakistan held discussions on areas of mutual scientific interest and agreed on triangular working arrangements, lead by CSU during May 2009. This offers significant opportunities for future cooperation and collaborative Projects.
5 Intellectual property

There are no intellectual property and other regulatory compliance concerns in the project, at this stage. Information generated, technologies tested and model developed will be handed over to the respective stakeholders to facilitate their implementation and adoption. All intellectual property issues will be subject to the standard clause under the Australian state and territory regulations.
6 Variations to future activities

This project officially commenced in January 2008. However, because of the changes in management due to the departure of some key personnel, the project activities effectively commenced from October 2008. This variation caused some delays, but the project team in Australia and PC has worked intensively and as a result the project remains on track in terms of its overall activities and achievement of the milestones for year-1.

There are no major variations to year-2 activities at this stage. However, the PC and Australian project team agree to replace Sultan Bhakra Distributary with Bhalak Distributary as the study site for biophysical and socioeconomic modelling. In the command area of Bhalak distributary, the underlying groundwater is fresh; resultanty groundwater pumping and use is wide spread in this area - as was the case with Sultan Bhakra Distributary. This variation was desirable due to logistics and some operational issues identified by the PC team and agreed by the Australian team. Both teams also agree that this variation will be supportive to the success of the project. With this variation, the study sites in PC are:

Bhalak Distributary (in Faisalabad district): In the command area of this distributary, the underlying groundwater is fresh; resultanty groundwater pumping and use is wide spread in this area;

Khiikki Distributary (in Toba Tek Singh district): In the command area, the underlying groundwater is highly saline; which means that there is no groundwater pumping potential;

Turkhani Distributary (in Faisalabad district): In the command area of this distributary, relatively fresh groundwater aquifer exists that promises a potential for conjunctive use of canal and groundwater.
# Variations to personnel

The following personnel are available for ACIAR Project.

<table>
<thead>
<tr>
<th>Contract Named Person</th>
<th>Role</th>
<th>% of Time</th>
<th>Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/Prof. Mohsin Hafeez</td>
<td>Spatial hydrology, water management, Project Leader</td>
<td>20%</td>
<td>CSU</td>
</tr>
<tr>
<td>Prof. John Blackwell</td>
<td>Water management</td>
<td>10%</td>
<td>CSU</td>
</tr>
<tr>
<td>Dr. Nadeem Asghar</td>
<td>Hydrology, water management</td>
<td>40%</td>
<td>CSU</td>
</tr>
<tr>
<td>Dr. Richard Claus</td>
<td>Economics, economic analysis and resource use optimisation</td>
<td>20%</td>
<td>CSU</td>
</tr>
<tr>
<td>Mr. Munir Hanjra</td>
<td>Economics and water policy, equity and welfare analysis and participatory irrigation management</td>
<td>20%</td>
<td>CSU</td>
</tr>
<tr>
<td>Dr. Ismail Hirsi</td>
<td>Socio-economic analysis using cost-effectiveness techniques</td>
<td>20%</td>
<td>CSU</td>
</tr>
<tr>
<td>Mr. Kaleem Ullah</td>
<td>Hydrology, system dynamics modelling, system optimisation</td>
<td>20%</td>
<td>CSU</td>
</tr>
<tr>
<td>Mr. Umair Rabbani</td>
<td>Remote Sensing and GIS, and spatial Hydrology</td>
<td>20%</td>
<td>CSU</td>
</tr>
<tr>
<td>Mr. Habib Ullah Bodla</td>
<td>Canal operations, Head PMIU, Project Coordinator</td>
<td>30%</td>
<td>PIDA</td>
</tr>
<tr>
<td>Dr. Muhammad Javaid</td>
<td>Hydrology, Groundwater data provisions and conjunctive management scenarios</td>
<td>50%</td>
<td>PIDA</td>
</tr>
<tr>
<td>Dr. Muhammad Riaz</td>
<td>Irrigation modeller, Decision support system</td>
<td>30%</td>
<td>PIDA</td>
</tr>
<tr>
<td>Mr. Azhar Javaid</td>
<td>Salinity and groundwater management, data provisions and modelling</td>
<td>50%</td>
<td>PIDA</td>
</tr>
<tr>
<td>Mr. Basharat Ullah</td>
<td>Agronomy, crop database development</td>
<td>50%</td>
<td>PIDA</td>
</tr>
</tbody>
</table>
Mr. Abdul Shakoor  IT and irrigation database development  30%  PIDA

Mr. Tauseef Ahmed  IT Professional and Developer, Database development  20%  PIDA

Mr. Ali Zeb  Irrigation Engineer  30%  PIDA

Mr. Usman Tehsin Shah  Assistant Director Monitoring, Discharge observation  30%  PIDA

M. Khurram Ilyas  Software developer, database development  30%  PIDA

Prof Dr. Rai Niaz  Project Co-Coordinator  30%  UAF

Dr Abdul Nasir Awan  Spatial hydrology, GIS, database development, water accounting  50%  UAF

Mr. Amir Saeed  Sociology, Farmer interviews  15%  UAF

M. Waseem Ahmad  Interviews with scientists and regulation agencies staff to identify issues  15%  UAF

Mr. Umer Draz Khan  Farmer interviews to identify their concerns and aspirations about the project  50%  UAF

Dr. Sher Muhammad  Agricultural extension, technology transfer and demonstration to farmers  25%  UAF

Dr. Muhammad Arshad  Irrigation and groundwater database development and scenarios development  40%  UAF

Mr. Buland Akram  Economist  50%  UAF

M. Saleem  Economics of crop  30%  UAF

Mr. Ahmad Waqas  Technical support for water accounting at farm, distributary and minor  50%  UAF

Mr. Aamir Khan  Sociology, Farmer interviews  50%  UAF

Mr. Arif Manzoor Khan  Agriculture, crop varieties and crop water demand  50%  UAF
8 Problems and opportunities

No major problems are identified at this stage.

New opportunities include:

1. New training opportunities for PC staff and students to use Remote Sensing tools for modelling the conjunctive use of surface and groundwater, and its coupling with socioeconomic data and analytical tools. Such training facilities are currently not available in Pakistan.

2. Training of UAF staff in template development for data collation, and use of statistical and econometric packages for data analysis.

3. Training of PC team in writing and publishing papers in Australian and other international journals.

4. Training of PC team in writing a Book for joint publication, with Australian team members as Editors and lead authors.

5. Two of the potential PhD students from PC are girls. Their successful training will contribute to gender empowerment and gender equity in PC.

As noted earlier, during May 2009 the two visiting parties from China and Pakistan held discussions on areas of mutual scientific interest and agreed on tri-angular working arrangements between PC, China and Australia, lead by CSU. This offers significant opportunities for future cooperation and collaborative Projects in PC and China.
9 Budget

There is no significant variation from the approved budget during the reporting period. A summary of expenditure is given below:

<table>
<thead>
<tr>
<th>Description</th>
<th>Expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milestone 1: Payment to Pakistan-Punjab Irrigation and Drainage Authority as per Contract</td>
<td>$21,400.00</td>
</tr>
<tr>
<td>Milestone 1: Payment to Pakistan-University of Agriculture, Faisalabad as per Contract</td>
<td>$23,100.00</td>
</tr>
<tr>
<td>CSU Expenses</td>
<td>$ 45,000.00</td>
</tr>
</tbody>
</table>