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**

ACIAR LWR/2005/144

**Period of report**

01 Jul 2011 to 30 June 2012

**Date due**

30 June 2012

**Date submitted**

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**Prepared by**

**Co-authors/contributors/collaborators**

**Approved by**
Contents

1 Progress summary .................................................................3

2 Achievements against activities and outputs/milestones ...............5

3 Impacts ..................................................................................12
   3.1 Scientific impacts .................................................................12
   3.2 Capacity impacts .................................................................13
   3.3 Community impacts .............................................................14
   3.4 Communication and dissemination activities .........................16

4 Training activities .................................................................18

5 Intellectual property ...............................................................19

6 Variations to future activities ...................................................20

7 Variations to personnel ...........................................................21

8 Problems and opportunities .....................................................22

9 Budget ..................................................................................23
1 Progress summary

This report presents project activities since the Mid-term Review of progress (held on 19th and 20th September 2011 at Charles Sturt University) to May 31, 2012. The report also incorporates a comprehensive work plan for the reminder of the project life, developed collaboratively with partners in Pakistan as well as the feedback from the Review of the project (held on 16th Dec 2011 at University of Agriculture, Faisalabad-Pakistan) attended by Dr Andrew Noble (RPM Land and Water ACIAR) and the three CSU team members.

The project builds on the strong track record of different federal and provincial organisations in participatory irrigation management, particularly, the current initiatives by Government of Punjab through Punjab Irrigation and Drainage Authority (PIDA), Punjab-Pakistan. PIDA is working closely with the Farmer Organisations (FOs) 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 (e.g. laser-levelling; raised beds; zero-till planting etc.) developed elsewhere by the project team and emerging scenarios on sharing water scarcity.

In Pakistan, the inequity of water distribution among the water users located at head, middle and tail reaches of the irrigation system is closely correlated to decreasing crop yields, and increasing land salinisation. The project seeks to improve equity of water distribution among the water users by devising the knowledge-based management option for improving livelihoods through maximizing crop production and managing salinisation in irrigated landscapes, by tackling the following objectives in Pakistan:

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;
2. To develop improved canal and groundwater management options acceptable to stakeholders by using the optimisation tools in a participatory mode with Farmer Organisations in Pakistan; and
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.

Since the project Review, 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:

- The groundwater model is now progressing well with the interchange between CSU and Pakistani partners. Once completed, calibration and validation will be undertaken prior to testing with local Pakistani hydrologic data.
- CSU has now completed the socio-economic panel data for analysis. The entry into a database was completed by the UAF team and Hanjra during his last visit to Pakistan.
- The training modules for groundwater and hydrologic modeling are being developed in conjunction with CSU and PIDA. This will be an ongoing task to ensure the take up, if the Federal government so desires.
- User Groups for the modeling tools being developed, both socioeconomic framework and the hydrologic model, have been established at UAF and PIDA.
- PIDA also plans to employ additional project staff to work in the further development of the model which will be helpful in capacity building and advanced training for those already working on the project.
Annual report: Optimising Canal and Groundwater Management to Assist Water User Associations in Maximizing Crop Production and Managing Salinisation in Australia and Pakistan

All of the above activities contribute to ongoing capacity building which formed an integral and important part of this project from inception.
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

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<thead>
<tr>
<th>No.</th>
<th>Activity/task</th>
<th>Outputs/ milestones</th>
<th>Completion date</th>
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<tr>
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<tr>
<td>Groundwater modeling in the LCC</td>
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</table>
| 1.1 | Task 1: Modeling set up (likely use, adoption) | Report | March 2012 | Task completed  
Task 1 Report is attached:  
A copy of the 'Draft_Revised Work plan_ACIR Water Management Project_Feb 01_2012.doc' has already been shared with all the project team members. |
| 1.2 | Task 2: Data gaps analysis (recharge, pumping) | Report | March 2012 | Task completed  
Task 2 report is attached:  
A copy of the 'Draft_Task 2 Report_Data gaps analysis_April 05_2012.doc' is ready for distribution to all the project team members. The report presents: (i) the status report of the Rechna Doab model (i.e., model description, a summary of the model input datasets, etc.) and (ii) a description of the future planning to upgrade the existing groundwater model (i.e., data gaps analysis, planning for the capacity building activities, a concise work plan for model upgradation to suite the project objectives, etc.). |
1.3 Task 3: Data collation and model input (database)  

Project database  

Activity on-going  

Activity on-going and project database will be completed in July 2012.

Task continued

A recommended by RPM in the Mid Term Review, a comprehensive inventory of all data sets and reports compiled before the Review was undertaken and an evaluation of data/information gaps was done. Consideration for the development of a relational data base was undertaken to house all of the data collected into the project database.

With the kind efforts of Dr. Riaz (PMIU), a number of datasets were received on Monday, 27 February 2012. The relevance and completeness of the datasets was checked, and an 'Updated summary of the datasets requested_12 March_2012.doc' was sent back to further necessary action.

A GIS-based database was developed by IWMI, which was used for the development of groundwater model for the ACIAR project (LWR1/1997/016, ACIAR project on Conjunctive Water Management). This database has been continuously improved (and used by various stakeholders); IWMI's Integrated Data Information System (IDIS) has about 450 layers of geo-referenced data (Gordon and Davis, 2007: 46).

Under this project, the groundwater model is being updated therefore the above geo-referenced dataset (IDIS) should be requested by the project management team.
| Task 4: Model testing and validation (GW model) | Model | Aug 2012 | Activity on-going  
Task continued  
Using the Processing Modflow Pro as a modeling platform, a step-by-step approach is adopted to prepare a training manual. The same platform was used to develop the original Rechna Doab model (LWR1/1997/016). Till October 2012, a series of handouts will be produced under this capacity building activity. The first handout, ‘Handout_01_March 16_2012.doc’ of this training manual has already been shared with all the project team members.  
Arc Hydro Groundwater is required for integrated database development and capacity building (Aquaveo, 2012).  
Based on the Arc Hydro Groundwater data model, the tools will enable Team to take advantage of the ArcGIS platform to archive, manage, and visualize groundwater information.  
- Expand ArcGIS software with groundwater and subsurface geoprocessing tools developed in collaboration with ESRI  
- Georeference subsurface data including boreholes, sketched cross sections, and geovolumes  
- Reduce the need for multiple applications - visualize model data inside of ArcGIS  
- Store, georeference, and create GIS maps of MODFLOW model input and solution data |
| Task 5: Scenario analysis (hydrology) | Training workshop | Oct 2012 | Activity to be started  
Arc Hydro Groundwater Tools has been ordered by the project Management Team. |

*PC = partner country, A = Australia*
**Objective 2: To use the developed optimisation tools in a participatory mode with Farmer Organisations in Pakistan to help determine possible improved (more equitable, economically efficient, and hydrologically sustainable) canal and groundwater management options acceptable to the irrigators.**

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<tr>
<th>No.</th>
<th>Activity/task</th>
<th>Outputs/ milestones</th>
<th>Completion date</th>
<th>Comments</th>
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<tbody>
<tr>
<td></td>
<td><strong>Socio-economic component</strong></td>
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</table>
| 2.1 | Task 1: Reviewing the progress (relevance) | Report | March 2012 | Task completed  
Task 1 report is attached  
A copy of the 'Draft_Revised Work plan_ACRIAR Water Management Project_Feb 01_2012.doc' has already been drafted and shared with all the project team members. This report presents the progress against ‘Task1: Reviewing the progress (relevance)’. With the comments and/or approval from the project team members, this report has been finalized. |
| 2.2 | Task 2: Identification of gaps (strategy, analysis) | Report | March 2012 | Task completed  
Task 2 report is attached.  
This activity has been completed and the report incorporated into the document entitled ‘Comprehensive work plan for the reminder of the project life’. The socio-economic component report presents: (i) the status report of the socioeconomic data (i.e., field mission summary, data gaps, a summary of the input datasets, etc.) and (ii) a description of the future planning to use the panel dataset (i.e., data gaps analysis, planning for the capacity building activities, etc). |
| 2.3 | Task 3: Field surveys (data collection, entry) | Panel dataset | Jul 2012 | Task continued  
Due for completion in Jul 2012  
Dr Munir A. Hanjra spent 2 months in Pakistan redrafting and training staff for the survey, and supervised its execution while working in the field with the PC team at UAF, and conducted field survey in Dec 2011-Feb 2012 to collect the socioeconomic data for the summer 2010, winter 2010-2011 cropping seasons to meet the minimum requirements of two years for adequate analysing of the panel data sets.  
Some datasets of the Socioeconomic Survey 2012 were received by email on 6 Match, 2012. The relevance and completeness of the datasets will be checked. CSU and PC teams will continue work on the panel dataset to complete this task, and have secured necessary hardware and software to analyse the panel data. |
| 2.4 | Task 4: Data synthesis and analysis | Analysis | August 2012 | Task continued  
Data synthesis and analysis will be undertaken after data checking and cleaning in consultation with PC team |
### 2.5 Task 5: Scenario analysis (economics)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Start Date</th>
<th>Progress</th>
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<tr>
<td>Analysis</td>
<td>Oct 2012</td>
<td>Activity to be started in June 2012. Planning in progress. Further scenarios to be defined through a national seminar involving water management and policy experts in PC.</td>
</tr>
</tbody>
</table>

### 2.6 Task 6: Report writing

<table>
<thead>
<tr>
<th>Activity</th>
<th>Start Date</th>
<th>Progress</th>
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### Hydrologic economic framework

#### 2.7 Task 1: Reviewing the progress (relevance)

<table>
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<tr>
<th>Activity</th>
<th>Start Date</th>
<th>Progress</th>
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<tbody>
<tr>
<td>Report</td>
<td>Mar 2012</td>
<td>Activity completed. Communications were made with PC teams for feedback on these user groups and for the development of the hydrologic economic framework and review of the progress. Review incorporated into Comprehensive work plan report.</td>
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</table>

#### 2.8 Task 2: Scenario analysis (hydrology, economics)

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<thead>
<tr>
<th>Activity</th>
<th>Start Date</th>
<th>Progress</th>
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<tbody>
<tr>
<td>Analysis</td>
<td>Dec 2012</td>
<td>Activity to be started. Planning in progress. This activity will commence in Jun 2012.</td>
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</table>

#### 2.9 Task 4: Report writing

<table>
<thead>
<tr>
<th>Activity</th>
<th>Start Date</th>
<th>Progress</th>
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<tbody>
<tr>
<td>Report</td>
<td>Jan 2013</td>
<td>Activity to be started. Planning in progress. This activity will commence in Jun 2012.</td>
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*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.

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<th>No.</th>
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<tr>
<td></td>
<td>Synthesis and learning from CIA</td>
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<tr>
<td>3.1</td>
<td>Task 1: Reviewing the progress (relevance)</td>
<td>Report</td>
<td>May 2012</td>
<td>Task continued. Report to be completed. Professor John Blackwell has very kindly taken the lead to pull together the historic data and archives from institutional repositories and informal/personal sources including his own collections. He will complement that with his rich experience and networking in the region as well as personal narrative on the history of development of MIA, with emphasis on economic, environmental (salinity management strategies, surface and ground water use and management, infrastructure modernisation, investments), and social dimensions including the need to resettle population, uplift agricultural productivity, enhance food security, and build resilient regional communities. Professor John Blackwell will also visit key stakeholders in MIA and CIA and blend that with previous data and project activities in CIA, to highlight how equity and salinity management issues were resolved in CIA. This synthesis will assist PC and FOs to understand how these issues could be tackled in LCC. Munir Hanjra will provide overall assistance with this and the Task and contribute to the write up. We will prepare the report on Synthesis and learning from CIA, and share that with PC team (as requested by them during the Review meeting held at UAF in Dec 2012). The synthesis article will be developed further for joint publication by the project team including PC and ACIAR.</td>
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|     | Supporting FOs |                     |                |          |
| 3.2 | Task 1: Reviewing the progress (relevance) | Report | March 2012 | Task completed. Report attached. A copy of the ‘Draft_Revised Work plan_ACIAR Water Management Project_Feb 01_2012.doc’ has already been drafted and shared with all the project team members. This report presents the progress against ‘Task1: Reviewing the progress (relevance)’. With the comments from the project team members, this report has been finalized. |
|------------------------|-------------------------------|--------------|--------------------|
| 3.3 Task 3: Project-end workshop | Workshop | Apr 2013 | Activity to be started. |
| 3.4 Task 4: Final report for project | Final Report | Jun 2013 | Activity to be started. |
# 3 Impacts

## 3.1 Scientific impacts

This project has immense scientific importance for advancing our understanding on sustainable land and water management policies and practices as a pathway to environmental sustainability in large irrigation systems and closing river basins as well as addressing the food security and environmental resilience issues across landscapes in the Indus basin and beyond. This project will develop and use, for the first time in the history of canal and groundwater management in Pakistan, the hydrologic and 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. More importantly, the project will couple hydrological data with socioeconomic panel data for developing the surface and groundwater supply and demand management options at various spatial scales, for tailoring water sectors adaptations to climate change while assisting water user associations to maximise crop production.

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.) and used as input for this project.

(iii) incorporating FO expectations and perspectives as one scenario into the emerging scenarios on water allocation and scarcity management, to be modelled and tested with PIDA, provincial policy makers, national experts and federal government.

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" and salinity impacts. This will need incorporation of hydrologic data with household level socioeconomic data, collected through in-person interviews using a detailed questionnaire having 11 Modules as noted above.

The project team is also making use of the existing farm level models (e.g. SWAGMAN for optimising land and water management decisions at farm level). For regional groundwater management and hydrologic scenario analysis, MODFLOW/MT3D is being used to better understand the dynamics of canal and ground water management on 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.

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 analysis will be carried out for all land uses within each land management unit to better understand groundwater dynamics and impacts on salinity. Further, CSU team is acquiring add on modules for use by the PC team, including: AHGW - Groundwater Analyst; ArcHydro Groundwater-MODFLOW Analyst; and ArcHydro Groundwater - Subsurface Analyst. This will have significant scientific impacts by advancing the academic and scientific capacity of the PC team.
3.2 Capacity impacts

CSU team has provided training to PC team on the use of GPS for the collection of georeferenced data, as well on the use of Electrical Conductivity (EC) meters for collecting data on water quality. CSU team has also helped PC team to resolve the issues they encountered with the downloading and processing of data from soil probes installed in the project area. Some of these data were never downloaded previously. CSU team also led on the development of questionnaire for the collection of socioeconomic data, and spent two months in redrafting and training PC staff for the survey, and supervised its execution in the field and successfully lead the data collection campaign in Jan-Feb 2012.

During the review mission in PC, CSU team visited the project area and made direct observations on the equipment, methods and protocol used for the collection of data on from peizometers and soil probes and had the opportunity to interact with some FO members. The team also interacted widely with the project staff and students and helped Masters and PhD students to refine their scientific work and tightly link it with the ACIAR project. A number of students who have been linked with the project gave presentations during the Mid-Term Review meeting on 16 Dec 2011 at UAF:

**PhD students:**

1. A framework to analyse water productivity under changing soil water mix in the LCC - Mr Hassan Bashir,
2. Evaluation of irrigation systems and management practices for corn (Zea maize) production using a modeling approach - Ms Lubna Anjum
3. Economic analysis of water and energy footprints in food production in the LCC - Mr Amir Saeed

**MSc students:**

4. A GIS base study to understand salinity and crop production interactions in the LCC- Mr Jehanzaib
5. Groundwater use in irrigation and its impact on salinity in the LCC system - Mr M Azam, Technical Officer & potential student

This is a demonstration of capacity development via student projects.

In addition, Professor Rai Niaz gave detailed presentations on ACIAR project activities for 2010-11 in Australia and Pakistan during the Review meeting at UAF. To discuss the Comprehensive Work plan and streamline the project activities for reminder of the project life, the Review session was conducted as focus group discussions and presentations focussing on each component, including:

**Project Management:** Introduction to day’s activities by Chair - Professor John Blackwell

ACIAR expectations and comments - Dr Andrew Noble

**Hydrology:**

Open discussion on Hydrological aspects - led by Dr Muhammad Riaz, Dr M Nadeem Asghar, Dr Muhammad Javed

**Socioeconomics:**

Overview of socio-economic component (surveys, analysis, outputs) - Dr Munir A. Hanjra

**Scenarios & Adoption Pathways:** Introduction of scenarios to date, data gaps, and interventions/adoption pathways
Data gaps: Discussion of data gaps, linking hydrological and socio-economic data (GTC), comprehensive work plan - Chaired by Professor John Blackwell

Assessment: Response and thoughts by ACIAR - Dr Andrew Noble

Open discussion: Open session Q & A / feedback / thoughts and ideas - Chaired by Professor John Blackwell

Closing: Vote of thanks / wrap up Professor Niaz Ahmad Rai & Dr Andrew Noble

The main highlight of the group presentations and discussion was an interactive model involving frequent and regular communications among the teams to progress the project activities and milestones in a much more interactive manner for shared learning and capacity building of PC team. The PC team appreciated this interactive and participatory model and made several solid contributions to advance the project activities. They also showed keen interest and enthusiasm in implementing this model to improve their own in-house meetings and institutional processes, which could make a sterling contribution in terms of shared learning and capacity impacts.

3.3 Community impacts

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 hydrologic 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.

Current governance framework is inadequate to address the water scarcity and quality challenges. Areas with saline groundwater are worst affected due to rising watertable, poor drainage, and lack of canal water to flush the salts down. The CSU and PC team visited many farms where highly saline groundwater, EC >7, have been standing in many cropped fields for months and even years and farmers were either unable to sow more crops or cropping was restricted and the yield were severally cut such that they lost investment into inputs, farming income and livelihood opportunities. Furthermore, this situation creates serious issues for land tenure arrangements, especially those involving shared-cropping and long-term leasing out, and challenges established community practices and social norms on natural resource management. For instance, pounded field with saline drainage are unproductive and unacceptable for lease or share cropping and are eventually abandoned and go out of production thereby worsening the water logging and salinisation issue. Such abandoned fields pose serious threats to the resilience and social vitality of the farming communities not only in the LCC systems but across the Indus basin.

Focus group sessions held during the socio-economic panel data collection 2012 showed that smallholder farmers are bearing the brunt of decline in agricultural productivity due to worsening salinity and water scarcity problem, typically at the tail-reaches of the system where canal water is scant and groundwater is generally saline. In addition, farming communities also expressed frustration over the complex problems threatening their food
security and livelihoods, including: high cost of input especially fertilizer, seeds and agrichemicals; non-availability of inputs; poor quality and black-marketing of inputs; highly volatile output prices; high transport cost to local markets and lack of support prices for most agricultural commodities; deterioration in terms of trade for major cash crops such as sugarcane, cotton and wheat; escalating energy and fertilizer prices; energy-irrigation nexus due to high dependence on electricity for lifting groundwater and desiccation of traditional water lifting devices; worsening law and order situation; threats to personal property and security; and apathy on part of some officials to handle farmer complaints including those on missed irrigation turns, channel breaches, misappropriate of canal water and outdated water laws and Penal Code, adulterated and low quality fertilizer and seeds and opportunistic pricing behaviour of input dealers and agents as well as law and order situation at large.

Although some of these issues do not squarely fall within the scope of the project, communities are hoping that, at least, the scientific findings of this project will go some way in shaping government policy and making water allocation policies more responsive to the emerging challenges.

The Indus Basin is experiencing worst drought and flooding during recent years. The 2011 floods left millions homeless and without food and badly affected crops throughout the Indus delta. Alongside, water scarcity has become a core issue, important to the livelihoods 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 challenges is another aspect that affects both the cost of on farm water management decisions as well the social costs and potential benefits to the nation. The availability water and viability of farming and implications for livelihoods into the future remains uncertain. This project aims to develop a science-based information for understanding the impacts of changes in irrigation technology and cropping decisions and their implications for crop production and livelihoods of irrigation dependent communities across the LCC system beyond. Some of these lessons could be scaled up and out.

3.3.1 Economic impacts

Optimizing water use to improve economic benefits and social equity among farmers is a key challenge facing irrigation management across Asia. In Pakistan, the economic payoffs of applying optimising canal and groundwater management options will accrue from three main pathways:

First, 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.

Second, it will generate economic gains 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.

Third, 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 the adoption and scaling up and out scientific outputs of the projects and this can potentially be assessed 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 and beyond.
More importantly, the multiplier and flow-on impacts will be substantial and will accrue to a much wider segment of the society and well beyond the command area of LCC system, improving social equity in favour of the smallholders and poor farmers.

3.3.2 Social impacts

Direct and indirect economic impacts will trigger social impacts for the wider community. 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 social benefit will be reduced third party salinity costs due to rational augmentation of surface and groundwater. 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. Improvements in upstream water management practices and salinity will have positive social impacts on downstream communities through improvements in water quality and environmental health.

3.3.3 Environmental impacts

The environmental impacts of this research in PC 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 the lower reaches of the Indus system of 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, and help restore environmental flows to the lower reaches of the Indus basin to positively impacts mangroves and fisheries and ecosystem services in general.

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 2012 and there was absolute media frenzy for interviews with the CSU team during the project mission in 2011.

During this visit, Professor John Blackwell chaired a session in the:

*International Seminar on “Water Issues and Options” December 12, 2011 (Monday), New Senate Hall, UAF*

The CSU team members also gave presentations at:

*International Seminar on High Efficiency Irrigation System (HEIS) / Resource Conservation Technologies (RCTs) on December 13, 2011 (Tuesday), New Senate Hall, UAF*
- Resource capture and energy recovery through land-based wastewater treatment for environmental sustainability and profitable agriculture in Pakistan – Professor John Blackwell
- Global change and water management challenges – Dr Munir A. Hanjra

These presentations were also attended by the members of a visiting delegation from Australia, Canada, USA and other countries. They also held discussions on areas of mutual scientific interest showed keen interest in tri-angular arrangements for new joint scientific projects to be led by CSU team.

Above all, Minister for Agriculture was present at one of the sessions in this two-day seminar at UAF. He personally thanked the Australian Government and CSU team, lead by Professor John Blackwell at the seminar, for their participation and scientific contribution to help Pakistan resolve its waxing issues of water scarcity and salinity management.
4 Training activities

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

1. Training to new PC team members on the use of GPS for the collection of geo-referenced data and the ground truthing of field data

2. Training on the use of Electrical Conductivity (EC) meters for collecting data on water quality (at farm and community water supplies), during the socio-economic panel data collection campaign.

3. Provided User Manual and follow up support for downloading data from soil probes installed in the project area

4. Provided training to 12 team members to conduct field survey in December 2011-February 2012 to collect the socio-economic data for summer 2010, winter 2010-2011 cropping seasons to meet the minimum requirement of two years for adequate analysing of the panel datasets.

5. Secured the necessary hardware and software to enter the data into the database, and provided hands-on training for networking of computers and build a 'server-based' network for use by the data entry team – which was never done before at UAF.

6. User Groups

As noted earlier, CSU and PC teams also held discussions on areas of mutual scientific interest for new projects, lead by CSU team. This offers significant opportunities for future cooperation and collaborative Projects with co-funding from Pakistan.
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

Enter text
7 Variations to personnel

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8 Problems and opportunities

No major problems are identified at this stage.

New opportunities include:

1. New training opportunities for PC staff 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 such as SPSS for data analysis, and support to the User Group established at UAF during 2012.

3. Advanced training to staff and students using EndNote for academic and scientific writing including Masters and PhD thesis as well as journal articles.

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

4. Contributing to gender equity, through support to girls students from PC for Master and PhD. Their successful training will contribute to gender empowerment and gender equity in PC.

5. Placement of PhD students from PC at Australian universities with funding from the Government of Punjab, Pakistan for 300 PhD places.

6. Scaling of the project up and out:
9 Budget

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