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Executive summary

The development of skills and capacity among women and men farmers to manage and maintain irrigation is required for Pakistan's continued economic growth, food security and poverty reduction. This Project sought a respectful, co designing approach, with women and men farmers engaged as equal co-research and co-learning partners.

The Project team knew that extension was not working for scale out, farmers trust other farmers more than others, and farmers did not know how to teach. The project team believed that farmers are very knowledgeable though their knowledge is ***different but of equal value*** to the researcher and stakeholders, thus we needed to build from that knowledge base and to learn together.

Three adult learning models were trialled: Value Management (VM), Collaborative Problem Solving (CPS) and Discovery Learning (DL) in the three Provinces. A total of 1136 farmers were involved (518 women and 618 men) in 48 villages. Farmers were introduced to a variety of tools and technologies developed by CSIRO and PCRWR which would enhance irrigation and water management practices.

Farmers chose which of the tools or technologies they wished to trial on their farms. A total of 400 sets of soil moisture sensors were provided to Farmers in 48 project sites. Moreover, 140 sets of Fullstops along with Chameleon EC meters and Nitrogen testing strips were provided. Approximately 700 farmers, researchers, scientists and engineers are aware of VIA tools. An ACIAR Small Research Activity (SRA) is currently being designed with CSIRO, at the request of the Federal Minister for Science and Technology, to expand access to and use of CSIRO's Chameleon and FullStop sensors for irrigation management in Pakistan.

Using VIA tools, farmers are learning to avoid irrigation if it is unnecessary. The use of tools and water conservation practices saved 20-30% irrigation time, frequency or both. Similarly, proper use of FullStop™ supported the saving of one bag per acre (i.e. up to 50%) of nitrogenous fertilizer (urea). Saving in crop inputs has increased net profit. Wider adaptation of these practices can reduce mining of ground water for surface irrigation along with reduction in leaching of extra chemical fertilizer in sub-soil water.

Feedback from women and men farmers and facilitators revealed the strengths and weaknesses of the adult learning models and new Farmer Integrated Learning Model (FILM) was co-developed by the team and the farmers. FILM was subsequently used at all sites. The approach to farmer engagement and learning developed during the project, will contribute directly to a new project *Adapting to Salinity in the Southern Indus Basin* (LWR 2017 027), starting in March 2021.

From the trial sites 89 men and 64 women farmers were identified to act as farmer facilitators, trained in the FILM technique, who subsequently enrolled 437 men and 307 women as trainees. These farmers developed and conducted experiments on the issues important to them. In total 260 experiments (126 by men and 134 by women) and practical activities were reported from 32 villages.

The high level of engagement of women (46% in the project overall) and in being trained to become facilitators for other women (41% of trainees) and engaged in farmer led research activities (51% led experiments) bears witness to the success of the FILM process to actively engage women. Women also reported being more involved in farm as well as household decision making through feeling empowered and more valued by their menfolk.

Use of FILM and Stakeholder forums have enabled women and men farmers to engage with districts level canal operators, extension officers, agricultural officers, local NGO's and research community present in their vicinity. As a result of these forums, men and women farmers can interact with these important professionals more readily than ever.

Background

The development of skills and capacity among farmers to manage and maintain irrigation is required for Pakistan's continued economic growth and food security. Irrigation is critical to Pakistan's economic development, yet Pakistan's irrigation profitability is among the world's lowest Laghari, Vanham & Rauch, 2012). The use of conventional irrigation methods and poor agronomic practices leads to overuse of water). Farmers believe that using more water on their crops results in higher yields. Small landholders have little way of knowing what is actually happening in their fields regarding water and nutrient management. Farmers with small to medium holdings have had little access to irrigation technologies, as affordable and accessible tools are neither produced nor widely distributed in Pakistan.

Poverty in Pakistan

Over 22% of Pakistan's rural population are living in poverty, with more than 12% of the population living on less than US$1.25 per day. Despite the increasing feminisation of the rural workforce, with approximately 72% of women in rural Pakistan being engaged in the industry, women and girls continue to experience the effects of poverty (FAO, 2015). Irrigation profitability is essential for reducing poverty, as there are strong links between irrigation, crop productivity, and poverty alleviation. Women actively participate in producing crops, the tending of livestock, and harvesting, yet they consider their work as a "part of life" rather than paid work. Youth of both genders in rural areas of Pakistan experience a lack of education and skills training and find it difficult to gain meaningful employment. However, when farmer communities capitalise on initiatives to enhance productivity and are provided with training and tools to diversify their livelihoods, individuals can positively transform their lives.

Irrigation in Pakistan

Irrigation is essential for Pakistan's food security and economic development, particularly in the Indus Basin, where most of the irrigation occurs. Improved irrigation profitability can be realised through improved irrigation systems and management practices. The use of conventional irrigation methods and poor agronomic practices leads to overuse of water (http://www.parc.gov.pk/index.php/en/caewri-rshprog/caewri-awmp). Farmers believe that using more water on their crops results in higher yields (Azad, 2003). However, farmers have little way of knowing what is happening in their fields regarding water and nutrient management. PCRWR has designed and manufactured instruments like tensiometers, gypsum blocks, water level indicators, sprinkler heads, rainguns, and salinity sensors, which are being provided to various research and development organisations but not yet to farmers at a low cost. These tools have not been manufactured and distributed on a large scale, and the potential for doing so has not been investigated (PCRWR scoping visit 2015).

The issue of poor adoption

While new technologies are available, farmers face significant socio-economic barriers to their adoption. It can be argued that the developed technologies and infrastructure investments have been "pushed" out to farmers. This is a top-down approach, rather than engaging and working with farmers in a collaborative manner to enhance farmer engagement, ownership, and understanding of these technologies and encourage farmers to adapt them to local conditions. Similarly, the poverty of smallholder farmers and the top-down approach retarded the adoption of new technologies. The development of skills and capacity among farmers to manage and maintain irrigation is critical to Pakistan's continued economic growth and food security (Azad, 2003).

Current approach to extending knowledge and capacity in Pakistan

The main challenge is how to scale out existing and new technologies over Pakistan's

vast irrigated areas. Extension approaches to farming in Pakistan occur in two ways: the traditional top-down, expert-to-farmer approach; and the interactive Farmer Field School (FFS) approach. The FFS approach has had varying degrees of success with the farmers involved (Waddington et al., 2014). However, the scale-out to other farmers has been lacking. Traditional "agricultural extension" was designed to increase farmers' knowledge and skills. Farmers believe that extension in its various forms is not successful because there is a lack of available, accessible, and affordable information. The knowledge that extension agents give them is too generic and does not fit the local context; the technology is unaffordable. There is a “growing resentment among farmers that they are not granted due respect in their society” (Siraj, 2010, p.36). Further, there is a gap in understanding between the scientists and farmers that extension agents are not adequately filling, and extension agents are poorly equipped and resourced (Focus Group 2016). FFS is an alternative approach to farmer education that has been used in Pakistan since the 1990s. FFS programs are used to transfer knowledge, skills and empower farmers by using experiential learning methods to build farmers' expertise through learning while doing. Farmers who participated had an increase in their knowledge, reduced pesticide use, increased crop yields, and reduced expenditure on pesticides. However, there was no evidence of effects on outcomes over the long term or of scale-out to other farmers (Waddington, 2014). Moreover, the FFS method is supply-driven and focuses on large farms with greater capacity to adopt new technologies and practices.

Thus, while technologies and tools exist in Pakistan, it is the farmer skills and knowledge of water and irrigation that must be improved. A respectful, collaborative designing approach, with women and men farmers engaged as equal research and learning partners and fostering adult learning skills and techniques among some farmers, will achieve scale-out of water technologies and tools.

Objectives

This project aims to develop and scale out tools and approaches for increasing farmers' irrigation management skills, and hence their livelihoods, on small- and middle-sized irrigated farms.

The objectives are to:

Objective 1: Determine the successful elements of existing on-farm irrigation water management initiatives and farmer training models in Pakistan (10%)

Objective 2: Develop and test farmer tools for on-farm soil water, nutrient-monitoring and supply chains, together with a system for collecting and collating the data for collaborative, problem-based learning (35%)

Objective 3: Develop and test effective, efficient and scalable approaches to improving farmers' irrigation water and nutrient management skills (35%)

Objective 4: Identify the effects of improving farmers' irrigation skills on irrigation profitability, labour, water and energy efficiency and social capital of farming households (20%)

Methodology

The in-field research was conducted in varied agro-ecological settings across Punjab, Sindh and Balochistan. It considered biophysical variation in crops, soils, irrigation systems, water sources and availability. The research had varied socio-economic settings but focused upon poor smallholder farmers. The project engaged women as much as possible, especially female-headed households.
The project operated in areas where there was the potential for farmers to access good markets, so that improved practices leading to increased yields provided an obvious and substantial financial benefit. In addition, areas where either groundwater or surface water pumping occurs were targeted, so that there was a cost-saving incentive for improved water management.
The farmers were provided with various well-researched options to test and contrast irrigation and nutrient management methods, such as laser levelling, raised beds/furrows, sprinklers and fertiliser type/timing/placement.

Objective 1: Determine the successful elements of existing on-farm irrigation water management initiatives and farmer training models in Pakistan (10%)

Participatory action research (PAR) (Minkler and Wallerstein, 2003) was used to gather data.
UC and NARC-SSRI teams undertook focus groups with:

1) groups of farmers to understand why they use particular practices, the benefits they have realised from those practices, the challenges in using those practices and the barriers to adoption of other practices
2) government and NGO extension agents to determine the extension methods they use. They will consider the benefits, the challenges and what improvements they consider may be useful to their role in educating farmers.
3) key informants from PCRWR to develop a deeper understanding of issues faced in research and development of tools and technologies and their adoption by farmers.

An extensive literature review, including grey literature, was conducted by PCRWR, CSIRO and UC staff to determine which water and nutrient management technologies and tools are currently being researched and used in Pakistan, and their opportunities and challenges for farmer adoption.
A background paper on the findings was developed in preparation for the initial project planning workshop with farmers, Pakistani and Australian project teams, and all relevant stakeholders. The background paper was used to inform and influence (guide) facilitators and participants in the workshops used in the methodology, and formed the basis for journal papers.

Objective 2: Develop and test farmer tools for on-farm soil water, nutrient-monitoring and supply chains, together with a system for collecting and collating the data for collaborative, problem-based learning (35%)

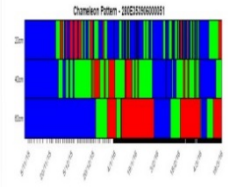
It was important to provide farmers with knowledge tools whereby they can collect data and assess their irrigation management decisions about what they should actually do. Knowledge workers critically reflect on and challenge the assumptions of what they are doing. There was a need for a system to collect data from many farmers and for them to be able to see their data, compare it with that of others, and discuss the significance. This second objective focused on transforming farmers from manual workers into knowledge workers.

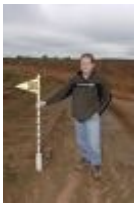
Measurement drives behaviour. Following the adages of “what gets measured gets managed” and “what gets measured gets improved” (Eureka, 2010), it is important to provide farmers with knowledge tools whereby they can collect data and assess their irrigation management decisions about what they should actually do.

The monitoring tools

Table 3 show the tools to be used to assist farmers to improve their irrigation skills. PCRWR already uses the tensiometer in Pakistan. The tools developed by CSIRO will also be introduced in the different learning models.

Table 3: Tools to be used in the learning systems

	PCRWR has made the farmer-friendly tensiometer. The blue range shows that the soil is at saturation. When the needle is on the green strip, it means there is sufficient moisture available. However, when the needle is on the yellow line, the farmer or the manager should prepare to irrigate their field. When the needle moves to the red zone, water must be applied. Tensiometers are available from PCRWR for $7–20, but they are not privately or mass manufactured.
	The Chameleon reader shows the water stress that plants are experiencing at four depths in the soil. The data are displayed as coloured lights (blue = wet, green = moist and red = dry). The Chameleon helps farmers to see how deep roots are extracting water, how deep irrigation water penetrates, and the optimal time and duration of irrigation. The Chameleon is an ACIAR-funded tool in early rollout, and is being tested in farmer fields. This project will fully test, improve the design of and develop a supply chain for this tool. Additional details are below.
	The FullStop Wetting Front Detector is buried in the soil and pops up an indicator when it captures a sample of infiltrating water from irrigation inside the funnel. This water can then be extracted for measurement of salt and nitrate. The FullStop Wetting Front Detector is a CSIRO-developed tool that is commercially available.
	Colour test strips are used to show farmers the nitrogen status of their soil and help minimise leaching of expensive nutrients. These are commercially available.
	The Salt Light displays the conductivity of irrigation, soil and drainage water by seven different coloured lights, to illustrate where salt is building up in the irrigation system. Salt Light is an ACIAR-funded tool. The beta version will be available soon.
	The Chameleon reader is wi-fi enabled and can hotspot off a phone and deliver the data to the website using the unique ID chip in every sensor array. The data is then collated and displayed in real time to give the ‘Chameleon water pattern’. Phone apps are used to collect, store, display and share data so participants can learn together in real time.

	This is an ACIAR-funded tool in early roll-out. It is already being tested with farmers.
	Watertable depth-monitoring with simple well and flag.

The Chameleon simplifies complex soil water content data to patterns, so a range of participants can quickly assimilate a large amount of information. Figure 1 gives the example below) from a maize crop in Tanzania (project FSC/2013/006). In that project, the monitoring tools were managed by the scientists, so the data was collected only weekly at best, when the scientists visited the schemes. Furthermore, we do not know how farmers responded to the information. This project was designed to capture more information (daily) and to record what the farmers think about the data and what action they have taken in response to it.

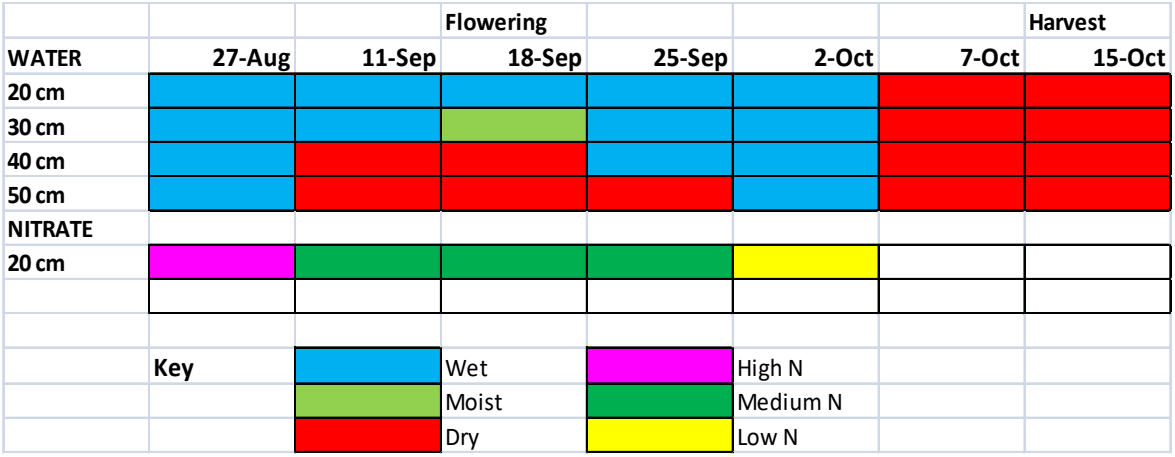


Figure 1: An example of colour patterns from the Chameleon and nitrate from a wetting front detector.

In each of the three learning models, farmers were exposed to the various tools that can assist them in water and nutrient management. Farmers were then able to select which of the tools they consider most suited to their farm and that they consider they can master. Thus, each farmer became a researcher in their own field, collected and interpreted data; made decisions about when to irrigate, and how much water and nutrient to use; and ke[t records of what they decided and why.

A relational database linked with a CMS that can handle all the data was developed. Individuals were able to access data in real time, displayed in visually appealing ways, allowing for sharing and comparison amongst groups of farmers.

At least two key critical aspects required the recording and use of data: firstly, farmers periodically monitored the data; secondly, researchers relied on data collection, processing and interpretation for their investigation.

In a project focussed on bottom up learning and one that encouraged farmer experimentation, it became a challenge to collect data and document the learning journey. The soil water monitoring equipment was upgraded to include a Wi-Fi chip that can connect to the hotspot facility of a Smartphone. In this scenario the farmer, or person who takes the reading in the field, is the first to see the data and can act on it. However the data was simultaneously captured on the project website through the smartphone. Each array of soil water monitoring equipment was uniquely identified with an ID chip, so time series data coming in from the field was collated to produce the Chameleon colour patterns i.e. a display of the change in soil water content with depth and time. Farmers

who owned those IDs then accessed their own data from the website. A relational database is the means by which we can capture data and display the colour patterns back to those who collected it.
Farmers were required to quantify their crop yields, which is normally done anyway for purposes of sale. They were encouraged to estimate their input costs so that a simple gross margin could be calculated and hence the profitability of the crop. The website has a facility for inputting crop type, variety, planting and harvest dates, fertiliser management, yield and profitability, so that the performance of the crop can be view together with the soil water and nutrient patterns. Thus farmers were able to see an overview of their soil water and nutrient management and the resultant yield and profitability.

For farmers, the Chameleon automatically collecedt data and uploaded it to the CMS. The CMS also has the capacity to store farmer narratives, uploaded from farmers' mobile phones, about what they are doing in their fields and how they have used the data patterns to alter irrigation and fertilising practices and the like. In addition, farmers completed a log book of their activities; SOFT has developed a log book which has been reliably used in FFS for several years. Farmers were encouraged to collect images to accompany the narratives on their mobile phones or other devices over the duration of the project to document changes in their fields, crops and practices over time. These images added to the richness of the data collected. This was an activity in which youth were able participate as image collectors.
To enable the scale-out of tools and the relational database CMS, there was continued interaction with importers, manufacturers and distributors of the tools. For scale-out to be successful, tools need to manufactured and distributed so that they are both accessible and affordable for farmers. Relevant discussions have already commenced in Pakistan and at the time of tis report are continuing.

The ongoing sustainable management of the relational database CMS also is also being explored with either government or private enterprise to ensure that farmers can continue to have access to it to upload the field data, including pictures, videos and other records of their stories, and to be able to visualise their data so as to manage irrigation on their farm. PCRWR and private service providers are being canvassed regarding future possibilities at the time of writing this report.

Objective 3: Develop and test effective, efficient and scalable approaches to improving farmers' irrigation water and nutrient management skills (35%)

Proposed farmer learning models

This research proposed the use of three distinctively contrasting methods of educational intervention to develop scalable, sustainable and cost-effective models of farmer-to-farmer engagement that achieve the overarching aim of irrigation profitability.
The three models for farmer training/learning that were tested differ along several dimensions: expertise levels of facilitators, a continuum of facilitated to self-directed approaches (degree of expert scaffolding and guidance delivered to participants), technical quantitative/analytical processes utilised, investment of resources (time and staff), formality/informality and monitoring requirements. Model 1 is very formal while model 2 is semi-formal and model 3 is largely informal along these dimensions.
The three models chosen for establishing a new problem-solving and learning process conform to principles of adult learning and collaborative problem-solving underpinned by action research and action learning. Each model has its strengths, based on similar philosophies and learning principles:

1) VM is a highly rigorous and scientific approach to structured and determined problem-solving of complex problems, such as irrigation profitability, resulting in robust action plans based on a highly proven and successful process (Osterwalder, Pigneur, Bernarda & Smith, 2014).

2) ORCD has been used successfully in Pakistan by Spriggs and Chambers (2011). Similarly, it is designed to tackle complex problems but has not been trialled in relation to irrigation problems. While it is also a rigorous and inclusive approach, it does not require the same sophistication of facilitation skills and scientific methods. This model could act as an equally effective alternative to VM.
3) An open-ended problem-solving approach relies on farmers to utilise their own orientations, insights and energy to trial solutions using the tools given to them. It requires minimal facilitation and direction for farmers to collaborate. Group cooperation, serendipity and insight are key concepts that are worthy of study as the group of farmers trial this open-ended discovery method. This model encourages farmers to cross the line of working as manual workers to farming as knowledge workers. The facilitation required at two key points includes assisting with critical reflection of the processes the farmers themselves invented and engaged in.

In short, three models were applied after being introduced in workshop activities (models 1 and 2) and by a technical facilitator who will explain the tools (model 3). Each district included in the project trialled the three models and applied them over a number of cropping seasons, where each model was randomly allocated to one group of farmers. This enabled comparative analysis across the models and provincial districts.
Table 4 below provides a summary of the three models to be applied across three regions of Pakistan, with each region being randomly allocated one model.
The three proposed models were presented at the initial CPSW for review by farmers, Pakistani and Australian project teams, and all relevant stakeholders. Following potential modification, the approved models were piloted at one location by trained facilitators and groups of farmers, evaluated and refined prior to full implementation in three districts – one in each province.

Table 4: Summary of three proposed models of farmer engagement

	Model 1 **Value Management**	**Model 2** **ORCD/CPSW**	**Model 3** **Discovery learning**
Structure	✓ Formal	✓ Semi-formal	X Informal
Scaffolding	✓ Scientific and strict	✓ Inclusive and participative	X None (critical self-reflection)
Monitoring	✓ High-level and detailed	✓ Semi-detailed and participative	X Informal and self-guided
Resources	✓ Intensive	✓ Variable	X Self-funded
Autonomy	X None	X Shared	✓ Fully self-directed
Facilitator	✓ Expert	✓ Semi-expert	X None (self-facilitation)
Duration of facilitation	2–5 days per workshop	2–4 days inclusive of CPWS and tools and technologies demonstration	Self-facilitated (ongoing informal learning) after demonstration of tools

SOFT conducted models 1 and 2, and PCRWR/SOFT staff demonstrated tools to farmers in model 3.
The evaluation methods ranged from naturalistic to quantitative and formal, and a mixture of both. Evaluation occurred generally across five levels:

1. examine reactions, take-up and engagement with the model and methods to see if intuitively and emotionally farmers were able to resonate with the approach. Do farmers like the model (approach) and find it useful?
2. learning, acquisition of new concepts and new attitudes, skills, confidence, commitment and practices. Do farmers have new knowledge? Do they think and feel differently?
3. changed behaviour and the application of what is learned from the approach used. Do farmers improve their practice? Do farmers transfer this new knowledge to their routine work behaviours?
4. whether there are results across farms in terms of irrigation profitability. Leading indicators will be established to determine the extent to which the changed behaviours positively affect farming and irrigation profitability.
5. extent of scaling and or the potential to be scaled out. Has the scaling-out process begun? Can it be sped up, nurtured, cascaded and adopted broadly across Pakistan?

Formative and summative evaluation of the three learning models was undertaken. Formative evaluation occurred during each process to determine if the various models were working well for farmers and facilitators alike. If not, considerations will be made of what could be done to improve the learning experiences. Farmers' learning was evaluated throughout by simple oral and skill assessment. This allowed changes to be made as necessary. It should be noted that, as the models are being trialled at several sites, the evaluation outcomes were variable and thus necessitated individualised modifications to be made. Summative evaluation took place at the end of each learning experience by surveying farmers and facilitators about the experience.
Farmer and facilitator surveys and semi-structured interviews were conducted to determine whether the introduction of simple tools increases farmer irrigation management skills and specifically which types of skills were developed. These methods also assisted in understanding how farmers' management decisions assist them in sharing new knowledge and practices with other farmers.

Objective 4: Identify the effects of improving farmers' irrigation skills on irrigation profitability and social capital of farming households (20%)

PAR again underpinned the methodology for this objective. Householders (heads and spouses) were surveyed at three intervals – baseline, midline and endline.
Through the surveys, interviews and case studies, agronomic and economic data from farmers using scientific instruments and the CMS was collected and analysed by the NARC-SSRI and UC teams to determine changes in productivity and profitability.
Men, women and youth participated in focus groups designed to give information on how groups think about socio-economic issues for farmers with small and medium holdings. Such issues include affordability, usability of technology and ways of working collaboratively as knowledge workers. Focus groups were conducted at each of the five sites, and with six to eight householders who participated in one of the three learning models.
In-depth interviews were conducted with men, women and youth to get a more rigorous and detailed interpretation of the identified issues both prior to and following the project interventions of water and nutrient management tools and techniques and farmer learning models (Dick, 2012; http://www.aral.com.au/resources/coin.pdf).
Case studies were also be conducted with farmers, as they are a sound human-centred research tool for investigating meaningful characteristics of real-life events.
Farmers also have recorded images of their fields, crops and practices over the duration of the project. These were included, along with the narratives and in-field conversations, to build a rich picture of change over time.

Achievements against activities and outputs/milestones

Objective 1: To determine the successful elements of existing on-farm irrigation water management initiatives and farmer training models in Pakistan (10%)

no.	Activity	outputs/ milestones	completion date	Comments
1.1	Conduct literature review inclusive of grey literature and large infrastructure improvement programmes	Background papers have been developed.	January 2017	
	A briefing paper was prepared for and circulated before Inception workshop to key participants. Appendix 1 This paper was compiled from information in **Appendices 2,3,4 and- 6** A 4 pages brief was circulated to all including farmers with a request to those who were literate to inform those who needed assistance **Appendix 5** Additionally, a literature review of women in irrigation in South East Asia was also completed. **Appendix 7** **Publication** "Faizan ul Hasan, Bareerah Fatima and Sandra Heaney-Mustafa. A critique of successful elements of existing on-farm irrigation water management initiatives in Pakistan. Agricultural Water Management, Volume 244 (2021) 106598, ISSN 0378-3774, https://doi.org/10.1016/j.agwat.2020.106598 ".			
1.2	Conduct training for NARC-SSRI and other enumerators in data collection methods required for research	Training conducted. Reliable data collection for analysis and informing report and publications.	September 2016	
	Project leader (PL) and SSRI team developed a preliminary survey for collection of data from farmers re current practices for briefing document and Inception workshop input. PL did some interview training with SSRI team on how to build relationship with farmer prior to commencing survey. Both activities were done using role plays. Initially the PL took the role of interviewer and the SSRI team member the role of the participant. After this, roles were changed with the SSRI team member acting a interviewer and PL as interviewee. The SSRI team members were then paired in one or other role and practices in both roles under the supervision of the PL and an experienced SSRI team interviewer.			

1.3	Collect survey data and narratives from farmers and other key informants on water management practices	Preliminary questionnaire designed Piloted and revised Questionnaire implemented Stories from farmers collected Data analysed Developed understanding of farmer practices to develop models in CPSW	November 2017	Preliminary data was collected from three provinces of Pakistan and analysed, Photographs of current practices as farmer narratives were presented at Inception workshop. **Appendix 8** A well structure questionnaire was used to collect data via Commcare App. The questionnaire had been piloted in one village in Bahawalpur Data were collected included the socio-economic characteristic of sampled respondents, main sources of irrigation and farmer learning experience about irrigation practices. Farmer stories was also collected via video and presented at the Inception Workshop.
1.4	Conduct focus groups with water scientists and extension workers re how they work with farmers	Preliminary focus group topics decided Revised in consultation with PC partners Focus groups held Data analysed Report (findings 1.1, 1.3 1.4) for all stakeholders in preparation planning CPSW	November 2017	PL, SSRI and PCRWR teams conducted 8 focus group discussions from the 3 provinces with extension agents, water engineers and scientists. Full report shared. Very successful outcome with enthusiastic, frank and open discussions as presented at Inception workshop – **Appendix 9**
1.5	Synthesise and publish all findings from objective 1 and the extent to which this objective has been addressed	Annual report to ACIAR	July 2018	
	Following documents have been prepared: Successful elements of existing on-farm irrigation water management initiatives in Pakistan (literature review report + abstract – refer Appendices 1-7) Sandra Heaney-Mustafa, Francesco Sofo, Mukaddas Afzal, Zubair Anwar, Bareerah Fatima and Faizan ul Hasan. "*Bridging Farmer and Researcher: Extension through the Eyes of Agents in Rural Pakistan",* Journal of International Agricultural and Extension Education. Volume 25, Issue 3, pp:111-124. doi: 10.5191/jiaee.2018.25308 Faizan ul Hasan, Bareerah Fatima and Sandra Heaney-Mustafa. *A critique of successful elements of existing on-farm irrigation water management initiatives in Pakistan*. Agricultural Water Management, Volume 244 (2021) 106598, ISSN 0378-3774, https://doi.org/10.1016/j.agwat.2020.106598".			

PC = partner country, A = Australia

Objective 2: To develop and test farmer tools for on-farm soil water, nutrient-monitoring and supply chains, together with a system for collecting and collating the data for collaborative, problem-based learning (35%)

no.	Activity	outputs/ milestones	completion date	Comments
2.1	Develop new or refine existing farmer tools and technologies	Functional tools ready for use with farmers	March 2017 and on-going	
	(Ist Annual Report) Refinement of existing tools is ongoing PCRWR also prepared a comprehensive review of the current water and irrigation system in Pakistan which was circulated prior to Inception workshop and is embedded at 1.1. A presentation was also given at the Inception Workshop **Appendix 10** (2nd Annual report) Refinement of Chameleon sensor and reader is being made by CSIRO from time to time based on the feedback of users in Pakistan. VIA page is also being updated. Developed PCRWR's capacity for local repair of Chameleon readers.			
	PCRWR staff training re tools and CMS in Australia (in conjunction with activity 3.2)	Effective trained personnel competent in use of tools and database	March 2017	
	5 PCRWR staff visited CSIRO Canberra for training in use of new tools SOFT and SSRI teams were also present and found the visit to be highly successful and beneficial. A total of 20 participants were involved in the training. PCRWR 1 woman and 4 men SSRI 2 women and 3 men this number included one woman and one man who were current UC doctoral candidates SOFT 5 women and 5 men Report and Program at **Appendices 11 and 12** respectively			
2.2	Build a relational database that links irrigation schemes to farmers to fields to monitoring sites within fields Develop wi-fi enabled readers for automated data collection	Database built and available to all partners Data collection automated Data visualised – farmers' management stories documented	March 2017 and on-going	

Data being collected from sites in all 3 provinces in Pakistan with the assistance of SOFT personnel as well as PCRWR staff in those areas.

Readers operational and feeding data back to database.

Virtual Irrigation Academy support person in PC country trained to support farmers and PC partners as project continues.

The tool distribution strategy

- Since the beginning of the project, it was agreed by the project team tools are for farmers in project sites and are for free
- Before and during the project a total of 50 sensor arrays were given to SOFT facilitators, researchers of PCRWR to conduct research on tools for their own learning
- On three pilot sites tools were distributed at the rate of; 10 sensor arrays and 2 readers (fullstops did not arrive to Pakistan by that time)
- Among 46 trial sites tools were distributed at the rate of; 5 sensor arrays, 1 reader, 3 fullstop, 1 EC meter and 1 nitrogen strip box, 5 tensiometers
- The number of readers, EC meters and nitrogen test strip was kept 1 per village site to enhance the interaction and partnership among the farmers
- The entire tool distribution strategy was discussed and decisions were made in monthly or quarterly project team meetings
- Since the number of tools were limited and are free of cost, it was decided that tools must be given to those farmers who are willing to experiment on them and protect them. However, still many tools were lost, stolen, damaged, but a large majority is being used repeatedly over the project duration
- In order to give tools to other researcher/ university meetings it was decided in the team meetings that submission of a research proposal is necessary to get the tools for experimentation purposes

Farmer Experience Documentation Strategy

- Two types of data were collected; manual and automated. For Fullstop a data collection tool was designed replicating the VIA.Farm data requirement of Fullstop
- Once the tools are installed, a VIA installation datasheet is supplied by the facilitator of a particular village so that farms and irrigation bays are created on VIA.farm
- VIA IDs were created for facilitators working closely with farmers to manage/view farmer uploaded data and report in case of any error
- End of season VIA data collection was made documenting farmer's experience of using the tools during a particular cropping seasons. With each annual project report, a VIA report is always provided summarizing the detail on how farmers are dealing with tools. All these reports are submitted along final project report.
- All the manual tools used for farmer data collection were replication of VIA.farm data requirements.
- It was a challenging task to attract farmers to use small and limited number of tools which were so new to them. Therefore, VIA competition were organized awarding farmers with maximum number of uploads and data documentation on VIA farm.
- Female farmers were very much encouraged to use the tools. In almost each village site at least one chameleon sensor or tensiometer is installed in the Kitchen garden managed by females
- In this entire farmer documentation strategy, all field facilitators of SOFT and PCRWR field teams played a great role. Each field team member shared the documentation of his respective village site.

Tools repair strategy

- Tools were experimented on sites with 2-3 crops over a season so there was a high tool damage frequency during harvest or decommissioning the tools every season.
- Damaged readers were repaired by PCRWR
- Damaged sensor arrays were repaired if either of the sensor is damaged or replaced in case of complete damage. The replacement was made on the merit and interest of farmers.

Current Situation of Tools

- Farmers who have tools saved after the repeated removal and installation are still using these tools and demanding to bring these useful tool in the market
- Progressive farmers are also demanding these tools
- As per our latest survey with farmers and end line survey approximately 40% of farmers are still using the tools.

Refer appendices 14, 14A, 15 and 16

Table 1:Tools Provided from Australia to Pakistan and then to project sites

Sr. No.	Tool Name	Numbers	Comments
1	Chameleon moisture sensors (Supplied from Australia)	450	400 sensors are distributed to farmers in all 49 project sites, whereas 05 sensors are distributed to researchers involved in the project activities. Out of these numbers 50 sensors were given to researchers for their own learning
2	Chameleon field reader (Supplied from Australia)	80	A total of 70 Chameleon readers are provided to 49 project sites whereas 10 readers are being used by researchers in all three provinces.
3	Tensiometer (Supplied by PCRWR)	250	Tensiometer manufactured in PCRWR were prepared and transported to PCRWR regional offices for further distribution to SOFT
4	FULLSTOP (Wetting Front Detector) 200 Fullstop paired were supplied from CSIRO	160	FULLSTOP are distributed to all sites (older and new). Farmers have installed it and shared some good results. Fullstop were also provided to researchers to conduct research
5	Nitrogen Test strips (18 boxes were procured from Pakistan rest were supplied from Australia)	50	Nitrogen test strips are also short in the local market due to import issues
6	EC meters (Supplied from Australia)	60	EC meters are supplied along with FULLSTOPS to the project sites
7	VIA Farms (Created by VIA Manager, Pakistan)	60	These IDs were created for all field facilitators for virtual data management on VIA.farm. A different strategy water opted for documenting farmer stories.

Table 2: Model-wise of supply of tools to site

Tools	SOFT (CPS, VM and FILM)	PCRWR (Discovery Learning and Researchers)
Chameleon Sensor	316	125
Chameleon Reader	63	31
Fullstop	100	60
EC meter	40	18
Nitrogen Strips	30	13
Tensiometer	150	100
VIA ID's	11	8

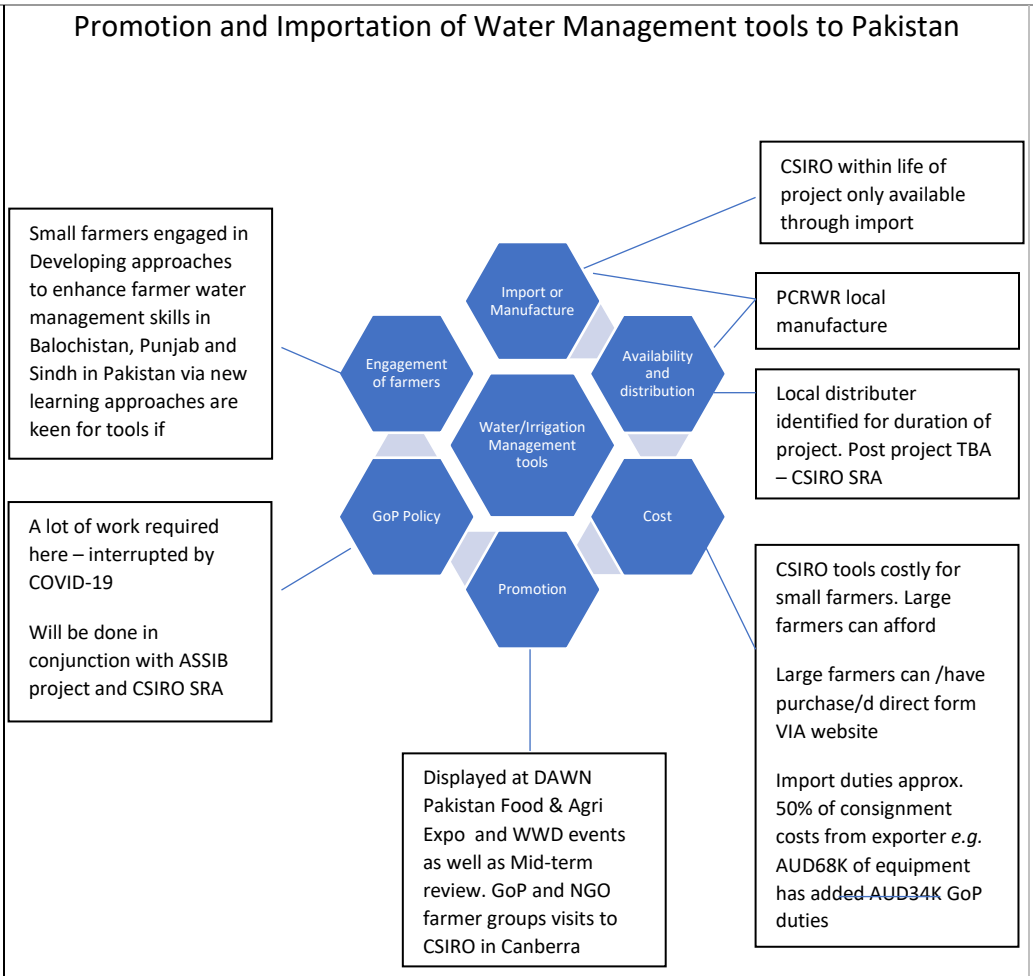
2.3	Evaluate the suitability of the farmer selected tools introduced to farmers in the 3 models to the on-farm situation .	Semi-structured interviews conducted and narratives collected from farmers Reasons for technology selection and implementation challenges documented Process of change analysed (through log books) (A, PC)	2017/18 2019/20 July/December 2017 Nov/Dec 2018 03-06 Dec, 2018 March/Dec 2019 March 2019 and March 2021	
	Evaluate the efficiency of the tools and technologies in improving on-farm water and nutrient management Evaluate the efficiency of the tools and technologies in improving on-farm profitability and household livelihood Farmers will quantify crop yields and estimate input costs	Data from relational database analysed Agronomic and economic analysis (PC) Data from relational database analysed Agronomic and economic analysis **(PC)**	July 2018 /19/20	
	(2nd Annual Report) Chameleon moisture sensor has different results in each site of the projects. Following are the brief outcomes of chameleon use in different crops: For Bahawalpur and Sargodha in Punjab cotton crop, 2-6 monds increase in yield with saving of 1-3 irrigations For Bahawalpur in Punjab and Tando Jam in Sindh Wheat crop, 1-5 monds increase in yield saving at least 2 irrigations, and providing cushion to farmers during severe canal water crisis during the season For Tando Jam in Sindh Banana crop, reducing/skipping three irrigations have not impacted crop produce negatively For Tando Jam in Sindh sugarcane crop, reducing/skipping three irrigations have increased production by 500 monds/acre. • There are big challenges to gain full benefits of these useful tools: • An impact of chameleon use for only one season is not sufficient to draw its usefulness. • Chameleon moisture sensors are becoming popular among farmers so they should be available in market. • The adaptability and understanding of this tool require a thorough attention of facilitators and farmer including frequent experimentation on tool use. Focus Group discussion conducted by the PL on March/April 2019 field trips revealed that most farmers were able to explain how the chameleon, wetting front detector and nitrate test stirps could be utilised to manage irrigation and fertilisation. Farmer at each site could explain that fertilising after irrigation was better as the nitrate strip indicated that there remained fertiliser at root level and it was not all washed away as when they used to fertilise before or at irrigation. Farmers were also able to explain how they used soil moisture levels			

	detected by the chameleon in conjunction with inspecting the crop for colour and strength of leaves to make a decision to skip or reduce the time of an irrigation. In all villages farmers not in the project who did not have access to tools were following the practices of those farmers who had tools – though others were waiting to see over time what the results were. In the banana crop for example farmers decide to set aside a control plot where they practiced their usual irrigation pattern and one with installation of chameleons. The sowing method, fertilizer application and other agronomic practices are same for in both conventional and chameleon field. However, using chameleon moisture sensors, farmers have saved 3 irrigations on Banana. The daily Chameleon probes placed at 15, 30 and 45 cam depth readings showed the farmers there was still moisture at the deeper levels and so water was not required.			
2.4	Evaluate the value and suitability of data collection for relational database introduced to farmers in the 3 models to the on-farm situation Semi-structured interview data descriptive analysis	• Ability to connect to connect reader to smartphones is still a problem, which is causing data loss even stored in chameleon moisture sensor. • With increasing project sites, issues regarding security of tools becoming very prominent. In 03 sites of Sindh, 5 out of 30 sensors are stolen whereas the same number has been damaged by predators in the field. • Chameleon moisture sensor is a farmer friendly tool, but a farmer requires more than 1 cropping season to completely understand it. Due to limitation in numbers of sensors to this projects' farmers, these tools are not available to farmers more than two cropping season. • Taking out chameleon sensor by the end of the season is a risk, and leaving it in the field prior to land • preparation for next crop is a bigger risk. Data uploaded on VIA was simultaneously done by the farmers. The VIA Journey and VIA Reports A**ppendices 14,14A,15,16**		
	The analysis regarding the use of **chameleon and tensiometer** was performed to see their usage status and effectiveness. The **results indicated that most of the participating farmers viewed these moisture monitoring tools effective and useful but not ready to adopt it due to wara bandi system of canal irrigation system in Punjab and Sindh (water scheduling).** Actually, as per irrigation schedule, canal water was provided after every 15 or 8 days and time allocated for one acre of land ranged between 15-25 minutes. If the tools indicating sufficient moisture before 2 days of his water turn and farmer leave his irrigation turn and before the next turn if tools indicating shortage of moisture in the field then from where they will irrigate their fields. Actually, **this situation has created a fear among the farmers that if they left their turn then from where they will irrigate their crop**. Although, the farmers having supplementary sources (tube wells) they don't want to leave their canal water turn due to high cost of tube- well water and poor quality of underground water. So, due to these issues, majority of the farmers were reluctant to use moisture monitoring tools. Similarly, farmers were also questioned about the **effectiveness of full stop (Nitrogen monitoring meter).** Overall, **farmers had perceived it beneficial for them, however at the same time they adhered to their traditional practices of fertilizer application rather than adopting the improved practices. Basically, it was a matter of attitude and behavior, further due to small land holdings they don't want to take risk.** At the time of this survey they were still at the testing and verification stage. So, to some extent farmers reluctance was understandable because majority of them had not been provided full stop and testing strips. However, **some farmers have reported saving of 1 bag of urea from wheat and 3 bags from onion crop by effectively using the Full-Stop device**. The key issue for farmers was the limited supply of tools and other equipment and until a secure import route can be established this will remain a limiting factor. A steady supply at a reasonable cost for small farmers needs to be established. An attempt to address this is being made with the SRA that CSIRO is establishing. This will however require GoP cooperation to ease costs of importation and to establish policy at provincial and national levels to encourage farmer adoption though farmer and multiple stakeholder friendly adult learning approaches such as FILM or its successor Rural Research Engagement and Learning Model (R^2EaLM).			

	Farmers will quantify crop yields and estimate input costs Evaluate the efficiency of the relational database in improving on-farm water and nutrient management	Agronomic and economic analysis (A, PC)	June 2018 June 2019	IFS-WESA sheets filled by farmers during the cropping season were collected and compiled into VIA-Evaluation sheet to determine the performance of tools in farmer's field. Draft Publication A joint publication analysing performance of tools along with learning models. Combining data from social survey, VIA farmer database and narratives from SOFT is under preparation.
	Evaluate the efficiency of the relational database in improving on-farm profitability and household livelihood Surveys at activity 4.1 baseline, midline and endline.	Agronomic and economic analysis (A, PC)	July 2019	Draft Publication A publication is being drafted analysing data collections during 2017 Kharif to 2019 Rabi season. Farmer experience of VIA. The research article describes farmer's learning journey for combined management of moisture and nutrients. Work continues on preparation of both publications though delay is anticipated due to project completion and staff deployment to other work
2.5	Investigate the opportunities and constraints of tool import and production in Pakistan, including costs, and identify producers	Feasibility established by dialogue with potential importers and producers Feasibility report to ACIAR 1 and all stakeholders Identification of equipment needed and sources Equipment ordered from local suppliers Local manufacture of equipment items investigated and commenced (A, PC)	June 2018	
	The PL met with CEO Mr Ruman Wasae of **S&A Agri Sciences (pvt) Ltd.** who was recommended by Dr M Kazmi ACIAR Country Manager and following discussions with CSIRO, PCRWR, SSRI and SOFT it was agreed S&A Agri sciences would facilitate the import of tools to Pakistan for the purposes of research in the project. The contract was established in May 2017. The agent was not forthcoming with the cost involved in securing the import of tools into Pakistan so this limited the possibility of determining the costs of subsequent imports. However under the SRA by CSIRO we have been advised the duties on importing AUD69K would be AUD 34K – this will be further investigated in the SRA. The Chameleon was manufactured by CSIRO at this time and so it would not be commercially available within the life of the Project. Funds were available to establish demonstration plots for villages and the surrounds. Tools would be promoted at DAWN Pakistan Food & Agri Expo each year as well as World water day events hosted by the Project However, local manufacture of tools except for tensiometer is not yet made possible. Current discussion with CSIRO and market researchers investigating commercial viability for Chameleon.			

A mechanism for importing tools to Pakistan through private enterprise is being explored. A proposed Grand Challenge for young entrepreneurs linked to the Office of Research Innovation and Commercialisation (ORIC) at various universities is also being explored.

The feasibility study and SWOT analysis were not completed due to the inability of staff to travel in the COVID-19 pandemic. A schematic below outlines key points for consideration – this will be further investigated in the SRA.



2.6	Synthesise and publish all findings from objective 2 and the extent to which this objective has been addressed	Report to ACIAR Publications	May 2017,18,19,20	

Annual Reports to ACIAR

Mid-term Review report to ACIAR 2018

Publications:

1- "Bridging Farmer and Researcher: Extension through the Eyes of the Agents in Rural Pakistan"- Published in JIAEE: Journal of International Agricultural Extension Education.
2- Draft paper entitled "women participation in agriculture: contribution towards household income in Pakistan"
3- Draft paper entitled "Access and usage of Modern technology among rural women in Sindh, Pakistan"

Draft publication is under process "experience based learning on small and medium landholders on combined management of moisture and nutrient through VIA"

PC = partner country, A = Australia

Objective 3: Develop and test effective, efficient and scalable approaches to improving farmers' irrigation water and nutrient management skills 35%

No.	Activity	Outputs/ Milestones	Completion date/ period	Comments
3.1	EBSCO literature search and analysis Critical analysis of extant research regarding key elements of successful existing Pakistani farmer education	Background paper 1 to partners for comment (A, PC)	January 2017	Review embedded at 1.1 Appendix 1 and 4 above.
3.2	UC, CSIRO staff development in value management (VM) and organic research collaborative development (ORCD) approaches UC adult educators refine the 3 suggested different learning approaches	Workshops held and evaluated (A) Models refined for presentation to farmers, all project partners and relevant stakeholders at planning collaborative problem-solving workshop (CPSW)	September 2016 November 2016 March 2017	UC project staff experienced a VM workshop and as result it was decided to enhance collaboration with other water project teams by holding a cross team VM workshop for this purpose The four water related projects in Pakistan/India inclusive of CSIRO staff participated in a VM workshop with the result of improved communication and collaboration between teams PC partners participated in a 3 day VM workshop and then the SOFT participants spent 2 additional days in specific training in the VM process and aspects thought most suitable for the Pakistan context. Refer **Appendix 17**
3.3	Workshop the findings from objective 1 with farmers, extension agents and facilitators and other key stakeholders at planning collaborative problem-solving Workshop	Site selection, dates and participants decide in collaboration with PC partners Participants invited/ venue booked Travel/accommodation arrangements for participants finalised Briefing documents to participants Program finalised Workshop held and evaluated Report to ACIAR and partners A and PC on CPSW (A, PC)	March 2017	CPSW methodology was presented at Inception Worksop which also utilised the CPS process **Appendix 18** Criteria for site selection were determined at Inception workshop and refined during PC teams A visit. **Appendix 19** **Appendix 20** contains the report of the Inception workshop overall
3.2	Conduct experiential VM and ORCD workshop for 10 SOFT facilitators and 4 PCRWR provincial staff (male and female) in Australia (details below) Introduce new tools for use in learning models	Capacity building of 10 SOFT facilitators and 8 staff members of PCRWR & SSRI for in the learning approaches and develop competence in use of new tools	20 Feb –03 March 2017	18 PC delegates from PCRWR (5), SSRI (3) and SOFT (10) visited Canberra for 2 weeks to undertake training in VM, CPSW and Discovery learning techniques and get familiarisation and training in the use of various water and irrigation tools developed by CSRIO. These techniques were employed in a pilot study in June 2017 and evaluated. Refer Appendix 11

				SOFT has also conducted a training program for master facilitators in each province and has included PCRWR and SSRI staff in the program. Reports at **Appendices 21-25**
3.4	Refine 3 learning approaches and resources as required by particular model	Learning approaches determined and ready for use Draft manuals prepared and learning resources available as determined for each approach (A, PC)	March 2017	Manuals were prepared on the CPS and VM methodology in English and translated in to Sindhi and Urdu – these have now been superseded by the FILM manual and in association with the Adapting to salinity in the Southern Indus Basin (ASSIB) project the model has been developed to incorpate research and co-inquiry.
3.5	Activity: Conduct pilot and formative and summative evaluation of the approved learning approaches with farmers to assist with design and development phase of models and program Compare 3 learning approaches for acceptability to farmers NB number of farmers to be determined at planning CPSW when learning approaches are confirmed		Pilot commenced Models piloted and refined – manual/s published if and as appropriate Capacity in water management built in farmers (A, PC)	

The project trialled three different adult education models – Discovery Learning, Value Management and Collaborative Problem Solving - in several villages across three provinces. Farmers and facilitators provided feedback on the various models after 3 cropping cycles (20 months). A total of 22 farmers, 9 women and 13 men, were interviewed and 19 facilitators 7 women and 12 men were surveyed. Overall the CPS and VM models appear to be well understood by facilitators and they have good ideas about how to go about introducing the models in new villages when required. The various models appeared less understood by farmers. Farmers did however report on reduced irrigations and fertiliser use under all three models.

Farmers, women and me, and facilitators pointed to the benefits of the models in building collaboration, increasing awareness of valuing and using local resources. Also, notions of problem identification, planning and implementing plans has been taken up by most farmers and the women in the villages with an increase in kitchen gardening as a result under the VM or CPS models. The DL model like CPS and VM encourages farmer experimentation but is not inclusive of women.

Challenges and opportunities were articulated in respect of available time for farmers to participate and a solution being to get the farmers to nominate the times for sessions. The complexity of the VM model was noted and some ideas posited to modify it for the benefit of facilitators as well as farmers. For farmer to farmer teaching, the facilitators generally felt most farmers were not yet ready to engage with this but could identify some willing and able to take the next step. **Complete report at appendix 25A.**

The strengths of each model were analysed and the research team decided to amalgamate the models into one new model utilising the best aspects of each. Key aspects from each model were retained in FILM.

- From CPS the workshop to identify and prioritise challenges and then develop action and evaluation plans was retained
- From VM the SWOT analysis was incorporated in to the priority setting phase of the CPS workshop to identify the most feasible, cost effective and efficient action to embark upon.
- The DL method was then utilised with the support of facilitation in the action and evaluation stages of farmer experimentation and learning.

Conference presentations summarise the process of arriving at the Farmer Integrated Learning Model (FILM) which was subsequently used at all sites as the women and men farmers preferred model. **Appendices 26,27 and 28**

		Posters and presentations have been exhibited at TropAg conferences 2018 and 2019; Australian Pacific Extension Network (APEN) conference in 2019 and the MODSIM conference in 2019. Covid has impacted on further event participation. FILM is also being used for farmer to farmer facilitation in neighbouring villages and in famer Led Research as indicated in SOFT **Appendices 29 and 30 – further details re this are at 3.13.**		
3.5.1	Project inception workshop	Development of Year-1 action plan for pilot testing of new approaches (A, PC) UoC, PCRWR, SSRI & SOFT teams participated	2-3 Feb. 2017	Developed draft action plan for pilot testing of new approaches to enhance farmer water management skills Appendix 20 as at 3.3 above Site/District/Village selection criteria developed in the inception workshop Appendix 19 as at 3.3 above
3.5.2	Training of Trainers/Facilitators for pilot phase in Bahawalpur	Training of the District Master Facilitators (DMFs) of SOFT and field staff of PCRWR in learning approaches (VM, CPS & DL) and is use of the irrigation water management tools/techniques.	16-23 April 2017	19 persons participated; [SOFT (4 M & 3 W), PCRWR (6 M), SSRI (1 M & 1 W), Students (2 M) & 2 local farmer facilitators] as at Appendix 21
3.5.3	Site/village selection for pilot phase in district Bahawalpur	Selection of 3 villages (one for each learning model; VM, CPS & DL) in district Bahawalpur	15-17 April 2017	Team of 8 persons; SOFT (3), PCRWR (4) & SSRI (1) surveyed 8 villages and finalized 3 villages (77-DB for DL, 86-DB for VM & Basti Karani for CPS). **Appendix 31**
3.5.4	Farmer profiling in the villages selected for CPS and VM models	To know personal characteristics, landholding and perceptions of the men & women farmers participating in CPS and VM learning approaches.	05 May 2017 (Basti Karani) 08 May 2017 (86-DB)	Men and women farmers of villages 86-DB (VM model) & Basti Karani (CPS model) were interviewed and registered by SOFT facilitators with: name, age, education, landholding, experience etc. **Appendix-32**
3.5.5	Pilot testing/ implementation of CPS and VM models in Bahawalpur	To test and practice the CPS and VM models with farming communities In Pakistan	Kharif crop season (May-Oct. 2017	An overview of all training sessions is at **Appendix 32A** and reference to specific Appendices for each session are made within. For this session refer **Appendix 33** 2 villages were included one for VM with 15 men and 8 women farmers and one for CPS with 14 men and 9 women farmers. **On avg. saved 2 irrigations with 2-6 Maunds increase in yield** (VIA report at Appendix-16) • A woman installed Chameleon and followed its outcome for irrigation of her kitchen garden • A farmer compared 3 Mung Bean sowing methods (bed, drill & broadcast). Drill sowing proved better. • Cotton irrigation management with Chameleon support and by furrow & bed-sowing
3.6	Prior to pilot, conduct surveys of all households	Preliminary questionnaire designed	December 2016	Preliminary questionnaire was developed

	(details below) for the farmers involved in the approved learning approaches to establish a socio-economic baseline	Piloted and revised Questionnaire implemented (A, PC)	January 2017 May 2017	-Farmers were interviewed and their feedback was documented -Data was analysed and report write up was completed -Report was compiled and shared with the team **Appendix 33** and presentation at Appendix 8 SSRI team have conducted baseline survey using CommCare (MAD) application.. Focus Group Discussions (FGDs) and interviews of farmers were conducted with farmers for project performance and their involvement in the project activities. As outlined at 2.3 above
3.7	Identify farmers from each pilot willing to act as farmer-to-farmer (F-F) facilitators (3 to 5 from each model) Conduct F-F engagement pilot and complete formative and summative evaluation of the 3 learning models Compare approved learning approaches for effectiveness of enhancing farmers' facilitation skills and abilities to engage other farmers Indicators to be developed in collaboration with farmers and Pakistani partners	A small group of farmers identified to become farmer-to-farmer facilitators (A, PC) Farmers successfully engaged by farmer facilitators and have water and nutrient management skills enhanced (A, PC)	September 2017 March 2018	Only two farmers (one male and one female) were identified as F-F facilitators from CPS pilot village. This was deferred to give farmers an additional season to familiarise themselves with the learning model with which they engaged. Subsequent to the introduction of FILM to engage farmers who on interview after one cropping cycle felt more comfortable and understood the way of learning **89 men and 64 women farmers were identified to act as farmer facilitators**, trained in the FILM technique, who subsequently **enrolled 437 men and 307 women as trainees.** These farmers developed and conducted experiments on the issues important to them. In total **260 experiments (126 by men and 134 by women) and practical activities were reported from 32 villages.**
3.8	Collect water and nutrient management data and narratives from farmers and other key informants on water management practices using web-based CMS) and SOFT log books Quantitative analysis of uploaded data Descriptive analysis of narrative data	Demonstrated farmers have learned through use of relational database (A, PC)	Winter 2018-19 completed	
	Majority of the farmers who installed the water tools appreciated the function of chameleon sensors in monitoring soil moisture and to support/assist decision for irrigation of the crops. Most of the them rated it user friendly but a few consider the use of tool time consuming specially data downloading and uploading.			

	Data was collected simultaneously by the start of cropping the reporting period. Manual datasheets for keeping the record of FULLSTOP data was collected and time to time collected. 1. The VIA farm has a default questionnaire against each sensor. This information was converted into a paper based sheet including a few more questions just to understand the scenario of the farm and farmer (sample sheet is attached) 2. With the help of facilitators/field team farmers recorded their experience of using chameleon moisture sensors/full stop in comparison to irrigation decisions in another field of the same crop and similar sowing method, but without chameleon. 3. Comments from the farmers were also collected as per their general observations, issues they faced during the cropping season and what further improvements they desire in tools. 4. Once received these survey forms are analyzed and compiled into a report. 5. A synthesis/analysis is being compiled in form a paper which is with Dr Richard presently Although we as researchers are not able to address all the problems of farmers such as water availability, laser land levelling and support for watercourse improvements, we were able to understand the situation of farmers during a particular cropping season. For instance, unprecedented rainfall during the 2019-20 wheat crop season, Heatwave during 2018-19 wheat season, the Covid 19 situation, the impact of Locust swarm. Through these analyses we were able to learn what were the possible limitations in the technology learning process. Sometimes it is not the fault of technology itself or the farmer's willingness. End of Season data collection was made and data received from all of the sites in Sindh and Punjab province. Data analysis in relation to data uploaded on VIA was made and a report was compiled as at Appendix 15			
3.9	Interviews with farmers to enrich data gathered during and after pilot Descriptive analysis of narrative data	Deeper understanding of effectiveness of the approved learning approaches	March 2019 December 2019 March/April 2021	ACIAR sponsored intern has done qualitative interviews with men and women in Sindh and Punjab (Bahwalpur). As at Appendix 13 above. PL conducted in depth interviews in Sargodha and Faisalabad. ACIAR sponsored intern 2 has done qualitative interviews with men and women in Sindh and Punjab (Bahwalpur and Sargodha). Report to be finalised June 2021
	Baseline survey: Data was collected from project sites in all 3 provinces in Pakistan with the assistance of SOFT personnel as well as PCRWR staff in those areas. Their feedback was documented. On average data was collection from 10-15 males and 10-15 females from each village as per pattern active male and active female of same household. Data was collected on a sequential basis commencing with 3 pilot villages in Bahawalpur then in 3 villages of 3 districts in each province at the start of each cropping season. This was repeated again by adding 3 villages in each district in the new seasons. An overview of Baseline data is at **Appendix 8A.** Individual provincial reports are available on request if required.. **Midline survey:** **Farmers from project sites were interviewed regarding learning models, understanding of learning models and its effect on their water management skills. Their feedback was documented. On average data was collection from 10-15 males and 10-15 females from each village as per pattern active male and active female of same household. Data was collected in a similar rotational pattern. Detailed reports are available if required.**			

Appendix 8B offers insight into changes between base and mid line data collection regarding participation and decision making. This report will be prepared for publication by the SSRI team in due course as two papers; 1) Comparison of the different extension/learning models and 2) Use of the tools.

FGDs (Focus Group Discussions) with farmers;

Focus Group Discussions (FGDs) and interviews of farmers project team members and project leader, when of field trips, were conducted with farmers for project performance and their involvement in the project activities.
FGDs were conducted in all districts except Balochistan due to travel restrictions

Appendix 8C reports on a field trip where Focussed discussions revealed changes in perceptions and attitudes of farmers both women and men. Both men and women noted that water was now more openly discussed and that there was greater cooperation and collaboration between farmers to utilise water more wisely.

Farmers showed an understanding that it was poor use of resources rather than an actual shortage of water that was one of the main issues.

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One-on- One interviews with farmers between ACIAR funded interns and social sciences team and Project leader in Tandojam, Sindh and Sargodha and Bahwalpur, Punjab.
Note due to COVID 19 the 2021 interviews were done via ZOOM and had been a result of a postponed planned field trip to take place in March 2020
The purpose of the research conducted by the Interns was:
2019 – The aim of this report is to outline the degree of success or otherwise of the *Developing approaches to enhance farmer water management skills in Balochistan, Punjab and Sindh in Pakistan*' project has been for women and men farmers, as at March 2019, with a view to making improvements for the remainder of the project.
The evaluation sought to answer three key questions through these interviews:
1. What benefits have been experienced by women and men farmers engaged in the project, if any?

2. To what extent have rural farmers been impacted?

3. What is the likely sustainable impact of the project?

Report from 2019 Intern field trip at Appendix 13 – a summary of findings is below
55 interviews were conducted across 15 villages as follows:
 20 interviews in five villages in District Bahawalpur, 10 women and 10 men;

 11 interviews in three villages in District Nawab Shah, 6 women and 5 men; and

 24 interviews in seven villages in District Tando Jam, 11 women and 13 men.
Methodology for interviews was **Appreciative Inquiry and Most Significant Change**

- Farmers in villages where the VM and ORCD/CPSW models were being implemented were experiencing markedly greater improvements than those in villages under the DL model. In particular, results such as shared decision making between women and men, seed harvesting, helping behaviour to extend skills and information to farmers outside of the project, and sustainability of learning without the use of tools are much more pronounced in VM and ORCD/CPSW villages. In DL villages, impacts are limited, and people are less engaged in the project.
- One major subject that could not be adequately captured through the interview data was women's level of autonomy. Men across districts are, however, expressing an increasing appreciation of women. Notably, in villages under the DL model, women's involvement was usually referred to in the light of men permitting women to do things, rather than indicating improvement in women's autonomy.
- 50% of those interviewed engaged in Kitchen gardening which has been a major positive impact for women across all three districts. Women, and in some cases men, almost universally described the positive effects of kitchen gardening including saving money, making money, saving time, and having a healthy home grown food source to feed their families. The inclusion of kitchen gardening in the project has led to greater collaboration between women broadly, and between women and men in many villages. Via the various workshops women identified poor health of their children due to not having fresh produce and also in the past women had done kitchen gardening but the skills had been lost. So with the guidance of SOFT facilitators in all villages including DL those women who were

interested were supported in establishing gardens within their homes or on adjacent plots of land the men of the household gave them access to. Seeds were given to them for the first season and thereafter they saved seed for the following seasons.

- With respect to the **most important change, relationships and collaboration, effective water management and financial improvement each featured strongly across all regions**. This indicates that the project is having an overall positive impact on farmers in the project. When coupled with the knowledge that **many farmers within the project are disseminating information and skills to others outside the project**, it is possible to foresee that positive changes are likely being or will be experienced by some others in the broader community. The efficacy of KGs was evaluated in the interviews with women reporting a marked increase in the quality of the vegetables in terms of freshness. Households varied in size and so the savings varied accordingly from the money saved from having to purchase vegetables and the cost of fuel for a male member of the household needing to travel to markets. Women estimated a daily saving of 100-500PKR per day depending on family size. Women also commented on improved health of their children. Another advantage reported was being able to pick vegetables at a time that suited them for meal preparation and fitting it around other chores, rather than when the men brought them back from the distant market. The money saved was used for children's education, medicine and other family needs. At this stage they were not selling vegetable but sharing excess produce with others in the village.

2020 – to analyse the influences on women's engagement in the project with two objectives firstly, to elucidate the factors leading to a high level of women's engagement and secondly, to determine future practices to capitalise on those successful factors to help sustain and improve women's engagement. This was done by examining factors which help or hinder engagement and to what extent has gender mainstreaming in rural Pakistan been enabled by the project.

Interviews and focussed discussions were undertaken via Zoom or Teams due to Covid travel restrictions

Methodology utilised was Most Significant Change as well as focus groups and individual interviews

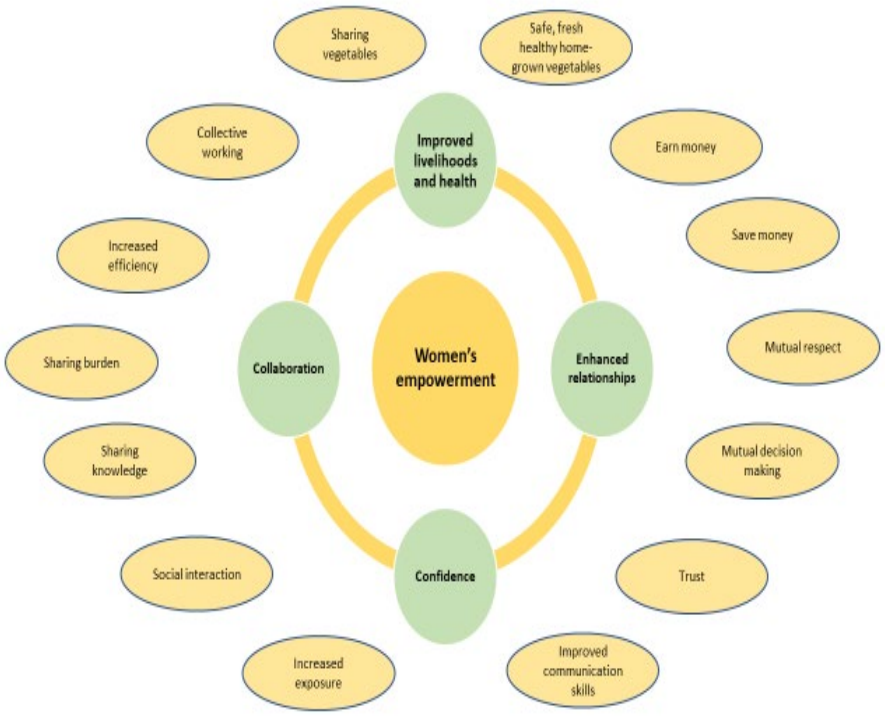
Summary of findings – full report is at Appendix 13A

One of the most crucial factors for women's initial engagement in the Project was deduced to be the support of their family (mainly their husbands), and the support of the host family was also identified as an enabling factor. Conversely, lack of support from the men, or not obtaining "permission" from the men as well as lack of interest and initial knowledge could hinder women's engagement in the Project.

The factors that could sustain and improve the continued active involvement of women were identified as direct project benefits of increased knowledge and skills, financial incentives, safe, fresh, and healthy vegetables as well as collective working with the families and other women in the 2 communities. Improved health (physical and mental) of the women as a result of healthy activity was also a benefit of the Project, identified by the men. The associated indirect benefits such as improved confidence, communication skills, collaboration, mutual decision-making, and enhanced relationships, and mutual respect were also found to promote women's engagement. Many aspects of project training contributed to the women's engagement in the Project including knowledge and skills, benefits associated with working collaboratively with their families and other women in the community as well as the confidence, good behaviour, good attitude, and energy of the facilitators. Positive and negative influences of community support were discussed, but no major influences that hindered women's participation in the Project were identified. All direct and indirect benefits were strongly interlinked and mutually interdependent. Further, the broad range of advantages brought about by women's engagement in the Project such as sharing the burden, equitable access to healthy and sufficient food, and empowering the women were well-aligned with the principles of the MDG3.

Some socio-cultural and religious factors were also identified. The men's support was found to be crucial for women to continue with the Project or implement any future plans, and this heavy reliance on men's support could pose a significant sociocultural limitation to women's engagement in any activities similar to those carried out under the Project. Some limitations faced by women due to cultural practices associated with the religion were also highlighted.

The Project integrates a gender perspective and gender-relevant approaches through gender sensitivity. The women were empowered through their improved knowledge, financial strength, enhanced confidence, improved mutual decision-making and mutual respect, and diminished social exclusion through collective working, although some ongoing unbalanced power relations and inequalities remain. The Project generated several aspects of societal

	transformations as well as changes in norms, attitudes, and perceptions. Whilst women could intervene to rectify some issues through their enhanced involvement in decision-making and contribute towards equitably enjoying human rights, there were ongoing issues (outside the scope of the Project) associated with girls' education and child marriages. The Project also brought transformations in gender roles and some major shifts in men's perceptions. It could therefore be concluded that the Project had achieved a significant degree of gender mainstreaming through the gender-sensitive, gender-specific, and gender-transformative methods adopted in the Project which had penetrated through the sociocultural fabric of these highly patriarchal societies. The diagram below shows the key factors leading to women's empowerment.  Factors leading to Women's Empowerment			
3.10	Conduct piloted learning approaches in three districts (1 per province) Prior to trials, conduct surveys of all households (details below) for the farmers involved in the 3 learning approaches to establish a socio-economic Activity: Demonstrate phase (Round-1) of the learning models and program. Compare the learning		November 2017 to March 2018	Staff trained in the use of the new Commcare application for data collection were equipped with tablets on which the baseline survey was available. There were a few issues to be resolved after the initial piloting, these were overcome and data collection went smoothly. Some delays were experienced in Balochistan due to security issues. Some preliminary analysis of data was available however no conclusions can be drawn until midline surveys by the end of December 2018. Data from the pilot sites was analysed and the findings from Bahawalpur were presented at the World Water Day 2018. **Appendix 34** For an overview of all farmer Site selection activities and **Appendices 35-44** and for more specific details re each session refer to Appendix 32 A and **Appendix 45**

	approaches for acceptability to farmers			Manuals on VM and CPS learning models prepared in Urdu and English, got printed and distributed field facilitators and farmers Guidelines for SOFT Facilitators (English & Urdu) (**Appendix- 46**)
3.11	Amalgamation the strengths and best aspects of VM, CPS and DL models in to new learning approach FILM.	**Development FILM learning approach and its workshop format for facilitators and farmers**	May 2019	Developed guidelines of FILM for SOFT Facilitators (with Urdu translation) to conduct trainings for Field Facilitators and Potential Farmer Facilitators (males & females) at district level **Appendix 54**

3.12	Identify farmers from each pilot/ trial site willing to act as farmer-to-farmer (F-F) facilitators (3 to 5 from each site	A small group of farmers identified to become farmer-to-farmer facilitators (A, PC)	Kharif crop season (May-Oct. 2019)	Potential farmers shortlisted by the SOFT Facilitators to work as Farmer Facilitators for Farmer to Farmer learnings (**Appendix 55**) A total of 89 men and 64 women were identified to become farmer to farmer facilitators and be trained in the FILM model. The 89 men then engaged with 437 men farmers in F2F activities. The 64 women then engaged with 307 women in F2F activities

3.13	Conduct F-F engagement trials and complete formative and summative evaluation of the approved learning models in which the farmer facilitators participated in the successive cropping cycle Compare approved learning approaches for effectiveness of enhancing farmers facilitation skills and ability to engage other farmers	Farmers successfully engaged by farmer facilitators and have water and nutrient management skills enhanced (A, PC)	January 2019	.
	Activities started in Basti Karani and Chak 86-DB Discussions with farmers and facilitators identified strengths and weaknesses of trial learning models and it was decided to amalgamate the three into a new model – Farmer Integrated Learning Model (FILM) **Refer to section 3.5 above for details of above and appendix 25A** Developed new guidelines for SOFT Facilitators on FILM model (with Urdu translation) and planning to organize and conduct comprehensive trainings and refreshers on FILM model for Field Facilitators and Potential Farmer Facilitators (males & females) at district level. Appendix 54 **FILM** Workshops for Training of Facilitators & Farmers (organized separately and simultaneously for men & women); In the first round of F2F training occurred in 25 villages with 125 men and 62 women being trained as facilitators Details can be found in appendix 23A and detailed reports at **Appendices 56-61.**			
		Trial-1 of FILM in six districts (Bahawalpur, Sargodha, Faisalabad, Tandojam, Shaheed Banazirabad (Nawabshah) and Pishin/Quetta) Adoption of the FILM approach by farming communities in six districts of three provinces of Pakistan **Appendix 62** contains the Master facilitators overview of the inclusion in the training Developed and printed a handout & poster containing key steps of FILM approach (Urdu and English) **Appendix-63**		

Developed and shared FILM workshop format (Urdu and English) to support learnings of farmer facilitators – supplementary to full guidelines
Appendix 64

FILM sessions were conducted in 29 villages See Table-15 in Appendix 32A and Details in Reports at **Appendices 65-74**
NOTE in conjunction with ASSIB FILM has undergone a reconceptualisation as the Rural Research Engagement and Learning Model (R2EaLM) refer Appendix 74 A. this has been written with clearer instructions and a more generic focus however the examples are those used in the previous FILM guidelines.

Strengths capacities and assets within each village are researched in the pre-workshop phase when doing the community profile refer **d**

Within FILM in the first phase of the workshop all participants share with each other some of their background and the skills they have, and these are documented on flip charts. As FILM was employed in villages which had already has workshops in VM or CPS mode the assets of the farmers, men and women, had already been documented. Included in this are other who may be present in the workshop e.g. engineers, agriculture extension agents and the like. This way the assets of all in each workshop are captured so as to bring a more holistic approach as problems or challenges are subsequently identified and action and evaluation plans established.

Assets may include physical structures within a village e.g. a place to meet that is safe for women etc,

- We recognize the skills and abilities of individuals within the community and find people who are passionate about the community and who are good at making connections.
- We identify voluntary community organizations and networks and what they offer (or could offer) to the community. (These are often called associations in literature from Northern America).
- We look at what institutions (e.g. non-government organizations, not for profits, government agencies, businesses) are already connected to the community. We pay particular attention to small, local institutions.
- We look at our physical environment (both natural and built) in a new way.
- We consider the local economy in a broad way so that we include the informal economy (e.g., people swapping goods and services, voluntary work) as well as the traditional economy (e.g. production, consumption).
- And finally we appreciate the stories, culture and heritage of the community

Challenges or problems are then identified in the next phase of the workshop

Trial-2 of FILM in six districts (Bahawalpur, Sargodha, Faisalabad, Tandojam, Shaheed Banazirabad (Nawabshah) and Pishin/Quetta)

Adoption of the FILM approach by farming communities in six districts of three provinces of Pakistan

See Table-17 in Appendix 32A and details in Report at **Appendix 75**

Appendix 76 contains a detailed report on the Kharif activities

Following the review of the FILM model as previously reported at **3.5 and in appendix 25A** SOFT facilitators together with farmers in each of the villages identified those farmers, women and men, who were interested in becoming **Farmer to Farmer facilitators.** These F to F were then given some additional training in use of the FILM model prior to going to neighbouring villages to work with other farmers using FILM. As a result of their interaction farmers, women and men in the second villages (or in the case of women other in their own village if they were unable for cultural reasons to go to other villages) undertook experiments of their choosing around the action plans developed in the FILM workshops. A brief account follows.

Brief account
In total 119 experiments (55 by men and 64 by women) and practical activities are reported from 24 villages of 6 districts in the 3 provinces of Pakistan. Majority of the women experiments are pertaining to kitchen gardening. However, some have moved from homestead cultivation to large scale field/commercial experiments on vegetables and plant nursery production and value

addition of the extra produce from their kitchen gardens, raising poultry for egg production, vocational school to impart stitching skills to landless poor girls.

The reports of men show a great diversity i.e.

- use of soil nutrients and moisture monitoring tools (FullStop and Chameleon) to explore their role in fertilizer and irrigation management
- seed production of cotton, wheat and vegetables
- laser land levelling, wheat sowing on ridges and raised bed to save time and frequency of irrigations
- comparative performance of new and old wheat varieties
- intercropping of sugarcane and canola
- testing of low delta food (canola/mustard) and fodder (Rhodes grass) crops
- testing Modified Basin Irrigation System in citrus, apple and apricot orchards to save irrigations and management of gummosis disease
- seasonal monitoring of groundwater with respect to surface irrigation needs and recharging by surface moisture (snow and rains)
- moving from traditional cropping system to cultivation of high value horticulture crops
- organizing community for benefiting from government department (On-Farm Water Management) for lining of water courses
- livestock or calves rearing
- testing fertilizer applications in mixture versus solitary forms etc.

The outcome of majority of the experiments are promising and encouraging farmers for adoption at larger scale. The irrigation tools and other water conservation practices revealed about 25-30% saving of irrigation time, frequency or both. Farmers have obtained significantly higher net-income return by moving from traditional to high value crops.

In addition to the usual facilitation sessions farmer Led Experiments were conducted with support from the SOFT facilitators

"Farmer Led Research (Kharif 2020)" Report at **Appendix 29**
Summary

This is second report of informal research conceived and performed by farmers during the Kharif (summer) crop season of 2020 under FILM contains 141 practical activities (71 by men and 70 by women) including the five decided and executed jointly by farmer-families with women in lead role. The COVID-19 pandemic remained a limiting factor to Farmer-Facilitator interaction for almost all the year of 2020. However, the SOFT facilitators kept their communications alive through alternate means i.e. individual visits to lead farmers and experiment fields, telephone, WhatsApp contacts etc.

Women's main sentiment of family health, is reflected from the bulk of their activities revolving around small-scale vegetable farming either at homestead level or in nearby farmlands. Most of them adopted integrated crop management practices to reduce irrigation and chemical inputs i.e. fertilizers and pesticides, to get clean and healthy produce. However, some women took lead in family decision of intervening vegetable cultivations as cash crops for better income returns. A group of four women cooperated for raising backyard poultry of ≈100 birds for egg production and are successfully meeting their families' requirements for the last six months. Similarly, two women are getting earnings by imparting clothes stitching & embroidery skills to needy fellow women on nominal charges, as well as commercial sewing and embroidery of clothes. All such community activities are attributed to the opportunities of women gathering in FILM learning sessions/workshops.

The men's reports show relatively higher diversity such as, employments of soil-nutrients (Chameleon) and soil-moisture ((FullStop^{TM}) monitoring tools for need based applications of irrigations and chemical fertilizers; seed production of cotton and vegetables; laser land levelling, crops sowing on ridges and furrow-beds to save time and frequency of irrigations; comparative performance of cotton varieties; adopting best practices in cotton production; testing impacts of plant stimulants and soil conditioners, intercropping of vegetable and fodder crops in young orchards; testing of low delta food and fodder crops; practicing Modified Basin Irrigation System (MBIS) in citrus orchards to save irrigations and management of gummosis disease; moving from traditional cropping system to cultivation of high value vegetable and horticulture crops and nurseries; testing integrated practices pests and weeds management etc.

Farmers' top-ranked issue is the cost-effective production. The traditional crops (such as cotton, rice, sugarcane, wheat etc.) are proving unlucrative for their sustainable livelihood. So, they are always searching for new high value crops & varieties and improved production practices/technologies to reduce input costs and increase net income returns. Some farmers of

this report have obtained significantly higher net-income return by moving from traditional to high value crops. A number of the studies show farmers' potential of adopting water conservation techniques/practices i.e. laser land levelling, crops sowing on ridges and furrow-beds, MBIS etc. Provision of soil-moisture and nutrients monitoring tools were well accepted by farmers but their limited supply, inefficient technical support and mechanism of unpredictable/irregular canal water supply are noted as limiting factors for optimum outcome and impacts. However, the use of tools and water conservation practices has revealed saving of 20-30% irrigation time, frequency or both. Similarly, proper use of FullStop™ has supported to save one bag per acre (i.e. up to 50%) of nitrogenous fertilizer (Urea). With support of these tools, a banana farmer has reported saving of 12 irrigations and two bags of Urea over one-year period.

Appendix 30 Contains the Rabi season farmer led experiments.

Farmer Led Experiments were conducted in two seasons Kharif of 2020 and Rabi of 2021. Women and men had previously conducted their own experiments with the support and guidance of SOFT and PCRWR facilitators in one of the three learning models CPS, DL or VM and then subsequently utilising FILM in 2019 and who felt confident they understood FILM and were keen to share their knowledge acted as Farmer to Farmer Facilitators for women and men in other locations.

In the case of women unless they were accompanied by a male relative they were not able to go outside their village due to traditional cultural restrictions. These women thus worked within their own village with women who had not been previously engaged in the project. In some cases husband and wife teams travelled to nearby villages to work with others. **The lesson** here is that respecting and valuing local traditions and cultural dimension is key to success.

On the first visit to a new community the SOFT facilitators accompanied the women and men to introduce them to the village and to inform them about the project and the idea of F2F learning through FILM. The SOFT facilitators then sat in on the first FILM workshop as a support to the farmers. The SOFT facilitators were also able to provide links to relevant experts who could assist farmers conducting their experiments where to get advice or other support, such as good quality seed. The F2F facilitators then worked with the others to conduct their various experiments and SOFT facilitators were available on WhatsApp for questions or to offer guidance. As the outline above and the relevant Appendices 29 &30 indicate their were varying degrees of success with the experiments for both men and women farmers' attempts. What is a key factor is the FILM was easy to understand and employ by women and men F2F facilitators and the benefitting farmers felt the learning experience was respectful of their knowledge and practices and they learned some new and enhanced farming practices through the experience, as one female farmer commented *facilitators have exerted good efforts in capacity building of rural women through FILM learning approach.*

Those farmers who conducted experiments using the Chameleon and Full Stop were satisfied with not only the tools but the way their fellow farmers taught them in village 57JB Faisalabad one noted that the *Chameleon helped to know soil-moisture contents and the irrigations were carried out on need basis and the FullStop supported to monitor soil-nitrates therefore less urea fertilizer was used compared with fellow farmers. A*nother from the same village noted that the FILM *experience will support my irrigation and fertilizer management in other crops.* All F2F facilitators and the women and men they worked with valued the approach to learning and the support given by the SOFT facilitators during the process as well as the linkages the SOFT people were able to assist them with. **The lesson** here is that there forming networks during FILM workshops is important for transfer of skills, knowledge and resources and there needs to be a continuing mechanism for support for the F2F facilitators and that WhatsApp groups can well fill this need.

Experimentation with local resources is a sustainable way of smallholders' learning and skill development. Small farmers realize that the farmer-led research (experiential learning through an informal process of research and development) provides an opportunity to evaluate and adopt agriculture and natural resources related innovations, technologies, and practices.

Fellow farmers readily take up the success stories emerging from these processes, and it is considered the most common & efficient channel of information, knowledge, and skills dissemination, particularly for the uneducated segment of the rural/farming community. Many studies of reports on Farmer Led Experimentation show a significant increase in net income and considerable reduction in inputs by applying approved practices, techniques, and tools. This way of experiential learning carries the diverse potential of improved productions, yields, biodiversity, conservation of natural resources, social learning and collaboration, household income and rural livelihood.

		It is recommended for the future that capacity building of different stakeholders and institutions/organizations (agriculture research, extension, and other service providers) to apply this approach to their regular work can support harvesting its optimum benefits. An Urdu article on development and format of FILM has been published in a local magazine "Zarai Digest" Jan-March 2021 issue, published by University of Agriculture Faisalabad, Pakistan for wider circulation among extensionist, academicians, facilitators and farmers (**Appendix 77**).		
3.14	Collect water and nutrient management data and narratives from farmers and other key informants on water management practices using web-based CMS Statistical analysis of data Descriptive analysis of narratives and focus group data	Demonstrated farmers have learned and had skills enhanced through use of relational database (A, PC)		The Process of data collection is cyclic season-wise. Technical back-up support was provided to the farmers to keep tools in functional. Data collection was made both manually and Wi-Fi enabled uploads. Data providing moisture, nutrient and salt monitoring results was collected.
	Determine the bio-physical impacts of learning on water, nutrient and salt management (details below) Farmer collected data using CMS and SOFT log books Statistical analysis of data	Existing and new tools evaluated Any adaptation to existing or new tools documented and evaluated Data on crop yield, quality and water and nutrient use collected Data analysed and published in reports and journals (A, PC)		**Bahawalpur:** Chameleon installed by 13 Male farmers (wheat crop) and 4 Female farmers (vegetable plots). The comparison of wheat plots showed saving of 1-2 irrigation with 5-10% increase in yield **Sargodha:** Chak No 88-SB: 10 farmers installed chameleon sensors in their citrus orchards. Saved 1-2 irrigation with no yield loss Chak No. 130-SB: 4 farmers installed chameleon sensor in citrus (1) & vegetable (3) fields. Saved 1-2 irrigation. Chak No. 107-NB and 94-NB: Ten farmers (5 in each village) installed tensiometer. Found the tool user friendly and satisfied with its functions. **Faisalabad**: Chak No. 262-RB and 29-GB: only 4 famers installed the sensors. Saved 1 irrigation. Could not record yield data 5 farmers of these villages installed Tensiometers in their fodder and vegetable crops. They rated chameleon superior to tensiometer **Tandojam:** One farmer installed chameleon sensor in wheat and one in banana crop. Saved one irrigation.
3.15	Post learning experience evaluation of all farmers' decisions about and preferences for uptake of tools	Semi-structured interviews conducted and narratives collected from farmers Reasons for technology selection and	October 2019 February 2021	Midline data collection completed from project sites. Endline data collection completed from project sites.

	and learning experiences Interviews with farmers to enrich data gathered during and after pilot (NARC-SSRI, UC) Descriptive analysis of semi-structured interviews (e.g. using NVivo)	implementation challenges documented Process of change analysed (through relational data base and/or log books) Agronomic and economic analysis Data analysed and published in report and journals Deeper understanding of effectiveness of the approved learning approaches (A, PC)	July 2020 In Progress	Data from midline survey has been analysed, reports shared with the teams for review. Due to COVID 19 which delayed SSRI teams in the collection of end line data the comparative data analysis could not be completed. Inferences previously draw have been removed and will be replaced by a final overview. **Endline data analysis is in progress and will be available by August 31, 2021.**
3.16	Trial 2 activities 3.9–3.14 will then be repeated in the successive cropping cycle in the same districts at different sites			Trial Repeated in Each Cropping Season Reported in Activities 3.9-3.14
3.17	Trail 3 activities 3.9–3.14 will then be repeated in the successive cropping cycle in 3 new districts (1 district per province)			Trial Repeated in Each Cropping Season Reported in Activities 3.9-3.14
3.18	Trial 4 activities 3.9–3.14 will then be repeated in the successive cropping cycle in the new districts at different sites			Limited activity via ICT due to COVID- 19 since March
3.19	A second CPSW will be held with farmers, Pakistani and Australian partners and all relevant stakeholders to determine the plans scaling out the successful elements of the project in water and nutrient management and learning approaches more broadly in GoP relevant ministry representatives, water champions, NGOs)	Scale-out model developed Scale-out plans developed GoP amenable to policy to support scale out (A, PC)	Year 4 Month 1	Not held due to COVID- 19 since March – potential late 2020 or early 2021 The FILM was developed in collaboration with all team members and farmers of both genders. FtoF facilitation has taken place to scale out to other villages in the study districts. **Refer to 3.13 and appendices 29 and 30 for details of FtoF activities** Stakeholder workshops have been held in all districts which have included government representatives from local, provincial and federal levels. A champion is now needed to liaise with and encourage government support. Dr Bakshal Lashari who is the National co-ordinator for the the new Adapting to Salinity in the southern Indus Basin (ASSIB)project may be well placed to assume this role as the model is being utilised and further developed in that project

3.20	Synthesise and publish all findings from objective 3 and the extent to which this objective has been addressed	Annual report to ACIAR	July 2017 July 2018 July 2019 July 2020	1st Annual Report 2nd Annual Report 3rd Annual Report 4th Annual Report

PC = partner country, A = Australia

Objective 4: To identify the effects of improving farmers' irrigation skills on irrigation profitability and social capital of farming households (20%)

no.	Activity	outputs/ milestones	completion date	Comments
4.1	Base midline and endline surveys conducted for objective 3 will collect data on increased productivity and profitability. Post farmer learning experience evaluation of all households to determine changes to socio-economic circumstances of small- to medium-sized farming households and communities Focus groups with eight households at each project location to get deeper understanding of changed circumstances Case study of 3 households at each project location (1 from each learning model) to determine household changes and community relationships over time – this will be linked to relational database information collected throughout by the farmer	Comprehensive economic and agronomic analysis (A and PC) Preliminary midline questionnaire designed Questionnaire implemented data collected Focus Groups Conducted Portfolio on household gathered Data analysed and published in reports and journals (A, PC)	During May 2017-June 2019 During June- October, 2019 February 2021	Baseline survey of all the villages selected in 1st, 2nd and 3rd rounds has been completed, data processed and reports drafted and shared with the project teams. Midline survey of selected villages from 1st, 2nd and 3rd rounds has been completed, data processed and reports drafted and shared with the project teams. Baseline Reports are at **Appendices 78-83** Midline Reports are at **Appendices 84-87** Endline survey of all the villages selected in 1st, 2nd and 3rd rounds has been completed, data will be analysed, reports will be drafted and shared with the project teams. This activity was delayed by travel restrictions due to COVID 19. A very preliminary report has drawn some inferences about the impact and challenges of the project which will be further explicated when data analysis is complete. Refer **Appendix 88** **Base, Mid and Endline comparative data analysis is in progress and will be available by August 31, 2021.**

4.2	Determine the possibility and assist with the establishment of small-scale enterprises related to WP for women, youth and men.	Capacity inventories conducted Interested females, youths and males identified Market research conducted and potential enterprises identified Feasibility of such enterprises assessed Pre-requisites to establishing enterprise determined Feasibility report to ACIAR 1 and all stakeholders Small enterprise establishment commenced in 3 locations Monitoring and evaluation of progress of small enterprises **(A, PC)**		In year two of the project women in particular were engaged in kitchen gardening, some in their own compounds others on larger plots of land to which they had been given access by the men of their households. At this stage women were satisfied with the savings from not needing to buy vegetables. Also as is culturally acceptable to share any excess produce with others in the village. At that stage they did not desire to go beyond this level of activity. PCRWR had raised interest among women in 86Db Bahawalpur to develop a larger enterprise with some funding from PCRWR to establish tunnels for growing vegetaeble and training in business skills. Women were keen to be involved but PCRWR encountered issues with lack of staffing locally and the inability of travel due to COVID and so this did not progress. Discussions with ACIAR, CSIRO, PCRWR re this are ongoing. As this was a final year activity it has been severely restricted due to COVID 19. Some farmers who also operate small shops have expressed an interest in becoming suppliers of tools and ongoing support to their clients. This will continue to be explored in the new SRA that CSIRO is leading.
4.3	Make links with Pakistani government bodies such as Pakistan National Rural Support Programme and other NGOs that can assist with • establishment /funding for such enterprise • business skills training	Pakistani NGOs and other funding bodies identified Pakistani NGOs who train potential entrepreneurs in business skills identified **(A, PC)**	December 2018	Farmers in sites of Sindh and Balochistan are connected to technology dissemination project of ICARDA. The key skill involve; • Development of HIES coupled with solar power Conservation agriculture, such as innovative cultivation of banana and rice on beds reducing water waste in irrigation through conventional methods. Throughout the project in the FILM workshops as women and men have identified needs not directly linked with the project the SOFT facilitators have followed through with various organisations such as NRSP and aided villagers by providing them with relevant government contacts.

4.4	Synthesise and publish all findings from objective 4 and the extent to which this objective has been addressed	Report to ACIAR Publications and presentations	June 2017 June 2018	Following publications were compiled in the project; Research paper published: titled "The bridge between farmer and researcher: Extension through the eyes of the agents in rural Pakistan" Poster presentation in TROPAG Conference at Brisbane conventional center, Australia on 20-23 November 2017: **a.** "We have a vehicle but no tyres" – Challenges for technology adoption in rural Pakistan - **Dr. Sandra Heaney-Mustafa** **b.** Successful elements of existing on-farm irrigation water management initiatives in Pakistan- **Faizan ul Hasan, Bareerah Fatima** **c.** Adoption Potential of Virtual Irrigation Academy (VIA) Tools in Pakistan, **Bareerah Fatima, Faizan ul Hasan** **d.** Women Role in Irrigation Management in South Asia – **Uzma Iqbal** **e.** The Chameleon Sensor: a new tool of irrigation scheduling and managing pests in garlic crop - **Dr. Arif Shah Kaker** **f.** Abstract (Women land ownership and participation in irrigation management in Pakistan) publication in the international conference on Gender, Human rights & Islam, Dept. of Sociology, BZU, Multan, Pakistan on 23- 24 November 2017. **g.** 6 Baseline reports separately for Male and Female side analysis from Punjab, Sindh and Balochistan provinces. (From Baseline Data) **h.** 5 Baseline and midline comparative analysis reports separately for Male and Female side analysis from Punjab, Sindh and Balochistan provinces. (From baseline and midline data) **i.** Access and usage of mobile phone and computer among rural women in Sindh, Pakistan. (From Baseline Data) (Uzma Afzal) **j.** Women participation in agriculture: contribution towards household income in Punjab, Pakistan. (From Baseline Data) Mukaddas Afzal) **k.** Comparative analysis of community-based learning approaches of collaborative problem solving, value management and discovery learning models. (From Midline Data) (Mukaddas Afzal) In

				preparation. l. Project interventions to enhance major crops productivity and economic gains in Punjab province, Pakistan. (Qaiser Khan) In preparation

The following activity ran in tandem with project activities though was included in the pre-project management activities.

0.2 Management Activities

No.	Activity	Outputs/ Milestones	Completion date	Comments
0.2.1	Linkage and coordination with National universities for students' research (special assignment)	Postgraduate level thesis research on various aspects of project activities by involving local academia and students	First quarter of 2018	Explored potential local universities, developed Terms and Conditions for sponsoring students research and facilitated the signing of Letters of Agreements between two the local universities (University of Sargodha and Sindh Agri. Univ., Tandojam) and Project Leader (UoC). **Appendix 89** Student reports contributed to their postgraduate studies and were co-supervised by an academic at the relevant University and a project team member. All students successfully attained their M. Phil degree. • *Communication strategies to enhance farmers water management skills: A case study of Bahawalpur farmers*. Islamia University Bahawalpur, Ms Komal Rubab. Research papers has been drafted and under review • *Analysis of Learning models for enhancing farmer water management skills: A case study of district Sargodha.* University of Sargodha, Mr Usman Rafique. Research paper is being drafted • *Effects of soil moisture depletion levels on growth and yield of Wheat (Triticum Aestivum L.).* Sindh Agriculture University Tandojam, Mr Mujahid Somroo. Thesis is being processed but university is closed due to Covid-19 Reports are at **Appendices 90, 91 and 92 respectively**

Key results and discussion

The initial activities of the project were focussed on establishing an environment in which all Partner Country (PC) teams' members have increased knowledge and skills in their respective areas of focus along with good understanding of the partners' frame of work. Central to this has been the need to develop a sense of a project team made-up of teams from multi-disciplinary areas, such as social science, farmer facilitation and extension and water and irrigation management.

Building the team as one from multidisciplinary teams was a key challenge in this project. Also developing the concept of farmers, women and men as well as youth as equal members of the team tested concepts of researchers as experts and farmers as recipients of that expertise. Through the utilisation of the Organic Research for Community Development (ORDC) approach and conducting regular team meetings using the Collaborative Problem-Solving Workshop (CPSW) methodology both these trails were overcome. Women and men farmers were invited to the Inception workshop which was also run using CPSW in which all present were valued for the ideas and capacities they brought to the workshop. Farmers knowledge though different was of equal value to that of the engineers, researchers and other team members. Following the Inception workshop team members commented that this was a way of working with farmers and other disciplines they had neither hear of or tried and they could see how beneficial it could be.

Role of SOFT was mainly centred to develop, test and scale-out two of the three learning approaches (Value Management; VM and Organic Research and Collaborative Development, ORCD or Collaborative Problem-Solving, CPS) to improve farmers' irrigation water and nutrient management skills. Responsibility of the 3rd approach (Discovery Learning, DL) was entrusted to PCRWR. The project's activities were initiated with an inception workshop on 2-3 Feb. 2017 at Islamabad in which first year action plan and village/site selection criteria were developed. Thereafter, 10 SOFT facilitators (5 men and 5 women) along with other partners' teams got training in the use of various soil-moisture and nutrients monitoring tools and preparation in the new adult education methods for use in farmer education engagement – specifically Collaborative Problem-Solving workshop (CPSW) techniques and Value Management techniques on 20 Feb. - 03 Mar. 2017 in Australia.

Following the return of the PC teams to Pakistan, a training for the master facilitators from each province in both water techniques and technologies as well as new adult learning models was organized at Bahawalpur on 16-23 April 2017 in which 19 persons participated. For pilot testings, two villages (86-DB for VM and Basti Karani for ORCD/CPS) were selected and profiling of farmers were carried out in April 2017. The two learning approaches were implemented over Kharif crop season (May-Oct.) of 2017 with holding of about 14 learning sessions separately for men and women in each village (3.5.5). Farmers tested water tools in cotton crop (men) and kitchen gardens (women). There reported an avg. saving of 2 irrigations with 2-6 Maunds increase in yield of cotton.

From Rabi crop season (Nov. 2017 – April 2018) the project activities were extended to eight villages (one each for VM and ORCD/CPS model in each district) of

Bahawalpur, Sargodha, Tandojam and Quetta districts in the three provinces. Two villages of pilot phase of Bahawalpur were carried forward in this round. A training workshop was organized at Tandojam on 18-24 Oct. 2017 for the training of District Master Facilitators (DMFs) to implement the learning approaches (3.6). In this season, 16 women in Bahawalpur established kitchen gardens with installation of Chameleon sensors in some plots for irrigation management. Male farmers used chameleon in wheat, citrus and apple orchards beside other practices of irrigation conservation (3.6.4). Women participation in Baluchistan was a challenge due to tribal and religious norms.

The activities were further extended to six districts in Kharif season (May-Oct) of 2018 under round-2 (3.7). A training workshop was conducted for new entrant DMFs at Nawabshah (Shaheed Benazirabad) on 20-22 April 2018. Beside installation water tools, the farmers also experimented other water conservation practice such as bed & ridge sowing, cultivation of low delta crops, soil testing to use proper fertilizers. Value addition activities contained cotton seed production while women cultivated strawberry beside usual vegetable cultivation in kitchen garden plots. A village of Nawabshah and one of Quetta were dropped due to non-cooperation of the farming communities. Participation of women in Baluchistan and some villages of Sindh and Punjab also, remained challenge due to tribal, religious, social customs.

Over the course of implementation, it was realized that language (English) of the given literature on the learning approaches is limiting learnings of facilitators (with low qualification) and farmers. Therefore, dual language (English & Urdu) guidelines was developed and printed for field staff and farmers (3.7.5)

Another set of two villages in each district was added in the Rabi crop season i.e. Nov. 2018 – April 2019 (3.8). Two trainings of trainers (refreshers) were conducted in Sargodha and Quetta at the start of season. The set target of farmer to farmer learning till this stage was not yet achieved and to find out the reasons a simple survey was devised and conducted to get feedback of field facilitators on pros and cons of the two learning approaches.

Positive attributes of the models included identification and realization values of farmers' resources, collective wisdom, sharing, brainstorming on new possibilities/ideas, collaborative planning, experimentation and sharing the outcomes, equal opportunities and respect of participants. The challenges indicated; the complexity of models (specially VM), participation 2-3 days consecutively, farmers hesitation to wear DeBono hats in VM model, inability of uneducated farmers to prepare & read flip charts, feeling bore and unpleasant due to long hours of participation, non-provision of inputs and costs to conduct experiments. The recommendations include reducing the learning steps, duration of workshop, exclusion of De-Bono hats and need of more emphasis on practical aspects. This feedback supported revision of the learning approaches under context of Pakistani situation.

An Intern funded by ACIAR when exploring the benefits of the project found farmers in villages where the VM and ORCD/CPSW models were being implemented were experiencing markedly greater improvements than those in villages under the DL model. In particular, results such as shared decision making between women and

men, seed harvesting, helping behaviour to extend skills and information to farmers outside of the project, and sustainability of learning without the use of tools are much more pronounced in VM and ORCD/CPSW villages. In DL villages, impacts are limited and people are less engaged in the project.

After critical analysis the research team decided to amalgamate the acceptable and dynamic steps of the three models into one new model “Farmer Integrated Learning Model (FILM)”. Consequently, guidelines on FILM was developed (with Urdu translation) to conduct trainings for field facilitators and potential farmer facilitators (males & females) at local levels. Each step was elaborated by local examples and photographs.

From Kharif season (May-Oct. 2019) the activities in the villages designated for VM and ORCD/CPS were shifted to FILM (3.9.4). Identified 89 male and 64 female farmers from the pilot/ trial sites willing to act as farmer-to-farmer (F-F) facilitators, who subsequently enrolled 437 men and 307 women as trainees. A series of FILM workshops were conducted in two rounds at village levels in each district to facilitate maximum participation of the farmers. In the first round six workshops 125 men and 62 women belonging to 24 villages participated. A one-page handout and poster (in Urdu and English) comprising 10 steps of FILM was developed and printed, made available to the participating farmers as ready reference and for display at the workshops’ venues. A step-wise format of FILM workshop (Urdu and English) was also developed and provided to the field facilitators and farmers. The project activities were restricted due to COVID-19 outbreak. In second round, the FILM workshops were increased to ten to support the farmers participation, particularly for women who generally are not allowed to go another village. The activity was halted during the first wave of COVID-19 and resumed in Sep. 2020. Participants were 315 men and 241 women of 32 villages.

Over the course of three crop seasons (Kharif 2019, Rabi 2019-20 and Kharif 2020) farmers took good initiatives in developing and conducting experiments on the issues important to them. In total 260 experiments (126 by men and 134 by women) and practical activities were reported from 32 villages. These also included the five experiments decided and executed jointly by farmer-families with women in lead role. The COVID-19 pandemic remained a limiting factor to Farmer-Facilitator interaction for almost all the year of 2020. However, the SOFT facilitators kept their communications alive through alternate means i.e. individual visits to lead farmers and experiment fields, telephone, WhatsApp contacts etc.

Family health, a matter of women’s concern, is reflected from the bulk of their activities revolving around small-scale vegetable farming either at homestead level or in nearby farmlands. Most of them adopted integrated crop management practices to reduce irrigation and chemical inputs i.e. fertilizers and pesticides, to get clean and healthy produce. A group of four women cooperated for raising backyard poultry of ≈100 birds for egg production and are successfully met their families’ requirements. Similarly, two women got earnings by imparting clothes stitching & embroidery skills to needy fellow women on nominal charges, as well as commercial sewing and embroidery of clothes. All such community activities are attributed to the opportunities of women gathering in FILM learning sessions/workshops.

The men's reports included employments of soil-nutrients (Chameleon) and soil-moisture (FullStop™) monitoring tools for need based applications of irrigations and chemical fertilizers; seed production of cotton wheat and vegetables; laser land levelling, crop sowing on ridges and furrow-beds to save time and frequency of irrigations; comparative performance of new and old varieties; adopting best practices in cotton and wheat production; testing impacts of plant stimulants and soil conditioners, testing of low delta food (canola/mustard) and fodder (Rhodes grass) crops; testing and adaptation of Modified Basin Irrigation System in citrus, apple and apricot orchards to save irrigations and management of gummosis disease; intercropping of vegetable and fodder crops in young orchards; moving from traditional cropping system to cultivation of high value vegetable and horticulture crops and nurseries; testing integrated practices of pests and weeds management, organizing community for benefiting from government department (On-Farm Water Management) for lining of water courses; livestock or calves rearing; testing fertilizer applications in blended versus solitary forms etc.

Farmers' top-ranked issue is the cost-effective production. The traditional crops (such as cotton, rice, sugarcane, wheat etc.) are proving unlucrative for their sustainable livelihood. So, they are always searching for new high value crops & varieties and improved production practices/technologies to reduce input costs and increase net income returns. Some farmers of these reports have obtained significantly higher net-income return by moving from traditional to high value crops. A number of the studies show farmers' potential of adopting water conservation techniques/practices i.e. laser land levelling, crops sowing on ridges and furrow-beds, MBIS etc. Provision of soil-moisture and nutrients monitoring tools were well accepted by farmers but their limited supply, inefficient technical support and mechanism of unpredictable/irregular canal water supply are noted as limiting factors for optimum outcome and impacts. However, the use of tools and water conservation practices have revealed saving of 20-30% irrigation time, frequency or both. Similarly, proper use of FullStop™ has supported to save one bag per acre (i.e. up to 50%) of nitrogenous fertilizer (Urea). With support of these tools, a banana farmer has reported saving of 12 irrigations and two bags of Urea over one-year period.

The key issue for adoption by farmers was the limited supply of tools and other equipment and until a secure import route can be established this will remain a limiting factor. A steady supply at a reasonable cost for small farmers needs to be established. An attempt to address this is being made with the SRA that CSIRO is establishing. This will however require GoP cooperation to ease costs of importation and to establish policy at provincial and national levels to encourage farmer adoption though farmer and multiple stakeholder friendly adult learning approaches such as FILM or its successor Rural Research Engagement and Learning Model (R^2EaLM).

Some points of considerations are:

i) This project has to some extent has attempted to change the behaviour of researchers, extension services providers and engineers. The impact of earlier and redundant activities is still pronounced. More behaviour change projects need to be launched for the scientists and researchers to bring about a greater change in narrative
ii) The project design and work-frame had no provision of any resources for encouragement of resource poor small farmers to conduct experiments on

potential water conservation practices, which is unlike such projects currently in progress or executed in the past (e.g. FFS based projects by FAO and CABI). Rather than offering any direct incentive(s) the proposed learning approach (VM & CPS) were requiring farmers precious time for participation in learning process as well as conducting experiments for experiential learnings from their own resources, inputs and costs. This factor remained a big challenge in attracting/participation of the farming communities.

iii) The SOFT organizational structure consisted of volunteer members, majority of whom have their full-time employments/business elsewhere. The project provided partial financial support to only a few managerial and support staff. While the resources for research operation were insufficient to engage district level field facilitators on full-time basis. Therefore, execution was carried out by part-time engagement of fresh graduates and FFS trained farmer facilitators. This issue remained a major challenge in the project execution, as there was high turnover of the field facilitators. Over the project life, 38 facilitators (23 men and 15 women) were engaged with average stay period of 569 days. Regular/periodical trainings and refreshers were conducted for capacity building of the new entrants. A positive attribute of this arrangement was that the project trainings and job experience became a stepping stones for many of the field facilitators and based on their experience in learning approaches (VM, CPS and FILM), they got lucrative jobs in FFS based projects executed by national and international organization such as FAO, CABI, HDF etc.

iv) A team of social scientists was integral part of the project executors for carrying out research on the defined objective(s). In addition, their role was monitoring and evaluation of the proposed learning approaches. The contributed well in village selection and afterward confined their activities on baseline, mid-line and final surveys to see the impact and comparative successes of the learning approaches. Having Social scientists among the SOFT facilitators skilled at collecting qualitative data could enhance the process. Evaluation of small and uneducated farmers for answering on steps and narrations of the learning approaches may not be true assessment of the success. Moreover, the Farmer to Farmer learning may not only confined to "a farmer will formally teach other farmer(s)". It can be learning/adaptation of fellow farmers from successful experiment(s) or practice(s) conducted by a lead farmer. The reports on farmer-led research reflect experiential learning through an informal process of research and development. Fellow farmers readily take up the success stories emerging from these processes, and it is considered the most common & efficient channel of information, knowledge, and skills dissemination, particularly for the uneducated segment of the rural/farming community. Several studies of these volumes show a significant increase in net income and considerable reduction in inputs by applying approved practices, techniques, and tools. This way of experiential learning carries the diverse potential of improved productions, yields, biodiversity, conservation of natural resources, social learning and collaboration, household income and rural livelihood.

Some progressive and educated farmers have well understood the mechanisms and operation of the water tools introduced in this project. For example, with use of Chameleon they have developed understanding of crop root zone (e.g. wheat, cotton) and soil moisture contents but fear/uncertainty of non-availability of canal water on their turn and at required time force them to over-irrigate a

crop. Development of on-farm water storage (excess canal and rain water) may provide regular supply of water during a period of water scarcity.

Generally, farmers are provided pre-set recommendations on irrigation schedule of a crop variety along with seed supply. For example, irrigation shall not be missed at flowering, grain filling or fruit formation of a crop or orchard. Such top-down recommendations prevent farmers to follow the outcome of water tools. Soil-moisture and nutrients monitoring tools shall be integral part of crop agronomy and seed/varietal development research for general recommendation on irrigation and fertilizer applications.

Impacts

Scientific impacts – now and in 5 years

Farmer led research trials on technologies with testing of adult learning approaches and scientific data on such research activities are very scarce in Pakistan. This is the root cause of poor decision making and weaker methodology of technology dissemination projects. A greatest asset of this research project is baseline, midline and end line survey data of farmer experience with the project with rather innovative approaches. This data will be transformed into potential publications. Some of these publications are already published in high impact international journals;

Sr	The Paper	Status
1	Bridging farmer and researcher: extension through the eyes of agents in rural Pakistan.	Published
2	A critique of successful elements of existing on-farm irrigation water management initiatives in Pakistan	Published
3	Experience based learning of small and medium landholders on combined management of moisture and nutrient through VIA	Draft stage
4	Technology testing and Adult learning approaches-A Social Science Perspective	Pre-draft stage

The Farmer Integrated Learning Model (FILM) emerged from the trials of Value Management (VM) and Organic Research and Collaborative Development (ORCD) with strong elements of Asset-based Community Development (ABCD), carries potential of alternative to Farmer Field School (FFS) approach being used in Pakistan since the 1990s. Comparative efficacies of both the approaches can be evaluated in terms of their cost-effectiveness, scaling-up and scaling-out potentials, sustainability and long-term impact on farmers learnings.

Presentations on development of FILM at Asia-Pacific Extension Network (APEN) Conference on 12-13 Sept. 2019 at Darwin, Australia have transmitted project learning to wide audience in Australia. Likewise, FILM project workshops at Sargodha University and MNS Agriculture University Multan has also informed a wider audience regarding project learning. The introduction of the evolution of the FILM Model at the prestigious MODSIM 2019 Annual Conference in Canberra reached a wide and appreciative audience.

Following post-graduate level students' thesis research has been conducted on the learning approaches;

Communication strategies to enhance farmers water management skills: A case study of Bahawalpur farmers. Islamia University Bahawalpur, Ms. Komal Rubab.

Analysis of Learning models for enhancing farmer water management skills: A case study of district Sargodha. University of Sargodha, Mr. Usman Rafique.

An Urdu article on development and format of FILM has been published in a local magazine “Zarai Digest” Jan-March 2021 issue, published by University of Agriculture Faisalabad, Pakistan for wider circulation among extensionist, academicians, facilitators and farmers (Appendix-60).

Outcome of the experiments conducted by farmers (with their own resources) can assist scientists in getting feedback on the technologies/practices tested at the farmer field. This can support understanding of the strengths and weaknesses of the approved technologies and practices when moved into farmer hands. It can trigger process of participatory research leading to sustainable development.

Another important impact that has emerged is; professionals, facilitators, educated & progressive farmers are able to install and operate tools and make decisions of irrigations accordingly. Beside conservation of irrigation water, one of the major impacts on the farmers is that they have started understanding that over-irrigation can leach down the nutrients, thereby wasting their money. During course of experimentation with the tools, facilitators and farmers have learned about effective root zone of different crops in various cropping zones.

The VIA web is platform that represent all farmers where Chameleon moisture sensors have been installed throughout the project duration. Whenever farmer connects his sensor with reader and uploads the data through the reader it reached to VIA cloud representing filed moisture patterns. These moisture patterns enable researchers to observe farmer irrigation practices.

Those with formal experience in soil water monitoring were provided with Chameleon equipment at the start of the project so they could familiarise themselves with how it works. This opportunity to build up some local experience was considered to be essential before approaching farmers through the field schools.
The visit by a number of these staff to the CSIRO labs in February 2017 allowed for more in depth training in how the sensors work, how they are fabricated, installation and interpretation of data, and how to use the VIA on-line platform.
Sensors have been installed and data uploaded to the website from the following locations

-PCRWR Head Quarters Islamabad (Citrus)
-Quetta -Rani Bagh (Garlic)
-Regional Lahore office (Turf)
-Agriculture Training Institute Sindh Province (Tomato and Okra)

The Quetta experience is of particular interest, as the abstract by Assoc Prof Arif Shah below indicates In this case the soil water stress, calculated on the VIA as % blue/green/red averaged over time and depth, was used as a whole of season

measure of what the plants experienced. These soil moisture summaries showed that more blue and less red correlated with yield (positive), weeds (negative) and pests (positive). Arif Shah made a video of his experience and pasted it on Facebook. https://www.facebook.com/virtual.irrigation.academy/

CHAMELEON: A NEW TOOL FOR IRRIGATION SCHEDULING AND MANAGING PESTS IN GARLIC CROP

Abstract: Garlic (*Allium sativum* L.) is an important commercial vegetable crop in Pakistan. Insect pests and moisture stress are considered to be the most important factors limiting the yield of garlic. Cultural practices (irrigation) and host plant vigour are important management tools that can create unfavourable conditions for pests to establish on the crop. It was aimed to quantify pests (thrips &weeds) infestation and assess yield response of garlic by using the Chameleon sensors. The Chameleon consists of an array of three moisture sensors and one temperature plus ID sensor that are permanently installed at different depths in the soil. A portable hand held reader is connected to each sensor and displays the soil moisture by coloured light. Each depth is represented by a light and each light can read blue (wet soil), green (moist soil) and red (dry soil). The lights give a picture /pattern of soil water conditions from the top to the bottom of root zone. Successive readings through the season give colour patterns that illustrate soil water tension. This study was carried out during the 2017 (3rd January-25th May 2017) at the Directorate of Floriculture Rani Bagh Quetta. Two irrigation regimes (treatments) in total were laid out in a randomized complete block design with three replications. In both treatments soil moisture sensors were fixed at the depth of 10, 20 and 30 cm depth and all other variable were kept constant. Thrips population was counted using Yellow sticky traps (YST) and actual count of entire plants. Results revealed that soil water tension significantly affect horticulture variables, thrips and weeds infestation. Except root length, significantly higher bulb weight, neck length, leaf length and no of leaves was recorded in garlic plot (T_2) with soil moisture summary colour pattern of 40% Blue; 57% Green and 3% Red colours compared to garlic plot ($T_{1)}$ with soil moisture summary colour pattern 23% Blue; 57% Green and 20% Red. Thrips and weeds population was positively and negatively correlated with soil water tension, respectively. In conclusion, Farmers can easily monitor soil moisture and avoid crop stress (biotic and abiotic) through by proper irrigation scheduling in light of colour pattern.

The project is also expected to impact within five years on irrigation and water management as follows:

The FILM has been recommended for implementation and further development in the 2.5-year ACIAR supported formative project, “Adapting to Salinity in the Southern Indus Basin” launched on 15 March 2021 in Punjab and Sindh Provinces of Pakistan. This participatory research phase would provide a base for development of a 10-year action research program.

Exploration of import avenues for the CSIRO developed tools in the SRA lead by CSIRO should see an increased availability and distribution of tools throughout Pakistan.

Potential publications and presentations at conferences will reach a wider audience regarding tools and technologies as well as farmer learning approaches.

Farmers who led research projects in their field will be able to share experiences and encourage others to similarly experiment to find most suitable adaptions for irrigation and water management to their farms.

As tools are further modified and adapted to suit the Pakistan ecology the VIA web platform will provide a continuous source of information for researchers as a scientific knowledge base to collect data with patterns of irrigation followed by farmers in whole cropping season.

Capacity impacts – now and in 5 years

A total of 400 set of soil moisture sensors were provided to Farmers in 49 project sites. Moreover, 140 sets of Fullstops along with Chameleon EC meters and Nitrogen testing strips were provided. During very initial season of experimentation on tools there was a lot of wastage and loss of tools due to the reasons that facilitation was limited on the tools. Farmers gradually became independent on tool experimentation. The overall impact of this project is that; approximately 700 farmers, researchers, scientists and engineers are aware of VIA tools. All of the farmers who have participated in the project are aware of “combined nutrient and irrigation management” to balance their field economics and overall environmental benefits. This project has enabled researchers to sit in farmer’s shoes and see his problem through his eyes. Being able to conceive a problem the way it exists, is the best thing happened to researchers. A collaboration of ideas among social scientists, field facilitators and water engineers has set an example of integrated water resources management.

The project has introduced a potential new approach (FILM) of participatory learning. A group of 38 facilitators (15 women and 23 men) has entered into the national manpower pool who are working at gross-root level with smallholders on different aspects of agricultural developments and capacity building projects.

A series of FILM workshops were conducted in two rounds at village levels in each district to facilitate maximum participation of the farmers. In the first round of six workshops; 125 men and 62 women belonging to 24 villages participated. In the second round, the FILM workshops were increased to 10 to support the farmers participation, particularly for women who generally are not allowed to go another village. Participants were 315 men and 241 women of 32 villages.

From the trial sites identified 89 men and 64 women farmers to act as farmer facilitators who subsequently enrolled 437 men and 307 women as trainees. These farmers took good initiatives in developing and conducting experiments on the

issues important to them. In total 260 experiments (126 by men and 134 by women) and practical activities were reported from 32 villages. The success stories seen and approved by local farmers carry high probability of wider adaptation on sustainable basis.

The FILM approach, with support of active facilitation, carries potential to develop farmers capacity in finding solutions of their problems by experimenting from own resources. The approach has engaged young women to become confident in working as facilitators within their villages and has been utilised to resolve community issues beyond farming demonstrating increased problem-solving capacity.

The capacity of facilitators and farmers is enhanced in understanding the web part of VIA. A close interaction of scientists with farmers has developed in resolving difficult field level problems. The capacity of facilitators and farmers have been enhanced in water and irrigation management skills. Specifically, some farmers are able to understand about crop water and nutrients requirements. The knowledge about effective root zone of different crops in different cropping zones is also developed among researchers, scientists, facilitators and farmers.

The capacity of SOFT team has increased in documentation and writing reports on training workshops and success stories on experiments conducted by farmers.

The learning models have helped to increase farmers mutual interactions and more broadly enhanced cooperation and collaboration in the communities involved. Organization of “stakeholder forum” has involved state governance systems in these processes allowing farmers’ views to be heard and considered. This broader engagement has seen communities showing concerns about their environment and health e.g. pesticide free vegetables, safe & clean drinking water, hepatitis etc.

All PC teams have had capacity built in working in cross disciplinary teams, this has been facilitated by the Project Leader (PL) in a team building workshop in Islamabad in September 2016 and again in Collaborative Problem Solving Workshop process at the Inception Workshop in February 2017.

Participation by all teams in the Impact Pathways and evaluation workshop facilitated by Ted Rowley in January 2017 also enhanced the teams’ capacity for cross disciplinary collaboration. As well as skill in developing impact pathways and monitoring plans.

Capacity has been enhanced in water and irrigation management skills for both the PCRWR and SOFT teams.

Skills in the use of Mobile Acquired Data (MAD) collection have been gained by the SSRI team. The Project Officers, research assistants and financial assistants employed in both PC and A have had skills developed in managing the process of projects as well as specific tasks in their respective portfolios.

The trainers who obtained training from the Australia, conducted training of 40 Facilitators in Tandojam on three learning models, tools and water management practices. The Project Leader also held a training session on CPS

and VM models with the facilitators in classroom and in the field with the farmers.

An electrical engineer from PCRWR who had 3 months training at CSIRO and can fix minor issues with the Chameleon sensors and readers. It has emerged that professionals, facilitators and some farmers are able to install tools and adapt irrigation accordingly.

PCRWR researchers has discovered while working with the farmers is that Chameleon sensors are not suitable for water logged and saline soil and consequently capacity in problem solving has been enhanced.

The capacity of facilitators and farmers have been enhanced in water and irrigation management skills. Specifically, some farmers can understand about crop water and nutrients requirements. One of the major impact on the farmers is that they have started to understand that over irrigation can leach down the nutrients, thereby wasting their money. Subsequently, the farmers have saved 1-3 irrigations while increasing the yield by 2-6 monds per acre in the fields. Researchers and scientists as well as facilitators and farmers have started learning about effective root zone of different crops in different cropping zones. As a result, enhanced observational and problem-solving capacities have been enhanced.

Women and youth have had capacity built in cultivation and irrigation management. Using new learning models has facilitated and motivated female farmers in pilot villages to do kitchen gardening they did not do previously. On their combined vegetable garden, they installed chameleon sensor and tensiometer and irrigated accordingly as a result they picked vegetables with one irrigation and 4 rains. This demonstrated capacity building among women farmers as they could recognise by using the water management tools that irrigation was not required when it rained. In Sargodha school boys aged 10 are taking readings using the chameleon and advising mothers on when to irrigate.

The capacity of facilitators and farmers is enhanced in understanding the web part of VIA. During the reporting period, 11 new VIA ID’s has been created for the facilitators enabling them to manage VIA farm data. Each ID is at least being used by 2 facilitators in joint learning manner. Now in process of seeking farmer’s willingness to manage their data themselves on VIA farm. A close interaction of farmers and scientists has helped both parties in resolving difficult problems of field faced by the farmers and misunderstood by the researchers/scientists.
The impact stories from project sites revealed that farmers are developing capacity to think on alternative ideas for solution of their problems.

The project started with a new concept of better water management “combined management of water and nutrients” a bigger goal. To begin with project team, capacity is developed in using VIA tools and how to engage with farmers in this learning process. As a result, women and men farmers capacity has been developed and now they are in position to explain the use and effectiveness of these tools to other farmers and researchers.

The capacity of team members has increased to write-up of scientific work. SSRI team has written several reports on midline survey and research papers. It created skills among team members to write scientific work.

The FILM with support of active facilitation has potential to develop farmers capacity in finding solutions of their problems by experimenting from own resources. The FILM model has engaged young women to become confident in working as facilitators within their villages and has been utilised to resolve community issues beyond farming demonstrating increased problem solving capacity.

The project is also expected to impact within five years on irrigation and water management and farmer learning as follows:

> SOFT facilitators trained in FILM techniques will be available to work in other organisations, government and non-government using it to enhance community engagement in adaptive agricultural practices to improve productivity and profitability of their farms thus helping reduce poverty.
>
> Farmers now skilled as facilitators will be able to work with other farmers to gain understanding and adapt irrigations and water management practice to their farms.
>
> Farmer Led Research will continue to bring adaptive change in other agricultural practices

Community impacts – now and in 5 years

Economic impacts

Farmers' top issue is cost-effective production. The traditional crops (such as cotton, rice, sugarcane, wheat etc.) are proving unlucrative for their sustainable livelihood. So, they are always searching for new high value crops & varieties and improved production practices/technologies to reduce input costs and increase net income returns. Through the learning approaches, many of the project farmers have obtained significantly higher net-income return by moving from traditional to high value crops. A number of their studies showed farmers' potential of adopting water conservation techniques/practices i.e. laser land levelling, crops sowing on ridges and furrow-beds, MBIS etc. However, the use of tools and water conservation practices have revealed saving of 20-30% irrigation time, frequency or both. Similarly, proper use of FullStop^{TM} has supported to save one bag per acre (i.e. up to 50%) of nitrogenous fertilizer (Urea). Saving in crop inputs e.g. irrigations and fertilizers thus getting increased net profit. Kitchen gardening by women have micro-economic positive impact on household level. Given the scope of project its scale remained less than expected but contain the potential to be out scaled on broader level.

The Fullstop, Wetting Front Detector has enabled farmers to understand the impact of over irrigation on fertilizer leaching. They reported to having changed their practice of fertilizer application, i.e. after irrigation. Moreover, farmers running

irrigation on tube well operation were able to avoid 1-2 irrigations saving the cost of pumping.

The farmers have obtained significantly higher return of net-income by moving from traditional to high value crops. Such learning by doing approach by relying on their own resources, can be useful in scaling up the water conservation and other best practices of crops' management. The economically viable ones can be taken up for scaling out for better net income/profit by the fellow farmers/communities in minimum possible time. However, it would require a functional and sustainable facilitation/extension system for efficient provision of technical support and linkages.

The Project focused on community involvement and collaborative work. This approach developed community collaborative working among farmers. Different types of discussions were conducted with farmers in different times to keep track of project activities as well as to enhance community interest in the irrigation and water management. With the efforts of the project team on average farmers saved 1-3 irrigations while increasing the yield by 2-6 monds per acre in the fields.

The capacity of facilitators and farmers is enhanced in understanding the web part of VIA. During the reporting period, 6 new VIA ID's has been created for the facilitators enabling them to manage VIA farm data. Each ID is at least being used by 2 facilitators in joint learning manner. Now in process of seeking farmer's willingness to manage their data themselves on VIA farm. A close interaction of farmers and scientists has helped both parties in resolving difficult problems of field faced by the farmers and misunderstood by the researchers/scientists.
The impact stories from project sites revealed that farmers are developing capacity to think on alternative ideas for solution of their problems.

Farmers learn, practice and test best practices by the way of learning by doing and interaction with researchers. The economically viable ones can be taken up for scaling out for better net income/profit. An immediate outcome of experimentation on tools is farmer's understanding of "over irrigation and its impacts on limited success with fertilizer application". Saving an irrigation saves on the cost of irrigation and fertilizer thus reducing overall cost of production.

Social impacts

Farmers meetings on the learning approaches provided opportunities for development of social interaction and cooperation among the communities. For example; i) five farmers contributed (5000 PKR each) for fabrication of a furrow digger/developer to develop Modified Basin Irrigation System (MBIS) in citrus orchards of Sargodha, ii) Stakeholder Forums at Sargodha and Bahawalpur provided opportunities to farmers for direct interaction with officials of On-Farm Water Management (OFWM) and developed community groups/committees to get support for lining of their water courses, iii) The women attributed their group kitchen gardening activities, cooperative raising of backyard poultry on share basis and establishment of local training and skill development facilities on embroidery and clothes stitching to women gathering in FILM learning sessions/workshops.

At the end of the CPS session eight male farmers decided to purchase plough for modified basin irrigation of citrus trees. Each Farmer contributed 5000 rupees to buy plough amounting Rs. 40,000/- rupees. All farmers showed commitment to use this plough on their own land as well as to share with other farmers on rental basis.

The learning approaches in this project have engaged and activated women and youth in the farming community. Previously despite the work they did they were largely unrecognised and considered inactive outside the household.

It was also noticed at some places that the farmers who were not convinced to install any tool in their fields, on seeing their neighbour farmer who has installed tool and deciding irrigation as per these tools started copying him. It was also commented on by both men and women that water has become a topic of discussion at community and family gatherings.

- The project activities have increased interaction among farmers enabling them to share their experiences and best practices with other farmers
- Application of VIA tools is serving as corridor for attracting and empowering women and youth in irrigation practices
- The impact of lesser number of available tools goes either way; farmers interact more in order to resolve their issues with more discussion or farmers with no tools lose their interest
- In Bahawalpur where several male and female farmers have now been selected to become facilitators and teach other farmers they feel they are distinctive in this role and are proud of their achievements and ability to share their knowledge.

Stakeholder forums have enabled women and men farmers to engage with districts level canal operators, extension officers, agricultural officers, local NGO's and research community present in their vicinity. As a result of these forums, men and women farmers are able to interact with these important professionals more readily than ever.

Environmental impacts

Employment of irrigation tools and water conservation practices have revealed saving of 20-30% irrigation time, frequency or both, as well as a considerable reduction in use of chemical fertilizers. Wider adaptation of these practices can reduce mining of ground water for surface irrigation along with reduction in leaching of extra chemical fertilizer in sub-soil water.

Created awareness to utilize crop and animal waste to prepare compost for use as organic fertilizer and clean the environment. The compost making introduced by the facilitators and introduction of organic kitchen gardening concept has not only produced healthy vegetables but also reduced environmental burden.

Through use of tools, developed understanding among farmers on over application of fertilizers and irrigations and its detrimental impact on human and land health

Kitchen gardening has generated a potential of decentralized and healthier vegetable cultivation. On the broader scale, reducing share in vegetable grown in intensive pesticide and fertilizer farming.

One of the farmer in pilot site who saved 3 irrigations in his cotton crops, experienced less attack of pests. Another farmer, who applied less fertilizer due to less number of irrigation, has reduced his share in groundwater contamination. Compost making introduced by the facilitators and introduction of organic kitchen gardening concept has not only produced healthy vegetables but also reduced environmental burden.

The project has following indirect environmental impact;

- Through VIA tools, developed understanding among farmers on over application of fertilizer and irrigation and its detrimental impact on human and land health
- Piloting kitchen gardening is generating a potential of decentralized and healthier vegetable cultivation. On the broader scale, reducing share in vegetable grown in intensive pesticide and fertilizer farming
- Created awareness to utilize crop and animal waste to prepare compost for use as organic fertilizer and clean the environment

Farmer have learned to use organic wastes for composting and its use in vegetables and crops to get organic produce. Kitchen gardening has helped women to grow healthy vegetable protecting the health of their family.

Saving one single irrigation eliminates its share into 15 million-ton salts that are being contributed into groundwaters of Pakistan annually due to fertilizer application (Briscoe and Qamar, 2005). Likewise leaching of pesticide residue with irrigation water is also reduced. Farmers are learning to avoid irrigation if it is unnecessary using VIA tools.

The project is also expected to impact within five years on irrigation and water management and farmer learning as follows:

> The wider distribution of tools and technologies will result in higher production of quality crops through reduced irrigation and judicious nutrient application thus increased income and financial benefit to farming families.
>
> Increased womens' participation in decision making encouraged through the FILM process will enhance the status of women and girls.
>
> Further judicious of water through enhanced tools and technologies will improve the environmental impact the current overuse of water.

Communication and dissemination activities

The member Science and Technology, Planning Commission of Pakistan experimented on the sensor and remotely manage his farm located in central Punjab while stationed in Islamabad. He recommended the tool to Federal Minister for

Science and Technology, being one of the most effective soil moisture management tools. The Federal Minister for Science and Technology in his meeting with the ACIAR CEO Professor Andrew Campbell regarding the prospects of transferring the chameleon sensor technology to Pakistan.

Basecamp platform and the Aik Saath platform had been regularly updated with reports of field activities and quarterly reports. This has allowed communication between all projects operating in Pakistan including biophysical and social scientists, extension workers, agriculture service providers, field assistants and those NGO and others whom the Aik Saath umbrella has encompassed, both nationally and internationally.

Farmers (men & women) and facilitators participation in annual World Water Days provided opportunities of communicating project activities with policy makers, researchers, extensionist and media. Activities like, prize distribution among male and female farmers with regards to Chameleon sensor and vegetable garden, displayed of project documentary highlighting various activities, case studies, posters display, presentations and sharing of farmers stories have proved effective in encouragement of the farmers.

Stakeholder forums have also allowed famers for exchange of ideas and techniques with biophysical and social scientists, representatives of local public and private organizations

Regular organizations of Trainings of Trainers (ToTs) and FILM Workshops at local village levels remained an effective way of communication and engagement with farming communities.

Workshops/ToT reports, quarterly and annual progress reports communicated information on project progress.

Development, translations (Urdu) and printing of learning materials and distribution among facilitators and farmers facilitated learning process.

Participation and presentations in Asia-Pacific Extension Network (APEN) Conference on 12-13 Sept. 2019 at Darwin, Australia and the MODSIM Conference in Canberra shared the project achievements at international level.

Development of reports on farmers experiments (Farmer-led Research) and distribution among facilitators and farmers proved an effective element to induce sense of ownership and encouragement to enhance participation and experimentations.

The SOFT facilitators created a WhatsApp group by the name “**SOFT-LWR Project**” on 14 March 2018. It remained one of the most effective way of communication among the field facilitators and project management over the project life. Sharing short-movies, pictures and briefs of daily activities led to generate fruitful discussion and exchange of ideas. It proved as source/pool of information for project team at Islamabad while developing technical reports. It also enabled work to continue during the COVID-19 pandemic.

Farmer visits to field experiments of fellow farmers proved an efficient channel of information, knowledge and skill dissemination, particularly among uneducated farmers. Documentation of these activities further enhance the interest of the concerned farmers and facilitators.

Conclusions and recommendations

The Farmer Integrated Learning Model (FILM) emerged from the trials of Value Management (VM) and Organic Research and Collaborative Development (ORCD) with strong elements of Asset-based Community Development (ABCD). It has proved to be a viable potential learning approach for small farmers. There needs a critical comparative analysis of the approach with the Farmer Field School (FFS) approach being used in Pakistan since the 1990s.

For introduction and adaptation of new tools, technologies and practices, famers self-experience (learning by doing) carries potential of their scaling out. Along with all possible contribution of farmers, the project needs to provide resources (beyond the capacity of smallholders) so that the approved/proposed technology could be practiced and disseminated at full zeal. The core theme of the project, aiming at testing of technologies with the help of farmers have proven very useful for the researcher's learning. In areas where farmers were not able to grasp the concept of the tools it was because the facilitators were not adequately trained.

Limitations arose from engagement of field facilitators on volunteer basis. Reliance on volunteers was based on older facilitation approaches driven from Farm Field Schools, Integrated Pest Management projects and experience of executing development nature projects for water conservation. We suggest that project field team should be engaged on regular/competitive basis for sustainability of manpower. For development of a critical human resource, fresh graduates can be engaged on internship with small financial assistance to support their logistics.

Famers workshops should be conducted at local/village level to facilitate maximum participation of farmers, particularly the women who are generally not allowed to travel to other villages for day long learning. It also enhances men farmers' participation in view of their unavoidable daily routine activities pertaining to agriculture and livestock.

Stakeholder (SH) fora showed stakeholders how farmers benefit from their involvement. These fora should be integral part of regular FILM workshops conducted at village level, to expose the SH to the full extent of famers' problems and facilitate in finding solutions of farmers problems with support and inputs of relevant SH(s).

Social scientists, ideally with adult education experience, should be engaged in regular process monitoring and evaluation of the learning approach. Evaluation only at the end of the project could miss many practical aspects critical to farmers participation, learning and adaptations of tools and technologies. Having social scientists on the SOFT team of facilitators, as well as those from agricultural or engineering backgrounds, would facilitate collection of qualitative data to meet this need. The regular ME of learning process would provide feedback to implementor(s) for needful corrective measures.

Tools, technologies and practices tested and approved through farmers experimentation should be available on commercial scale for sustainable use and out-scaling. In this project, resarchers were responsible for the process ofexperimenting on the tools.

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Appendixes

Appendix 1 Inception Wshop Briefing Document

Appendix 2 Successful elements on farm irrigation

Appendix 3 focus group discussions

Appendix 4 briefing doc refs

Appendix 5 Summary for participants

Appendix 6 Overview of farmer learning

Appendix 7 Women's' role in irrigation

Appendix 8 Preparatory Farmer Survey and Story Collection

Appendix 8A Baseline Survey

Appendix 8B Punjab Female Comparative analysis of Baseline and Midline Survey Report

Appendix 8C July visit report

Appendix 9 FG pres for Inc Workshop

Appendix 10 Elements of existing on-farm irrigation and water management initiatives in Pakistan

Appendix 11 Partner visit to Australia Feb_March 2017 Milestone 2

Appendix 12 Aust visit program.doc

Appendix 13 2020-01 D Oakes Feedback from field report

Appendix 14 Journey of VIA_Pakistan

Appendix 14A VIA_2017_18

Appendix 15 VIA_report_2019

Appendix 16 VIA_2019_2020_1

Appendix 17 (VM workshop 27 Feb - 01 Mar 2017 UoC)

Appendix 18 CPSW or CPW

Appendix 19(Site Selection Criteria)

Appendix 20 (Inception Workshop 2-3 Feb 2017)

Appendix 21 (ToT Report-Bahawalpur)

Appendix 22 ToT Report Nawabshah

Appendix 23(ToT Report-Tandojam) (1)

Appendix 24 ToT Report-Sargodha

Appendix 25 ToT Report-Quetta

Appendix 25A Learning Model Report

Appendix 26 APEN conf sept 2019 Heaney-Mustafa Farmer Integrated Learning Model (FILM)
Appendix 27 APEN Presentation (Iftikhar)2
Appendix 28 MODSIM Engaging farmers in modelling
Appendix 29 (Farmer-led Research July-2020)
Appendix 30 (Farmer-led Research Jan-2021)
Appendix 31 (Site selection-BWP) Pilot & Round-1)
Appendix 32 (Farmers Profiles)
Appendix 32A Overview of Farmer Engagement Activities
Appendix 33 (Facilitation Sessions Kharif-2017 Pilot-BWP)
Appendix 34 WWD presentation SSRI
Appendix 35 (Site selection-Sargodha) Round-1
Appendix 36 (Site selection-Tandojam) Round-1
Appendix 37 (Site selection-Quetta) Round-1
Appendix 38 (Facilitation Sessions Round-1 Rabi 2017-18)
Appendix 39 (Site selection-BWP) Round-2
Appendix 40 (Site selection-Sargodha) Round-2
Appendix 41 (Site selection-Faisalabad) Round-2
Appendix 42 (Site selection-Tandojam) Round-2
Appendix 43 (Site selection-Nawabshah) Round-2
Appendix 44 (Site selection-Quetta) Round-2
Appendix 45 (Facilitation Sessions Round-2 Kharif 2018)
Appendix 46 Guidelines for SOFT Facilitators (English & Urdu)
Appendix 47(Site selection-BWP) Round-3
Appendix 48 (Site Selection-Sargodha) Round-3
Appendix 49 (Site Selection-Faisalabad) Round-3
Appendix 50 (Site selection-Tandojam) Round-3
Appendix 51 (Site selection-Quetta) Round-3
Appendix 52 (SOFT-Facilitators Feedback)
Appendix 53 (Facilitation Sessions Rabi 2018-19 Round-3)
Appendix 54 FILM Guidelines for SOFT Facilitators (English & Urdu)
Appendix 55 (F to F Farmer List) SOFT
Appendix 56 (FILM Workshop-I 86-DB BWP)
Appendix 57 (FILM Workshop-I Ali Sher Rajpoot Tandojam)

Appendix 58 (FILM Workshop-I 107-NB SGD)

Appendix 59 (FILM Workshop-I 57-JB FSD)

Appendix 60 (FILM-Workshop-1 Gowal Quetta)

Appendix 61 (FILM Workshop-I Naseer Unar Shaheed Benazirabad)

Appendix 62 (FILM Sessions Kharif May-Oct 2019 Trial-1)

Appendix 63 (FILM Handout)

Appendix 64 (FILM Workshop-Format English & Urdu)

Appendix 65 (FILM Workshop-II Jalal Thebo Tandojam)

Appendix 66 (FILM Workshop-II Naseer Unar Shaheed Benazirabad)

Appendix 67 (FILM Workshop-II Basti Karani-BWP)

Appendix 68(FILM Workshop-II 86-DB BWP)

Appendix 69 (FILM Workshop-II 57-JB FSD)

Appendix 70 (FILM Workshop-II 262-RB FSD)

Appendix 71 (FILM Workshop-II 94-NB SGD)

Appendix 72 (FILM Workshop-II 107-NB SGD)

Appendix 73 (FILM Workshop-II Guwal Pishin-Quetta)

Appendix 74 (FILM Workshop-II Margha Pishin-Quetta)

Appendix 75 (FILM Sessions Rabi Nov 2019 to April 2020 Trial-2)

Appendix 76 (FILM Sessions Kharif May-Oct 2020 Trial-3)

Appendix 77 (FILM Urdu Article Zarai Digest-UAF Jan-Mar 2021)

Appendix 78 Baseline Female report Sindh

Appendix 79 Baseline Female Baluchistan report

Appendix 80 Baseline Female report Punjab

Appendix 81 Baseline Male Baluchistan report

Appendix 82 Baseline Male Punjab report

Appendix 83 Baseline Male Sindh report

Appendix 84 Midline Male Sindh report Nov 2020

Appendix 85 Midline report female sindh.june 2020 (1) (1)

Appendix 86 Midline Report-Balochistan-Final draft-Significance

Appendix 87 Report Male Punjab Midline

Appendix 88 SSRI End line Preliminary Impressions

Appendix 89 (Students Research)

Appendix 90 Complete Thesis -Komal Raba-Islamia University Bahawalpur

Appendix 91 Complete Thesis-Usman Rafique-Sargodha University

Appendix 92 Complete thesis Mujahid SAU