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Small research and development activity

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1 List of acronyms

ACIAR – Australian Centre for International Agricultural Research

ADB – Asian Development Bank

AHC – Australian High Commission

CSIRO – Commonwealth Scientific and Industrial Research Organisation

CSU – Charles Sturt University

DRIP – Drainage and Reclamation Institute of Pakistan

FAO – Food and Agriculture Organisation

FFC – Fauji Fertilizer Company

GCUF – Government College University Faisalabad

ICARDA – International Center for Agricultural Research in the Dry Areas

ICBA – International Center for Biosaline Agriculture

IUCN – International Union for the Conservation of Nature

LBOD – Left Bank Outfall Drain

LWR – Land and Water Resources

MDF – Management and Development Foundation

MNSUAM – Muhammad Nawaz Sharif University of Agriculture, Multan

MUET – Mehran University of Engineering and Technology

NARC – National Agricultural Research Centre

NIAB – Nuclear Institute for Agriculture and Biology

NIBGE – National Institute for Biotechnology and Genetic Engineering

PARC – Pakistan Agricultural Research Council

PCRWR – Pakistan Council of Research in Water Resources

PERI – Punjab Economic Research Institution

SCARP – Salinity Control and Reclamation Project

SOFT – Society of Facilitators and Trainers

UAF – University of Agriculture, Faisalabad

2 Acknowledgments

We are grateful to Dr Evan Christen, former ACIAR Research Program Manager for inspiring us to consider taking on the challenge of exploring a new approach to dealing with salinity in Pakistan, and to his replacement, Dr Robyn Johnston for her support and enthusiasm for the project. The project would not have been able to proceed without the skill, hard work and wonderful connections provided by ACIAR's Country Program Manager, Dr Munawar Kazmi. Together with support from PCRWR, and Ms Kanza Javad and Dr Ashfaq Sheikh in particular, Dr Kazmi arranged all the invitations to the workshop we organised as the central activity for the project. We would also like to express appreciation to our UAF collaborators for helping with accommodation and venue arrangements, and to Dr Javaid Akhtar for organising the field trip for us.

3 Executive summary

Waterlogging and salinisation are major impediments to the sustainability of irrigated agriculture and livelihoods of farming families across the Indus Basin of Pakistan. About 6.3 million ha in Pakistan are affected by different levels and types of salinity. Nearly half of this area is under irrigated agriculture. The drive for higher cropping intensities coupled with the lack of adequate surface water supplies has caused farmers to use poor-quality groundwater as a supplemental source of irrigation. The large scale exploitation of poor quality groundwater has increased the risks of soil salinisation and sodicity. About 4.5 million ha are already affected by secondary salinisation of which about half are located in irrigated areas. Another 1 million ha is affected by water logging (Qureshi et al., 2008). In Punjab, about 20% of the land suffers from salinity and another 20 to 30% has high groundwater levels, due to over application of surface water. Soil salinity problems are particularly serious in Sindh province where some 70 to 80% of the soil is classified as moderately or severely saline (Smedema, 2000). The southern districts of Lower Sindh, Thatta and Badin are particularly vulnerable to salinity due to waterlogging and seawater intrusion in coastal agricultural areas.

A holistic approach that incorporates the social, environmental, technical and economic aspects of salinity management is needed in Pakistan. Such an approach offers better prospects for identifying and exploring adaptation measures and building resilience for communities affected by salinity.

This SRA has established the need for a holistic approach to salinity and water management, and has laid the basis for developing a shared understanding of the risks and opportunities for farming and coastal communities in salinity affected areas of the Indus Basin of Pakistan. Central to this is an understanding of the spatial and temporal dimensions of salinity in the landscape.

The SRA offered the opportunity to establish a network of researchers, research users and intended research beneficiaries who will contribute to the purpose and design of a longer term four-year project for improving agricultural water and salinity management in the Indus Basin of Pakistan. The four-year project will identify and pursue opportunities for enhancing livelihoods of farming and coastal communities affected by salinity, and explore the application of an ecosystem services approach for landscape restoration. The network of researchers, research users and intended research beneficiaries will co-design an integrated salinity management framework for Pakistan, laying the basis for investigating policy settings and institutional arrangements through which adaptation pathways can be pursued by affected communities as a longer term project outcome.

The initial work on establishing the network took place between November 2017 and February 2018 with initial face-to-face meetings with researchers and organisations that have an established record of addressing salinity issues in the Indus Basin. A workshop was held where participants were invited to explain the extent of efforts that have contributed to a holistic approach to salinity and water management, and have offered practical solutions for enhancing livelihoods for farming and coastal communities living with salinity. From this we have identified key individuals and organisations best able to practically contribute to our research agenda, and seek their input towards designing key aspects of the research. A desk top review was undertaken by Dr Akhtar Ali to investigate the evidence for adopting a holistic approach to salinity management in Pakistan. Reviews were also undertaken into past and current ACIAR and other projects relevant to the proposed project, and to explore the benefits of adopting an ecosystem services framing approach drawing on examples from other similar parts of Asia. As part of the SRA we also undertook extensive field trips to selected salinity affected areas in Punjab and Sindh to develop an understanding of the on-ground situation that farming and coastal communities are facing, and to identify examples of community led adaptations.

4 Introduction

The objectives for this SRA were:

1. Develop a holistic understanding of the underlying causes of salinity, and the difficulties that result for farming and coastal communities affected, through review of existing technical, economic and social assessments of salinity.

2. Develop a case for incorporating the broad concept of ecosystem services into an integrated salinity management framework for Pakistan, by exploring its potential to (i) enhance appreciation of salinity as a systemic issue, and (ii) help identify opportunities for amelioration of those impacts and/or improve livelihoods of those living with salinity.

3. Establish a network of researchers and intended research beneficiaries with whom the case for a more holistic approach to salinity management can be discussed, and who can then take a leading role in designing an ACIAR funded research project through which an integrated salinity management framework for Pakistan can be developed and applied.

The idea to explore a new approach to salinity management in Pakistan was initiated at a side meeting held at the launch of the Australian Water Program for Pakistan in January 2017. The key idea emanating from that meeting was to explore, with communities affected by salinity, whether new ways of living with salinity could be identified. A follow up discussion between Dr Evan Christen, Prof Max Finlayson and Dr Michael Mitchell raised the prospect of adopting a holistic and sustainable approach to salinity management by paying greater attention to how ecological factors intersected with livelihood outcomes and opportunities, and in particular to explore the extent that a more comprehensive set of risks and opportunities for saline affected communities could be identified using the framing of ecosystem services (the benefits that people obtained from ecosystems, including agricultural ecosystems).

This short research and development activity was proposed to test these ideas further with key salinity experts and stakeholders. We aimed to establish and work with a network of researchers and intended research beneficiaries to discuss the merits of making the case for a holistic approach to salinity management, which by its nature would complement other approaches.

The key activities planned to enable the establishment of this network were via a workshop conducted in Faisalabad, Pakistan on November 15-16, 2017. Additional activities were to be a set of face-to-face meetings with representatives of key government and non-government agencies taking on responsibilities related to salinity management in Pakistan, and a field trip and rapid assessment of on-ground actions for managing different aspects of salinity across the Indus Basin.

The intention was that the above mentioned activities would be supported with a preliminary desk top review that would investigate the evidence for adopting a holistic approach to improving salinity and agriculture water management in the Indus Basin of Pakistan. This review would focus on a critical assessment of the outcomes and learnings from past projects related to salinity management.

Pakistan's ongoing security issues constrained delivery of all of our plans within the three months available, from October 1 to December 31, 2017. The Australian High Commission in Pakistan (AHC) ensures that Australian researchers travelling to Pakistan are provided with full security detail throughout their trips, and this included the trip we undertook in November 2017. This of course places a strain on the resources of the AHC, and it is not always possible to provide resources to meet the timing and locations of all our intended research activities. On this occasion, during our trip in November 2017, we were unable to arrange separate meetings with key government and non-government organisations, and we were unable to conduct field excursions beyond the field trip organised as part of the workshop in Faisalabad, including to any salinity affected field sites in Sindh province. We had also planned and budgeted for two

workshops, one in Punjab and one in Sindh, but were only able to hold the one workshop in Faisalabad (Punjab) on this occasion.

The activities that we could not undertake in November 2017 were postponed to coincide with a separately organised trip in February 2018 associated with another ACIAR project that is part of the Australian Water Program for Pakistan (LWR/2015/036). We were able to meet with delegations from both the Punjab and Sindh provincial agricultural departments, and held a small two-hour workshop in Karachi with Sindh-based salinity experts who were unable to attend the workshop in Faisalabad. This report therefore includes an account of our learnings from these field trips and the outcomes of the meetings held in February 2018 (see Section 10 and Appendix 8). Our decision to organise these activities at a later time had the added benefit of allowing us to re-engage with network members, and allow further discussions that has informed the drafting of our project proposal.

We redirected some of the funds from 2017 to pay an expert consultant to provide the above-referred desk top review, and to contribute to the travel costs in advance associated with the trip to Pakistan in February 2018. An acquittal of expenses for this SRA project is attached as Appendix 1.

This report therefore provides an account of the outcomes from the following activities:

1. The establishment of a network of researchers and intended research beneficiaries (Section 5).
2. The workshop and field trip in November 2017 (Section 6).
3. The desk top review undertaken by Dr Akhtar Ali to investigate the evidence for adopting a holistic approach to salinity management in Pakistan (Section 7).
4. A review of past and current ACIAR and other projects relevant to our proposed salinity management project in Pakistan (Section 8)
5. A review of the literature related to the use of an ecosystem services framing in other similar parts of Asia (Section 9).
6. A summary of learnings and outcomes from our visit to salinity affected field sites and our meetings conducted in Feb 2018 (Section 10).

5 Establishing a network of experts

Our first activity as part of the SRA was to identify the kinds of people we wanted included as part of the salinity expert network to discuss the case for taking an increasingly holistic approach to salinity management. A core group was created to help identify an initial list of experts for the network, and to oversee our other planned SRA activities. This core group involved:

From Australia: Prof Max Finlayson, Dr Michael Mitchell, Assoc Prof Catherine Allan and Dr Richard Culas (CSU), Dr Jay Puntahkey (ecoseal), Dr Ed Barrett-Lennard (Murdoch) and Dr Robyn Johnston (ACIAR).

From Pakistan: Prof Bakhshal Lashari (MUET), Dr Javaid Akhtar, Prof Muhammad Ashfaq (UAF), Dr Ashfaq Sheikh, Mr Zeeshan Ahmed, Ms Kanza Javed (PCRWR) and Dr Munawar Kazmi (ACIAR).

The initial list contained people from the following categories:

1. Federal government agencies (e.g. PCRWR, PARC, NARC)
2. Provincial government agencies (e.g. water, agriculture and environment departments)
3. Universities (UAF, MUET, GCUF, PERI, etc.)
4. Key specialists (retired)
5. International organisations (e.g. FAO, ICBA, IUCN)
6. Non-governmental organisations (e.g. SOFT, MDF)
7. Farmer organisations

To populate the list, we sought key experts and organisations whose input we required at the workshop. Identifying key experts involved pooling ideas and resources from the core group, and some of these matched with the organisations that we sought. Where this left gaps among the organisations that we wanted represented at the workshop, we sought advice from Dr Kazmi who assisted us to make the necessary contacts.

Once the list was finalised, Dr Kazmi arranged invitations to all to attend the workshop in November 2017, and provided a copy of the project summary (included with Appendix 2). The list of those who accepted our invitations and attended the workshop (or sent their apologies) is included as part of Appendix 3.

Because the workshop was held in Punjab, and there was heavy smog at the time, we were unable to secure participation from enough people and organisations based in Sindh. Follow up contacts made in February 2018 have enabled us to extend the network. We will continue to build on the network.

At the workshop, and at the conclusion of each subsequent meeting, we have secured agreement to send our draft proposal document to all those wishing to be a part of the network, and obtained email addresses to this end. We will be asking those who receive the draft proposal to consider whether they would like to contribute to the ongoing design and delivery of the proposed project.

6 Workshop and field trip, Faisalabad, 14-15 November 2017

A full report of the workshop is attached as Appendix 3.

The one-day workshop was attended by 40 participants. Apart from an opportunity to establish a network, the main purpose of the workshop was to tap in to the knowledge of that network to identify examples of innovative and holistic approaches to salinity management in the Indus Basin. These were documented with the help of students and staff from UAF. A 'World Cafe' approach was used, allowing small group discussions to focus on the following four themes:

1. *Understanding Salinity as a Systemic Issue*: Case examples where a holistic or integrated approach to salinity management has been trialled or put into practice.
2. *Save our Environments*: Case examples where a focus on broader environmental causes of salinity has resulted in improved landscapes or livelihoods.
3. *Bottom Up is Best*: Case examples of innovative salinity management practices developed by communities through their own efforts.
4. *Successful Adoptions*: Case examples of innovative salinity management practices introduced to a community that they have adopted and implemented.

As part of this exercise, participants were asked to nominate field sites to visit illustrating these case examples. The suggestions focused mostly on successful trials of innovative approaches where there had been some uptake by farmers in salt affected areas. However, the most useful outcome of the exercise was the identification of research questions arising out of the small group discussions. These were compiled, edited and consolidated by removing duplicates. We ended up with over 50 distinct questions across the four themes. A separate 'voting' activity was then arranged so that we could identify which research questions were seen as the most important to pursue. The following seven questions received the most votes:

1. What are the best practice/innovative approaches to managing salinity?
2. Can linking with climate change promote integration?
3. How do we ensure economic feasibility is included in project interventions?
4. How do we ensure social adoptability is included in salinity projects?
5. What salt tolerant varieties should be explored, adopted and their adoption accelerated across Pakistan?
6. How can integrated approaches be sustained in the long term?
7. What kind of spatial mapping data can we provide to support targeted education and awareness programs?

We also arranged separate small group activities to tap into the network's knowledge of key literature (especially grey or unpublished literature) that we should be aware of, and other people we should connect with. All of this has been documented in Appendix 3.

A set of introductory presentations were also provided, as follows:

1. Salinity issues and management options in Pakistan (Dr Ashfaq Sheikh, PCRWR)
2. Brief overview of state of salinity research internationally and Pakistan, and rationale for currently proposed project (Dr Ed Barrett-Lennard, Murdoch University)
3. Brief overview of holistic approaches to salinity research and management in Punjab (Dr Javaid Akhtar, UAF)
4. Brief overview of holistic approaches to salinity research and management in Sindh (Dr Altaf Ali Siyal, MUET)
5. Improving salinity and agricultural water management in the Indus Basin of Pakistan: using holistic or ecosystem approaches (Prof Max Finlayson, CSU)

We would suggest that the most significant outcome of the workshop was the shared enthusiasm for pursuing the proposed new approach to salinity management. This seemed apparent to all, and we heard terms used for this as ‘a consensus’ and ‘a buzz in the room’. The sense of shared enthusiasm is also reflected in comments provided in response to the evaluation questionnaire, with the most dominant theme about what worked well relating to group interactions, dynamics and discussions (see Appendix 4).

The field trip took place the next day, providing opportunities for the discussions and networking to continue. We visited two sites, both showing examples of farmers’ approaches to reclaim salt affected land. One involved a recently harvested rice crop, the other a plot prepared for wheat. The delineation between the rice field and the surrounding salt affected waste land was stark. The extent of the wasteland was dramatic, and despite recent rain, surface salt was clearly visible. Surface salt was also apparent at the second site, but in this case the abandoned land also served as a place to dump salt affected soil: one portion of the land sacrificed to keep the other portion viable.

Site 1: Recently harvested rice crop next to salt affected wasteland

Site 2: Field prepared for wheat crop in the background

7 Desk top review by Dr Akhtar Ali: A summary

We commissioned Dr Akhtar Ali to undertake a desk top review to investigate the evidence for adopting a holistic approach to improving salinity and agriculture water management in the Indus Basin of Pakistan. Dr Ali is a retired salinity and water management expert, who previously worked for ICARDA and ADB. The resulting report (see Appendix 5) has been widely lauded, and Dr Ed Barrett-Lennard has offered to work with Dr Ali to repackage the report for publication in an international academic journal. We also suggest that the existing report be made available on the ACIAR website. Dr Barrett-Lennard will also supplement the report with additional information related to saline agriculture projects, and has provided a summary paragraph containing the key points from this experience below. The rest of the following summary contains key points from Dr Ali's report as identified by Dr Jay Punthakey, together with some concluding reflections.

Summary of key points from Dr Ali's report – Jay Punthakey

A noteworthy conclusion from Dr Ali's report is that on-farm approaches have had limited success and that early success of basin-wide interventions could not be sustained. This inability to successfully intervene to manage the impacts for those living in salinity affected landscapes has affected their farm productivity and livelihoods, the surrounding environment, and, at a broader scale, the economic growth of the agricultural sector. The reasons for the lack of success are varied. For example, deep pumping of groundwater under the umbrella of the Salinity Control and Reclamation Projects (SCARPs) managed to lower watertables and showed early success, and are continuing to lower watertables in some areas. However, ongoing operational and maintenance issues have meant that most of the SCARP wells are now not operating or have been privatised.

The Left Bank Outfall Drain (LBOD) project has had mixed success. While it has helped drain saline groundwater for disposal to the sea, it has also led to saline effluent affecting agricultural land surrounding the LBOD when it overflows due to flooding in the kharif season. The National Drainage Program has also been a failure and was largely abandoned. Most of these mega projects were either poorly designed, failed to consider farmer concerns, and were not sustained due to a lack of operational and maintenance planning.

A serendipitous outcome was the natural growth in private tubewells due to the extreme drought conditions during 1996–2001 (Qureshi et al. 2003). Access to groundwater by several thousands of farmers lowered groundwater tables and also allowed cropping intensities to increase. At present, in many areas of the Punjab, cropping intensities are in excess of 180 percent and as much as 50 percent of the water is supplied from groundwater. In Sindh, the growth of tubewells is about 10 percent of that in Punjab with over 100,000 tubewells located in freshwater zones. These freshwater zones are pockets of freshwater resulting from seepage from canals and possibly irrigation recharge over time which has allowed a thin lens of freshwater to develop. The risks are plenty, as increased use of groundwater is resulting in depletion of these freshwater zones in Sindh, and to some extent in the Punjab where watertables have decreased rapidly such as around the lower reaches of the Bari Doab. Moreover, there is a trend amongst farmers to rely on brackish or marginal quality groundwater blended with surface water for irrigation when surface water supplies are in short supply. This is another factor accelerating the growth of secondary salinisation in what were once productive lands. An additional component to understanding the spatial and temporal nature of salinity in the landscape is to examine the twin dimensions of water management: agricultural water management which affects salinity at the farm scale as well as cumulative impacts at the basin scale, and the management of groundwater at the subregional and regional scale.

In 1997 the total salinity affected area was 6.2 million hectares, which included 4.3 million ha severely affected (70%) and 3.4 million ha was not cultivated (Government of Pakistan, 1997). Experts at the Faisalabad workshop in November 2017 agreed that 6.2 million ha

of land in the Indus Basin is still affected by salinity and represents about 40 percent of the basin's irrigated lands. This is a telling story, as it means the area affected by salinity has remained at 6.2 million ha despite a slew of mega and small research projects. In the desk top review, Dr Ali indicates that groundwater and salinisation are very closely linked (2 Mha suffer from secondary salinisation due to use of poor quality groundwater), moreover groundwater management is a weak and neglected segment. This is an emerging challenge for groundwater irrigators in the Indus Basin.

Key points arising from saline agriculture projects in Pakistan – Ed Barrett-Lennard

One of the strong features of Pakistan's response to salinity and waterlogging, has been the development of a dispersed but highly motivated community of researchers interested in the development of better ways of obtaining agricultural production from salinized land ("the biosaline approach"). This approach has been pioneered (and still actively researched) by a wide range of researchers at universities and national research institutes such as (but not limited to) UAF, NIAB, NIBGE, the NARC and the Atomic Energy Commission Tando Jam. Notable achievements in this area have included the widespread use of kallar grass and sesbania as forages for saline waterlogged land, the increased use of trees (especially Australian eucalyptus), and the development the salt tolerant 'SARC' wheat lines. While international linkages have supported some of this work, the main impetus has been indigenous. Many of the innovations and practices developed by biosaline researchers are relevant to current salinity/waterlogging regimes in Pakistan. They just need to be better extended to farmers.

Concluding reflections – Jay Punthakey

The nature of salinity affecting the Indus Basin landscape is the spatial dimension and transient nature of salinity. With continuous irrigation of the landscape it is estimated that over 14 million tonnes of salt accumulate in the landscape, roughly equivalent to 1 tonne per ha. Removing salinity from the landscape is not an option, which calls for a new approach which examines the issues around salinity within a holistic framework. By that we mean an approach that looks closely at integrating the spatial and temporal aspects of salinity in the landscape and inclusion of communities, institutions and ecosystems within the framework. Moreover, the concept of communities living with salinity and developing new and innovative enterprises which enhance livelihoods is a consideration that needs to evolve as an integral part of the project we are proposing to pursue. Living with salinity does not mean suffering the consequences of salinity. Rather it means developing a community based framework for environmental and ecosystem services that will add value to the landscape and communities, and will improve livelihoods.

8 Review of relevant ACIAR and other projects

This section summarises some current and past ACIAR projects that we identified were important for us to review in preparation for us considering a project on salinity management in Pakistan. Further details on these and other relevant projects are provided in Appendix 6.

ACIAR has invested in a range of salinity management and amelioration projects in Pakistan since the early 1980s. Some projects focused on products from saline systems, for example projects FST 1986/033 and FST/1993/016 considered timber and other woody products, CIM/2006/177 sought suitable wheat varieties, and suitable forage species were trialled in projects FOG 1986/019, LWR1/1993/002/ and LPS/2016/022. Management of on farm and district saline process were explored through engineering solutions such as raised beds in LWR2/1998/131 and LWR/2002/034, and canal and ground water management in LWR/2005/14. Biological amelioration through plants was attempted, unsuccessfully, in LWR/2000/013. While some of these trials, such as raised beds and forage species showed that productivity and profitability could be increased, upscaling and uptake has been slow. The adoption findings from ADP/2015/004 are thus also relevant to this research; policy settings, reactive rather than proactive agencies and economic constraints feature in the poor scaling up of the capacity built through the raised bed project. It is notable that technical findings and 'adoption' by the range of research users continue to be considered separately in this ACIAR adoption report.

Some recent ACIAR projects are addressing the systemic nature of the 'scaling up', though not in Pakistan. Project LWR/2009/034 in Iraq is considering drivers of salt distribution, integrating both biophysical and social parameters. LWR/2011/045, sought to identify both physical and institutional interventions to improve water management in the Nile Delta using an integrated approach across scales, encountering a range of operational issues.

The current project builds on all of the above projects by acknowledging the wealth of technical solutions developed in them, situating that knowledge with an appreciation that agricultural systems involve complex and co-evolving social–ecological interactions, and seeking holistic approaches that will enable these solutions to be more fully used.

ACIAR has already started setting the agenda for this holistic research direction to salinity management. The ACIAR Country Office, in collaboration with ICARDA, has conducted two stakeholder consultations to gauge the depth of understanding of this issue. A report is being prepared by ICARDA which will be shared with the Planning Commission and relevant Ministry in Pakistan for a possible donor search. A short research and development activity was also conducted in late 2017 to gauge expert opinion on the proposed research direction being proposed here, receiving strong endorsement.

In early 2017, ACIAR also launched a set of water-related research projects that is helping to inform this project and establish contact with relevant stakeholders. These are LWR/2014/074 on new approaches and tools to facilitate farmer learning related in irrigation, and LWR/2015/036 on improving groundwater management to enhance agriculture and farming livelihoods in Pakistan. CSIRO is also undertaking a DFAT funded project, under the SDIP, aiming to develop an integrated river system model of Pakistan. A groundwater flow model for the alluvial parts of the Indus Basin is being developed as part of this project. These projects are providing valuable lessons for how to develop an integrated and participatory approach and support outcomes of ACIAR and CSIRO water projects in Pakistan.

In addition, one of the intended project partners (MUET's Centre for Advanced Studies in Water Resources) has received substantial USAID funding through which another intended partner, PCRWR, will undertake a climate change adaptation study to monitor seawater intrusion in the Indus Delta. This study will offer valuable data on groundwater salinity in the Thatta and Badin districts of Lower Sindh.

9 Literature review on ecosystem services

One of our five proposed project objectives is explore the extent that an ecosystem services framing can contribute to a shared understanding of the situations facing communities in saline affected areas, and to identifying new approaches for improving their livelihoods. The rationale for use of an ecosystem services framing as part of the proposed project has not yet been well understood by our Pakistan partners. There preference has been to refer to a holistic or integrated approach. Our review (see Appendix 7) first examines these terms and their limitations, before reviewing literature that relates an ecosystem services framing to salinity management and agricultural practices in contexts similar to the Indus Basin.

A holistic approach involves considering all aspects of a situation as part of the whole. Depicting this is a challenge, as any depiction would require showing all the parts that make up the whole. To be holistic requires integration: integrating perspectives across academic disciplines; and integrating perspectives from researchers, research users (government agencies, non-government organisations and community based organisations) and research beneficiaries (resource dependent communities and families). An integrating process is ongoing, and there is no end point where a state of being integrated has been reached.

It is this context that we suggest that an essential component of a holistic approach to salinity management that is not well appreciated is the supporting role that ecosystems and ecosystem processes can play. An ecosystem services framing helps articulate the range of services provided by ecosystems and ecosystem processes. The range of services can be categorised as provisioning (e.g. food, water, fibre, fuel); regulating (e.g. water, climate and erosion regulation); cultural (e.g. sources of inspiration, recreation and education); and supporting (e.g. soil formation and nutrient cycling). By understanding and articulating the range of services that each specific ecosystem might offer, and applying them to aspects related to enhancing livelihoods of those communities living in salinity affected areas, it may be possible to articulate and investigate additional risks and opportunities for these communities.

Many salinity management strategies rely on the potential for ecosystem processes to regulate water flows, but the ecosystem services go beyond these. For example, shading the soil surface using mulch helps regulate against the upward movement of moisture in the soil, and thus reduces salt crusting on the surface. Mulching of agricultural residues also offers provisions to the soil and nutrient cycling. When sugar cane residues are burnt, they may add potassium and phosphorous to the soil underneath, but the carbon, nitrogen and sulphur are lost. Other examples of ecosystem services include eucalypt plantations that help to lower the water table in waterlogged areas. Mangroves also provide a regulating effect as a barrier to the upsurge of seawater into the delta by wave action. The reduction of fresh water flowing through the delta constrains the water regulation ecosystem processes that had helped reduce saline intrusion.

Our review identified work in Pakistan related to salinity management that had taken a similar systems approach (Iman et al., 2015). Their participatory approach of developing models using conceptual maps is much the same as the approach we intend to adopt. However, a key difference is that we will use these conceptual maps to identify scenarios that stretch stakeholder imagination about intervention options rather than test existing salinity management options as was the approach by Iman et al. (2017).

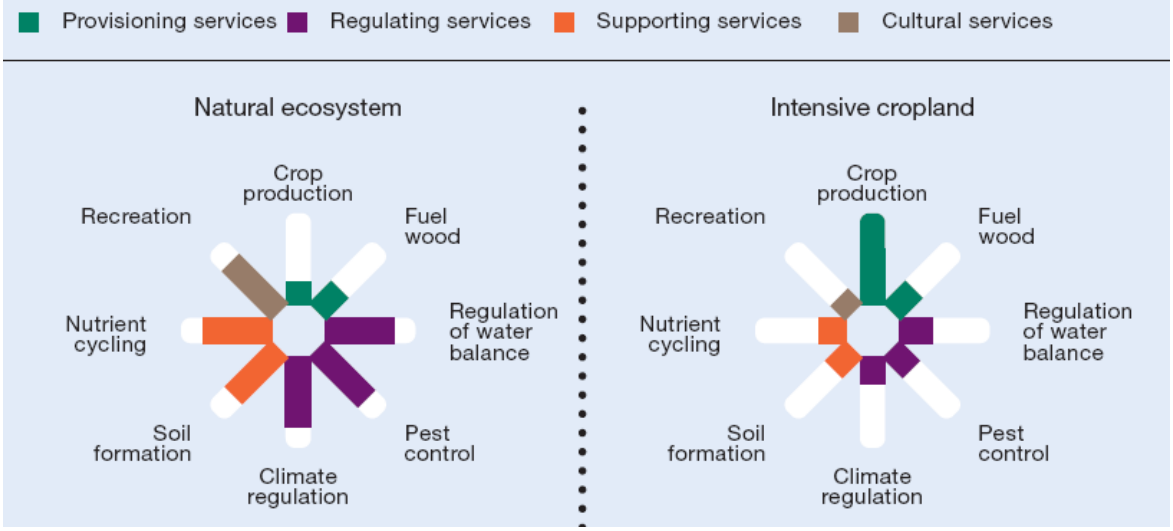
Our review mostly identified cursory reference to ecosystem services. A long-term UK funded research program in Bangladesh refers specifically to ecosystem services for poverty alleviation. While they invested considerably in multi-disciplinary data for integrated modelling purposes, it was not actually apparent the extent that the above ecosystem services framing was used. Instead, they developed a framework that incorporated ecosystem services.

Our plan is therefore to draw on the framing to explore the range of services in a similar way to that undertaken for the Millennium Ecosystem Assessment (2005), including how different types of landscapes emphasise different types of services (see examples below). This approach will be modified as needed by reference to the recently conducted assessments undertaken by the Intergovernmental Panel for Biodiversity and Ecosystem Services and being released in March 2018 (https://www.ipbes.net/).

Table1: Ecosystem services framing using examples related to wetlands

Services	Comments and Examples
Provisioning	
Food	production of fish, wild game, fruits and grains
Fresh water	storage and retention of water for domestic, industrial and agricultural use
Fibre and fuel	production of logs, fuelwood, peat, fodder
Biochemical	extraction of medicines and other materials from biota
Genetic materials	genes for resistance to plant pathogens, ornamental species and so on
Regulating	
Climate regulation	source of and sink for greenhouse gases; influence local and regional temperature, precipitation and other climatic processes
Water regulation (hydrological flows)	groundwater recharge/discharge
Water purification and waste treatment	retention, recovery, and removal of excess nutrients and other pollutants
Erosion regulation	retention of soils and sediments
Natural hazard regulation	flood control, storm protection
Pollination	habitat for pollinators
Cultural	
Spiritual and inspirational	source of inspiration; many religions attach spiritual and religious values to aspects of wetland ecosystems
Recreational	opportunities for recreational activities
Aesthetic	many people find beauty or aesthetic value in aspects of wetland ecosystems
Educational	opportunities for formal and informal education and training
Supporting	
Soil formation	sediment retention and accumulation of organic matter
Nutrient cycling	storage, recycling, processing and acquisition of nutrients

Source: Millennium Ecosystem Assessment, 2005, Table 1, p. 2



Source: modified from Gordon et al. 2010 Fig. 1, p. 513

10 Field visits and meetings in February 2018

Ed Barrett-Lennard, Jay Punthakey, Richard Culas and Michael Mitchell undertook a second visit to Pakistan in Feb 2018. A detailed report from this trip is attached as Appendix 8.

For the entire time we were accompanied by two PCRWR staff, Naveed Iqbal and Khuram Ejaz. Our visit in Sindh was managed by PCRWR's regional director, Abdul Salam Arain, and Dr Qureshi from MUET. The opportunity to see the range of salt affected landscapes across the Indus Basin has helped to confirm the urgent necessity for the proposed project, and served as a vehicle to enhance enthusiasm from our collaborating partners. Our learnings and discussions along the way influenced the design of the project proposal. The injection of places and activities fuelled these discussions, and we were able to bounce ideas off our hosts as well.

Impacts of salinity on wheat crops between Faisalabad and Multan in Punjab

The following sites were visited:

- Fish ponds in Punjab near Jhang and between Sharkot and Kabirwala
- Salt affected fields on the side of the road near Multan
- The MNSUAM experimental demonstration farm, south of Multan
- Dalda Foods farm in Thatta
- Muhammad Sarwar's farm in the delta
- Sujawal
- PCRWR's DRIP station in Tando Jam
- Uptake of bedding systems on the side of the road near Tando Jam
- Nawazabad Farm near Mirpurkhas
- An abandoned SCARP site north of Mirpurkhas
- A disused salt affected farm near Matli in Badin
- A couple of PCRWR piezometers in Badin

Meetings were held with the following:

- Director General Malik Muhammad Malik and staff from Punjab's Agriculture Directorate General for On-Farm Water Management
- Secretary Sajid Jamal Abro and staff from Sindh Department of Agriculture, Supply and Prices
- MNSUAM Vice Chancellor and staff
- IUCN's Country Director and staff
- University of Karachi academics
- Banaras Khan (FAO) and Richard Soppe (ex-CSIRO)

The field visits and meetings helped confirm that our strategy to identify spatial zones of similar types of salinity was appropriate, and that a nested case study approach was a preferred approach to ensure depth of interaction.

The meetings also confirmed considerable interest in an updated encyclopaedia of options for making a living on saline affected landscapes. We have added this as a major focus of activity and output from the proposed project. This may require some investment in adaptation trials.

We became aware that dissemination of best practice expertise by PCRWR and others tends to reach early adopters and wealthier farmers only. Overseas funding provides the means for this work to extend to the most impoverished farmers, and reinforces ACIAR's focus on poverty alleviation. This recognition reinforced the need to consider new approaches to extension, and the benefit for us of exploring new strategies for dissemination of information via mobile devices.

To ensure commitment and active engagement of key organisational stakeholders in the project, we determined that we may need to develop a three-tiered approach. The first tier would comprise our contractual partners (currently PCRWR and MUET). These contractual partners would then have sub-contractual arrangements with key organisational stakeholders as a second tier (especially the two provincial agricultural departments), and may serve as a kind of project coordinating committee. The third tier would comprise a broader range of individuals as an advisory network. Investment in this network is important for post project adoption of approaches developed during the project.

Virender Kumar from Dalda Foods showing Jay and Ed a field of sunflowers grown in reclaimed salt affected soils in the Thatta delta areas of Sindh. These were planted in when the soil was still moist from a prior Kharif crop (vegetables)

11 Conclusions and recommendations

This Short Research and Development Activity has confirmed an urgent need to develop a new approach to salinity management in the Indus Basin of Pakistan. A review of past approaches to salinity management suggests that early successes of large and/or basin-wide approaches could not be sustained, and that a major contributing factor is the failure to consider farmer concerns, and insufficient operational and maintenance planning. The range of innovative and alternative on-farm approaches to making a living on salt-affected landscapes have not been well disseminated. Uptake of such practices is mostly restricted to a few mostly wealthy, early adopters.

We have therefore identified a clear need to take a participatory, holistic approach, and one that takes into account the different systemic causes of salinity in the landscape. We have also acquired an appreciation that effective targeting of interventions needs to be developed in collaboration with those living in saline affected landscapes, and that there may be potential to identify a set of zones across the Indus Basin that match different types of salinity.

We therefore recommend:

1. Dissemination of a draft project proposal by the end of February 2018 to all those people who are part of the network established at the Faisalabad workshop.
2. Modification of the proposal in light of feedback provided by the network to be finalised by the end of March 2018.
3. Committing the first year of the project to developing a shared, holistic and spatial understanding of the range of situations facing communities living in saline affected areas, and to use that to identify a set of case studies for the project.
4. Investigation into the establishment of a website where we can start compiling success stories, best practice case studies, appropriate adaptations related to salinity landscapes as the project progresses, and identifying a responsible agency to maintain the website beyond the life of the project.
5. Investigate strategies to disseminate the information being compiled above out to the widest range of farmers, with a focus on the most impoverished, together with extension agents and the use of mobile technologies.
6. The eventual publication of an updated handbook of options for those living in saline affected landscapes, based on Qureshi & Barrett-Lennard (1998), but extended to cover a wider range of ways to make a livelihood (e.g. to include aquaculture options).
7. Consolidating the commitment from provincial agricultural department agencies and others to the project, and extending that to include others working with communities living in saline affected landscapes.
8. Facilitating the commitment of all those who have shown interest in being a part of the salinity network.

12 References

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13 Appendices

13.1 Appendix 1: Financial acquittal report

Attached separately. The spreadsheet is accurate as of 23 February 2018. There are some small additional expenses that will need to be added, and will result in us exceeding the AUD 50,000 allocated. CSU will bear these additional costs.

13.2 Appendix 2: Workshop program and project summary

Attached separately.

13.3 Appendix 3: Workshop report and list of participants

Attached separately.

13.4 Appendix 4: Workshop evaluation

Attached separately.

13.5 Appendix 5: Desk-top review by Dr Akhtar Ali

Attached separately

13.6 Appendix 6: Matrix summarising some past projects related to salinity management

Attached separately. This document is a work in progress.

13.7 Appendix 7: Literature review and bibliography

Attached separately

13.8 Appendix 8: Trip report, February 2018

Attached separately.