

## PCRWR developed Satellite-based Irrigation Advisory Services for Pakistan: Implementation and Impact Evaluation

### Background

Agriculture contributes more than 21% to the national GDP of Pakistan and more than 50% to the work force employment. More than 90% of Pakistan's water resources are used in agriculture. The country's primary irrigation system, also called Indus Basin Irrigation System (IBIS), was originally designed to bring more area under cultivation but at a low cropping intensity ranging from 60-80%. However, according to the latest agro-economic survey, the cropping intensity in IBIS has increased to 129% in 1988 and 172% in 2011. The increase in cropping intensity has been afforded by groundwater, which now contributes more than 60% of irrigation water supplies. The present irrigation water deficit in the country is currently about 15%, and is expected to increase to 30% by 2025. The cropping pattern of Pakistan is shown in Figure 1.

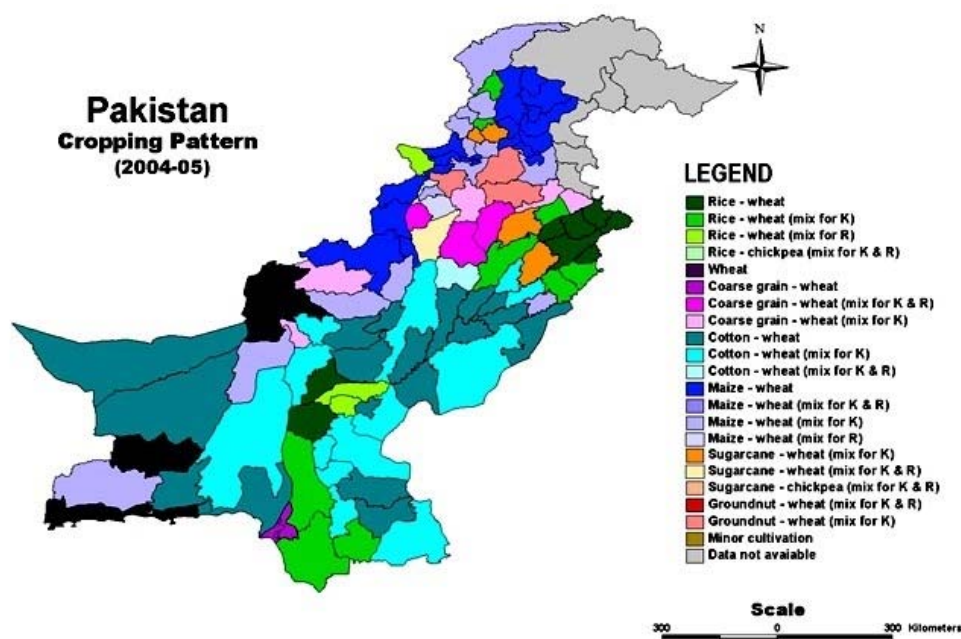


Figure 1: Cropping pattern of Pakistan (Courtesy: PARC, 2006)

A major portion of irrigation water losses (40%) takes place in fields because of over-irrigation due to an outdated mindset of farmers that more water would produce more yields. For proper irrigation scheduling, the knowledge of crop water requirement (CWR) is necessary. A simplified approach to estimating crop water requirements ( $ET_c$ ) is linking it with reference evapotranspiration ( $ET_o$ ) by a crop coefficient ( $K_c$ ). Pakistan Council of Research in Water Resources (PCRWR) has determined  $K_c$  values of all the major crops through lysimetric studies in the upper and lower Indus basin of Pakistan. However, ground-based lysimetric studies are

appropriate for identifying crop's coefficient parameter as a function of growth stage; they are not practicable for routine estimation of crop water demand.

### **The Irrigation Advisory System co-developed by University of Washington (UW) and PCRWR**

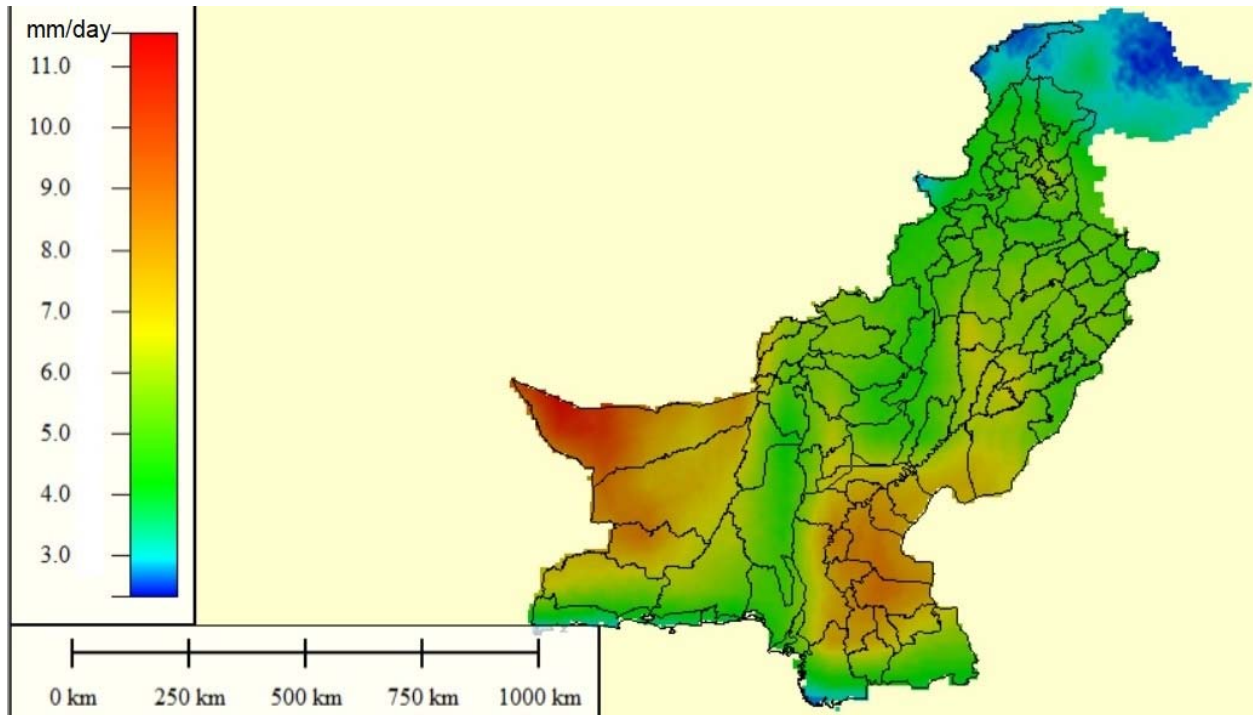
Remote sensing techniques have made it possible to estimate the nowcast reference ET of the recent past. Numerical weather prediction (NWP) based weather forecasting can also forecast reference ET for the short-term future (weeks). These two techniques (nowcasting and forecasting) were recently developed for PCRWR, in collaboration with University of Washington. The nowcast and forecasting systems for CWR and precipitation were then operationalized for PCRWR to estimate weekly crop water requirements of different crops at nowcast (last 1 week) and forecast (next 1 week) timescales.

Since 2016, PCRWR has been sending messages to farmers of different agro-ecological zones through cell phones. Initial SMS operations started with 700 farmers in April of 2016. Given the success of the cellphone (SMS) based irrigation advisory, the service was then expanded to 10,000 farmers of 21 districts of different agro-climatic zones in January, 2017. The districts where advisory services are currently being provided include Sialkot, Gujrat, Gujranwala, Mandi Bahauddin, Sargodha, Hafizabad, Sheikhpura, Lahore, Kasur, Okara, Faisalabad, Toba Tek Singh, Jhang, Muzafargarh, DG Khan, Rajan Pur, Rahim Yar Khan, Bahawalnagar, Bahawalpur, Hyderabad, and Peshawar.

The message contained in the irrigation advisory system informs the farmer on how much water has been (or will be) used by its crop (inches) during the last (next) week, excluding effective rainfall in order to replenish the same through irrigation. For example, a message recently sent to the farmers of Bahawalnagar district reads as, "*Dear farmer friend, this is to inform you that between 21 and 28 July 2017 in your area (Bahawalnagar), the crops used this much water (cotton 1.6 inch, sugarcane 1.7 inch). Next week, rain is predicted in some parts of your region. Therefore please irrigate your crops accordingly. For further assistance please call 03459213698. Thanks*"

Climatic parameters used in calculating the reference ET at nowcast timescales are remotely sensed from NASA satellites and derived from National Ocean and Atmospheric Administration (NOAA)'s global NWP models. The Sustainability, Satellites, Water and Environment (SASWE; [www.saswe.net](http://www.saswe.net)) research group of University of Washington volunteered its services to develop the necessary computer models and tools for automated computation of the nowcast and forecast ET<sub>o</sub> for the entire Pakistan on a daily basis. A web portal was developed wherefrom the data on ET<sub>o</sub> can be downloaded (<http://depts.washington.edu/saswe/>). Additional information such as precipitation (nowcast and forecast) and temperature (forecast) was also being provided on the web interface for PCRWR staff. This is essential to take into account the rainfall that occurred (or is likely to occur) in different parts of Pakistan for rationalizing irrigation requirements.

The  $ET_o$  computed by the NASA data were calibrated and validated using the ground based weather stations of PCRWR and an over-estimation factor of 1.5 was found, which was not unusual for satellite data or NWP data. Similarly, some discrepancies were found about the rainfall occurrence in different parts of the country. Therefore, the lowermost number obtained from different weather applications (like accuweather) was used in calculating the irrigation requirements. For improving rainfall's quantitative accuracy, the SASWE group implemented a dynamic web-crawled based correction scheme for satellite precipitation data. This scheme corrects satellite precipitation by dynamically acquiring the in-situ nowcast rainfall that is posted on the web and using it for bias adjustment. The forecast component was also added so that prediction of the rainfall and ET during the upcoming week can be included in the message for optimizing irrigation at forecast scale. A view of the  $ET_o$  map developed for Pakistan is given in the Figure 1.



*Figure 1: An  $ET_o$  map of Pakistan (22<sup>nd</sup> June, 2017) using UW data*

### **Irrigation Scheduling Message Formulation and Broadcast**

The major crops of the Pakistan namely wheat, maize, sugarcane, cotton; rice and banana were targeted in the current irrigation advisory service. The calculations of the advisory service can be outlined as follows:

1. The  $ET_o$  values of the preceding week (or following week) is downloaded and arranged for different regions at an over-estimation factor of 1.5 (as determined by PCRWR during the validation) as tabulated for the dates (as an example) from 3<sup>rd</sup> to 10<sup>th</sup> August, 2017:

**Impact Evaluation Report of Satellite Based Irrigation Advisory Service in Pakistan- 2017**

Location	ET <sub>o</sub> (mm/day)								Total (mm)
	03-Aug	04-Aug	05-Aug	06-Aug	07-Aug	08-Aug	09-Aug	10-Aug	
Peshawar	3.39	3.33	3.29	3.34	3.20	3.36	3.35	3.46	26.71
Sargodha	3.93	3.71	3.75	3.69	3.71	3.75	3.79	3.62	29.95
Hyderabad	5.41	5.32	5.12	4.59	4.89	4.06	4.25	4.08	37.71

2. The effective rainfall (75% of the total rainfall) is downloaded, arranged and cumulated as given in table:

Location	Precipitation (mm)								
	03-Aug	04-Aug	05-Aug	06-Aug	07-Aug	08-Aug	09-Aug	10-Aug	Total
Peshawar	0.00	0.00	0.21	0.00	4.62	0.00	0.00	0.00	4.83
Sargodha	38.80	0.12	21.05	0.00	0.58	0.00	0.00	42.00	102.55
Hyderabad	0.00	1.19	0.00	3.70	0.10	0.79	1.35	0.66	7.79

3. The net weekly crop consumption is calculated by cumulating the weekly ET<sub>o</sub>, subtracting the effective precipitation, multiplication with the respective K<sub>c</sub> value of the crop and dividing by an application efficiency of 75% as given in table:

Location	Weekly ET <sub>o</sub> (3 - 10 Aug)	K <sub>c</sub>	ET <sub>c</sub> (mm)	Effective Prec.(mm)	Net Weekly Irrigation Requirement (mm)	Net Weekly Irrigation Requirement (inches)	Key Irrigation Advisory Message
Peshawar	26.71	Maize = 0.62	16.56	3.62	17.25	0.7	Irrigate
Sargodha	29.95	Maize = 0.62	18.57	76.91	-77.80	-3.1	Do not Irrigate or lessen irrigation
	29.95	Rice = 1.10	32.94	76.91	-58.63	-2.3	Same
	29.95	Sugarcane = 1.10	32.94	76.91	-58.63	-2.3	Same
Hyderabad	37.71	Banana = 1.50	56.56	5.84	67.62	2.7	Irrigate
	37.71	Cotton = 0.60	22.62	5.84	22.38	0.9	Irrigate
	37.71	Sugarcane = 0.80	30.17	5.84	32.43	1.3	Irrigate

4. Cell broadcast of short messaging service (SMS) is designed for simultaneous delivery of message to multiple users in a specified area. Cell broadcast services have become common in Pakistan for cost-effective delivery of the messages to the masses mostly by the private companies to promote their business. PCRWR used cell broad cast service provided for delivery of weekly messages to 100,000 farmers as shown in Figure 2:



Figure 2: A sample message in Urdu sent on 12 May, 2017

5. A cellular phone company was engaged through competitive bidding process to provide the cell broadcast service. The contract was signed with M/s Telenor @ US\$Rs. 0.003/message. It is pertinent to mention here that one IAS message consisted of 4 message length, hence was charged as US\$ 0.01/message.
6. Farmers receiving the irrigation advisory via SMS cellphone broadcast were then interviewed and the feedback is compiled for further improvement of the message for the farmer. The inventory of the farmers was developed using relevant information sources (University of Agriculture, Faisalabad, Agriculture extension Department and International Centre for Agricultural Research in Dry Areas (ICARDA). Districts were selected depending upon different agro-climatic zones of the country for better distribution.
7. The broadcasted messages of the last four weeks for different districts are also uploaded on PCRWR website for ready reference ([www.pcrwr.gov.pk/compaign.php](http://www.pcrwr.gov.pk/compaign.php)).

The logical flow sheet of the message formulation and delivery are shown in Figure 3

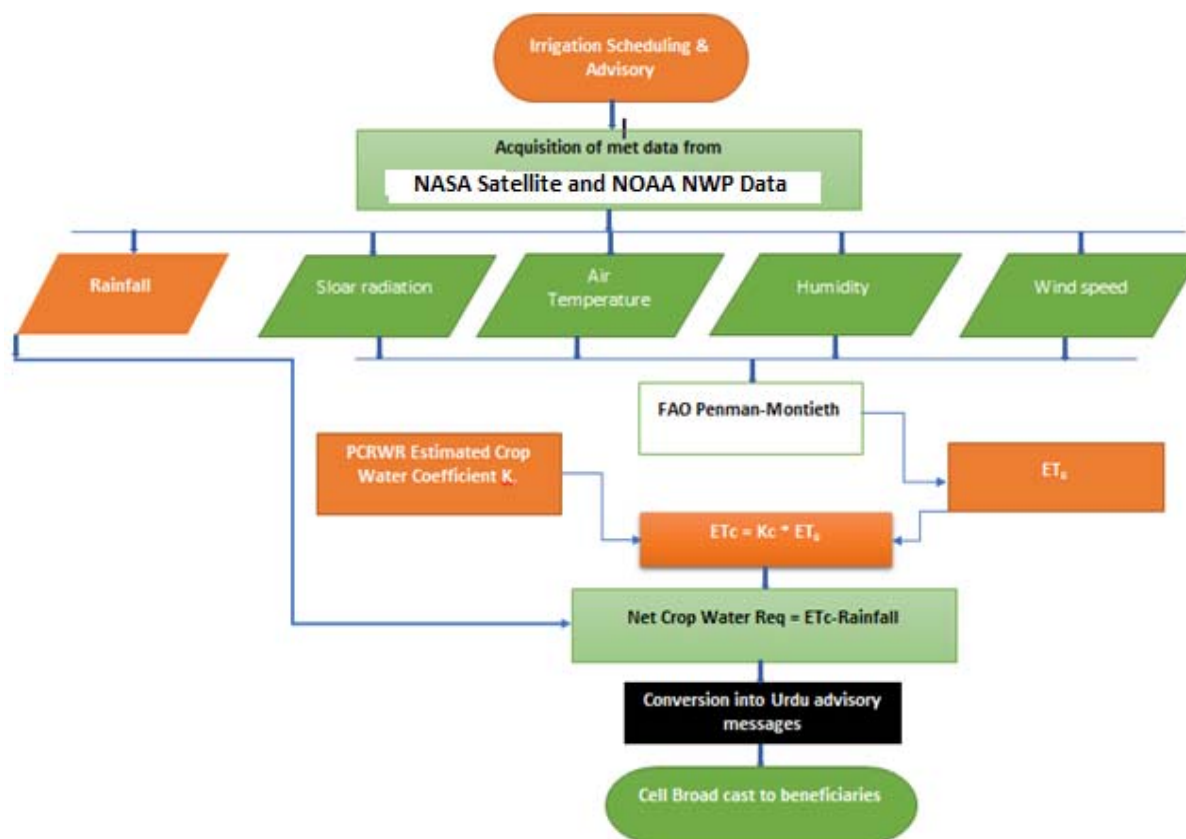


Figure 3: Flow diagram of the message formulation and broadcast via cellphones

### Impact Analysis of the PCRWR Irrigation Advisory Service

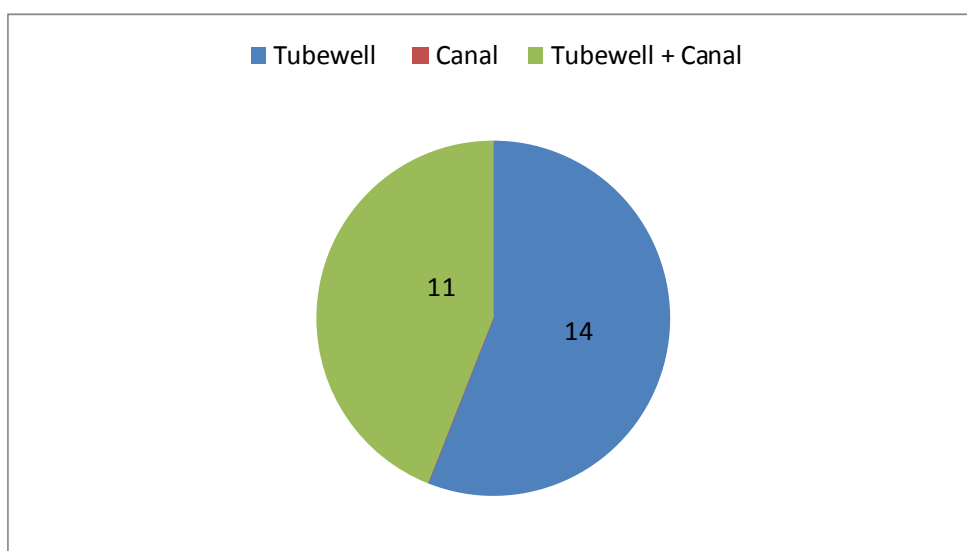
The beneficiary farmers (i.e. the farmers receiving the SMS service) were provided with a call back number for further assistance and asked to provide feedback on the irrigation messages they received. The farmers were also called randomly for their feedback since the implementation of the service. An impact analysis was carried out during August, 2017 by calling the beneficiaries of different agro-climatic zones to assess the impact of the services on water conservation and yield improvement. The evaluation targeted a minimum of 25 beneficiary farmers from each of the 4 agro-climatic zones, namely rice-wheat, cotton-wheat, mixed cropping and orchard-crops.

A questionnaire was developed that carried the following queries on: Name, district, contact number, cultivated area, crops grown, irrigation water sources, weekly message delivery/receipt, message comprehension (understanding), message utilization (action triggered), issues in using message, reduction in water use, yield improvement and willingness for further interview. Appendix-I provides a summary of this questionnaire with the

comprehensive responses received from each surveyed farmer. The impact analysis survey is broken down zone wise and are presented in the sections that follow.

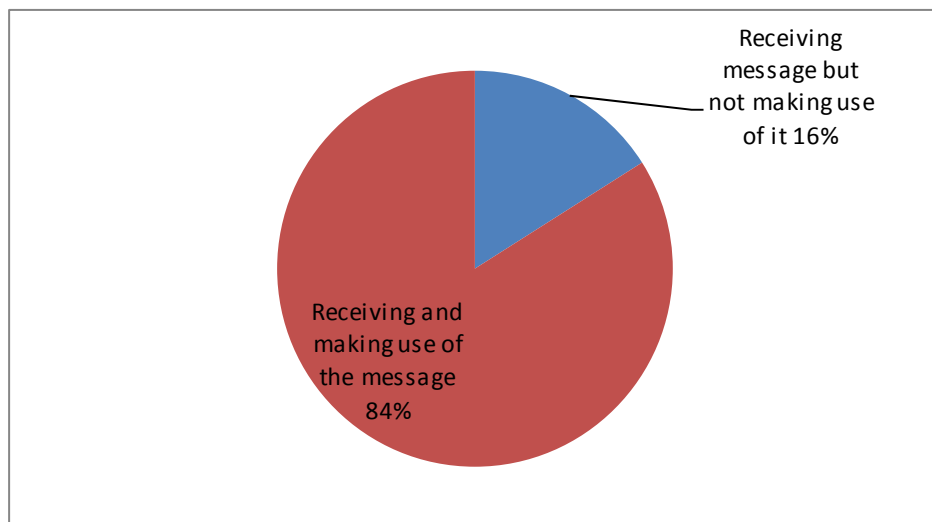
**(i) Rice-Wheat Zone**

The zone lies in the north-eastern part of Punjab and is famous for producing the finest quality rice of the world called *Basmati* as can be seen in Figure 1. The average annual rainfall in the area is 800 mm, most of which is during the monsoon *i.e.* the season when the rice nursery is transplanted in the region. The surveyed farmers belonged to the districts Lahore, Gujranwala, Sheikhupura and Sialkot. Although the zone is classified as rice-wheat, but it was found to have vegetables, maize, grass, fodder and even moringa is cultivated on commercial basis. Almost 35 farmers were randomly selected and called for the feedback as per the questionnaire. The area is mostly groundwater irrigated as shown in Figure below:



Distribution of irrigation water sources in the surveyed rice-wheat zone

- Twenty five farmers (62%) responded while the rest didn't respond to the survey.
- Most of the farmers were dependent upon groundwater (56%) while the others were having canal supplies as well.
- Twenty one farmers (84%) received and acted on the messages on a weekly basis. They understood the message and made use of it for irrigation scheduling. Only 4 farmers (16%) did not act. The likely reason is that they were either uneducated or perceived the advisory system as unreliable.
- The rainfall forecast was particularly appreciated by all farmers who responded. The monsoon rains started early this year, the advisory message helped farmers about the upcoming rainfalls and they planned their transplantation of rice nursery accordingly well on time.



Message utility percentage among the respondents in the rice-wheat zone

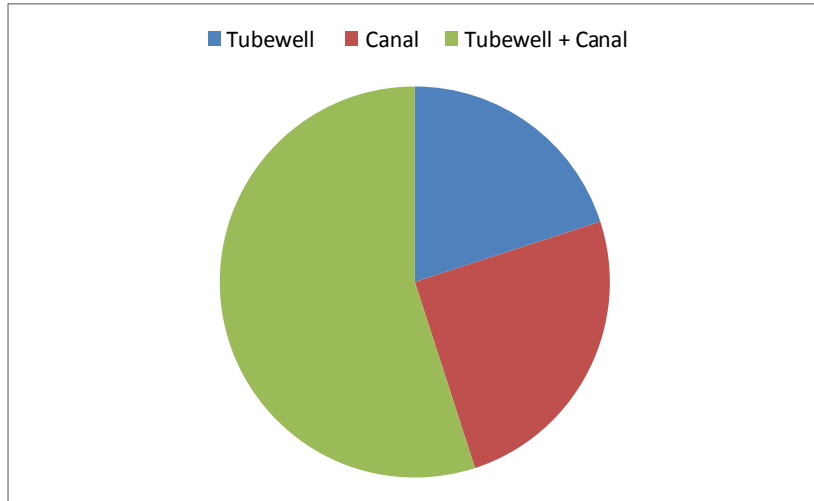
- All the 21 respondents (84%) recorded that they have obtained better yields with much less water; however they couldn't quantify it (increase in yield) because they do not have water measuring gadgets.
- Farmers indicated that the irrigation advisory service should also include *Moringa Olifeira* and vegetables.
- Farmers also suggested that the rainfall forecast be extended up to 15 days in order to be more proactive in planning the rice transplantation from the nursery.

**(ii) Cotton-wheat zone**

This zone mostly makes up the southern Punjab and Upper Sindh regions (Figure 1). Pakistani cotton was once famous in the world and produced in the zone. The survey was randomly conducted in the districts of Rahim Yar Khan, Multan, Bahawalpur, Bahawalnagar and Rajanpur. There is less rainfall in the region ranging from 250-300 mm in a year. Groundwater is marginal and mostly the crops are dependent upon canal supplies. Almost 45 farmers were called out of which 25 (60%) submitted their proper feedback. The findings are as follows:

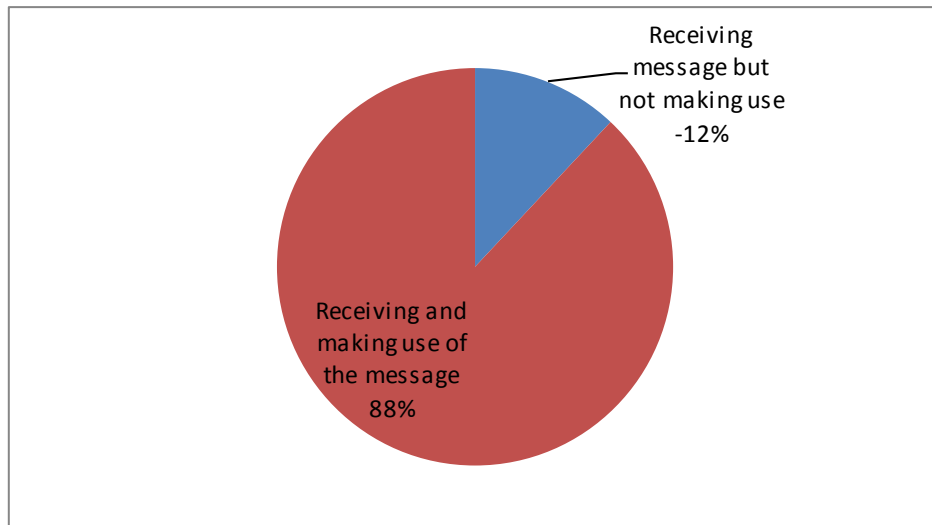
- Four farmers were entirely dependent upon groundwater (16%), while the rest either have canal water or both canal and tubewell water.





Distribution of irrigation water sources in the surveyed cotton-wheat zone

- Only 3 farmers (12%) out of the sampled 25 were not making use of the irrigation advisory message being uneducated or due to many fake messaging services for the promotion of different items by other cellular operators.



Message utility percentage among the respondents in cotton-wheat zone

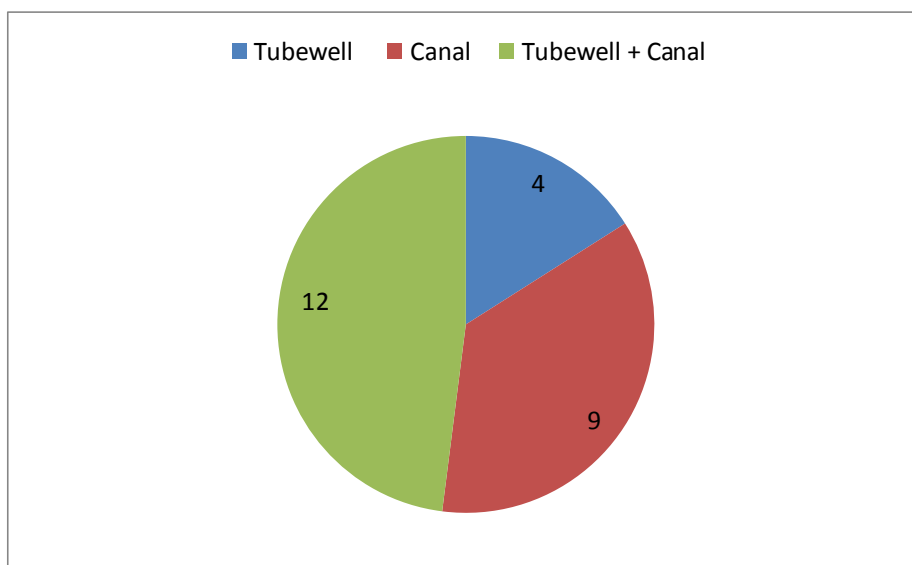
- Marginal quality groundwater is used during the canal closure period (6 months), which have detrimental effects on their crops and soil health. Therefore, the irrigation advisory service was found particularly useful by farmers during the canal closure period, as it helped farmers in rationalizing the irrigation and save 15-20% water and 30-40% reduction in their fuel costs.

- The zone lies in the low rainfall areas of Pakistan; therefore rainfall forecast in the message was of particular interest to farmers. The canal water supplies are traded considering the rainfall forecast.
- Farmers emphasized that fertilizer and pesticide application advisory would be in demand, as maximum use of pesticides is for cotton.
- Training can improve utility of the service
- Windstorms are getting common; a forecast about the windstorm can be very helpful for better preparedness.

**(ii) Mixed Zone**

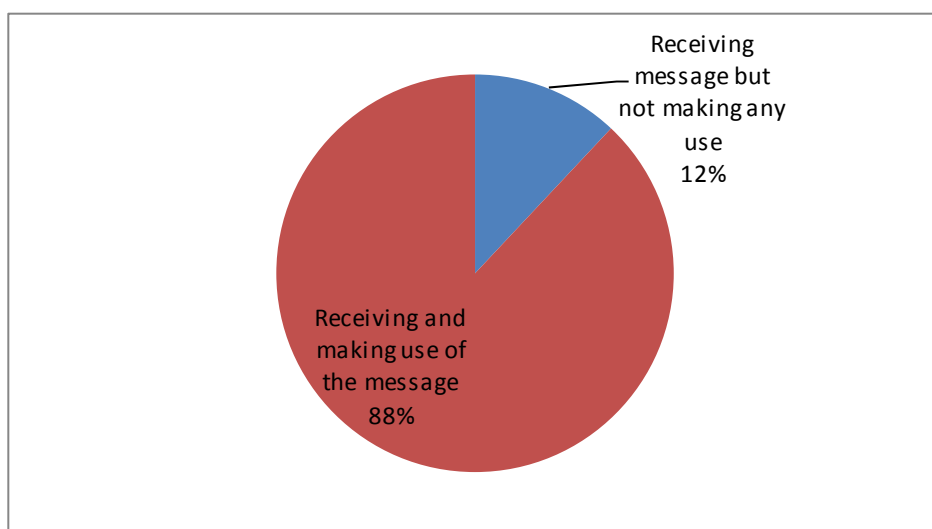
The survey was conducted in the districts of Faisalabad, T.T. Singh and Sargodha mostly. The zone lies in central Punjab, where both canal and groundwater of relatively good quality is available for irrigation. The zone has diverse crops like sugarcane, rice, orchards, wheat and vegetables. The area is particularly renowned for producing vegetables and fruits like oranges, guava and lemon etc. The average rainfall in the area is 300-500 mm/year. A total of 32 farmers were surveyed, out of which 25 (78%) properly responded. The findings are:

- Most of the farmers had canal and tubewell water supplies, while only 4 (16%) were entirely dependent upon groundwater.
- The average landholding of the respondents came out to be 17.5 acres, though a lot of variations exist.
- Only 4 farmers (12%) were not using the service being uneducated or believing it to be unreliable. Twenty-one farmers (84%) received the messages weekly and making use of it.



Distribution of irrigation water sources in the surveyed mixed zone

- Groundwater dependent farmers applied irrigation on Saturday morning (46%) after receiving the message and applied requisite depth of irrigation accordingly.
- Canal water was supposedly providing only a fraction of their irrigation requirements. However, the irrigation advisory system has now allowed them realized that the canal water is almost equal to the crop water requirements, so dependency on groundwater has lessened.
- Improvement in crops yield due to less application of groundwater being of marginal quality has been observed by many farmers.

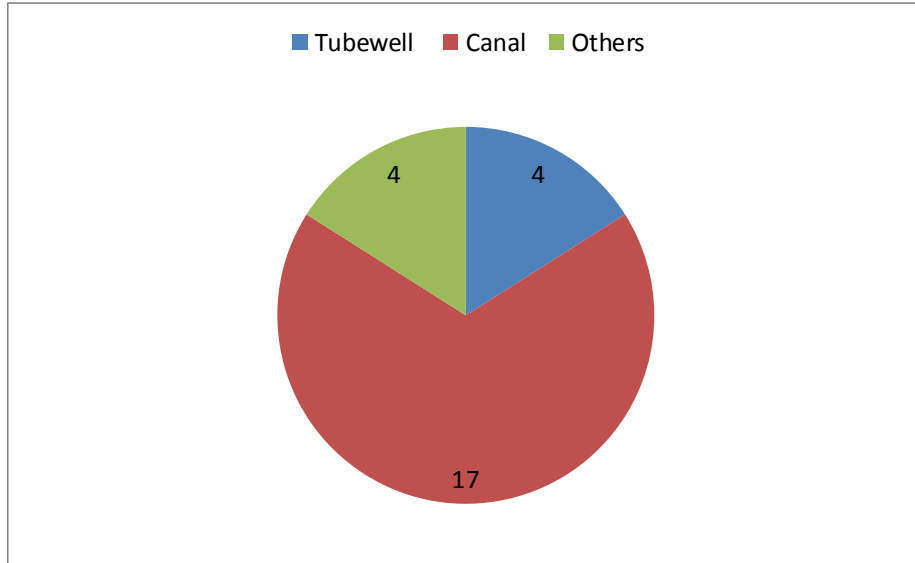


Message utility percentage among the respondents in mixed zone

- Seventy percent farmers skipped irrigation when rainfall was forecasted, which not only helped them save irrigation costs but also protected their crops from lodging
- Irrigation advisory for vegetables and fruit plants can be very useful.
- Many farmers (40%) expressed their desire to be trained on drip irrigation system for their orchards.

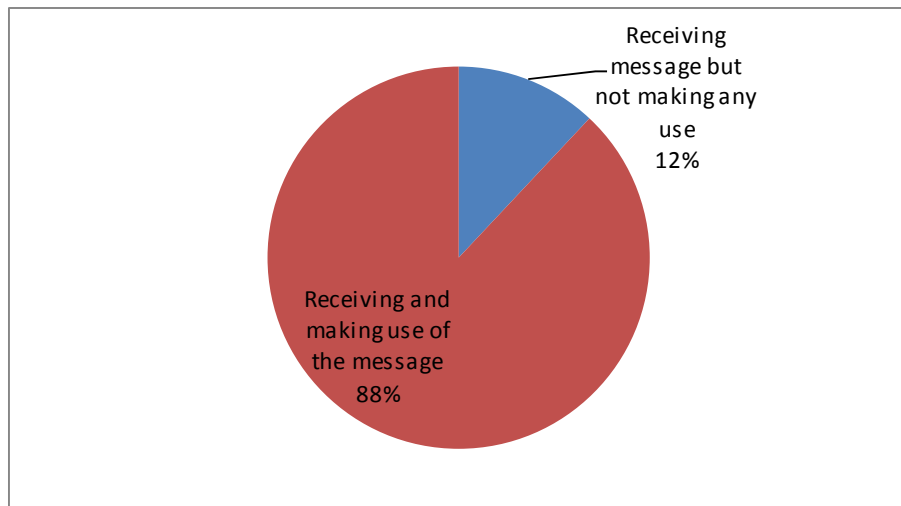
#### **(iv) Crops-Orchard Zone**

The northern and southern parts of the country are under this zone. Orchards are becoming an important component of the maize-wheat rotation in Peshawar (KP province) and banana for the cotton-wheat rotation in Hyderabad (Sindh province). The surveyed farmers belonged to the same districts. The annual rainfall in Peshawar is high but the Hyderabad area is quite arid and receives about 200 mm. Almost 45 farmers were contacted out of which 25 responded. The findings of the survey are as follows:



Distribution of irrigation water sources in the surveyed mixed zone

- Only 3 farmers (12%) were not using the service, while the rest are receiving and making use of it for irrigation scheduling advice.
- Most of the farmers had canal supplies, while four farmers (15%) were exclusively dependent upon groundwater and the remaining 3 (12%) were dependent upon rainfall and spring water.



Message utility percentage among the respondents in crops-orchard zone

- The major portion of the agriculture income in this zone comes from orchards, plum, peach, pear, tomato, and apricot etc. in Peshawar and banana in Hyderabad.
- Particularly, the farmers of the Peshawar area asked to include the advisory for the orchard crops.

- Almost 70% farmers of Peshawar emphasized that messages should be in Pashto (regional language in KP province).

### **Impact Analysis – Individual and Personal Stories from Farmers**

- Mr. Hussain Abad Khan, Jalalpur, District Multan, a progressive farmer owning 400 acres of land shared that he read the story of PCRWR Irrigation Advisory Service (IAS) published on Voice of America online. He said, *“I was not a beneficiary of the service, but when I came to know, how much it is beneficial for the others, I found out the PCRWR number from web and called them to include my number in the beneficiary list of the Multan district since 11<sup>th</sup> August, 2017. Being an educated farmer, I knew the importance of the information provided by PCRWR as it can substantially reduce my irrigation costs, which makes up a huge chunk, almost 60%, of the total input costs of my crops.”*
- Mr. Nazir Ahmad Choudhary, District Faisalabad, a progressive farmer of 14 acres is also an Ex-Extension officer. He told that he is a beneficiary of the PCRWR IAS and a member of the local *Kisan Ittehad* (farmers’ union group) forum in Faisalabad. Convinced on the efficacy of the message in water saving and yield improvement, he is not only using the messages for optimizing his own irrigation schedule but also explains it to the other beneficiary farmers during the group meetings.
- Muhammad Ashraf, Hayatabad, Sargodha, recorded his feedback on 11<sup>th</sup> May 2017 as, *“I had grown wheat on my 12 acres land this season and continuously received irrigation advisory messages from PCRWR system,” he said, speaking in his native Urdu. “Keeping in view the advised water consumption and rainfall forecast, I only applied three irrigations, whereas my neighboring farmers applied six to seven irrigations. I have recently harvested my crop and got 48 maunds/acre [4,742 kg/ha] yields, whereas my neighbors could get 42 maunds/acre [4,149 kg/ha]. I am thankful to PCRWR for their advice, which not only let me get better yields but the irrigation cost was substantially reduced.”*
- Mr. Sajjad Hussain, District Gujranwala, an agronomist and owner of 90 acres farm. He shared that he is properly using the IAS message and have got convinced that he is saving at least 40% water. A grower of crops like sugarcane, wheat, rice and fodder, he shared that he cultivates the said crops mostly beds or ridges. He offered his services to arrange a field day at his farm where he would demonstrate to the farmers that how he is using the message information for application of water to the crops.
- Haji Nazeer Ahmad Qazi, Makhdoom, District Sargodha recorded feedback on 28<sup>th</sup> March, 2017 as, *“I had grown wheat on 10 acres. I received PCRWR message that 0.5 inch rainfall is expected in the upcoming week. Keeping in view of the expected rainfall and last week water consumption I skipped my last irrigation for wheat and used the same for leguminous crop. The rainfall forecast proved right, which not only saved me irrigation but protected wheat from lodging as his nearby farmers suffered”.*

- Mohammad Tariq, a beneficiary from Faisalabad says, *“I think the information they send is quite useful for us as by conserving water, our profit margins will be greater.”*
- Mr. Ghulam Ali, 20 acre farmer from Hyderabad District shared that grows banana, rice and sugarcane at this farm. He has estimated that he is approximately saving 60% water since the PCRWR started the IAS operations. He further told that his yields have substantially improved, though he could not quantify. *“The profit margins of the crops have enabled me to perform Hajj for the first time in my life during the 2017,”* he said.

## **CONCLUSION**

Our impact analysis survey of the satellite-based irrigation advisory system can be concluded with the following key findings:

- More than 80% of farmers have confirmed that they are receiving the messages on weekly basis and making use of it in terms of optimizing their irrigation schedules to minimize waste, maximize efficiency and crop production.
- Such an overwhelmingly positive response may be attributed to the selection of beneficiary farmers who had already received training from governmental or non-governmental organizations.
- When farmers were asked how the irrigation advisory messages have helped them in terms of optimizing their irrigation schedules, most replied that they either delayed the irrigation until the total water available by crops (excluding the rainfall) reached 3 inches or they applied irrigation as water becomes available from the canal system. Most of the farmers reported that they use fingers for water depth measurement. A finger has 3 portions, each approximately 1 inch, Farmers shut off the irrigation as soon as the water depth reaches 3 inches as they continuously measure it with their fingers in different parts of the field.
- Farmers frequently skip the irrigation when rainfall is forecasted in the coming week. In most of the cases (90%) the rainfall forecast informed by PCRWR is right in terms of occurrence. The PCRWR developed irrigation advisory system is particularly useful for groundwater irrigated areas where farmers have control on irrigation water supplies.
- In response to the survey question on how much the satellite-based irrigation advisory service has helped in terms of water saving or yield improvement, most farmers reported that they were unable to quantify the results. Water saving estimation is possible if farmers are provided some gadgets for water measurements for a future survey. However, many farmers guessed the savings to be in the range of 15-20%.

We provide the detailed survey results from individual farmers in Appendix-2 for the interested reader.

**APPENDIX -1**

**Questionnaire Survey for Farmers**

- I. What is your Name?
- II. How much area you have and cultivate?
- III. What crops do you grow?
- IV. What are the irrigation water sources?
- V. Are you receiving the message by PCRWR?
- VI. How many messages do you receive in a week and month?
- VII. Are you reading the message?
- VIII. Do you understand the message?
- IX. Are you making use of the message and how?
- X. Is the messaging service useful and what issues are you facing?
- XI. What benefits have you got so far?
- XII. What improvements can be made in the message for better utility?
- XIII. Can you be approached for onsite detailed interview?

## Annexure-I

### Farmers' Feedback in the Rice-Wheat Zone

Sr. #	Name	Cultivated area	Crops	District	Contact No.	Irrigation Water Sources	Message delivery	Understanding of message	Making use of message	Issues in using messages	Reduction in water use	Improvement in yield	Improvements options for better utility
1	Sajjad Ahmad	22 acre	Rice	Gujranwala	03006413960	Tubewell	Yes	Yes	Yes	-	Yes	Yes	<p>Moringa advisory be added</p> <p>The vegetables may also be included.</p> <p>Rainfall prediction be included for the next 15 days for better transplantation of rice</p> <p>Improved water application methods be also told.</p> <p>Training on properly using the messaging service</p>
2	Qaiser Nawaz	30 acre	Rice, Wheat	Gujranwala	03006429729	Tubewell	Yes	Yes	No	No reliability of message	-	-	
3	Salman	5-6 acre	Rice	Gujranwala	03006457129	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
4	Ahmad Manj	25 acre	Rice, Vegetables	Gujranwala	03006460740	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
5	Sajid Asghar	15 acre	Rice, Grass	Gujranwala	03476153990	Tubewell	Yes	Yes	Yes	-	Yes	Yes	
6	Rashid Minhas	2 kanal	Vegetables	Lahore	03334274953	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
7	M. Nasrullah	7 acre	Moringa, lucern	Lahore	03334251332	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
8	Gulam Ghous	8 acre	Maize, Rice	Sheikupura	03414102331	Tubewell	Yes	Yes	No	Uneducated	-	-	
9	M. Hanif	5-7 acre	Maize, Rice	Sheikupura	03354353891	Tubewell	Yes	Yes	No	Didn't take it seriously	-	-	
10	Shahzad Ahmad	15 acre	Vegetable, Wheat, Fodder	Lahore	03228033231	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
11	Naveed Ahmad	1 acre	Rice	Sheikupura	03008819701	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
12	Gulam M. Virk	100 acre	Wheat, rice	Sheikupura	03008878519	Tube well	Yes	Yes	Yes	-	Yes	Yes	



Sr. #	Name	Cultivated area	Crops	District	Contact No.	Irrigation Water Sources	Message delivery	Understanding of message	Making use of message	Issues in using messages	Reduction in water use	Improvement in yield	Improvements options for better utility
13	Asghar Ali	76 acre	Rice	Sheikupura	03004920008	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
14	M. Khalid	7 acre	Rice, Fodder	Gujranwala	03026479795	Tube well	Yes	Yes	No	Uneducated	-	-	
15	Hamid Nawaz	5.5 acre	Cotton	Gujranwala	03026522635	Tube well	Yes	Yes	Yes	-	Yes	Yes	
16	Mahmood Hussain	15 acre	Sugarcane, Cotton	Gujranwala	03026552418	Tube well	Yes	Yes	Yes	-	Yes	Yes	
17	Abbas	1.5 acre	Rice, Fodder	Gujranwala	03026601963	Tube well	Yes	Yes	Yes	-	Yes	Yes	
18	Toufeeq Ahmad	5 acre	Cotton	Gujranwala	03064949344	Tube well	Yes	Yes	Yes	-	Yes	Yes	
19	Mahboob Ellahi	22 acre	Vegetable, Rice, sorghum	Sheikupura	03004688879	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
20	Arshad	2 acre	Fodder	Sheikupura	03006672965	Tube well	Yes	Yes	Yes	-	Yes	Yes	
21	Abdul Rehman	60 acre	Rice, Maize Vegetable	Sheikupura	03014890620	Tube well	Yes	Yes	Yes	-	Yes	Yes	
22	M. Akhtar	250 acre	Rice, Maize	Lahore	03004926552	Tube well	Yes	Yes	Yes	-	Yes	Yes	
23	Shahid	25 acre	Maize, Rice	Lahore	03224540456	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
24	Sajjad Hussain	90 acre rice	Wheat, Sugar cane Fodder	Gujranwala	03008401687	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
25	Shahid Mahboob,	60 acre	Rice, Maize Vegetable	Lahore	03008462787	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	

**Annexure-II**

**Farmers' Feedback in the Cotton-Wheat Zone**

Sr. #	Name	Cultivated area	Crops	District	Contact #	Irrigation Water Sources	Message delivery	Understanding of message	Making use of message	Issues in using messages	Reduction in water use	Improvement in yield	Improvements options for better utility
1	M. Akhtar	12.5 acre	Cotton	Rahim Yar Khan	03008772614	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	Fertilizer and pesticide application advisory be included  Weather rainfall prediction may be improved as rainfall is scanty in the region  Further training on properly using the messaging service
2	Hafiz Saeed	7 acre	Sugarcane, Cotton	Rahim Yar Khan	03084583057	Canal	Yes	Yes	Yes	-	Yes	Yes	
3	Mukhtar	80 acre	Wheat, onion Bajra	Rahim Yar Khan	03467570114	Tubewell	Yes	Yes	No	Didn't take it seriously	-	-	
4	Umair Mujahid	12 acre	Cotton, sugarcane	Rahim Yar Khan	03008611509	Canal, Tubewell	Yes	Yes	Yes	-	Yes (20-25%)	Yes	
5	Shahbaz	12 acre	Cotton	Rahim Yar Khan	03008678984	Canal	Yes	Yes	Yes	-	Yes	Yes	
6	Hussain Abbas Khan	400 acre	Sugarcane, Cotton, Mango, Orange	Multan	03008733010	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
7	M. Arshad	12.5 acre	Cotton, sugarcane	Bahawalpur	03029620220	Tubewell	Yes	Yes	Yes	-	Yes (15-20%)	Yes	
8	M. Akhtar	32 acre	Cotton, Maize	Bahawalpur	03335937004	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
9	M. Jamil	3 acre	Cotton	Pakpattan	03336899291	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
10	Anees	25 acre	Sugarcane, Grass	Sahiwal	03336914361	Tubewell	Yes	Yes	Yes	-	Yes	Yes	
11	Rehmat ali	6 acre	Cotton, Maize, Wheat	Bahawalnagar	03467567802	Canal, Tubewell	Yes	Yes	No	Uneducated	-	-	
12	Nazeer Ahmad	31 acre	Cotton, Maize Sugarcane	Multan	03027475269	Canal, Tubewell	Yes	Yes	Yes	-	Yes (10-15%)	Yes	

Sr. #	Name	Cultivated area	Crops	District	Contact #	Irrigation Water Sources	Message delivery	Understanding of message	Making use of message	Issues in using messages	Reduction in water use	Improvement in yield	Improvements options for better utility
13	M. ashiq	8 acre	Cotton	Vehari	03027949260	Canal	Yes	Yes	No	Didn't consider it reliable	-	-	
14	M Shafi	17 acre	Cotton, orchard	Bahawalnagar	03026986882	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
15	M. Javaid	10 acre	Rice, Fodder	Bahawalnagar	03086059986	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
16	Zulfiqar	12 acre	Cotton, Maize	Multan	03075168220	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
17	Abdul Rehman	15 acre	Mung, Cotton, Fodder	Bhakhar	03338908679	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
18	M. Ashfaq	6 acre	Cotton, Fodder	Rajanpur	03341642718	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
19	M. Rafiq	65 acre	Rice, Cotton	Rajanpur	03343194769	Canal	Yes	Yes	Yes	-	Yes	Yes	
20	M. Junaid	3 acre	Cotton	Rajanpur	03345197284	Canal	Yes	Yes	Yes	-	Yes	Yes	
21	M. Bilal	1 acre	Cotton	Rajanpur	03346049584	Tubewell	Yes	Yes	No	Uneducated	-	-	
22	M. Hanif	29 acre	Cotton, Sugarcane	Rajanpur	03346656731	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
23	Ghulam Nazuk	50 acre	Cotton	Rajanpur	03346692530	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
24	M. Amjad	6 acre	Rice, Sugarcane	Faisalabad	03027000775	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
25	M. Azeem	65 acre	Sugarcane, Vegetables	Faisalabad	03007203683	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	

Annexure-III

Farmers' Feedback in the Mixed Zone

Sr. #	Name	Cultivated area	Crops	District	Contact #	Irrigation Water Sources	Message delivery	Understanding of message	Making use of message	Issues in using messages	Reduction in water use	Improvement in yield	Improvements options for better utility
1	Latif	5 acre	Sugarcane, Rice, Orchard	Sargodha	03026750065	Canal, Tubewell	Yes	Yes	Yes	-	Yes (10%)	Yes (15%)	Orchards have become almost an integral part of the cropping systems therefore irrigation advisory be issued for fruit plants like orange, guava, lemon etc.
2	Mumtaz	8 acre	Sugarcane, Rice, Orchard	Sargodha	03041057104	Canal	Yes	Yes	Yes	-	Yes	Yes (15%)	
3	Akhtar Ali	10 acre	Sugarcane, Rice	Sargodha	03005609814	Tubewell	Yes	Yes	Yes	-	Yes	Yes	
4	Faiz Rasool	8 acre	Sugarcane, Guava	Faisalabad	03007107974	Canal	Yes	Yes	No	Didn't consider it reliable	-	-	
5	Saleem Akhtar	75 acre	Wheat, Sugarcane, Rice, Potato	Faisalabad	03457831537	Tubewell, Canal	Yes	Yes	Yes	-	Yes	Yes	
6	Aalim Sher	12.5 acre	Sugarcane, Wheat	Faisalabad	03457894248	Canal	Yes	Yes	Yes	-	Yes	Yes	
7	Nazeer A. Ch	14 acre	Sugarcane, Lentil, Maize	Faisalabad	03007280071	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
8	Zia Ullah	22 acre	Sugarcane	Faisalabad	03458679911	Canal	Yes	Yes	Yes	-	Yes	Yes	
9	M. Arif	20 acre	Sugarcane, Wheat	Faisalabad	03007641783	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
10	Sadiq	5 acre	Sugarcane, Grass	Faisalabad	03464142270	Canal, Tubewell	Yes	Yes	No	Didn't consider it reliable	-	-	
11	Munawar Abbas	15 acre	Rice, Grass	Jhang	03436257941	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
12	Abdul Jabbar	12 acre	Sugarcane, Maize	T.T.Singh	03464849161	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	

Sr. #	Name	Cultivated area	Crops	District	Contact #	Irrigation Water Sources	Message delivery	Understanding of message	Making use of message	Issues in using messages	Reduction in water use	Improvement in yield	Improvements options for better utility
13	Malik Allah Ditta	3 acre	Maize, Sugarcane	T.T.Singh	03464854061	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
14	Maqsood Ahmad	8 acre	Maize, Sugarcane	T.T.Singh	03437378371	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
15	Akhtar Rasheed	23 acre	Maize, Rice	Okara	03034475277	Tubewell	Yes	Yes	Yes	-	Yes	Yes	
16	Munawar Hussain Khan	20 acre	Wheat , rice, sugarcane	Jhang	03418671015	Tubewell	Yes	Yes	Yes	-	Yes	Yes	
17	M. Nawaz	2 acre	Maize, Sugarcane	T.T.Singh	03467374368	Canal	Yes	Yes	Yes	-	Yes	Yes	
18	M. Arshad,	25 acre	Rice, Maize, Sugarcane	T.T.Singh	03437235556	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
19	Altaf,	12.5 acre	Sugarcane, Wheat	T.T.Singh	03464843318	Canal	Yes	Yes	Yes	-	Yes	Yes	
20	Ajmal feel Ahsan,	62.5 acre	Sugar, cane Fodder	Faisalabad	03006982115	Canal	Yes	Yes	Yes	-	Yes	Yes	
21	Naveed,	5 acre	Maize, Sugarcane	Faisalabad	0345471255	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
22	M. Ahsaan,	20 acre	Sugarcane, Fodder	Sargodha	03006040213	Canal, Tubewell	Yes	Yes	No	Believe in indigenous knowledge	-	-	
23	Zahid Mahmood	5 acre	Orchard, Fodder	Sargodha	03006032046	Canal	Yes	Yes	Yes	-	Yes	Yes	
24	Munawwar Hussain,	20 acre	Rice, Sugarcane	Jhang	03418671015	Tube well	Yes	Yes	Yes	-	Yes	Yes	
25	Ghaffar	25 acre	Sugarcane, Rice	Sargodha	03006023402	Canal	Yes	Yes	No	Didn't consider it reliable	-	-	

Annexure-IV

Farmers' Feedback in the Crop Orchards Zone

Sr. #	Name	Cultivated area	Crops	District	Contact No.	Irrigation Water Sources	Message delivery	Understanding of message	Making use of message	Issues in using messages	Reduction in water use	Improvement in yield	Improvements options for better utility
1	Dildar Hussain	6 acre	Sugarcane, Fodder, Orchard	Hyderabad	03344341316	Canal	Yes	Yes	Yes	-	Yes	Yes	Messages should be in Pashto (regional language in KP province).  The advisory should include orchard plants as well
2	Rhajesh Mal	20 acre	Cotton, Banana	Hyderabad	03132668981	Tubewell	Yes	Yes	Yes	-	Yes	Yes	
3	M. Zaman	70 acre	Banana, Sugarcane, Cotton, Onion	Hyderabad	03013523792	Tubewell	Yes	Yes	Yes	-	Yes (20%)	Yes (10-15%)	
4	M. Ali	60 acre	Sugarcane, Onion	Hyderabad	03003053430	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
5	Dewan Kumar	12 acre	Sugarcane, Cotton	Hyderabad	03120288241	Canal, Tubewell	Yes	Yes	Yes	-	Yes	Yes	
6	Mehwar Khan	8 acre	Peach	Peshawar	03111552700	Canal	Yes	Yes	Yes	-	Yes	Yes	
7	Sher Ali	12 acre	Wheat, sorghum, vegetables	Peshawar	03329935496	Canal	Yes	Yes	Yes	-	Yes	Yes	
8	Rahat Gul	20 acre	Maize, sorghum, Wheat	Peshawar	03427571050	Canal	Yes	Yes	Yes	-	Yes	Yes	
9	Habib Ur Rehman	15 acre	Wheat, Maize	Peshawar	03009395241	Rainfed	Yes	Yes	Yes	-	Yes	Yes	
10	Anwar Khan	20 acre	Plum	Peshawar	03369190709	Canal	Yes	Yes	Yes	-	Yes	Yes	
11	Sardar Muhammad	8 acre	Vegetables, Peach Plum	Peshawar	03005560428	Canal	Yes	Yes	Yes	-	Yes	Yes	

Sr. #	Name	Cultivated area	Crops	District	Contact No.	Irrigation Water Sources	Message delivery	Understanding of message	Making use of message	Issues in using messages	Reduction in water use	Improvement in yield	Improvements options for better utility
12	Fazalullah	2 acre	Plum	Peshawar	03135325313	Canal	Yes	Yes	No	Uneducated	-	-	
13	M. Saleem	3 acre	Wheat, Sugarcane, Grass	Peshawar	03320917059	Canal	Yes	Yes	Yes	-	Yes	Yes	
14	Quim Khan,	12 acre	Wheat, Fruit Orchard	Peshawar	03339149703	Canal	Yes	Yes	Yes	-	Yes	Yes	
15	M. Arif,	18 acre	Rice	Hyderabad	03004660520	Canal	Yes	Yes	Yes	-	Yes	Yes	
16	M. Amin,	30 acre	Vegetables	Peshawar	03028887723	Canal	Yes	Yes	No	-	Yes	Yes	
17	M. Ishaq,	36 acre	sorghum, Maize, Sugarcane, Orchard	Peshawar	03328815867	Tubewell	Yes	Yes	Yes	-	Yes	Yes	
18	Nasrullah	1.5 ac	Tomato, Vegetable	Peshawar	03334788301	Canal	Yes	Yes	No	Uneducated	-	-	
19	Ghulam Ali	20 acre	Sugarcane, Rice	Hyderabad	03443482638	Canal	Yes	Yes	Yes	-	Yes (60%)	Yes	
20	Meer Muhammad,	20 acre	Sugarcane, Banana, Vegetable	Hyderabad	03468262094	Canal	Yes	Yes	Yes	-	Yes	Yes	
21	Alao Khan,	400 acre	Mango orchard	Hyderabad	03062996514	Tubewell	Yes	Yes	Yes	-	Yes	Yes	
22	Swat	1 acre	Maize sorghum	Peshawar	03038069601	Canal	Yes	Yes	Yes	-	Yes	Yes	
23	Fyaz Khan	12 acre	lentil, Sugarcane sorghum	Peshawar	03337878800	Canal	Yes	Yes	Yes	-	Yes	Yes	
24	Sangeen Khan	20 acre	Maize	Peshawar	03449092022	Canal	Yes	Yes	Yes	-	Yes	Yes	
25	M. Nisar	40 acre	Wheat	Peshawar	03005935518	Rainfed, Spring	Yes	Yes	Yes	-	Yes	Yes	

