Assessing the use and benefits of weather and climate information services in Pakistan

Final report for the Asia Resilience to a changing climate programme

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Executive summary

This study was jointly pursued by the University of Leeds, the International Centre for Integrated Mountain Development (ICIMOD) and the Met Office together in collaboration with the Pakistan Meteorological Department (PMD) and under the auspices of the Asia Regional Resilience to a Changing Climate programme. This programme has been funded by the UK Foreign, Commonwealth and Development Office.

Purpose and scope of study

The study aimed at evaluating the use of PMD weather and climate information services in Pakistan by farming communities and covered four key objectives:

- Understand the user landscape i.e. who uses the services provided by PMD and who does not;
- Examine farmers' perceptions of the services provided by PMD in terms of how useful and usable they are;
- Explore the conditions that enable or constrain the use of weather and climate information services (WCIS);
- Determine the impacts, including socio-economic benefits and costs of the services provided.

Case study area and methods

The case study area focused on 24 villages across the Punjab and Sindh Provinces focusing on wheat and cotton crops. An equal representation by females and males' participants was purposely pursued to ensure a gender balance in our analysis. Data was collected through two rounds of farming households survey as well as 19 complementary Focus Group Discussions (FGD) with some of the farmers surveyed.

A total of 612 survey responses and qualitative comments from 126 participants during the FGD were collected and analysed using various software including R and Stata for the survey data and NVivo for the qualitative data from FGD.

General findings

A total of 612 survey responses were collected. Of these:

- 413 were based in Punjab and 199 were based in Sindh
- 311 were male respondents whilst 301 were female
- 340 were users of weather and climate information whilst 272 were non-users

All farming households surveyed depend on agriculture as their main income and most households experienced climate-related hazards in the past 10 years (2010-2020) with pests, plant diseases, rainfall and increase in temperature being those that most impacted respondents.

Main impacts from previous hazards were on farming households largely negative and linked to a decrease in cotton yield, a decrease in wheat yield, as well as a decrease in household income.

The main mechanisms for receiving warning related information were coming from friends or family, National TV channels, PMD SMS service and extension officers. The perceived benefits of using PMD advance warning information was helping them ensure an increase in wheat yield and a more efficient use of pesticides/fungicides.

Users of weather and climate information services

More than half of survey respondents (56%) identified themselves as WCIS users whilst 38% of respondents identified as non-users and the remaining 7% did not answer.

In total there were more WCIS users in Punjab than in Sindh (71% and 23%, respectively) whilst non-users of WCIS were great in Sindh than Punjab (77% and 29%, respectively). The number of male WCIS users was greater than female WCIS users (58% and 53%, respectively) whilst there is a greater number of female non-users than male non-users (47% and 42%, respectively).

The main source of information for users of WCIS in both Punjab and Sindh was PMD which also aligns with findings from the FGD, wit around 50% of WCIS users using PMD's daily weather forecasts closely followed by 40% who stated their daily use of farmer advisories. Other PMD products used daily but to a lesser extent include 3 days weather forecast, weekly weather outlooks, monthly outlooks and other types.

To note that many farmers use more than 1 source of WCIS information with around 40% using many of the PMD sources of information on a daily basis.

Two key PMD sources of information - weather news on national TV and PMD SMS service - are consistently used by approximately 40-50% of current users of WCIS to inform their key farming activities e.g. planting times, harvesting times, threshing times, irrigation, choice of planting varieties, use of pesticides and chemicals, and drying.

Socio-economic benefits of using weather and climate information services

Key benefits of using WCIS information identified by current users included:

- The information helps farmers make timely farming decisions
- The information helps increase crop yield or produce better quality crops
- Timely cotton picking/wheat harvesting
- More effective irrigation
- Better plan crop management and avoiding damages to crops
- Help protect crops from pests

To cross-check the perceived benefits of WCIS, we examined the impact of WCIS on profit, revenue, and cost for cultivating cotton and wheat crops from both provinces. There is no clear pattern on the direction of change on profit, revenue and cost between users and non-users of WCIS. Similar results are obtained for input costs (fertilizer, agro-chemicals, and irrigation).

Statistical analysis that helps accounting for household socio-economic characteristics and farm characteristics, suggests that there is no significant impact of WCIS on profits, revenue, cost and inputs cost except for cost of agro-chemicals for wheat crop, where WCIS farmers are spending 21.3% less on agro-chemicals.

Barriers to the use of weather and climate information services

This lack of impact on the key farm level outcomes may be due to the following challenges and concerns when using WCIS information as reported by farmers:

- Information is perceived as not being accurate
- Accessibility issues
- Information arrives late
- Information is too general and hard to use

Suggested ways of enhancing provision and use of WCIS information included:

- Improve spatial coverage so that information is provided at local level in local language
- Improve accuracy of information from trusted sources
- Require support from experts
- Training and education
- Improve WCIS information to better fit farmers' needs

Non-users of weather and climate information services

As mentioned above, 44% of survey respondents were non-users of WCIS many of them based in Sindh Province.

The main reason for not using this type of information related to difficulties in understanding it particularly regarding languages barriers as many of this information is provided in Urdu rather than more local

languages such as Sindhi, Punjabi and Saraiki. Other barriers for not using it related to limited access to information provided (as many are illiterate) as well as costs for accessing information; lack of relevance/ accuracy/usefulness of information; timeliness of information; and perceiving their own personal experience as more useful.

However, many non-users of WCIS would consider using this type of information it is was accurate, useful and their ability to understand strengthened; they would also prefer for the information to be delivered by extension officers and input dealers (trust).

Key conditions required for them to be able to use WCIS in the future included:

- Raising awareness and training amongst farmers;
- Provide timely information;
- Means for accessing information;
- Information provided by key informants; Financial stability.

Recommendations

Our study provides key recommendations for PMD regarding WCIS as well as other relevant government agencies such as Pakistan Agricultural Department. These include:

- **Gender considerations should be at the forefront when enhancing WCIS** and designing and implementing training and awareness raising activities;
- **Broadcast weather news on national/ regional TV at alternative times** as well as other relevant types of weather and climate information;
- **Raising awareness and implementing training activities;**
- **Enhance and expand existing extension services;**
- **Enhance weather and climate information currently provided** e.g. making information available in other local languages, provide information at higher spatial resolution, etc;
- **Further understanding the type of WCIS information that be useful** through effective co-production processes;
- **Set up feedback mechanisms** to enable ongoing learning and enhancement of WCIS provided to farmers.

40%

of farmers use many sources of PMD information daily

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1. Introduction

Funded by the UK Foreign, Commonwealth and Development Office, the Asia Regional Resilience to a Changing Climate Met Office Partnership (ARRCC MOP) aims to strengthen the provision and uptake of weather and climate information services (WCIS) across the South Asia Region. With a particular focus on Afghanistan, Bangladesh, Nepal and Pakistan and focusing on all meteorological timescales (weather, seasonal, climate) ARRCC MOP aims to build resilience to climate change and variability by improving the application and access to WCIS at regional to national levels. In addition, the programme supports the development of new technologies and innovative approaches to help vulnerable communities apply and use warnings and forecasts to better prepare for climate-related shocks.

The use of meteorological, hydrological, oceanographic and related information can deliver enormous benefits to society by enabling individuals, households, organisations, businesses and governments to make informed decisions that mitigate the impacts of weather and climate (WMO, 2015). In turn, this can have substantial social and economic benefits and contribute to sustainable development.

The importance of WCIS was emphasised in the IPCC's 2018 Special Report on Global Warming of 1.5°C, which recognised the critical role climate services can play in decision-making across all scales (IPCC, 2018). By improving the development, coordination and delivery of weather and climate information, there is significant potential to reduce the economic, social and human costs associated with poor planning and response (WMO, 2015). For example, it has been estimated that upgrading early warning systems across all developing countries in the world would result in between $300 million and $2 billion per year of avoided asset losses and save around 23,000 lives per year (Hallegatte, 2012).

Similarly, in one of the few evaluations of a WCIS in the region, Venkatasubramanian et al. (2014) assessed India's Integrated Agro-meteorological Advisory Service (which provides 5-day weather forecasts for seven parameters, including rainfall, maximum and minimum temperatures, wind speed and direction, relative humidity and cloudiness). Their analysis showed that farmers using the Advisory Service achieved up to a 15% increase in their yields and up to a 5% reduction in their costs of cultivation in relation to those farmers not using the service (Venkatasubramanian et al., 2014).

However, there is still limited empirical evidence of the scope and scale of potential benefits of using WCIS in the South Asia region (Suckall and Bruno Soares, 2022). This includes exploring barriers and bottlenecks in dissemination, assessing gaps in provision, and understanding how the process of producing and communicating WCIS could be improved within organisations across the region to ensure maximum value is generated.

The University of Leeds and the International Centre for Integrated Mountain Development (ICIMOD) are leading a study to evaluate the current provision of weather and climate information services (WCIS) in Pakistan by the Pakistan Meteorological Department (PMD). In particular, the study focuses on agricultural meteorological advisories aimed at cotton and wheat farmers in the Punjab and Sindh provinces of the country where rising temperatures, more frequent flooding and prolonged droughts threaten productivity (Raza and Ahmad, 2015).

PMD currently produces comprehensive agricultural meteorological (agro-met) advisories at various time scales relevant to farming communities, which covers the general forecast for the coming week, month and season along with crop specific suggestions. However, little is known about who uses the agro-met advisories, how farmers use the information, and if the use of the agro-met advisories are beneficial to the farm households in terms of revenue, cost saving, profit margin, and input usage as well as wider non-economic benefits. Therefore, the overall aim of the study is to provide empirical evidence on the use of agro-met advisories at the household level, as well as insights into their potential socio-economic benefits.

The overarching aim of this study is to identify areas where the agro-met advisories produced and disseminated by PMD could be improved. Underpinning this aim is the concept of equity i.e. in order to produce useful and usable WCIS the different information needs of men and women must be taken into account. To achieve this aim, the study is split into four research objectives:

- Understand the user landscape i.e. who uses the services provided by PMD and who does not
- Examine farmers' perceptions of the services provided by PMD in terms of how useful and usable they are
- Explore the conditions that enable or constrain the use of WCIS
- Determine the impacts, including socio-economic benefits and costs of the services provided

2. Agriculture, climate and weather in Pakistan

Agriculture is one of the dominant sectors of Pakistan's economy, contributing to 22.7% of national GDP and employing 37% of the country's labour force (Government of Pakistan, 2022). As Pakistan's staple food, wheat is grown extensively across the country and contributes to 50% of the nation's caloric intake (FAO, 2016).

Pakistan is also one of the world's largest cotton producers (Shuli et al.,2018). About 1.7 million farmers cultivate cotton in the country (Shuli et al., 2018). Cotton and cotton products account for nearly half of the foreign exchange earnings of the country. Cotton production supports Pakistan's largest industrial sector – textiles. The sector comprises a chain of mills, spinning factories, power looms, knitwear and garment units, ginners and oil extractors. Wheat and cotton are often grown together within a Cotton-Wheat Production System (CWPS) (Mayee et al., 2008). Across Pakistan, it is estimated that the CWPS covers 11.60 million hectares of land, the majority (76%) of which is in the Punjab province (Government of Pakistan, 2009).

There are two growing seasons in Pakistan, *rabi* (the winter season) when wheat is grown, and *kharif* (the summer season) when cotton is grown (Adnan and Khan, 2009). From July to September during the summer monsoon period about 60% of annual rainfall is received in most parts of Pakistan. Normally the depressions that form in the Arabian Sea and the Bay of Bengal produce rainfall over plains of Pakistan. According to the rainfall data analysis by Naheed et al. (2013) the upper parts of Khyber Pakhtoonkhwa province and the northern areas are found to be mainly vulnerable to increased variation in rainfall although the Punjab and Sindh provinces also observed some variation in the frequency trend. Cotton is grown under irrigated conditions in South Punjab and Upper Sindh which is popularly known as the Cotton Zone of Pakistan. Cotton production is highly dependent on weather conditions from sowing to final picking therefore continuous provision of accurate agro-met information ensures maximum yield. For instance, rainfall just after sowing makes a hard crust which doesn't allow seedlings to emerge and farmers are forced to replant again resulting in increased costs for seeds and fertiliser, in addition to delays. Likewise high humidity associated with high temperatures give rise to incidence of insects as well as pest attacks.

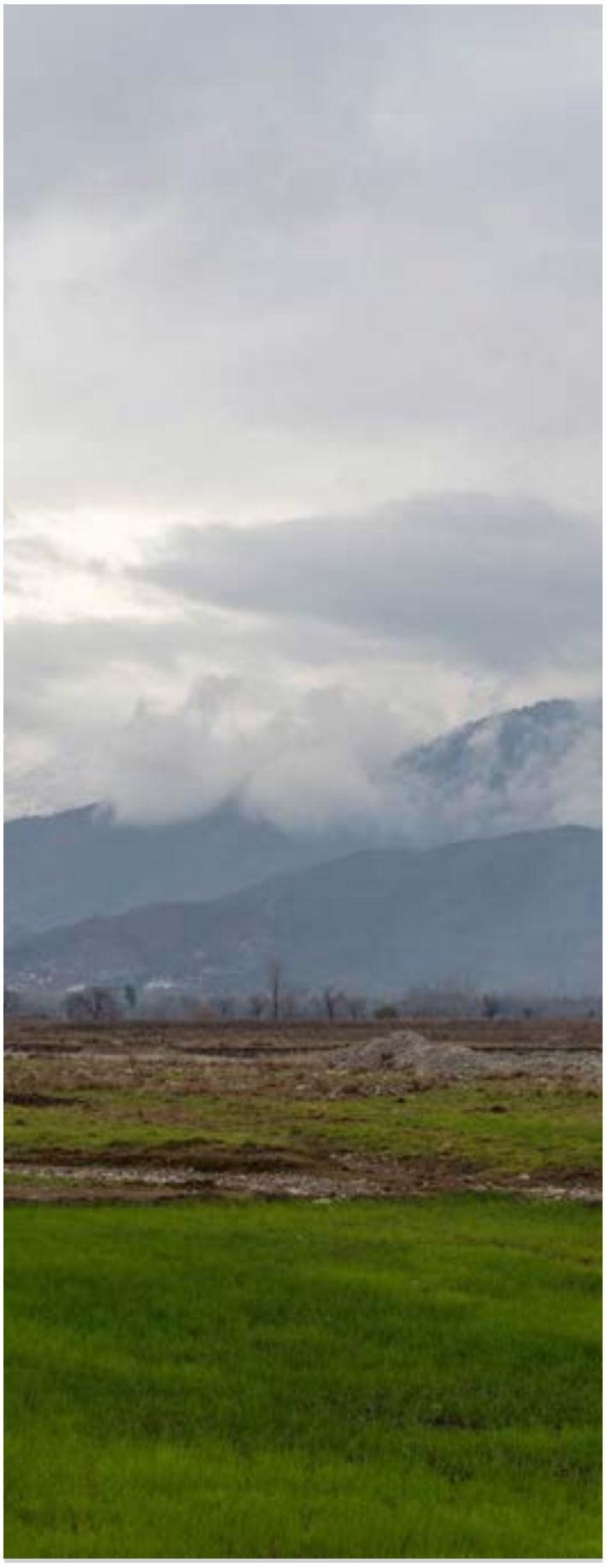
Both cotton and wheat face serious challenges from climate change and variability including changes to precipitation, floods, droughts and rising temperatures (Nomman and Schmitz, 2011, Gorst et al., 2015). The impacts of this are compounded by low adaptive capacity and poor infrastructure (Stocker et al., 2013). For example, following intense monsoon rains beginning in July 2010, flooding across the region caused widespread devastation of farmland and included over 700,000 acres of lost cotton crops (Dorosh et al., 2010). Similarly, there is some evidence that heavy rains and hailstorms in 2020 reduced wheat yields by 25-30% (WFP, 2020; FAO, 2020).

Cotton production supports Pakistan's largest industrial sector – textiles

PMD generates forecasts of different which aim to help reduce uncertainties and help farmers in planning their agricultural operations. Specifically, PMD produce the following services:

- A daily agro-met forecast that covers the proceeding three days, including parameters such as temperature, rainfall and wind.
- A weekly agro-met forecast at the sub-district level, which is issued every Monday.
- A seasonal agro climatic outlook is updated every month for the next three months.
- Weekly, ten day and monthly agro-met bulletins are prepared including the analysis of past data (temperature, rainfall, relative humidity, wind speed/direction and sun shine hours).
- Crop reports are prepared at the end of major cropping seasons i.e *Rabi* (winter) and *Kharif* (summer) seasons.
- Technical reports are prepared for a long-term (5-10 year) period.

Information is disseminated through a variety of means including: the government website (namc.pmd.gov.pk); a newsletter via email; and social media, such as WhatsApp groups, Facebook and YouTube e.g. "PMD weather TV". Agriculture departments and research institutes also help disseminate information. In addition, information is directly provided to a limited number of registered users. Information is provided in national and local languages.



3. Study Area

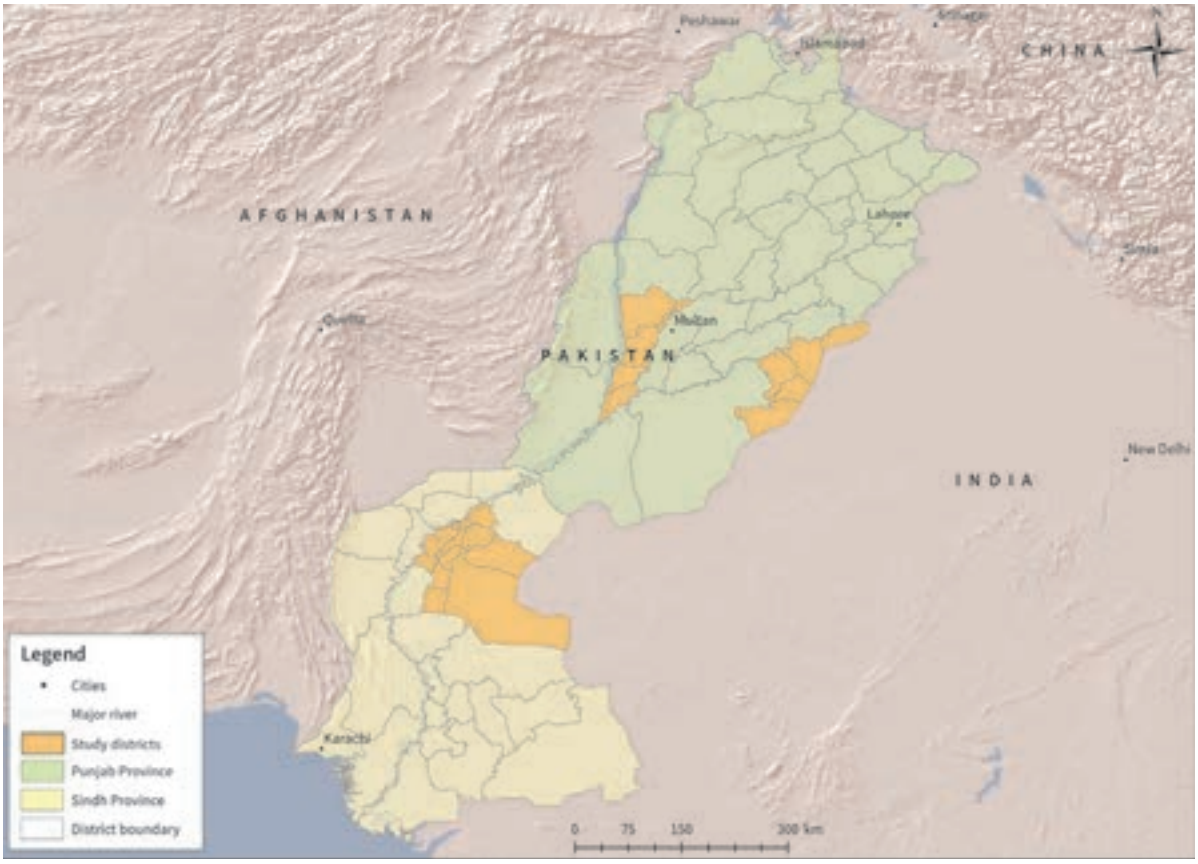
In consultation with PMD, two of Pakistan's four provinces have been identified for inclusion in this study: Punjab and Sindh (**Figure 1**). In both provinces, wheat is grown as a staple food crop, and cotton as a cash crop. These crops are increasingly grown in a sequential double cropping pattern.

Punjab is the most populous province in Pakistan and is home to around 110 million people, over half of the country's total population. It is also the second largest province at 20.63 million hectares, which is almost 30% of Pakistan's total land (Gov. of The Punjab, 2020). Agriculture is the biggest employer in the province, especially in rural areas where it employs 60% of the workforce (ILO, 2013). Gender divisions are evident with 74.4% of the female labour force engaged in farming, compared to 34.8% of the male labour force (ILO, 2013).

According to the 2016-17 agricultural census there are 5.2 million farms in Punjab of which 42% are less than one hectare. Sindh is located in the southeast of the country. It is the third largest province of Pakistan by area, and second largest province by population after Punjab. Sindh has a population of 42.4 million with around 50% of the population living in rural areas.

Although our case study focuses on areas where wheat and cotton are grown, we do not limit our analysis to these two crops. We are also interested in how farmers use WCIS to manage risk related to other aspects of farming and to rural livelihoods more generally. Similarly, our case study has selected districts based on their experience of floods and droughts (see **Appendix 1**), although we do not intend to limit the focus of our analysis on these two types of risk.

Figure 1 - Location of study area



3.1. Sampling

For this study, we adopted a multistage stratified random sampling to make our study representative to the cotton-wheat cropping areas in Pakistan. From each province, we selected two districts (total four districts) based on cotton-wheat cropping patterns that also represent flood-drought risk factors. From each district, we selected two Tehsils randomly (total 8 Tehsils), and from each Tehsil, two Union Councils from Punjab and one Union Council from each Tehsil from Sindh, making a total of 12 Union Councils in the sample. Then from each Union Council, we randomly selected two villages (total 24 villages), and from each village, we selected 2 wards (lowest level of administrative unit with an exception that we selected three wards from one of the villages) making a total of 50 wards in our sample. Then from each ward, we randomly selected 12 households for the survey (612 households total), where we interviewed women members of the household from every second household in the sample for making our survey gender balanced comprising 49.2% women respondents. **Table 1** provides a detailed sampling plan.

4. Research design, methods and data collection

We have taken a four-step approach to research design and data collection based on the research objectives outlined previously.

4.1. Research design

Understanding the user landscape

To help us understand the landscape of users in the two provinces, data on the use and non-use of weather and climate information was collected in the context of respondent demographics including: age, gender, education, land size, material wellbeing and past experiences of weather and climate shocks and stresses. Additionally, we have asked users and non-users of PMD's services for all the types of information they use when making decisions about different farming activities. In particular, we asked respondents what source of information, including information produced by PMD, they use when making decisions about: planting varieties, planting times, irrigation, fertiliser use, pesticide use, harvest time, storage of crop, sale time and price, use of hired labour and use of household labour. In our framework the use of weather and climate information is binary. In other words, people either use information or they do not.

However, we accept that some 'users' may not get their weather and climate information directly from a WCIS, instead this information may be shared to them by friends and neighbours. We refer to this type of user as a 'second-hand user'.

Understanding the usefulness and usability of PMD services to farmers

To understand the extent to which farmers feel that the weather and climate information provided by PMD is useful and usable, we collected data on the accessibility, affordability, accuracy, understandably, trust and timeliness of such information products. We also asked users of services about any changes they have noticed as a result of using those services e.g. increases or decreases in yields, use of inputs including labour, material well-being and subjective well-being. Additionally, we ask respondents about their past experiences of weather events within their village. We ask if they received any advanced warning of this event, where this warning came from (e.g. a service provided by PMD), and if this warning helped them plan an effective response.

Analysing the conditions that enable and/or constrain the use of weather and climate information services

To explore the conditions that enable or constrain the use of WCIS we asked about particular personal barriers to the use of information. We also explored how different demographic characteristics, including gender, affects access. For example, we ask who within the household has access to a cell phone for calls or SMS, who has access to the radio, TV and written documents. We also

We used a mixed methods approach to data collection in the field, this included farming household survey (two rounds) and focus group discussions (FGDs).

explore who participates in meetings/training with extension workers or other development outreach programmes.

Determining the impacts, including socio-economic benefits and costs of PMD services

To determine the economic benefits of using the weather and climate service we examine differences in yields, use of inputs and profit from sales between users and non-users of weather and climate information services. We will do this by comparing survey data among the users and non-users of WCIS from the 600 sample households. The non-user farmers serve as a comparison group while estimating the net-benefits of using the agro-met advisories or its impact on different outcomes.

A potential limitation of the approach proposed here is the threat to validity resulting from selection bias. To control for potentially confounding characteristics, we used regression analysis controlling for households' demographic and socio-economic characteristics, distance to markets, land holding size, irrigation facilities, harvesting methods, and so on. **Section 5.6.3** provides detailed information on the method.

4.2. Research methods and data collected

We used a mixed methods approach to data collection in the field, this included farming household survey (two rounds) and focus group discussions (FGDs). We take a two-phase approach to data collection which are described below.

4.2.1. Household surveys

Household surveys were conducted with farming households to collect quantitative data on key areas of this study including the use of weather and climate information, how these types of information and products help farmers make farming decisions, the perceived benefits of using such information, etc. The survey questionnaire can be found in **Appendix A**.

As we covered two crops in the study – wheat and cotton – we revisited the same households twice, first for collecting household information along with information related to wheat crop (April - May), and after four months (September - October), we collected information related to cotton cultivation. Even if we visited the same households twice, our data is still cross sectional since these are two different crops grown sequentially.

We collected approximately 600 household surveys from each round from farming communities in Punjab and Sindh and we aimed to survey an equal number of men and women.

Table 1 – Number of survey respondents per Province, District, Tehsil, UC and villages

Province	District	Tehsil	Union Council	Village
Punjab (N= 413)	Bahawalnagar (N= 211)	Haroonabad (N= 110)	42/3R (N= 48)	36/3R (N= 26)
				42/3R (N=22)
			432/6R (N= 62)	428/6R (N= 32)
				432/6R (N= 30)
		Chishtian (N= 101)	169 Murad (N= 47)	170/M (N= 24)
				138/M (N= 23)
			128 Murad (N= 54)	129/M (N= 30)
				126/M (N= 24)
	Muzafargarh (N= 202)	Kot Addu (N= 96)	UC22, Budh (N= 45)	Chakien wala (N= 23)
				Marhien wala (N= 22)
			UC-10, Dogar Kalasara (N= 51)	Khar Gharbi (N=22)
				Daya Chowk Gharbi (N= 29)
		Ali Pur (N= 106)	Dummer Wali (N= 48)	Basti Gabol (N= 24)
				Makhan Bela (N=24)
			Ghalwan (N= 58)	Ghalwan Shehr (N=23)
				Tibbi Arain (N= 35)
Sindh (N= 199)	Sukkur (N= 100)	Saleh Patt (N= 51)	Saleh Patt (N= 51)	Saleh Putt (N= 27)
				RD-71 (N= 24)
		Pano Aqil (N= 49)	Dadloi (N= 49)	Sahib Khan Korai (N= 26)
				Nubaho Malik village (N= 23)
	Khair Pur (N= 99)	Kingri (N= 50)	Kulaib Jail (N= 50)	Kolab Jial (N= 25)
				Shakaruddin Pujabi (N=25)
		Kot Diji (N= 49)	Talpur Wada (N= 49)	Abdul Raheem Kaskheli (N= 25)
				Babad Wada (N= 24)
Total	**4**	**8**	**12**	**24**

The survey data was analysed using software R (analysis of sections 5.1 to 5.5) as well as Stata (section 5.6.).

4.2.2. Focus group discussions

Focus Groups Discussions (FGDs) were pursued during the second round of surveys and aimed at qualitatively exploring key aspects e.g. what farmers find useful and usable in order to better understand the situation on the ground as well as triangulate this information with data from the household surveys. Given the differences between users and non-users of climate information and the importance of understanding the reasons behind such use/non-use, a different set of questions were used for the FGDs with users and non-users (independently of gender).

The set of questions used in the FGDs can be found in **Appendix B**. A total of 19 Focus groups discussions were conducted in Punjab and Sindh. These FGDs were split and organised by users and non-users of climate information as well as by gender.

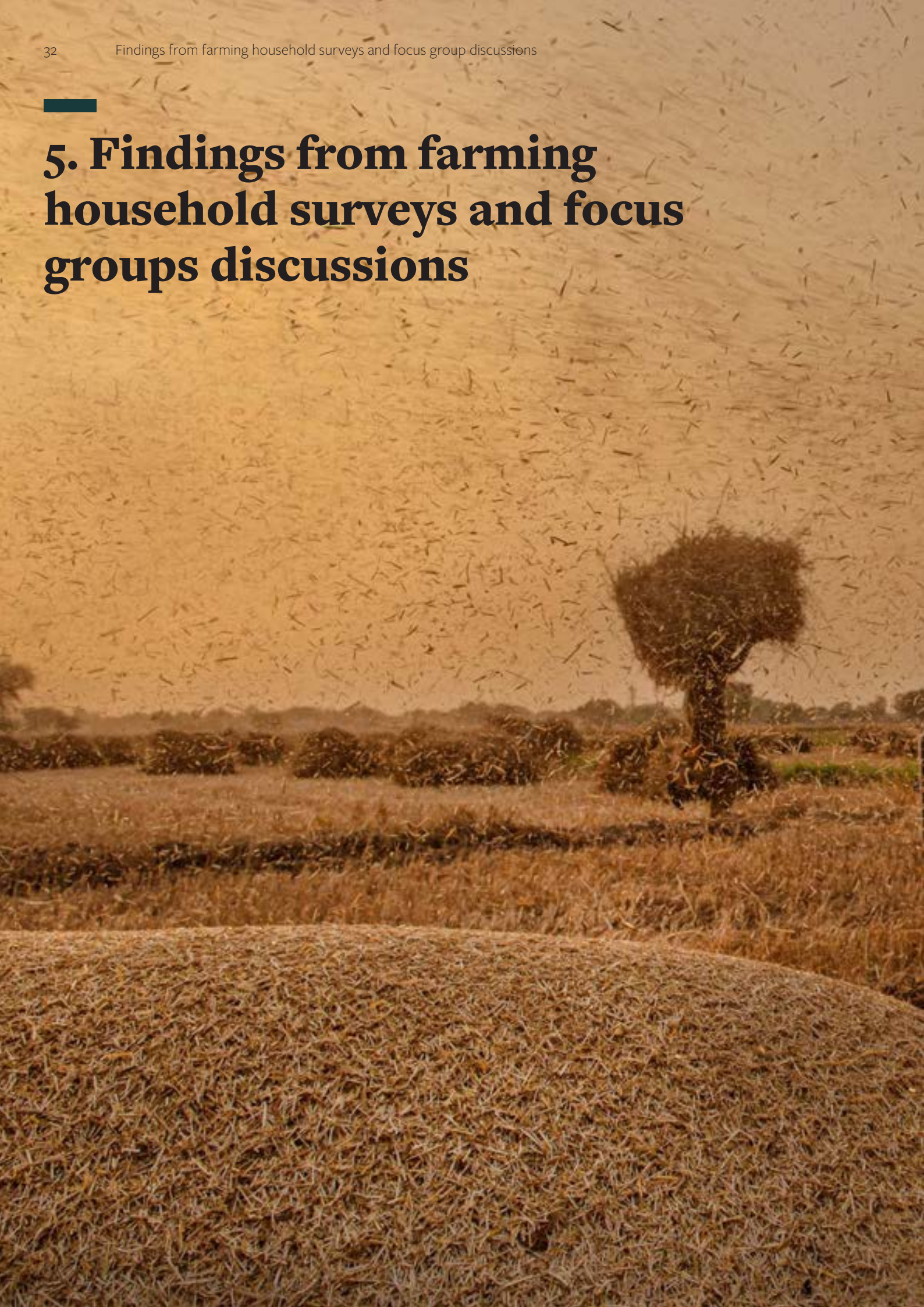
Table 2 – Focus group discussions conducted by number of participants, gender and use/non-use of weather and climate information services

Province	District	Village	Male participants		Female participants	
			User	Non-user	User	Non-user
Punjab (N=78)	Muzafargarh	Ghalwan Sher	5	6	5	5
	Bahawalnagar	129/M	13	5	6	7
		36/3RM	9	3	7	7
Sindh (N=48	Khairpur	Babar Wada	3	4	5	5
	Sukhur	Hussain Bakhsh Bhatti	3	5	5	5
	Sukkhur	Korai Village	3	5	0*	5
Total (N=126)			**36**	**28**	**28**	**34**

** As there were no females using weather and climate information services in Korai village, no FGD was conducted.*

The FGD data was transcribed by the local facilitators and then analysed using the software NVivo for qualitative data analysis. Thematic coding was applied to help us identify and organise key themes emerging from the FGD.

5. Findings from farming household surveys and focus groups discussions



5.1. General demographics

A total of 612 farming households were surveyed of which 413 respondents were based in Punjab province and the remaining 199 in Sindh province. From the 612 respondents, 311 were males and 301 were females; whilst a total of 340 respondents stated they were users of weather and climate information services (WCIS) and 272 were non-users of these types of information (Figure 2).

The majority of household heads were males (95%), were between 40-60 years old and had spent less than 5 years in school (on average less than 2 years) (Figure 3).

The majority of respondents were married (91%), 4.5% unmarried and 3.75% single. We found a high statistical difference in education between female and male groups. Also, female respondents have spent fewer years in school than males. The average for female education was 5 years, while that of male was 10 years. In addition, 47.9% male respondents (as opposed to 27.6% of female respondents) indicated to have received additional "informal" training during the last two years.

Furthermore, 9% of male respondents received additional informal training from Non-Governmental Organisations (NGOs) while no female respondents received such training. Finally, extension (OFWM) officers were able to train 46.3% of male respondents and 26.9% of female respondents. The data shows that, on average, females had more years of farming experience compared to male respondents with 183 female respondents having 5 or more years of experience compared to 44 male respondents.

All farming households surveyed in Punjab and Sindh depended on crops as one of the main sources of income followed by livestock (55% and 59%, respectively), government-related jobs (13% and 8%, respectively), shopkeeper (10% and 5%) and agricultural labour (7% and 9%m respectively) (Figure 5).

Figure 2 - Respondents by gender, provinces, and use of climate information

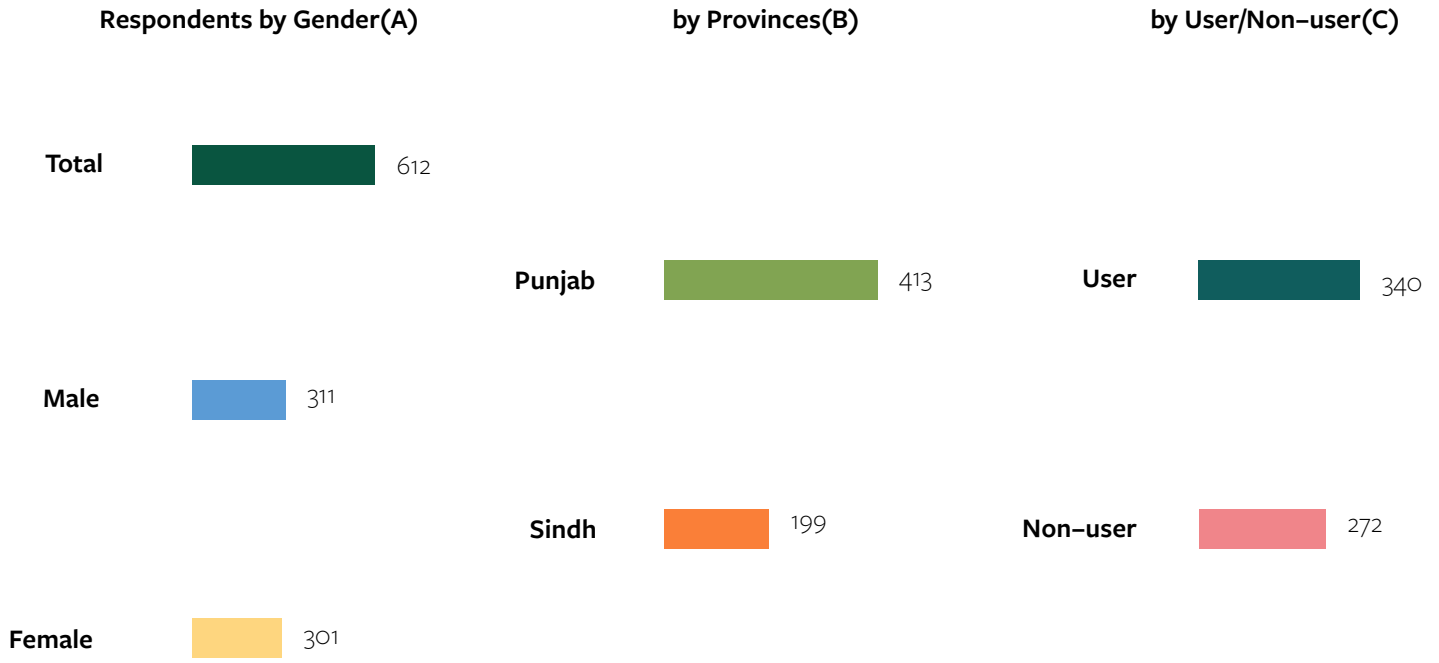


Figure 3 - Household heads by gender, age and years in school

Figure 4 - Respondents by gender, age, education, farming experience and informal education patterns

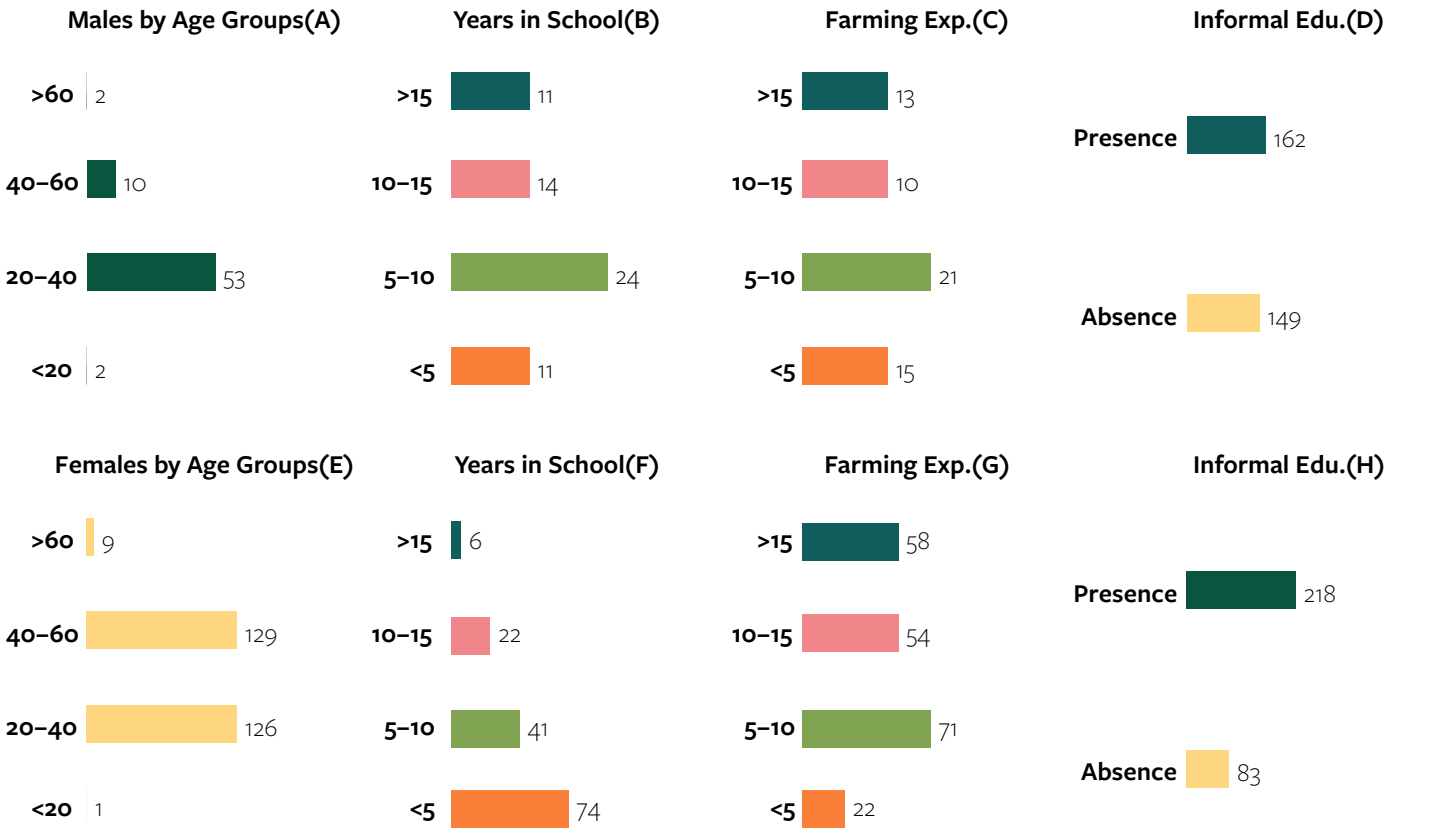
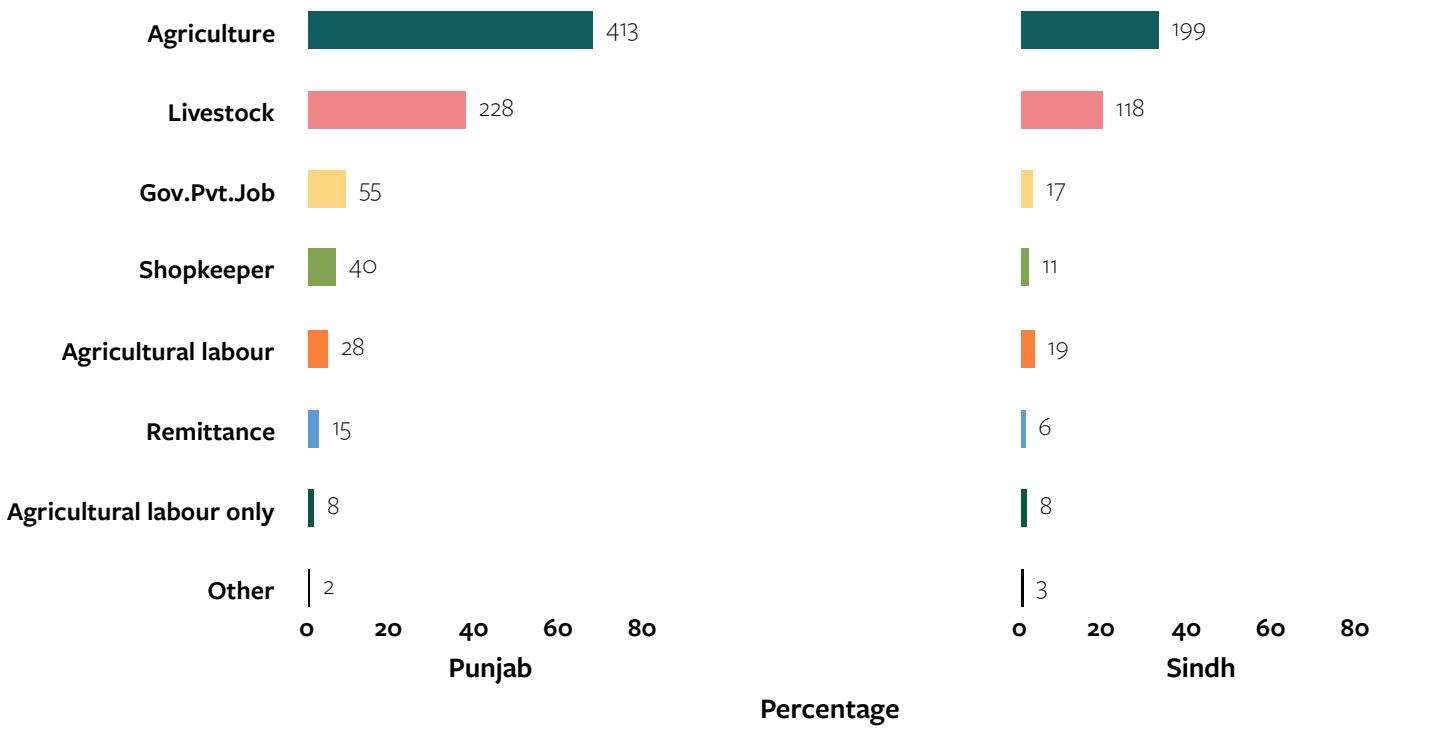


Figure 5 - Main sources of income per household in Punjab and Sindh provinces (showing percentages and total values)



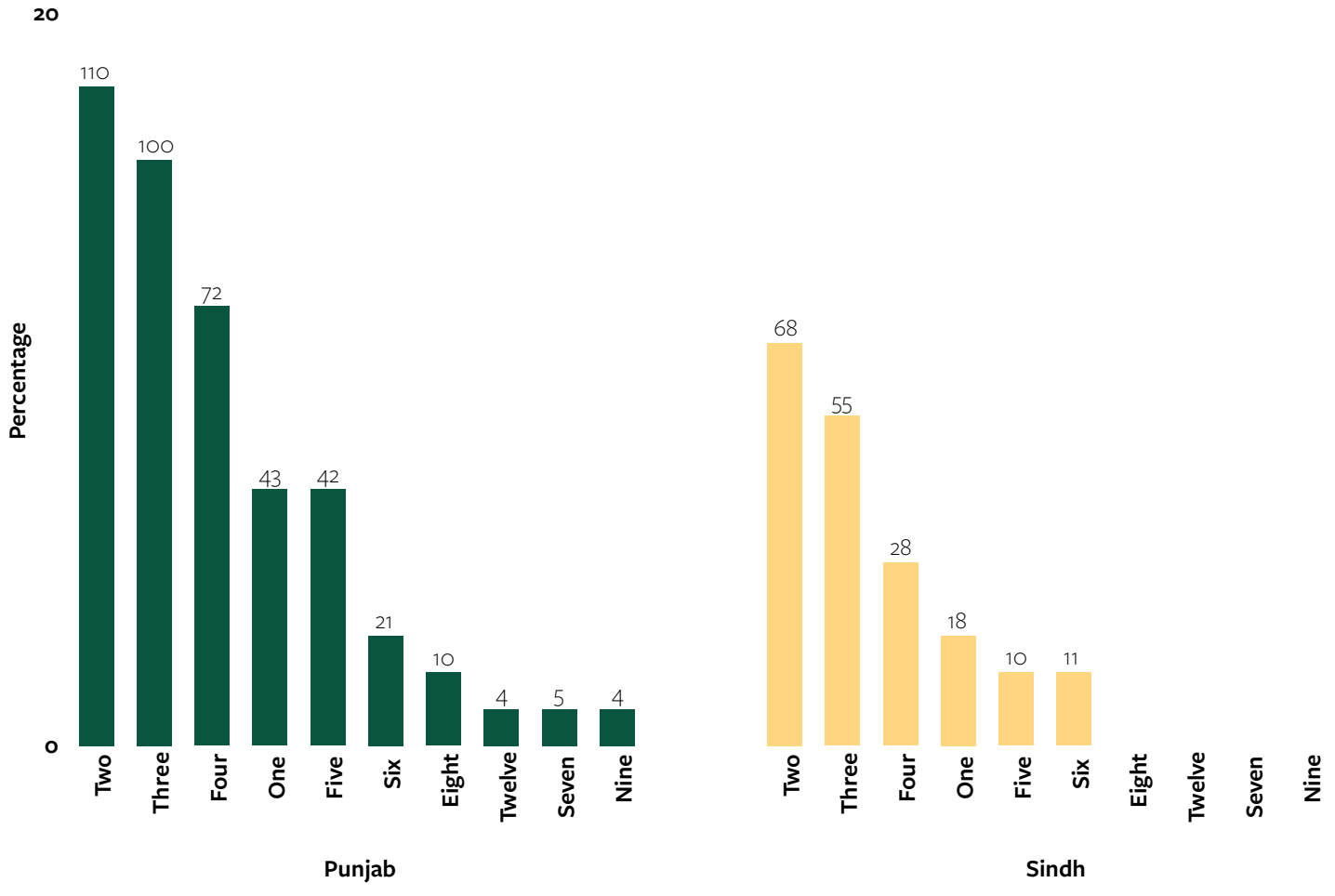
5.2. Household material wellbeing, housing and sanitation

The average size of the households is 8 family members. The majority of households in both provinces have between 2, 3 and 4 rooms (68% in Punjab and 76% in Sindh) (Figure 6).

Primary source of energy for cooking comes from fire-wood (95% in Punjab and 72% in Sindh) followed by cow dung (11% in Punjab and 28% in Sindh). Regarding sources of light, the majority of households in the Punjab and Sindh regions have access to electricity (99.5% and 100%, respectively). Sources of drinking water are varied in Punjab between piped water (32%), hand pump (27%), motor pump (25%) and well (15%); whilst in Sindh the majority has access to piped water (81%) and remaining households used hand pumps (16%) and wells (3%).

Regarding toilet infrastructure, the majority of households has access to a dry latrine in Punjab and Sindh (90% and 59%, respectively) followed by flush with pit (2% and 23%, respectively), no toilet (16% and 23%, respectively) or flush public sewage or open drains (5% in Sindh).

Figure 6 - Total number of rooms in household



5.3. Experiencing weather and climate hazards

5.3.1. Experiences of climate hazards over the last ten years

Most of the households experienced climate-related hazards in the past 10 years (2010-2020) with pests, plant diseases, rainfall and increase in temperature being those that most impacted respondents. Fewer households have been subjected to drought, flooding, and other hazards in the past 10 years (Figure 7). Similarly, looking across Punjab and Sindh provinces we found that most respondents in both provinces reported being affected by pests (95% and 91%, respectively) and diseases (90% and 69%, respectively) over the past 10 years (Figure 8).

Respondents in Sindh reported experiencing relatively more weather-related hazards, especially unusual rainfall, flooding and heat waves compared to Punjab although drought was more noticeable in Punjab than Sindh. Very few respondents from both provinces reported experiencing cold spells (Figure 8).

Figure 7 - Hazards experienced over the last ten years (showing percentages and total values)

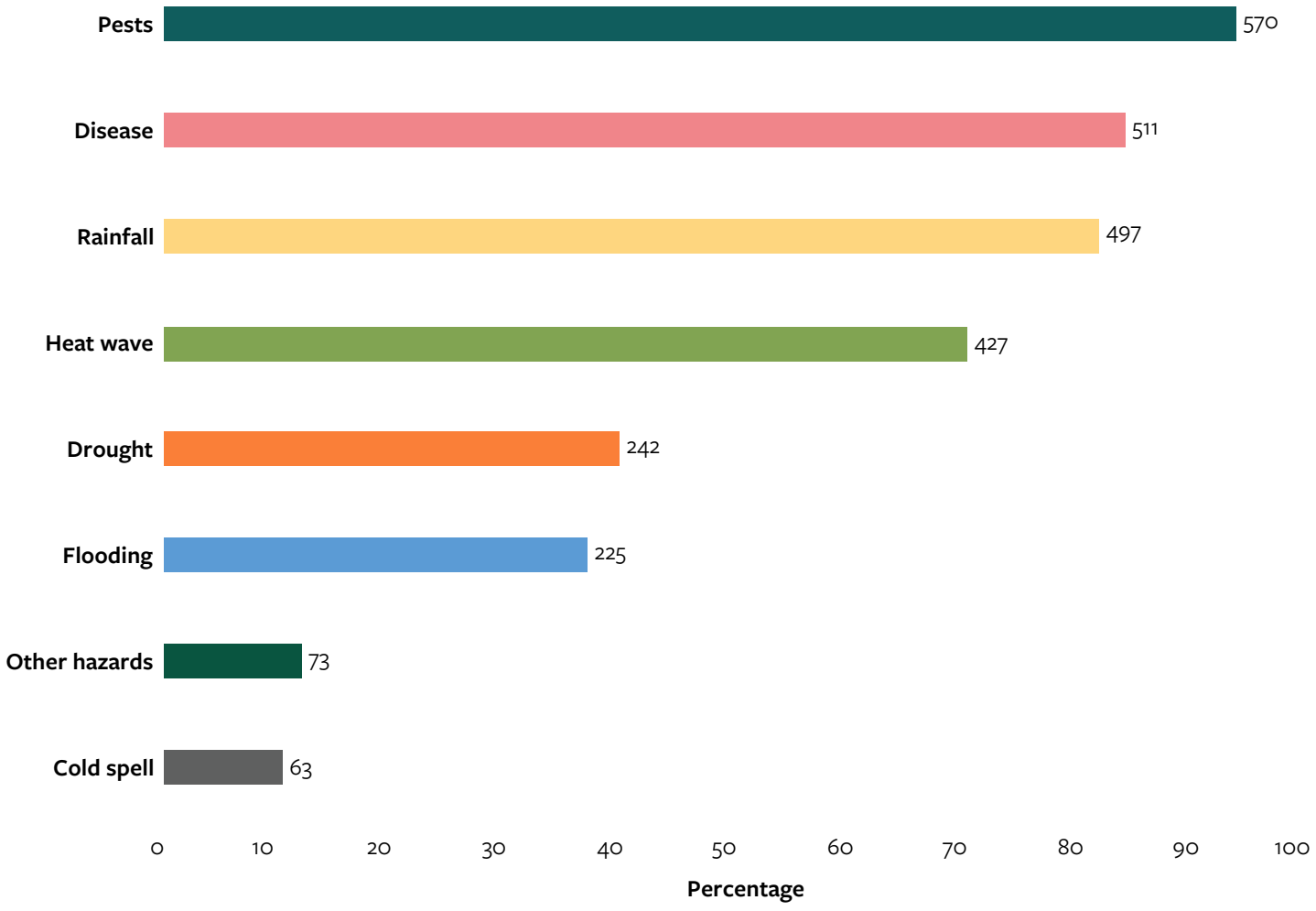


Figure 8 - Experiences of Hazards in Punjab and Sindh (showing percentages and total values)

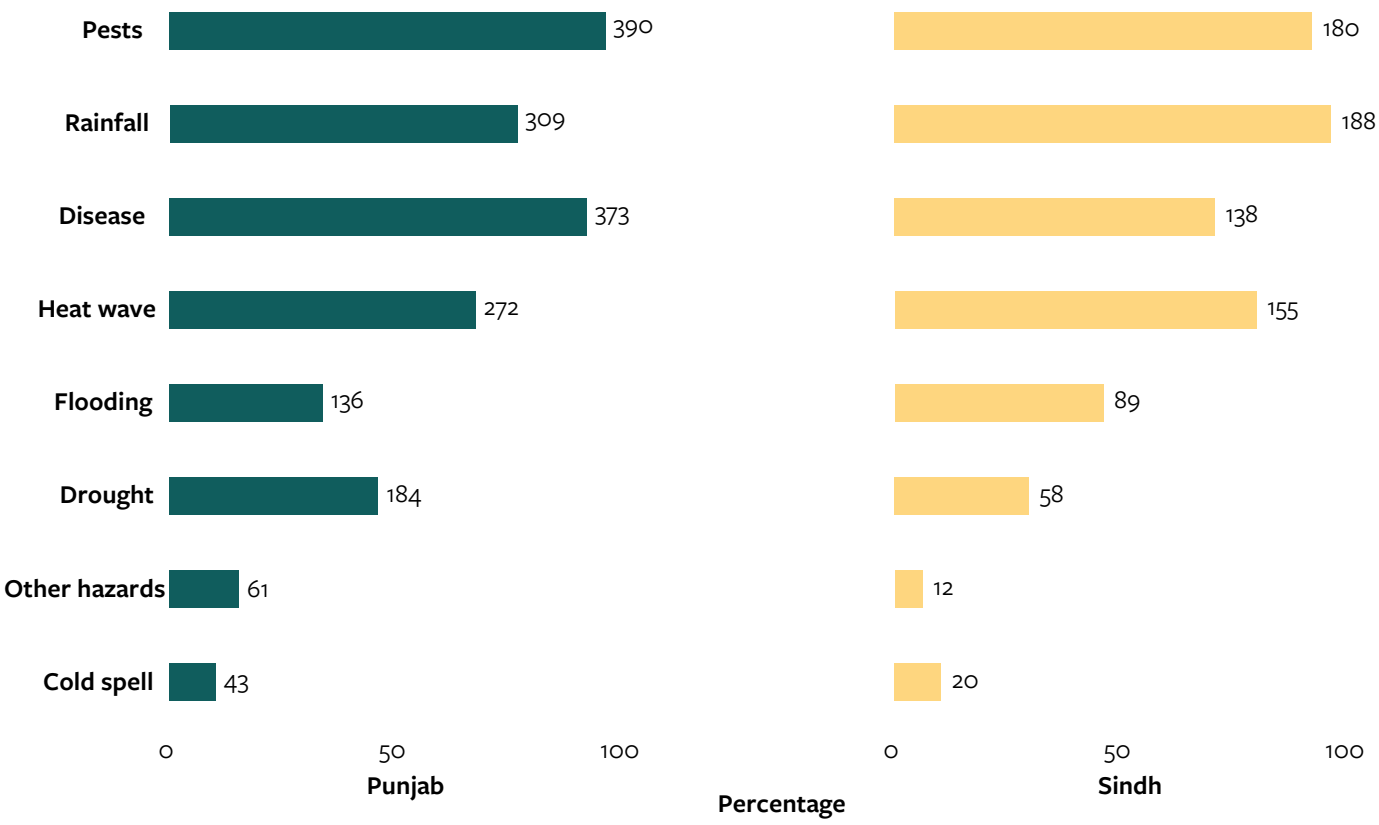
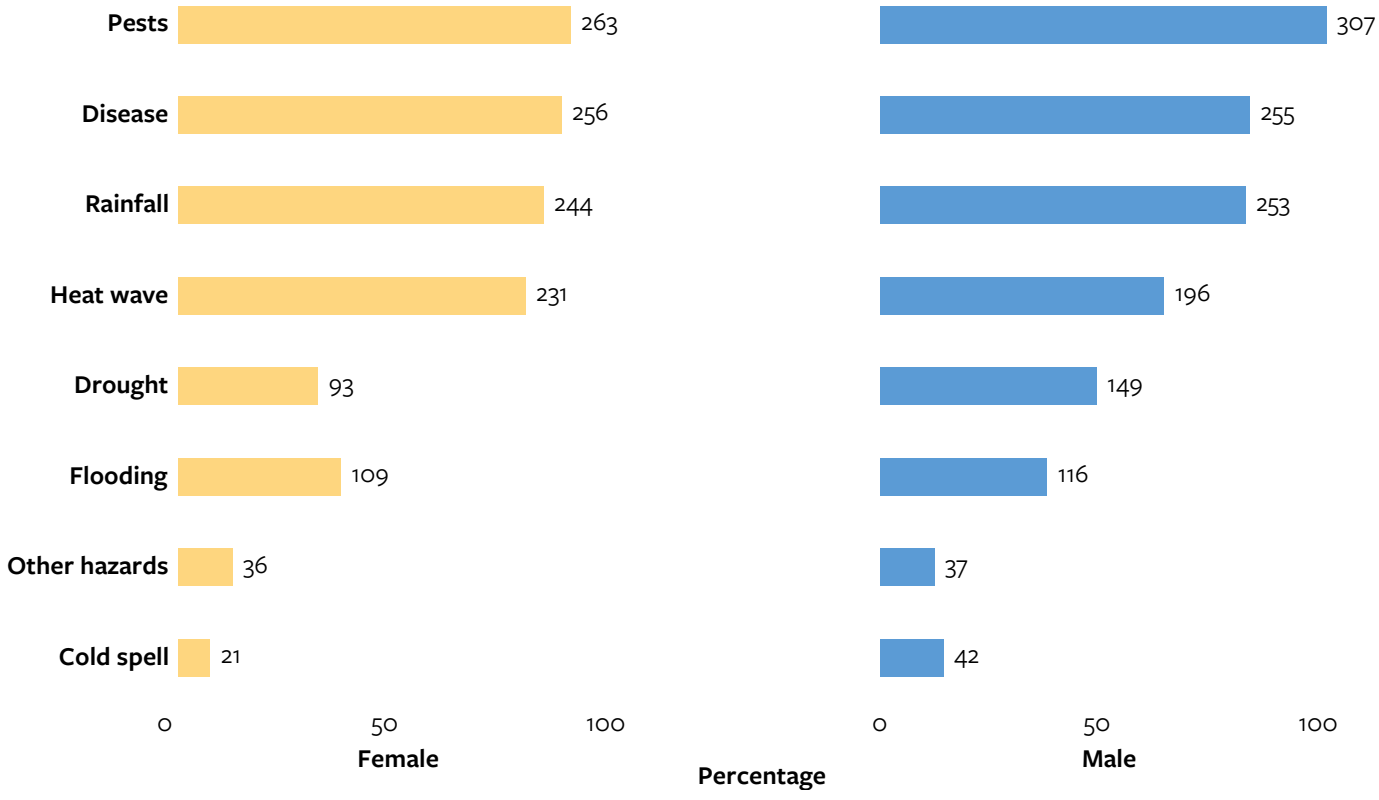


Figure 9 - Experiences of hazards among females and males (showing percentages and total values)



We also investigated the differences between male and females and found no significant difference on how both groups experienced the various hazards (Figure 9).

Respondents were also asked to choose three types of hazard events that have affected their households over the last 10 years by order of impact (i.e. choice 1, choice 2 and choice 3). As shown in Figure 10, pests, drought, rainfall and flooding were considered the top hazards with most impacts for these households over the last 10 years (choice 1 in Figure 10).

However, looking across the three levels of impacts ranking (i.e. choices 1, 2, and 3) we can see that pests, diseases, rainfall, heatwave and droughts are the types of hazards most experienced by these households over the last 10 years.

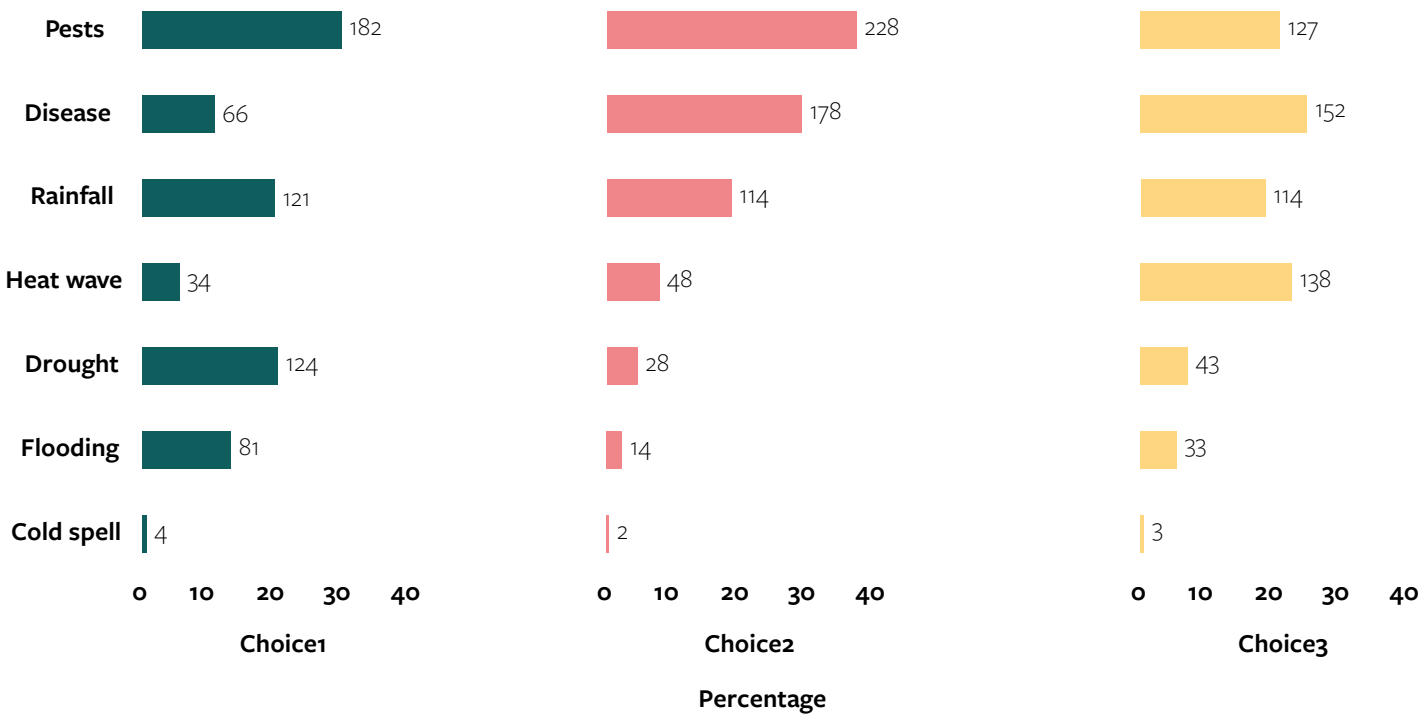
5.3.2. Impact of hazards and usefulness of hazard advanced warning information

The experience of these climatic hazards over the last 10 years have affected the socio-economic activities of users and non-users of weather and climate information (Figure 11).

The main impacts from previous hazards were largely negative and related to a decrease in cotton yield, a decrease in wheat yield, as well as a decrease in household income. Other impacts noted, although to a lesser extent, included a reduction in food security and yield from horticultural products followed by loss of livestock, loss of personal property and damage to house and impact on health.

No significant differences were observed between females and male, both provinces or users and non-users of weather/climate information in their experience of the impacts by hazards in the last 10 years.

Figure 10 - Hazard experienced by choices among respondents (showing percentages and total values)

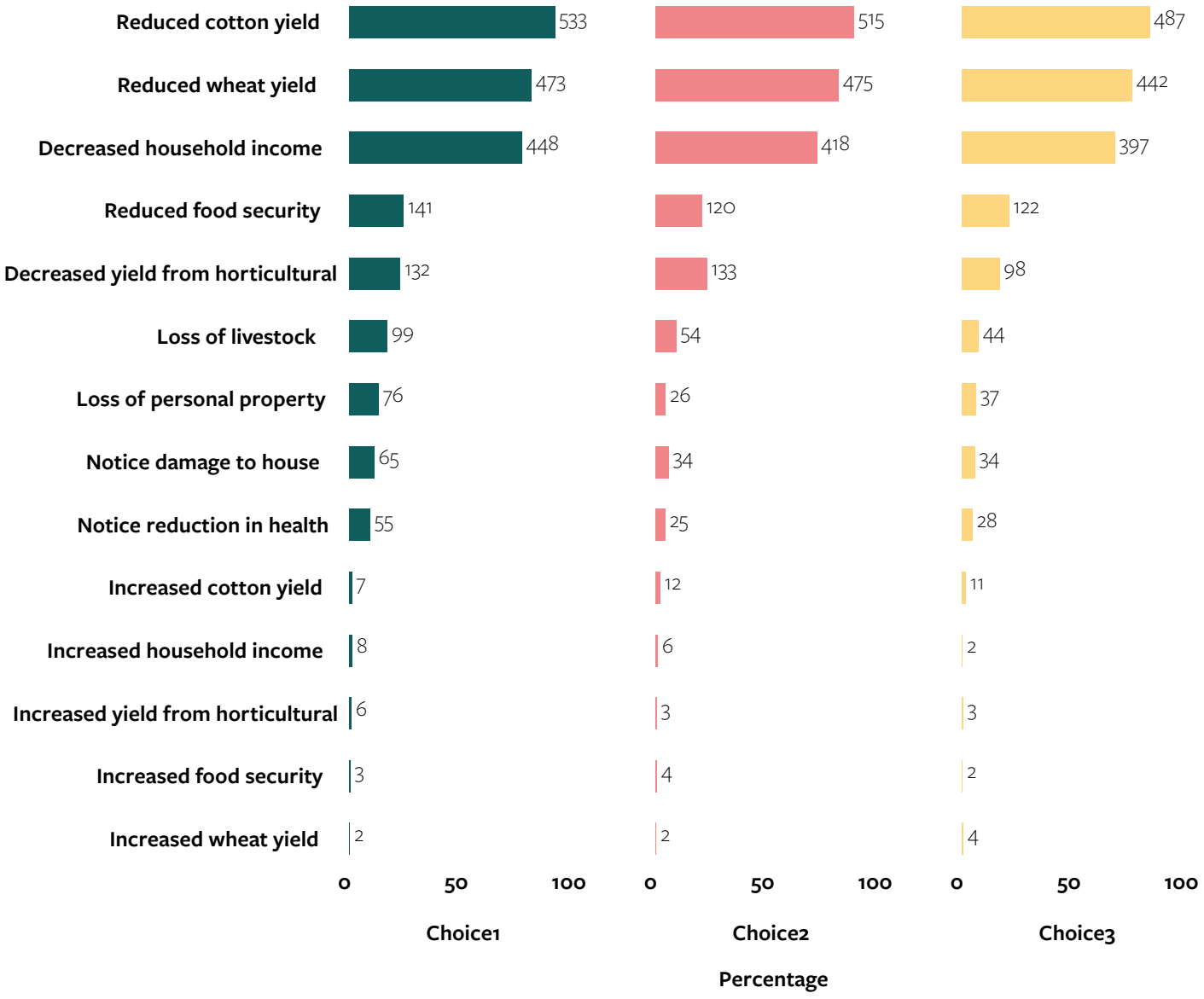


As a response to these hazards' impacts some participants took loans (n= 114 as their first choice of response to the hazards) and sold personal possessions (n= 21 as their first choice of response). Some participants stated not being affected at all by any hazards' impacts in the last 10 years (n= 40).

When looking at the ways in which participants react to advanced warnings about potential hazards the main response is to increase pesticide use to address pests and diseases (Figure 10). Others reported doing more or less irrigation (depending on the warning) and increasing or decreasing the use of fertilisers. Some respondents reported not taking any actions (Figure 12).

We further explored why those respondents that did not act on the warning information decided to do so. Our analysis shows that most respondents were not able to act due to the timing of the warning being too late for them to undertake any action on the ground.

Figure 11 - Perceived impacts of hazards per household (showing percentages and total values)



Others emphasised the lack of funding, information availability or lack of trust in the warnings received (Figure 13).

5.3.3. Sources and mechanisms for receiving hazard warnings

The main mechanisms for receiving warning information were largely coming from friends or family, National TV channels, PMD SMS service and extension officers (Figure 14).

No substantial differences between genders in terms of the mechanisms used to receive warning information were noted (i.e. main mechanisms/sources of warning were also friends or family followed by National TV channels).

However, there are some differences between sources of warning information between the two provinces with respondents in Punjab stating that their main sources are friend or family, National TV channels and extension services whilst in Sindh the main sources are National TV channels followed by PMD website and friend or family (Figures 15 and 16).

Figure 12 - Household responses to what action they would have taken if they had early warning (showing percentages and total values)

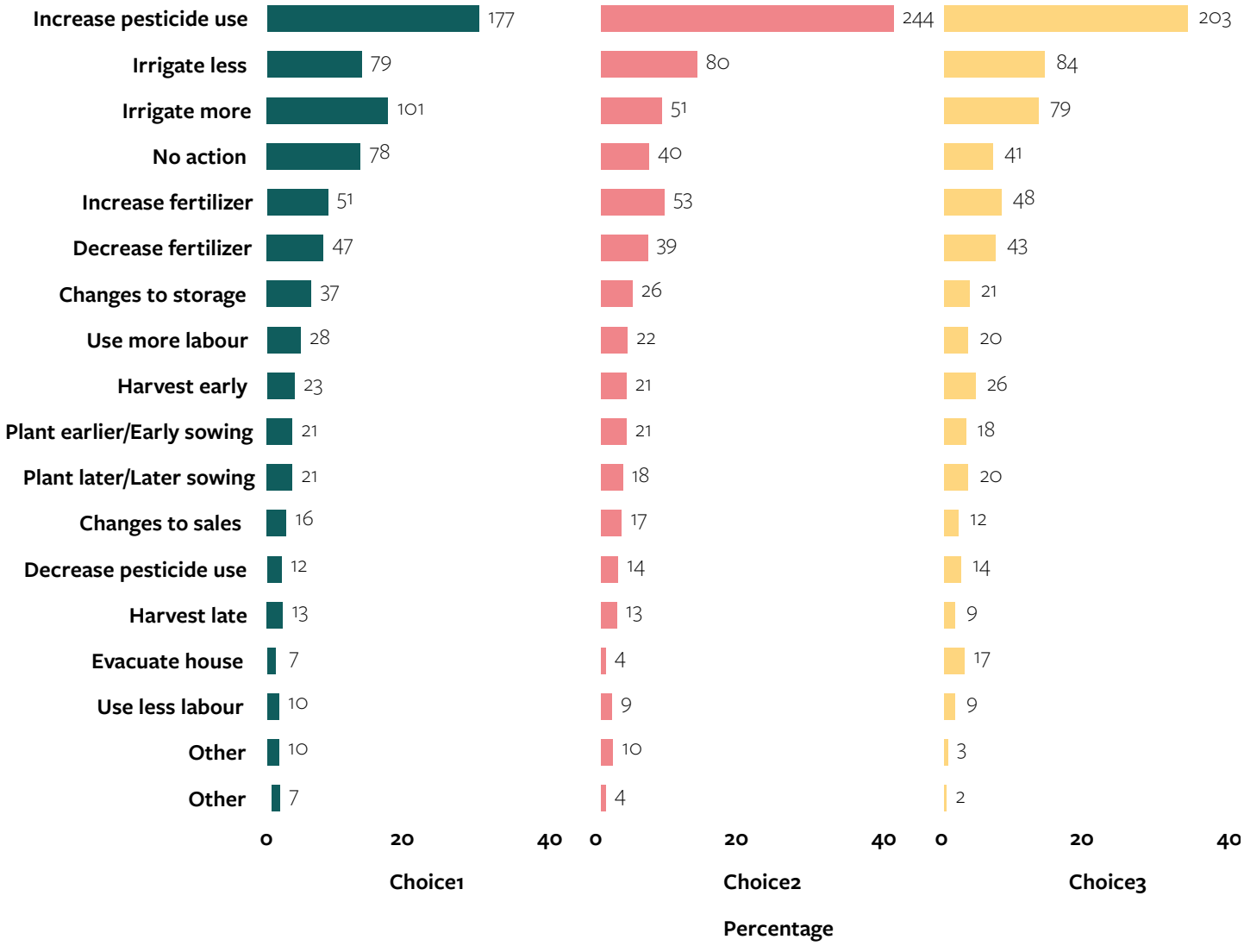


Figure 13 - Reasons for not taking action after receiving warning (showing percentages and total values)

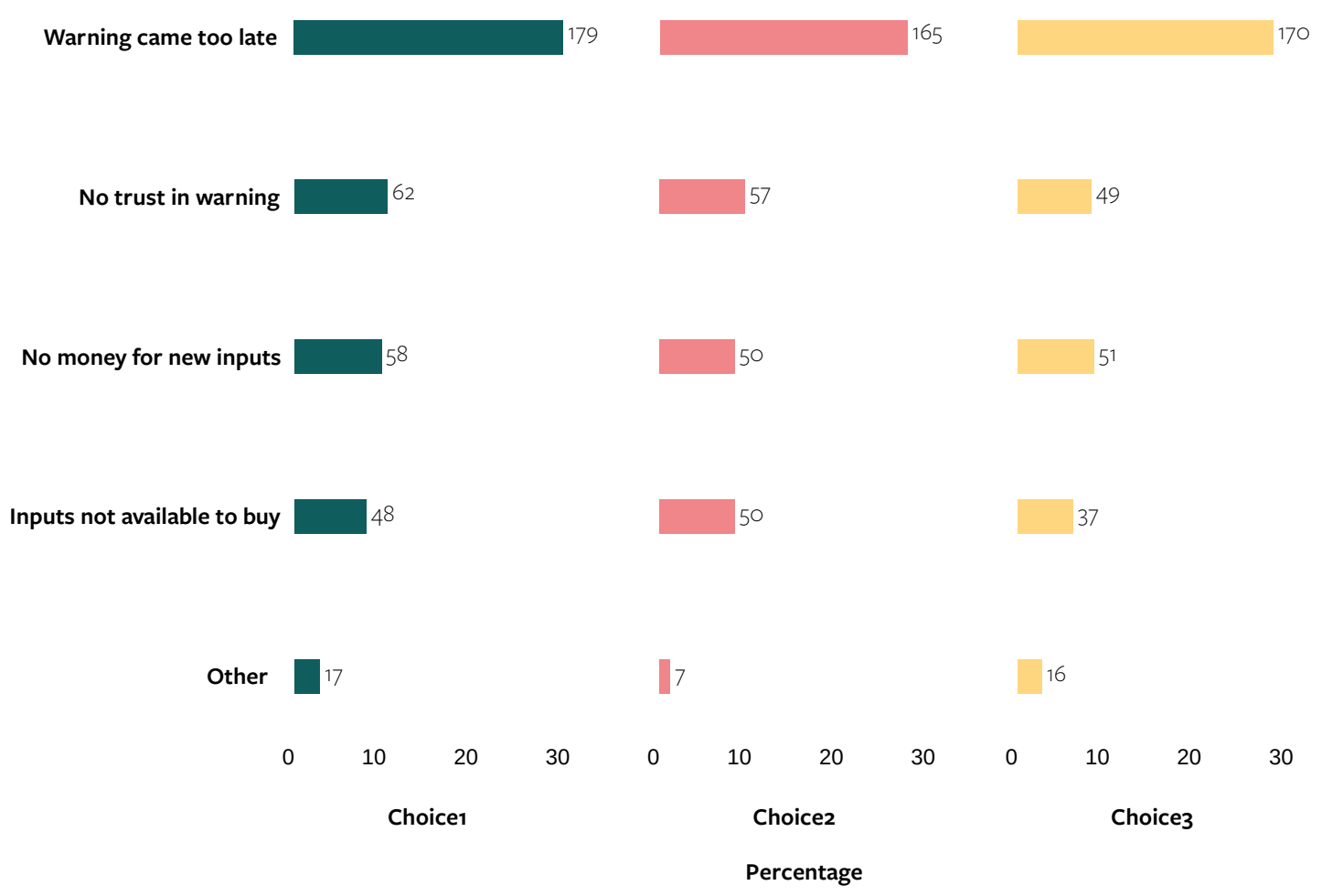


Figure 14 - Advanced hazard warning sources by respondent choice groups (showing percentages and total values)

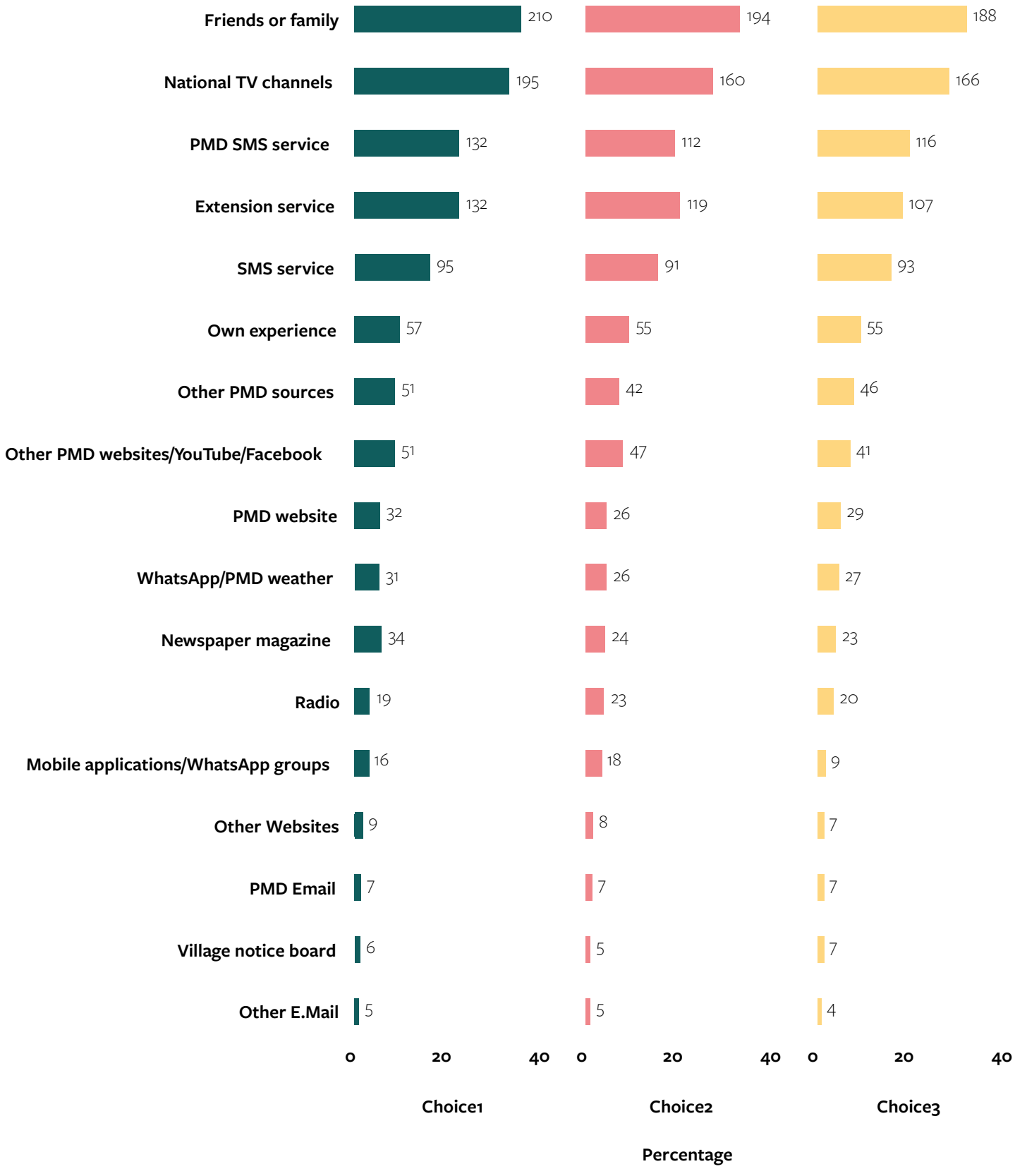


Figure 15 - Sources of warning information in Punjab (showing percentages and total values)

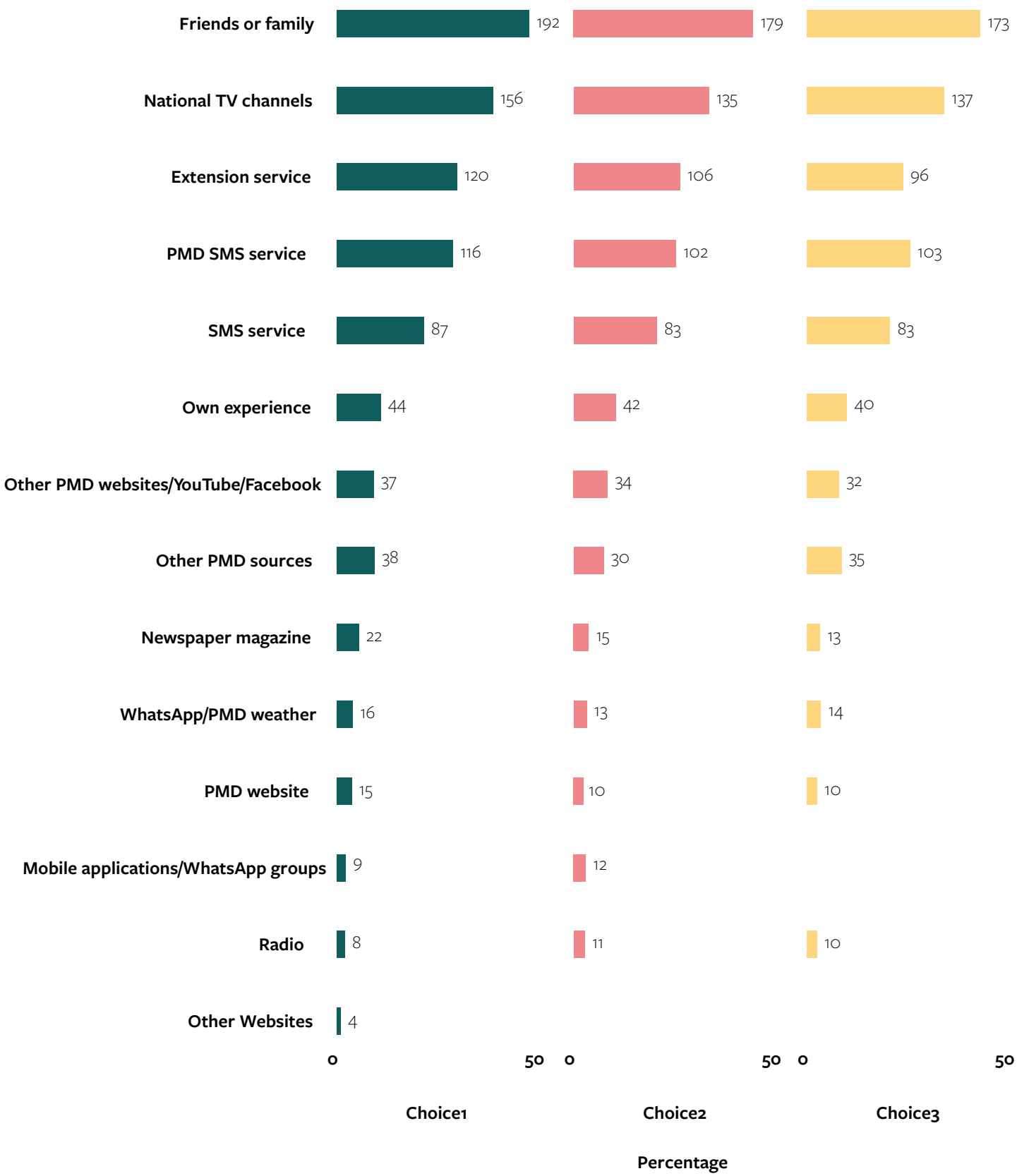
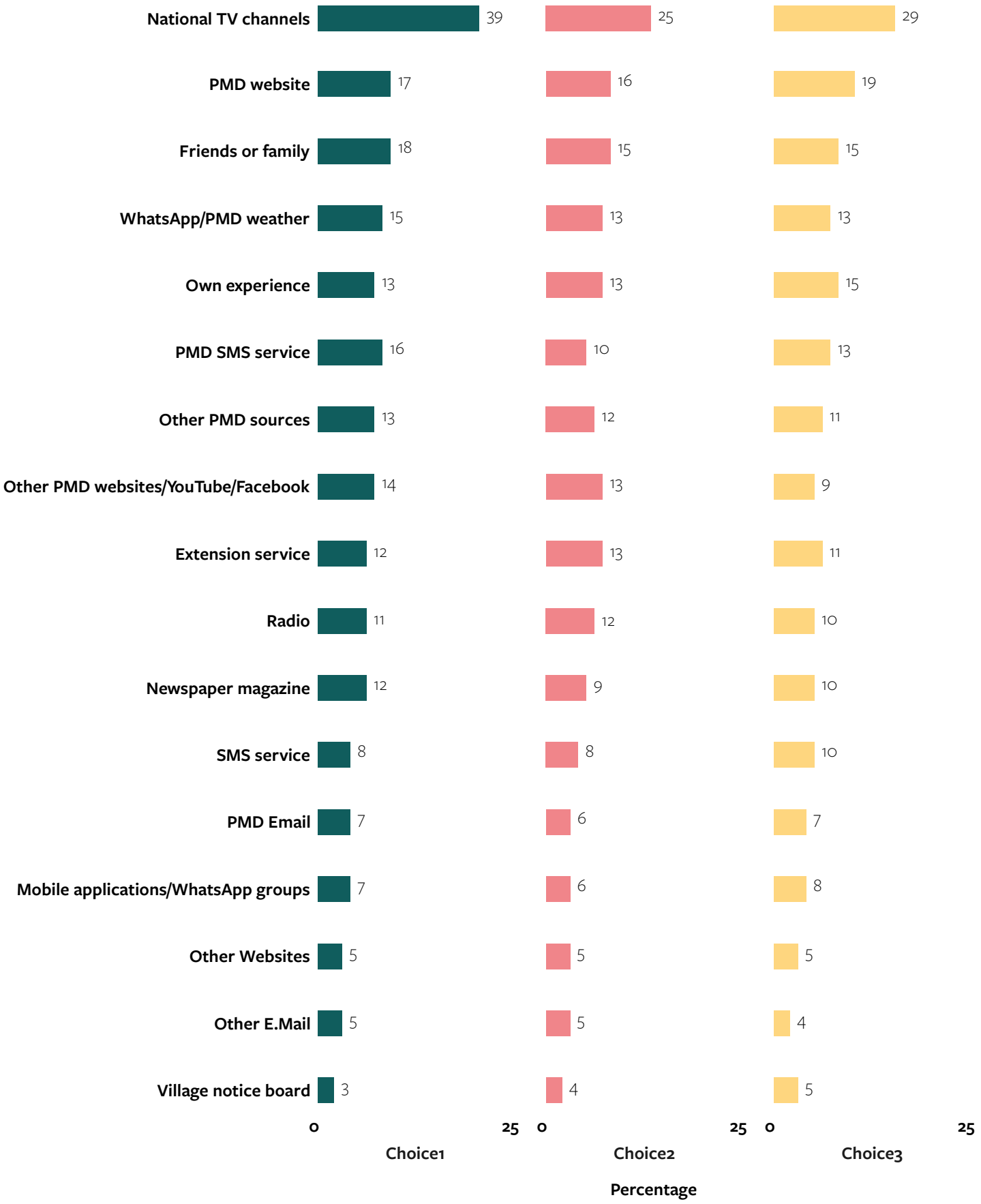


Figure 16 - Sources of warning information in Sindh (showing percentages and total values)

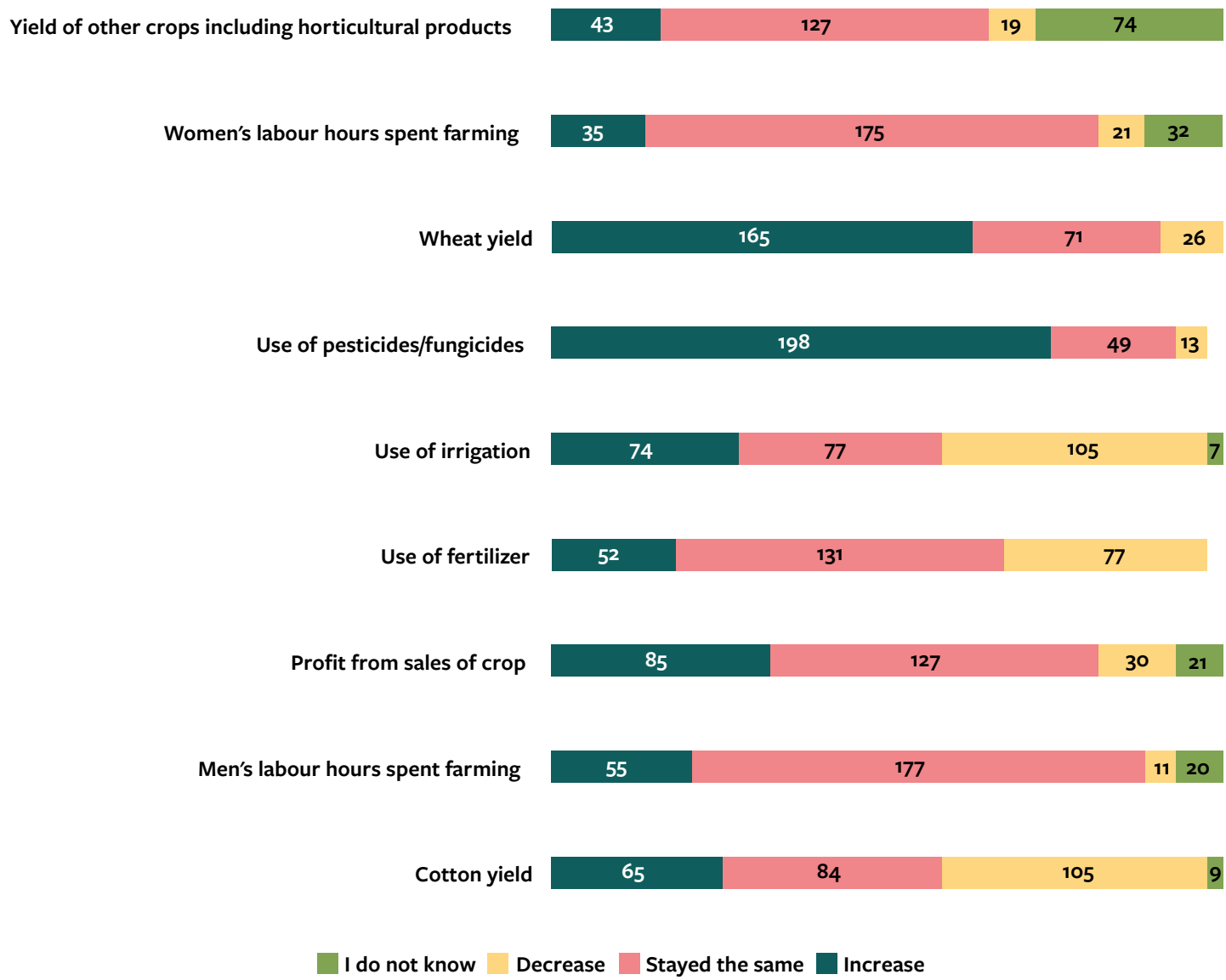


5.3.4. Perceived benefits of using advance warning information

We explored the perceived benefits of using advance warning information for the farming households surveyed. For most respondents that warning information came from PMD and helped them ensure an increase in wheat yield and a more efficient use of pesticides/fungicides (Figure 17). A significant proportion of respondents did not note significant changes in benefits from using warning information regarding other crops' yields, labour hours (both male and female), use of fertilisers and profit from sales of crops. A small proportion of respondents indicated a decrease in irrigation activities and use of fertilisers.

This issue is further analysed using an econometric method which helps controlling for the potential confounders and reduces the reporting biases (**section 5.6.3**).

Figure 17 - Perceived benefits from using weather and climate information services among households (showing total values)



The perceived benefits of using PMD warning information were the same for both male and female groups and were linked to the ability to increase the use of pesticides/fungicides in a more effective way as well as wheat yield (Figure 18).

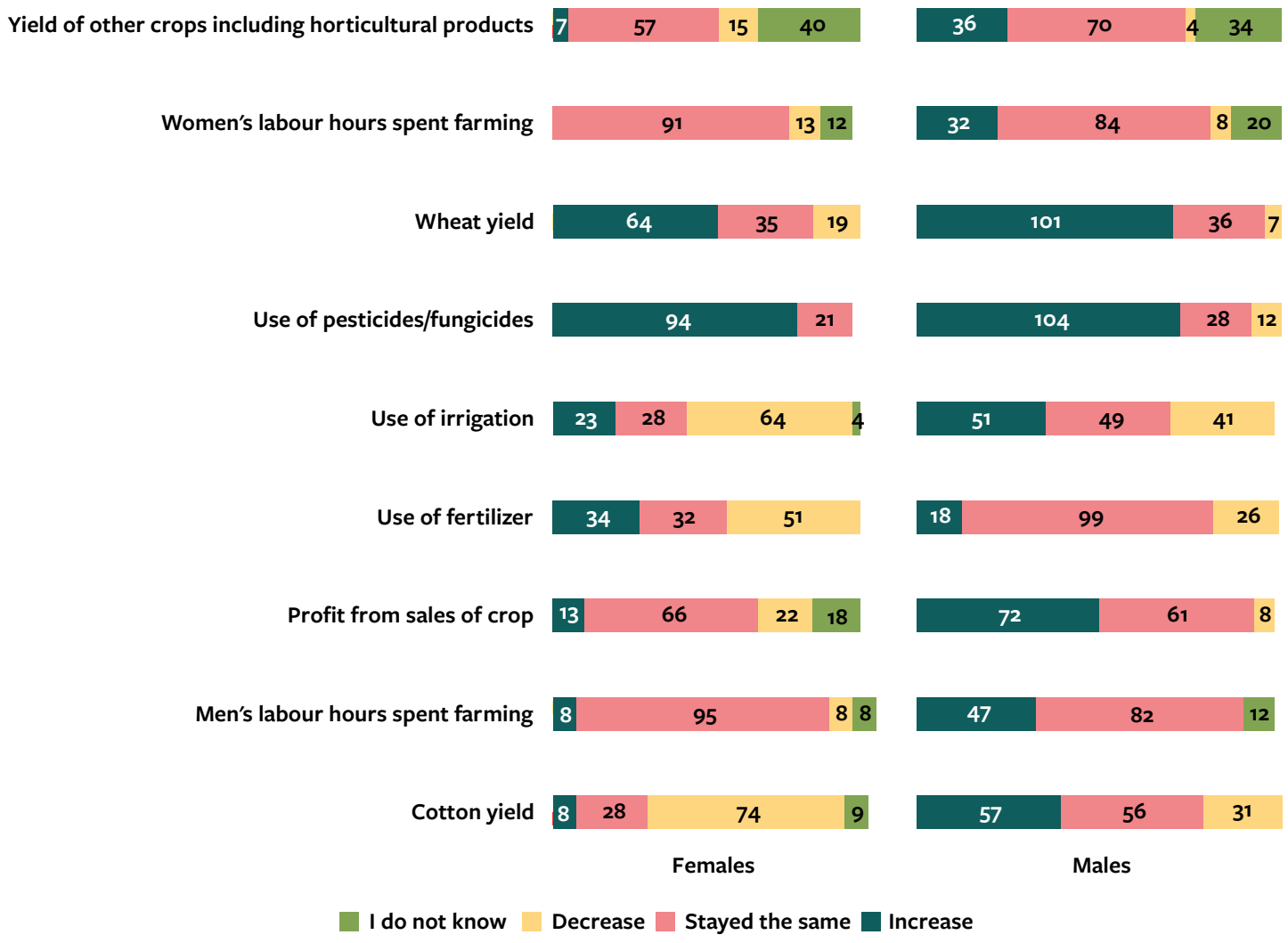
Male respondents also strongly agreed that this type of warning information helped increase profit from selling crops whilst females indicated a decrease in use of fertilisers and irrigation. Both groups indicated no changes in time spent by male and females in farming, and yield of other crops.

5.3.5. Access to weather and climate information services information means

Regarding means for accessing WCIS information, we found that household heads have greater access to, and means of obtaining, information than other household members. Since 95% of household heads are male (see Figure 3 above) we can assume that, in general, males have greater access to this type of information when compared to females.

The most common means between the head of household and spouse was TV, mobile phones (including for SMS) whilst for other

Figure 18 - Perceived benefits from using weather and climate information services between females and males (showing total values)



members of the household the main means of accessing information was internet and newspapers (Figure 19).

Survey respondents were also asked about their level of satisfaction from accessing diverse means of information. The greatest degree of agreement on satisfaction for both male (n=197) and female (n=205) informants was from access by television (Figure 20). This was followed by a great level of satisfaction from information sent by SMS directly to the phone (males n=176, females n=147). The least level of satisfaction came from village notice boards followed by PMD online sources (PMD website, Facebook, and YouTube).

We also found that there were some differences between male and female respondents on satisfaction from access to information including their satisfaction for voice message direct to phone (males n=157, female n=68) and extension staff members in the village (male n=147, female n=90) (Figure 21).

Survey respondents were also asked if they provide feedback on the information they use to help enhance WCIS and meet their needs adequately. Most respondents stated that they do not provide feedback. Those that provide feedback chose to do so through extension officers (male n=16; female n=6), local irrigation department (male n=10; female n=2) or other stakeholders and another two respondents did so when it was required. Few provided feedback on a monthly, daily, and weekly basis.

Figure 19 - Means of accessing information among household heads, spouse and other family members (showing percentages and total values)

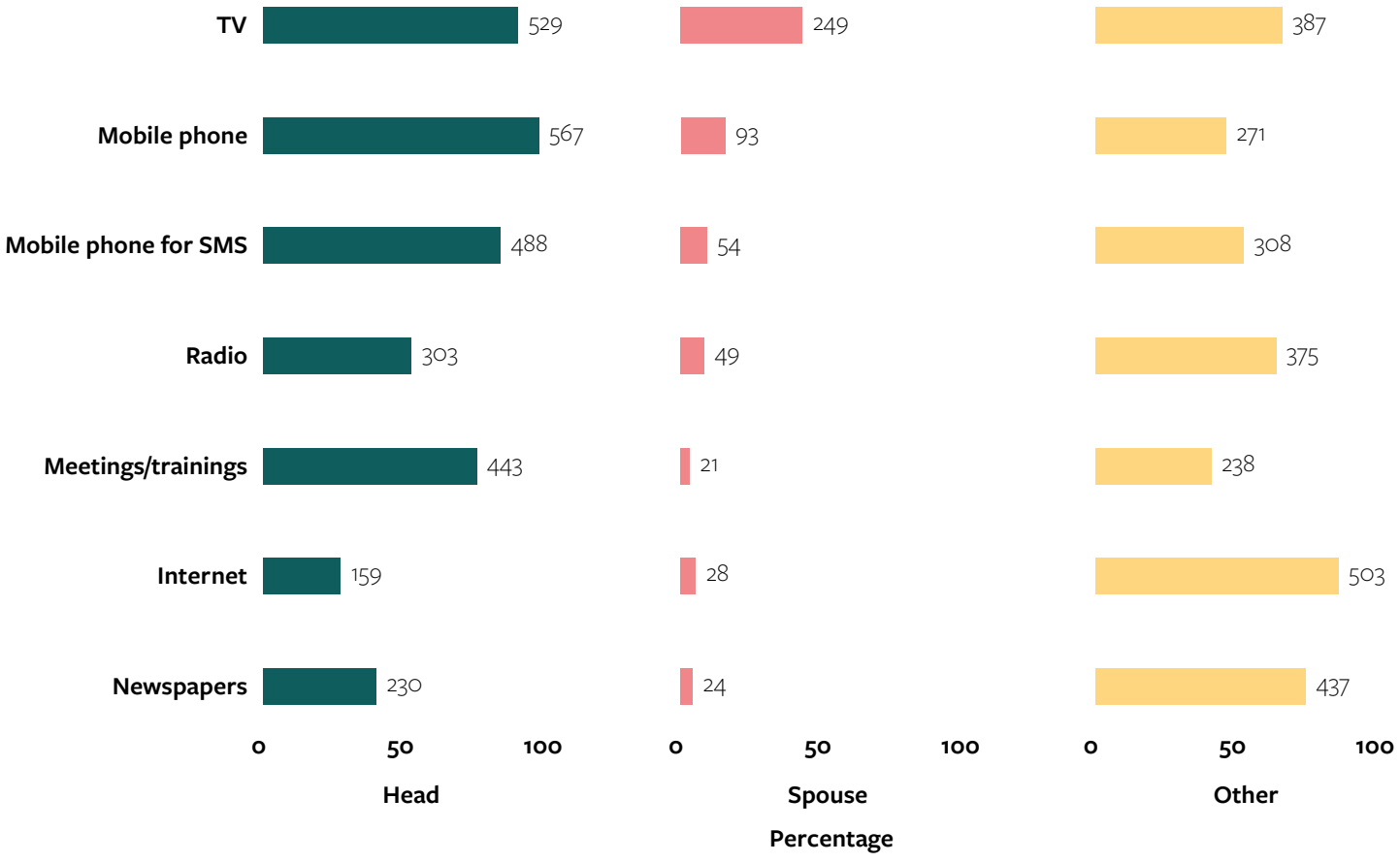


Figure 20 - Satisfaction from information accessibility means by households (showing total values)

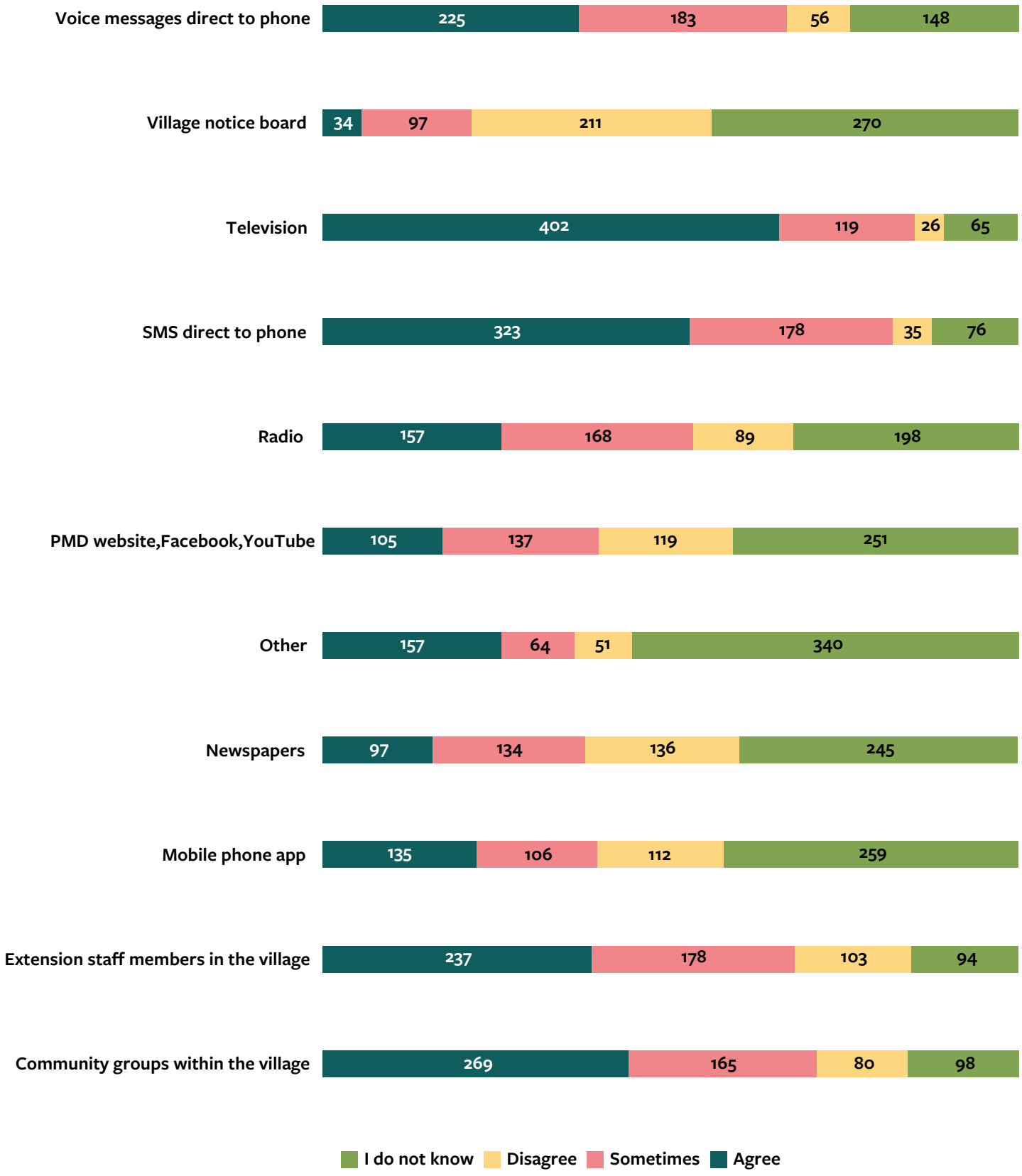


Figure 21 - Satisfaction from information accessibility means between females and males (showing total values)

5.4. Use of weather and climate information services

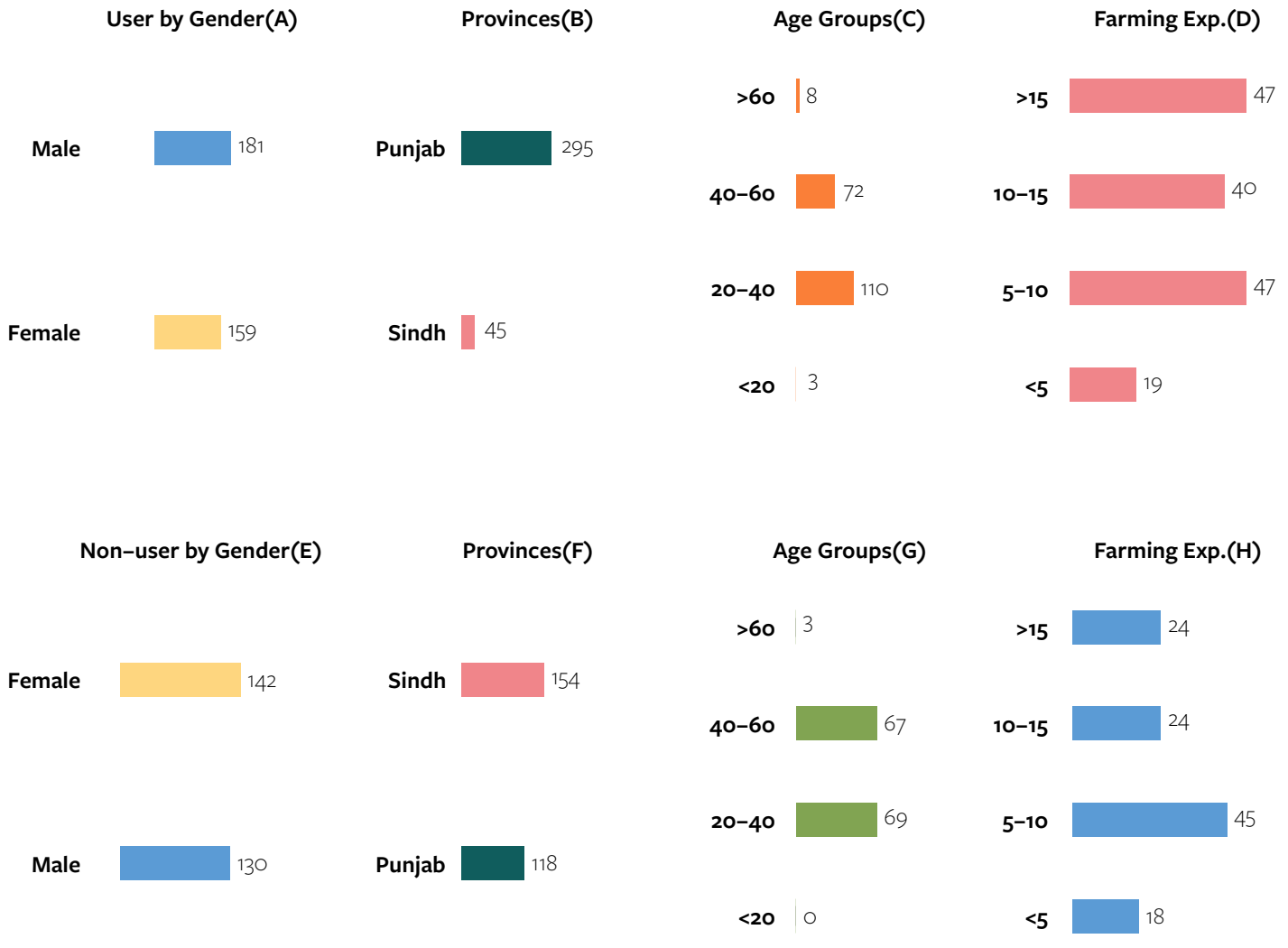
5.4.1. Users and sources of weather and climate information services

More than half of the respondents (56%) identified themselves as WCIS users whilst 38% of respondents identified as non-users and the remaining 7% did not answer.

The data shows that on average current users of WCIS had spent more years in school (i.e. users of WCIS spent on average around 6 years than non-users with an average of 4 years).

The number of female respondents in the non-user group was greater than the number of male respondents (n=132 and n=98, respectively). Only 45 respondents (23%) in the Sindh province were WCIS users while this number in Punjab was much larger with 295 (71%) respondents stating to be users of this type of information. Conversely, 154 (77%) of respondents from Sindh identified themselves as non-user of WCIS whilst the number in Punjab was smaller with only 118 (29%) stating to be non-users of WCIS (Figure 22).

Figure 22 - Users and non-users of WCIS according to gender, provinces, age group and farming experience (showing total values)



For users of WCIS, their main source of information was PMD in both Punjab and Sindh (Figure 23) which also aligned with findings from the FGDs. However, it is worth noting that in Punjab information from PMD was also often used in conjunction with other sources (i.e. participants receive information from both types of sources).

Regarding WCIS information sources and how frequently they are used, around 40% of current users of WCIS use many of the PMD sources of information on a daily basis (Figure 24). Around 50% use PMD National TV Channel and their SMS service when they need it.Regarding non-PMD sources of WCIS information, these tend to be used less and primarily when they need it.

These findings align with the FGDs where participants also identified similar means for accessing information. In fact, approximately 30 FGD participants stated that they use two or more sources/mechanisms for accessing information which include primarily family and friends, telecommunication companies (e.g. Telenor), SMS, call (voice message) and social media platforms (website, Facebook, WhatsApp, Internet). Others included mobile phones, extension officers and non-extension officers, private companies, input dealers such as fertiliser companies, landlords and radio.

Around 50% of WCIS users use PMD's daily weather forecasts closely followed by 40% who stated their daily use of farmer advisories. Other PMD products used daily but to a lesser extent include 3 days weather forecast, weekly weather outlooks, monthly outlooks and other types (Figure 25).

Figure 23 - Sources of WCIS information in Punjab and Sindh (showing total values)

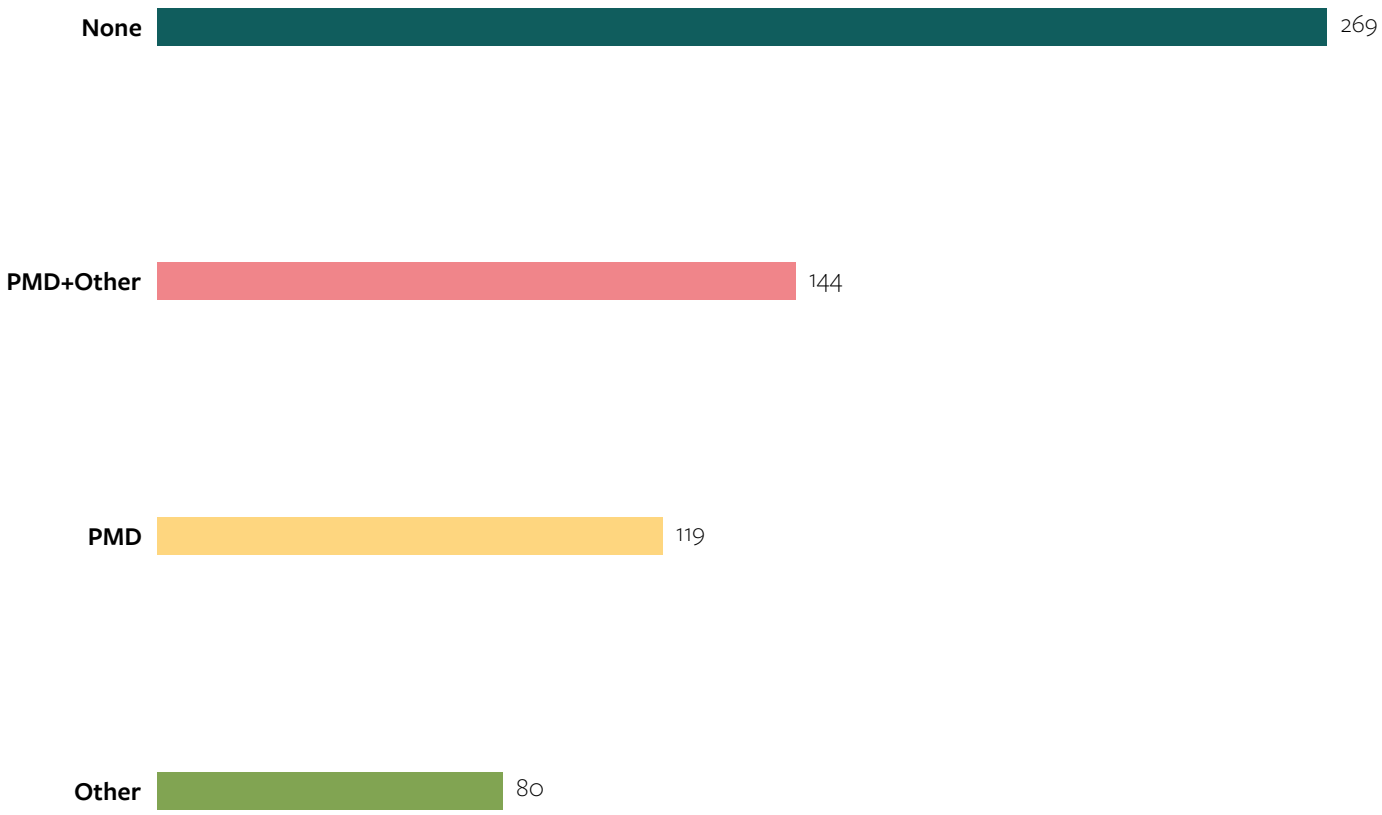


Figure 24 - WCIS Information sources and their frequency of use (showing percentages)

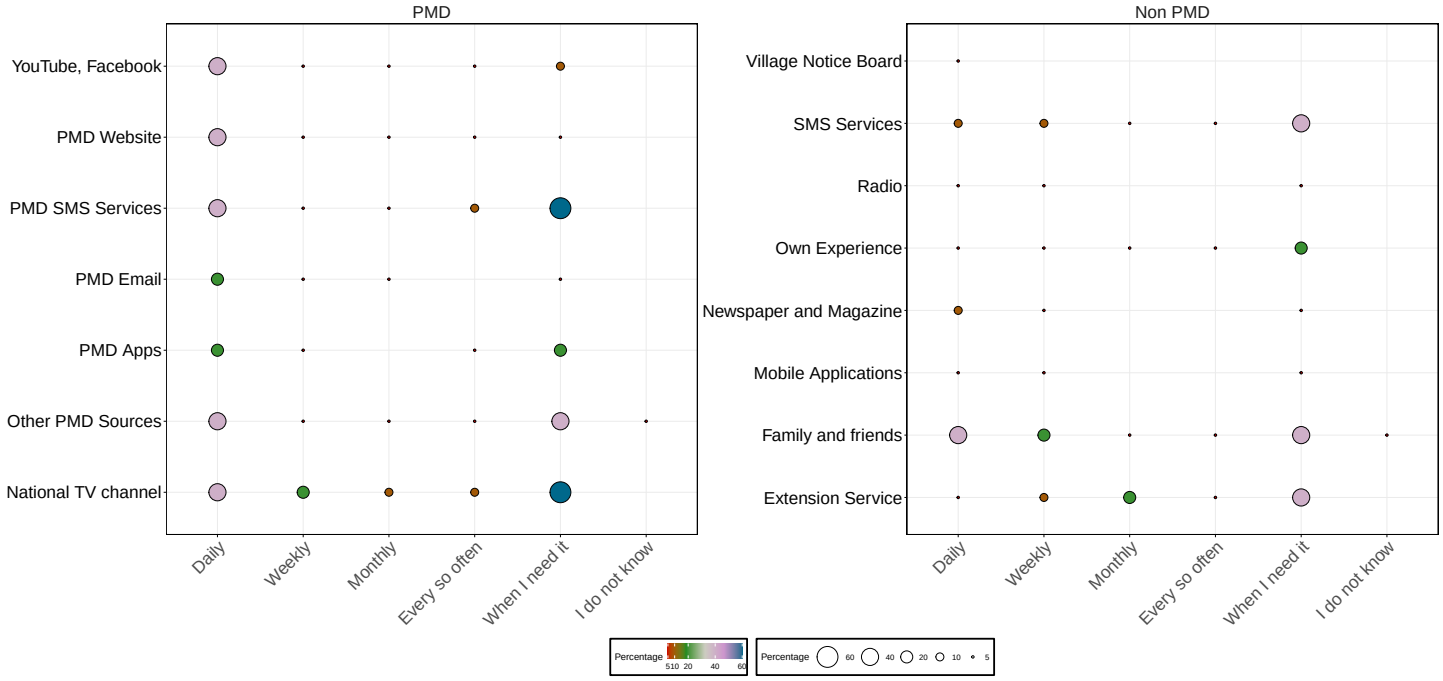
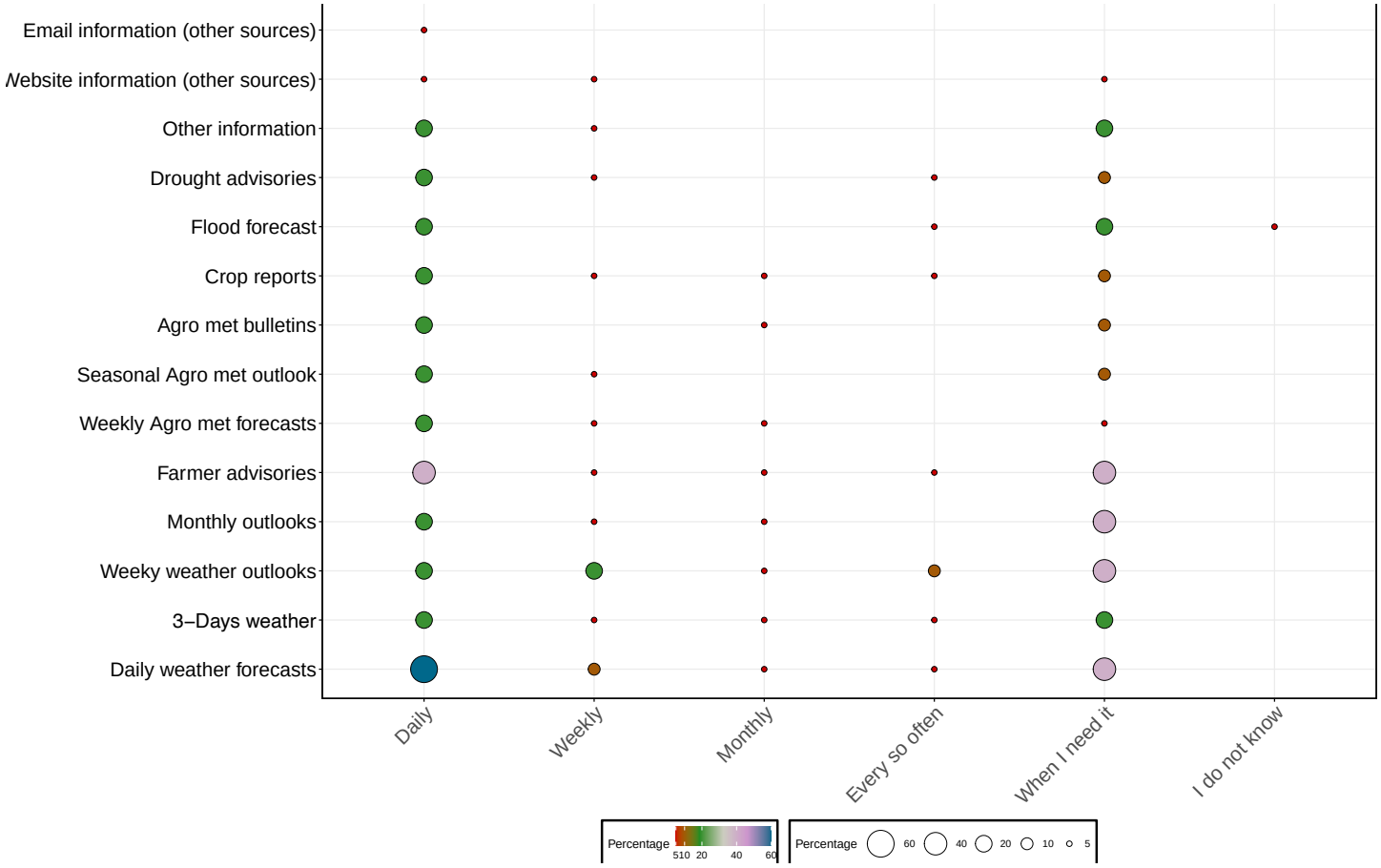


Figure 25 - Types and frequency of WCIS use (showing percentages)



Around 40% of current users also stated that they use farmers advisories, monthly outlooks, weekly weather forecasts and daily weather forecast only when they need it (Figure 25).

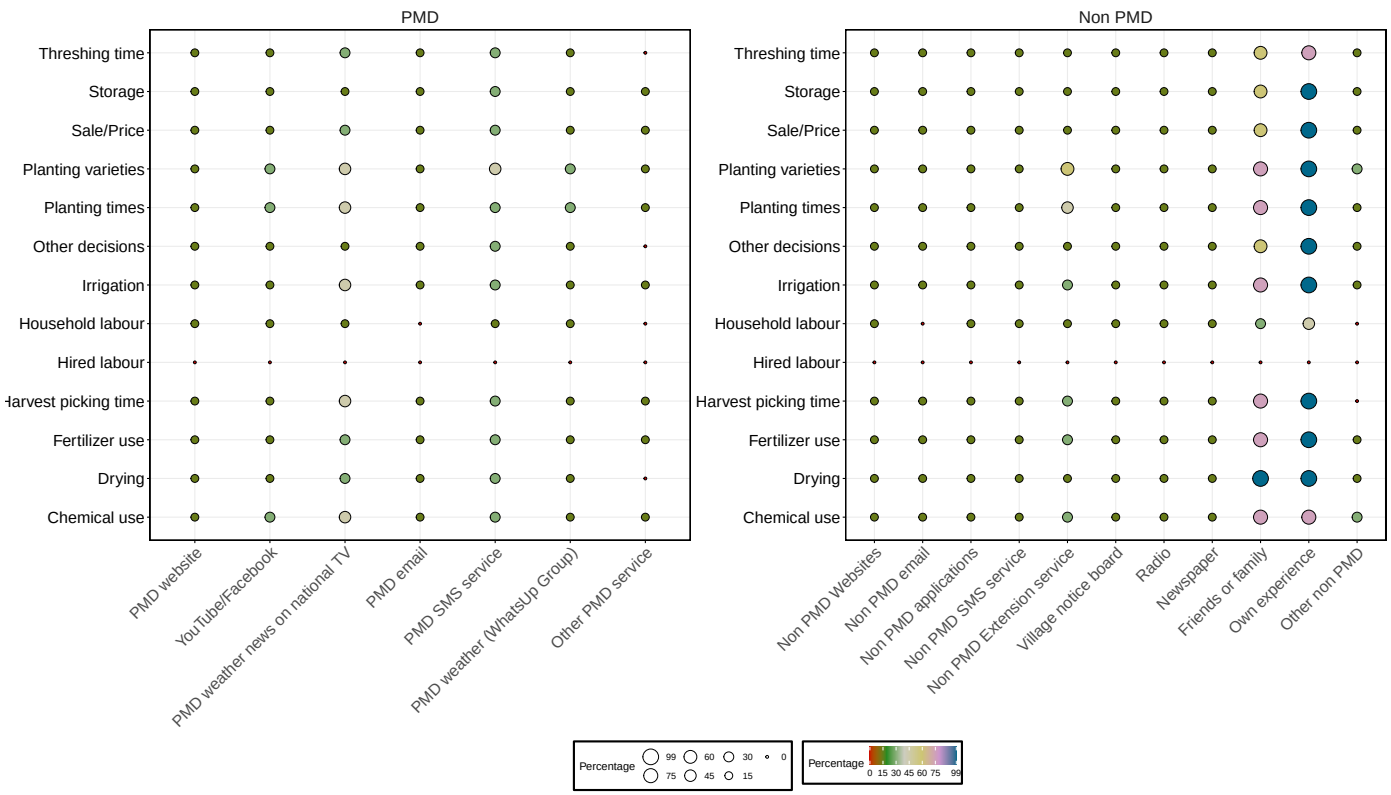
From the FGDs analysis it was clear that most participants use weather information and updates to make decisions in their farming operations. Weather information used included rainfall information (heavy rain), strong winds, temperature, clouds, and typhoons. However, the FGDs findings were not sufficiently clear to allow us to link the specific PMD products used with the types of farming decisions. This may be in part due to some lack of understanding about the types of WCIS received from PMD.

5.4.2. Use of weather and climate information services in farming decisions

The use of WCIS information in farming decisions was also analysed in both the farming household survey and FGDs. Figure 26 below shows the survey results in relation to the link between information sources - both from PMD and non-PMD sources - and how these are used to support farming decisions. Our analysis shows that two key PMD sources - weather news on national TV and PMD SMS service - are consistently used by approximately 40-50% of survey respondents in many of their key farming activities e.g. planting times, harvesting times, threshing times, irrigation, choice of planting varieties, use of pesticides and chemicals, and drying.

However, non-PMD sources, particularly using farmers' own experience and friends and family and, to a lesser extent other extension services, play a significant role in many of key farming decisions with around 80-90% of respondents using them (Figure 26).

Figure 26 - Types of farming decisions per type of information sources (showing percentages)



The analysis from the FGDs support these findings with many participants (n=39) agreeing that WCIS information is useful in making decisions at different stages of farming activity such as application of pesticides and fertilisers, harvesting, purchase of seeds, sowing, irrigation, storage and flowering. For example, as stated by a farmer "(...) [During] harvesting (...) we take care of weather conditions to prevent [protect] crops from any unexpected conditions because harvesting during rain or storm [can] deadly damage crops and decreased production". Information about rain after 2-3 weeks of sowing crops was perceived as useful for livestock keeping in terms of their food, bath and living planning. Weather and climate information is also used to make decisions about social activities, such as setting dates for marriage, "(...) we even fix marriage dates".

We also analysed the links between sources of information and types of decisions across Punjab and Sindh provinces. We found that respondents in Punjab tend to use a wider variety of sources of information for farming decisions as compared to those in Sindh (Figures 27 and 28). However, respondents from both provinces seems to rely more on their own experiences as well as information from friends and family when making farming decisions. In addition, in Sindh farmers tend to use more non-PMD sources of information and only use PMD weather information from national TV channels, social media and PMD SMS service for very specific decisions: choice of planting varieties and planting times (Figure 28).

Figure 27 – Types of farming decisions per type of information sources in Punjab (showing percentages)

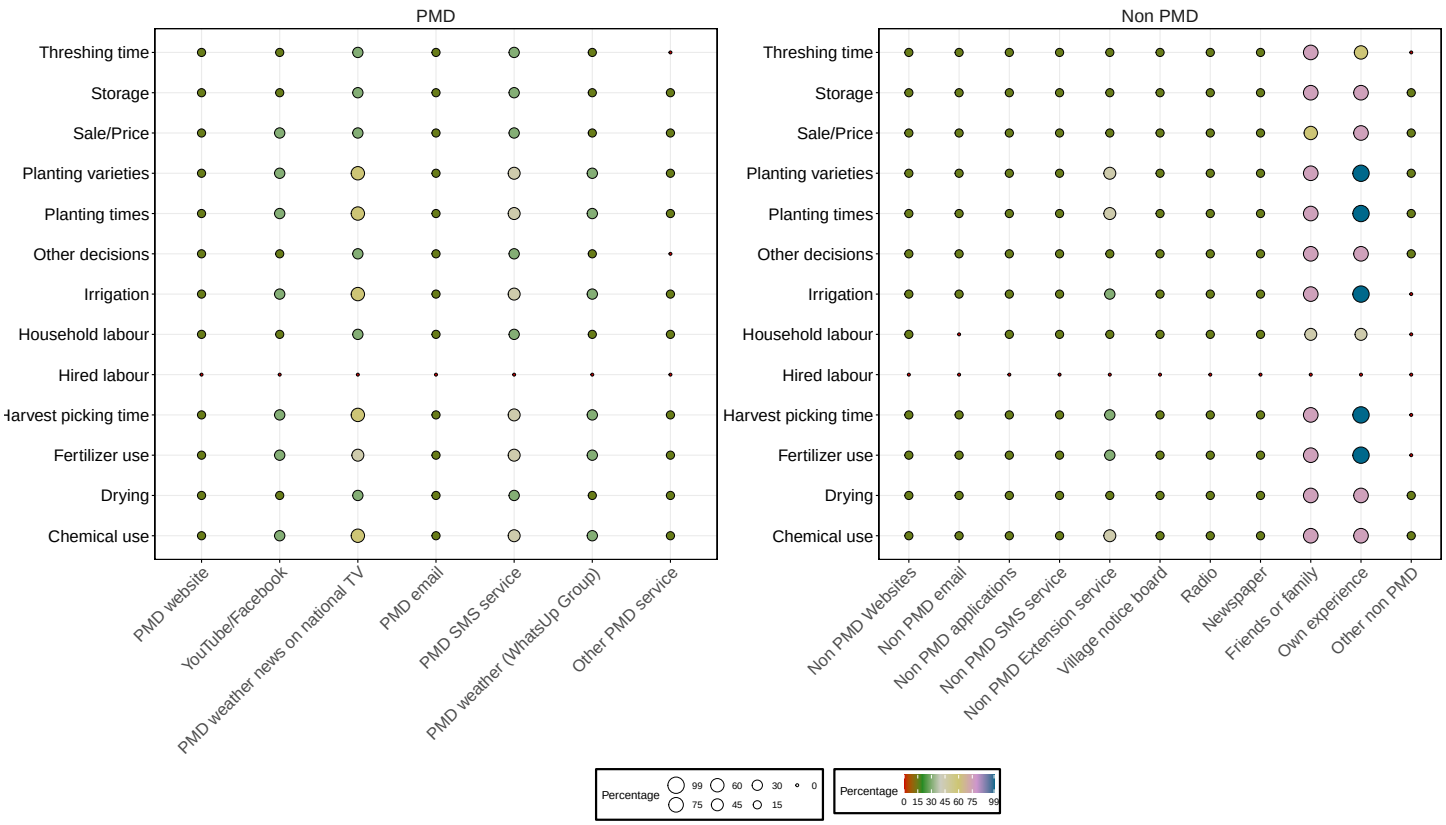


Figure 28 – Types of farming decisions per type of information sources in Sindh (showing percentages)

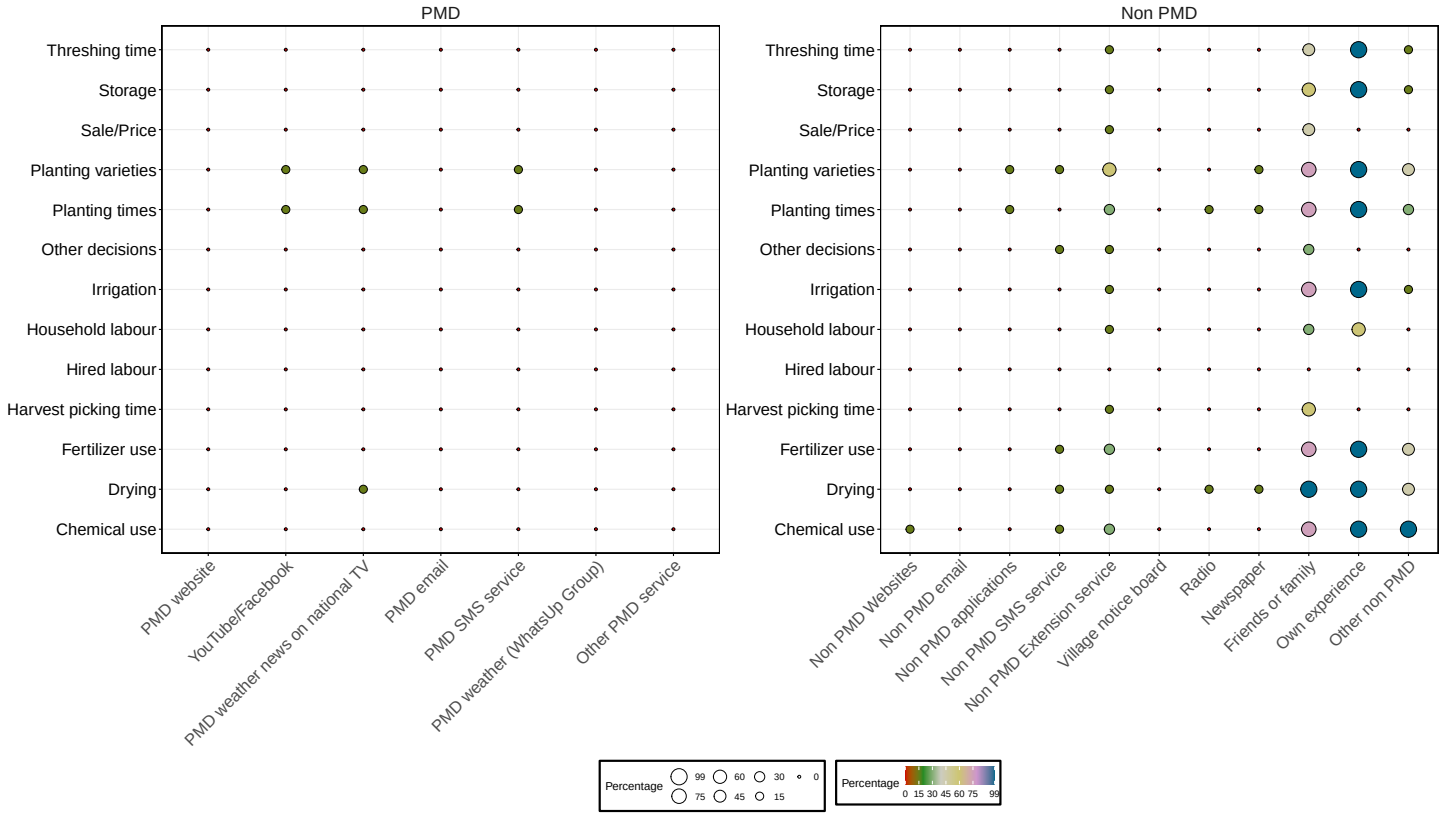
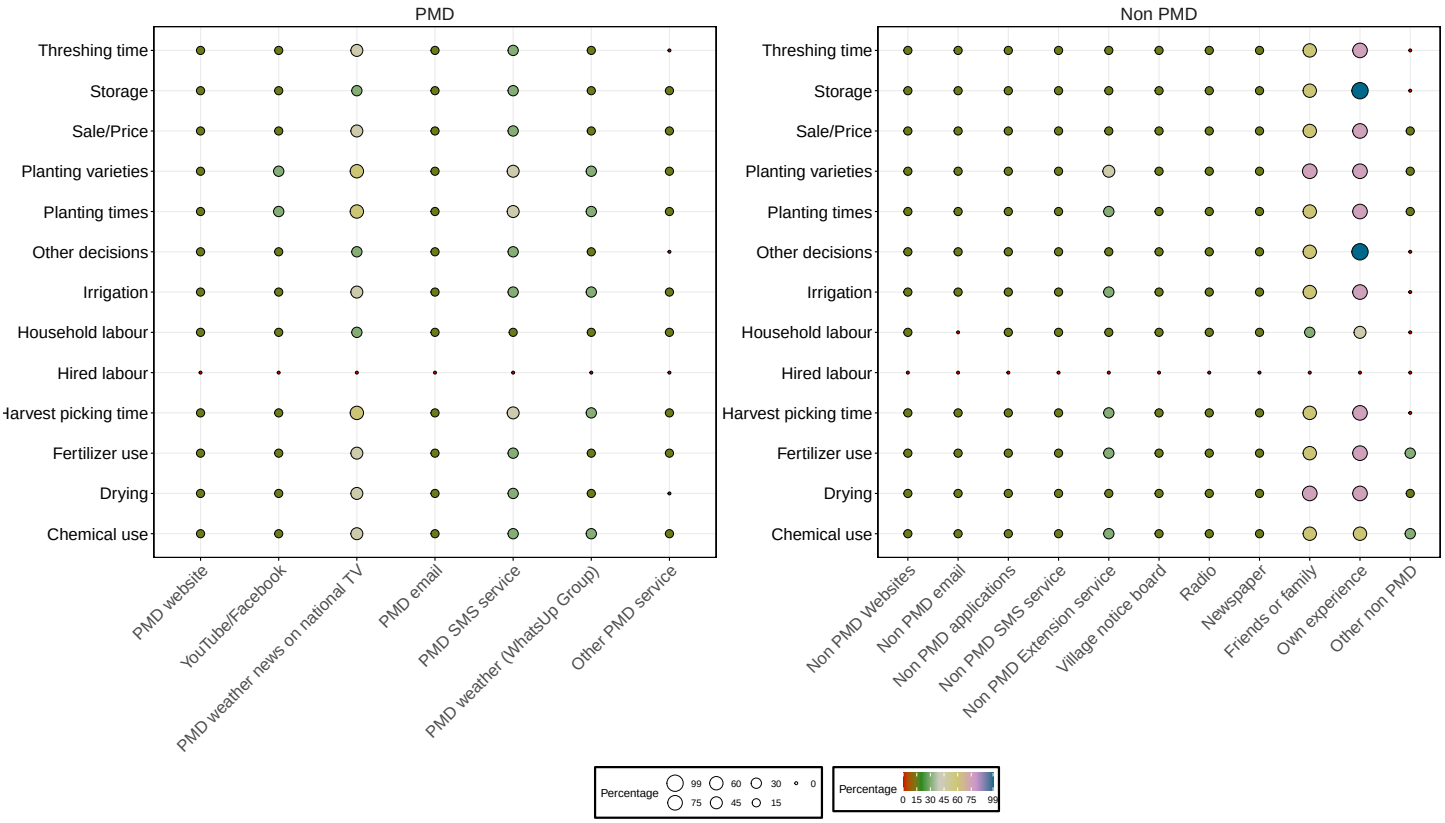
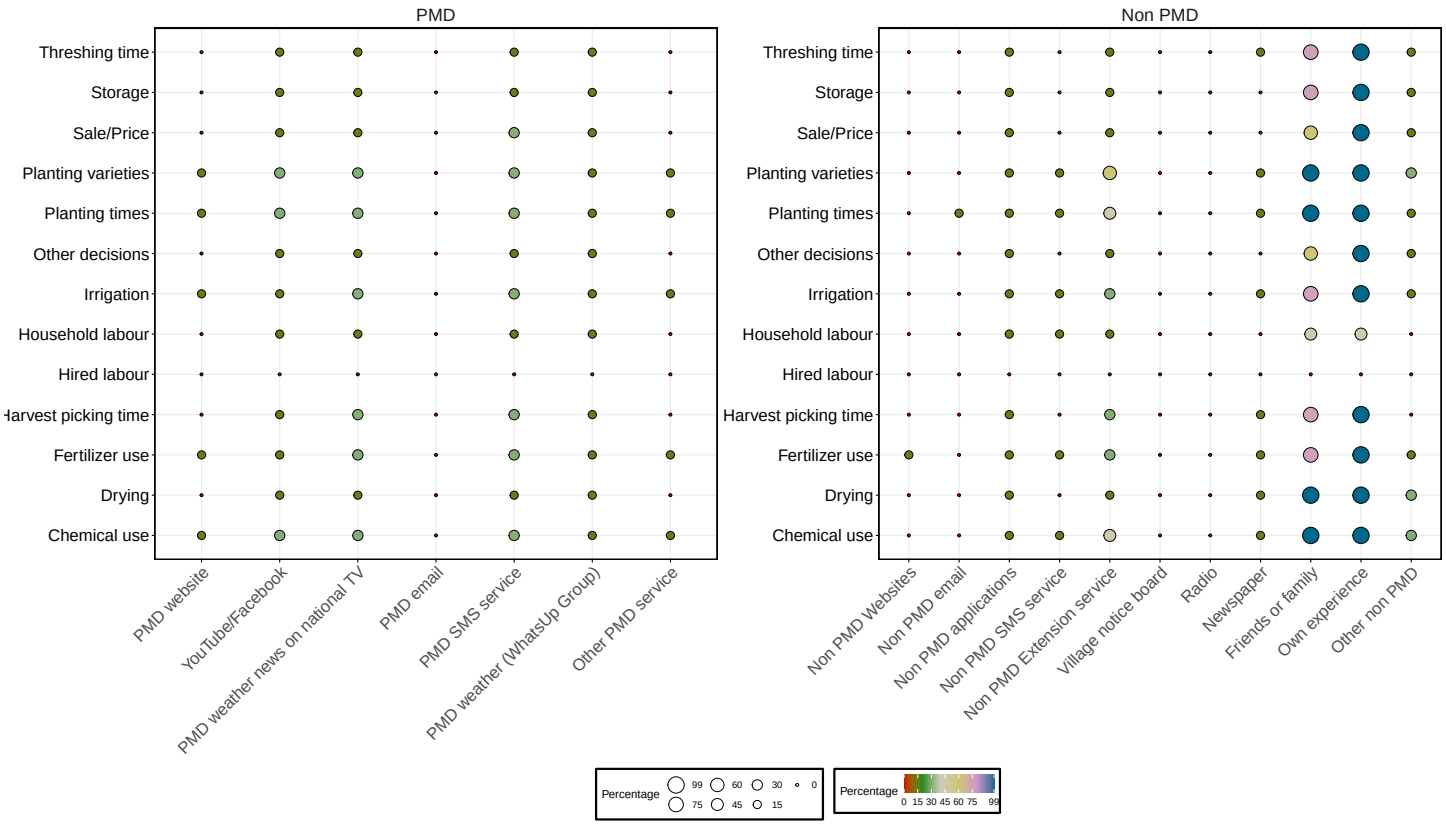


Figure 29 – Types of farming decisions per type of information sources amongst female respondents (showing percentages)



We also examined how different sources of information were used by males and females in their faring decisions (Figures 29 and 30). Not surprisingly, and in line with the general trend (Figure 26) both groups largely use their own experience and family and friends in their decisions as opposed to official PMD information. One of the main differences is that, females tend to use a wider variety of information sources (both from PMD and non-PMD sources) when compared to males who tend to focus more on their own experience, information from family and friend and non-PMD extension services (Figure 30).

Figure 30 – Types of farming decisions per type of information sources amongst male respondents (showing percentages)



5.4.3. Benefits and challenges of using WCIS information

A number of benefits and challenges of using weather and climate information services information were identified during FGDs. The type of benefits described by participants, included:

- **The information helps farmers make timely farming decisions.** For example, it was stated that "(...) *during cultivation and other tillage practices weather news are helpful for us. If we know about rain, we stop ploughing the soil because after rain weeds start growing. So, we start ploughing after rain which helps in controlling weeds" (male farmer, Sindh Province).*

- **The information helps increase crop yield or produce better quality crops** thus helps increase the price for which they sell their crops;

- **Timely cotton picking/wheat harvesting**. For example, "(...) *wind information is important in [the] case of cotton. The cotton balls fall down in case of wind and picking up becomes difficult. So, picking plans changes if there is a forecast of winds and storms"* (female farmer, Punjab Province);

- **More effective irrigation** by knowing when rain is expected;

- **Better plan crop management and avoiding damages to crops;**

- **Help protect crops from pests** including by using pesticides given by agriculture extension specialists.

In terms of the **key challenges** and concerns in using this type of information, farmers described a range of issues, including:

- **Information is perceived as not being accurate.** For example, one farmer statement captured the general feeling "(...) *people are afraid to believe the information given by PMD, because it is not reliable and authentic. People think they provide fake information sometimes"* (female farmer, Punjab Province);

- **Accessibility issues** in terms of electricity power cuts or speed of internet which can hinder their access to information in time to use it; or due to mobile network charges which can make it difficult for them to access information;

- **The information arrives late** in the sense that the WCIS they receive does not give them enough time to act on that information as described by a farmer: *"To react to weather information within a day is some time become very difficult. There is a forecasting of rain but we were unable to pick the cotton in two days"* (female farmer, Punjab Province);

- **Information is too general and hard to use** and they would like to have information at city and village level.

"It will help us to understand which crop will need to be cultivated in which season neither too early nor too late"

5.4.4. Enhancing the provision and use of WCIS information

During FGDs, users of WCIS were asked about how current WCIS could be improved to better suit their needs. A number of suggestions and recommendations were put forward by farmers, including:

- **Improve spatial coverage so that information is provided at local level** e.g. specific areas and villages (particularly raised by males in Punjab and Sindh Provinces). Farmers mentioned that the information they receive is about the whole district but they want information about their village or a specific area. This will also increase the efficiency of the farming practices;

- **Improve accuracy of information from trusted sources** (raised by males in Sindh Province). Farmers were referring to the fact that sometimes the information they receive is not from trustworthy sources and *"(...) if any of the government or agriculture department provide us this type of information it could be trustable and we will plan to protect our crop"* (male farmer, Sindh Province);

- **Require support from experts** e.g. extension officers, experts to inform farmers on daily weather conditions (particularly raised by females in Sindh Province). For example, a few farmers (both male and female in both provinces) preferred the information to be provided by UB [village fellow] because they understand and they are friendly. *"The information provided by UB [village fellow] is understandable. He talks like us. We can easily understand what they are saying."* (female farmer, Punjab Province);

- **Training and education** by Agricultural department and PMD at village level to educate farmers on how to deal with unexpected weather conditions (raised by females in Sindh Province);

- **Improve WCIS information to better fit farmers' needs** (raised by females both in Punjab and Sindh Provinces) as stated for example by a farmer *"(...) it will help us to understand which crop will need to be cultivated in which season neither too early nor too late"* (female farmer, Sindh Province);

- Additional comments included:

  - PMD weather and climate information provided through National TV channel (PTV) to be broadcasted in local languages (to also include Punjabi and Saraiki besides Urdu) to increase accessibility/ understandability of information;

  - It was also noted that these weather bulletins are broadcasted when most farmers are unable watch it. As such, it was suggested for the weather news to be broadcasted in the afternoon (12 noon) as most farmers are free at that time as stated by a farmer "The time should be arranged according to the availability of farmers. Mostly farmers are free after 12:00 noon so farming and weather related information should be provided at that time" (female farmer, Punjab Province).

  - Farmers also requested PMD to include information on their website for all crops according to their seasons (i.e. agronomical information, crop calendars) to help farmers decide when to spray, water, sow crops.

  - Farmers prefer the information to come from the government (PMD) or agriculture department as they sometime use information from non-trustworthy sources;

  - Further training and support for female farmers e.g. using female facilitators to deliver these on the ground.

FGDs participants were also asked about what other type of WCIS information would be useful for them to have in order to help better support their farming activities and decisions. Interestingly, many of the additional information requested were not directly related to weather and climate information. These included:

- Farmers would like government/PMD to organise seminars to inform farmers about new seeds and fertilisers (both male and female in both provinces);
- Information on price [of crops] and marketing (both males and females in Sindh Province);
- Concerns over canal water supply issues (farmers in both provinces) and requests for government to act on it to ensure more canal water availability to ensure an increase in area cultivated;
- Updates on new farming technology, machinery, and seeds' varieties coming into Pakistan (both males and females in Punjab Province);
- Other comments included:
  - Accurate information about rainfall at least a week before to ensure they can protect their crops;
  - Proper information about volume of rain expected as well as information about winds and storms to help them decide when to spread fertiliser/pesticides;
  - Information to be available in local languages;
  - Information on how to reduce impact on natural ecosystems;
  - Area specific weather-information;
  - Information on storage of cotton, best methods for selling crop at suitable price, information on subsidies and how to obtain finance from different sources;
  - Provide farmers with diesel on subsidised rates to help them increase yields.

5.5. Non-users of weather and climate information services

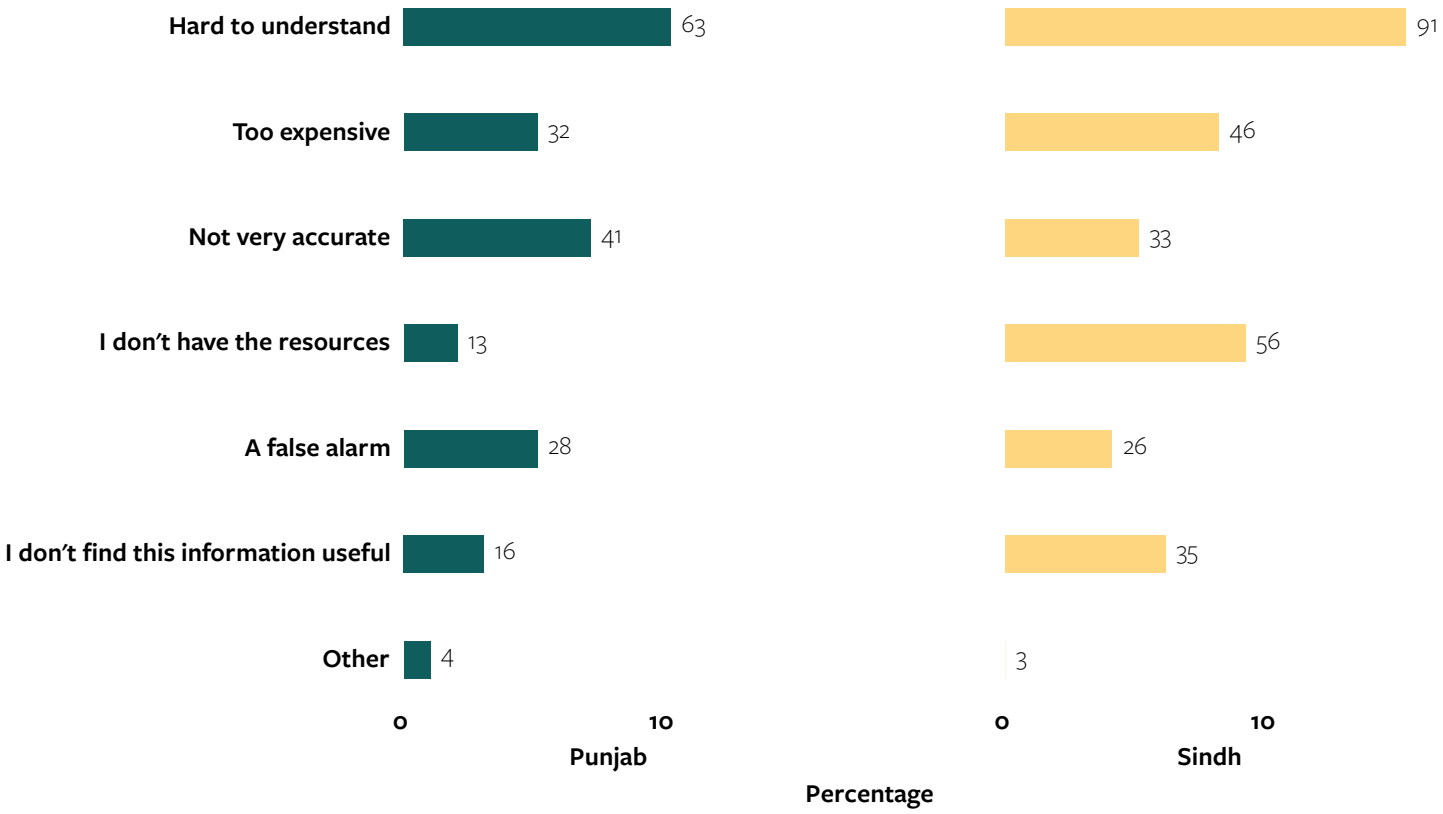
A total of 272 survey respondents (44%) were non-users of WCIS (Figure 2 above). Figure 31 below shows that there is a relatively higher number of non-users of WCIS in Sindh than in Punjab provinces (77% and 29%, respectively). The main reason for not using this type of information in both provinces is the difficulty in understanding the information.

Similarly, the difficulty in understanding the weather and climate information is also the main reason when looking at both females and males (Figure 32) although this percentage is higher in the female group than the male group (87% and 67%, respectively).

Findings from the FGDs shed further light on some of the current challenges faced within the non-user community surveyed. Almost half of the non-users that participated in the FGDs (particularly women in Sindh) stated that they did not know about weather and climate information. Others were aware of this type of information but not interested because they did not find it useful and/or they did not trust it due to past experiences. A sub-group was also aware but not interested as they prefer to believe in local knowledge and religion. Remaining participants were aware of it but could not access it e.g. due to language barriers, access to means of information.

The majority of non-users have access to one or multiple means for receiving weather and climate information with key ones including family members and friends, TV, mobile phones (calls 7272, SMS), extension officers

Figure 31 - Reasons for not using WCIS in Punjab and Sindh provinces (showing percentages and total values)



and big farmers' newspapers. However, although with access to means, some of these farmers indicated that they were unable to use the information due to literacy issues making them reliant on family and friends to access information:

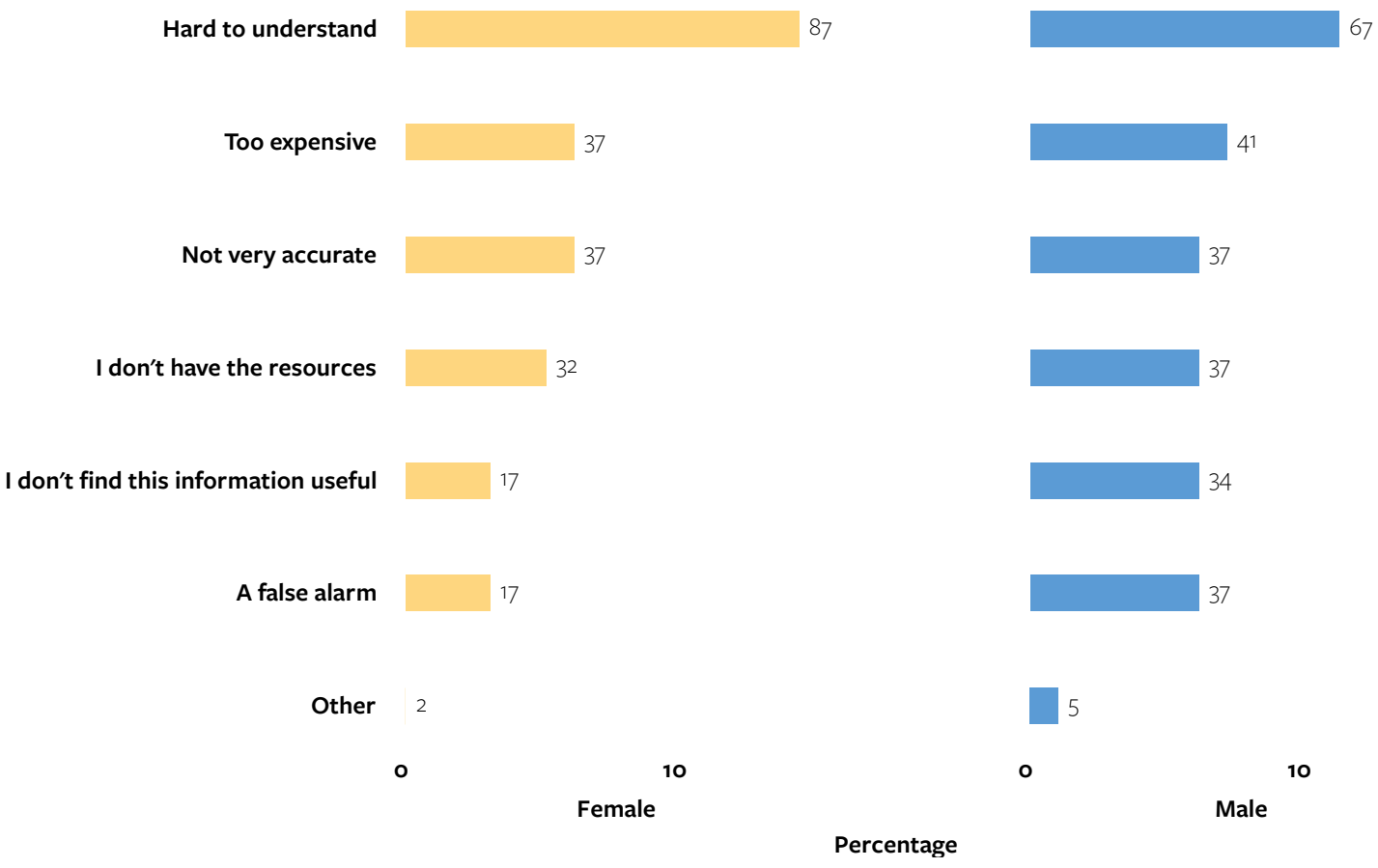
> "We don't watch TV, not listen radio, don't read newspaper because we are illiterate. I have simple mobile phone and cannot read msg [means text message] if it comes. I only get information through friends and family but not accurate" (male farmer, Punjab Province).

Many of the participants from Punjab and Sindh, stated they understand the weather and climate information provided.

However, **barriers to using such information** were also identified, including:

- **Language used and difficulty in understanding the information:** *"The information provided in Urdu language that I cannot understand properly"* (female farmer, Punjab Province). Saraiki speakers in Sindh, Punjabi speakers in Punjab and Urdu speakers in Punjab emphasised that the language barrier hindered their understanding of the information;
- **Limited access to information** (particularly by females in Sindh Province);
- **Lack of relevance, accuracy and usefulness of information:** *"Mostly information provided for irrelevant crops.*

Figure 32- Reasons for not using WCIS per female and male groups (showing percentages and total values)



We are not growing sugarcane, potato and rice etc. but they tell us about those crops. Such information is not useful for us" (female farmer, Punjab Province);

- **Timeliness of information** i.e. information reaching farmers too late to support their farming decisions;

- **Own personal experience** was also perceived to be more useful in some cases: *"(...) he has an experience of more than 35 years and he predicts weather on the basis of his experience, so he did not need any kind of information from PMD"* (male farmer, Punjab Province).

However, many of these participants would be willing to use the information if it was accurate, useful and their ability to understand strengthened:

"If they tell us what will be the weather and how to tackle it and secure our crops then we will be able to get benefits" (female farmer, Punjab Province).

They would also use the information if it was provided by extension officers and input dealers:

"I would like to have agriculture extension officers and input dealers to give us information about climate change information" (male farmer, Sindh Province).

Others included TV, government (i.e. PMD), mobile SMS or call and, to a lesser extent, village leaders, family members, internet, social media and radio. Females in Punjab expressed a preference for receiving this type of information on TV earlier in the day (e.g. between 12 and 2pm) so as not to clash with other home tasks in the morning and evenings. Receiving the information in local languages was also a recommendation from these FGDs particularly for women.

Regarding the **types of weather and climate information that would be useful** to help them, there were a few differences between genders:

- Females in Punjab and Sindh are interested in getting information on rain, wind, dust, unseasonable rain, and windstorms, changes in the environment/weather/climate, moisture, temperature, storm, heat waves.

- Men in Sindh province are interested in information on sandstorms, hail, temperature and temperature variations. Other information of interest included rain, bad weather, information related to sowing, harvesting and storm. Men were also interested in receiving information on irrigation schedules, insects, pests, diseases, high winds, clouds, warm weather and drought.

- Both females and males from both provinces were interested in obtaining timely and accurate weather information at the district level.

When asked about the **perceived benefits of using weather and climate information**, most participants referred to potential increase in yield and income, reduced losses, protection of livestock and crops, improved production and crop management. Other benefits identified were linked to the ability to cope with climate and weather challenges, the protection and safety of homes and the improvement of agricultural techniques. It would also have perceived benefits in agricultural activities such as pesticide spraying, harvesting, irrigation planning, fertiliser application and tillage.

However, some participants were unsure of the benefits due to uncertainty in weather and climate information or could not see any potential benefits in using weather and climate information.

Risks associated with using weather and climate information included the information arriving too late, potential economic losses, problems with the accuracy of information and not being able to act on the information due to other constraints to their farming activities:

> *"In case of cotton picking we used to start picking when we found labor for cotton picking. Whatever the weather forecast is, we will not be able to protect our crop from un-favorable weather if we don't have the labor"*
> (*female farmer, Punjab Province*).

Key conditions for enabling the use of this information in the future included:

- **Raising awareness and training amongst farmers.** A suggestion was provided for free schooling at night with awareness programs and training by the government. Training and awareness raising by female agricultural officers to female farmers was also suggested;

- **Timely information** from multiple sources and access to information is necessary to be able to use weather and climate information.

- **Means for accessing information** by providing farmers with mobile telephones, radio, and state-of-the-art technology. Also access to information free of charge from the mobile companies.

- **Information provided by key informants** including PMD office, experts, agriculture officers, input dealer, and local educated persons.

- **Financial stability** was also identified by a few (male) participants in Punjab as a key condition to use this type of information: "(...) financial stability is the main step to use this information in future" (male farmer, Punjab Province).

There were also other additional comments by non-users at the end of the FGDs which, although not directly related to the use of WCIS, captures some of the challenges and difficulties felt by farmers, including:

- Cotton seeds don't have quality, fertilisers are expensive and the price of products are not suitable, limited support from agricultural assistant to guide agriculture practices (male farmers in Sindh province);

- Inequalities and timely distribution of canal water for irrigation; difficulties in using tube wells due to bad water quality (farmers in both Sindh and Punjab);

- The need for information on pest attack at different stages of crop development (e.g. at the final stages of the crop).

5.6. Economic analysis of use of WCIS for wheat and cotton crops

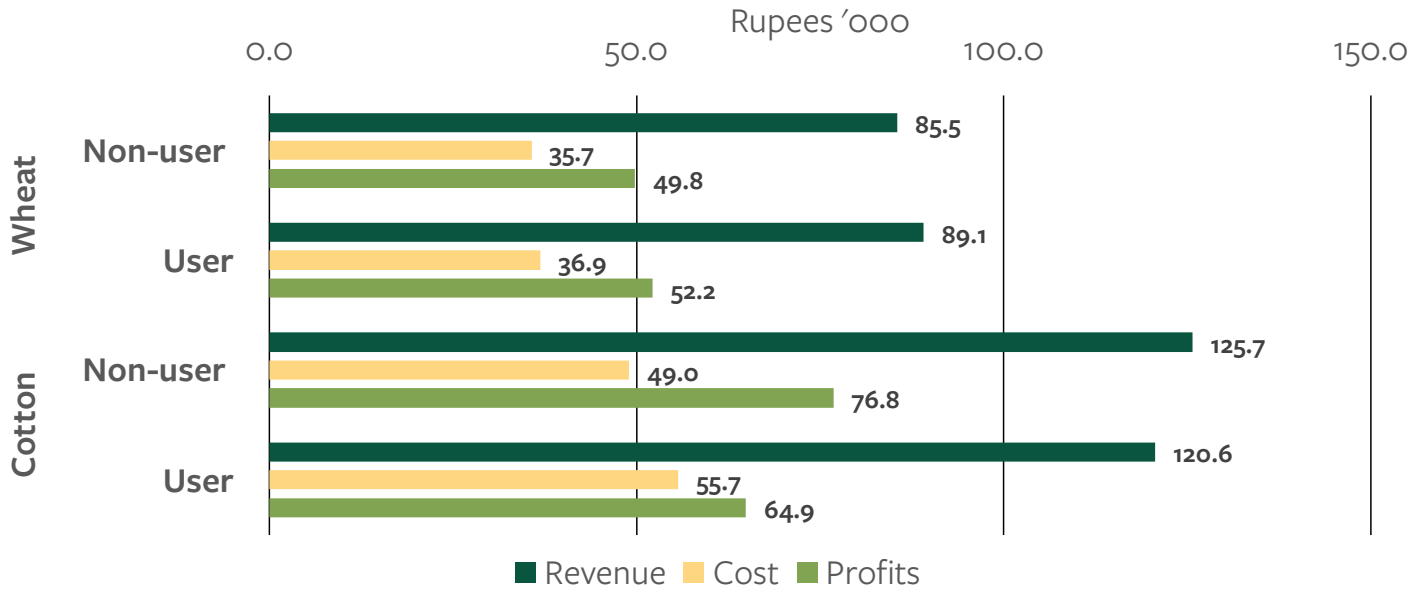
5.6.1. Economic Benefits of WCIS

In this section, we analyse the difference in some of the key economic variables such as per acre revenue, cost and profits among the farm households who use and who do not use the agro-met advisories. Figure 33 shows the per acre revenue, cost and profits from both Wheat and Cotton crops (in '000 PKR) to the households who are using WCIS and who do not.

For wheat crops, WCIS user households are getting slightly higher revenue (PKR 3,600/acre), higher profits (PKR 2,400/acre) and also higher cost (PKR 1,200/acre) as compared to the non-user households. Whereas for cotton crop, WCIS user households are getting relatively lower revenue PKR -5,100), lower profit but incurring higher cultivation costs (PKR 6,700) per acre. The similar pattern holds when we segregate the data based on the gender of the respondents (Figures 34 and 35).

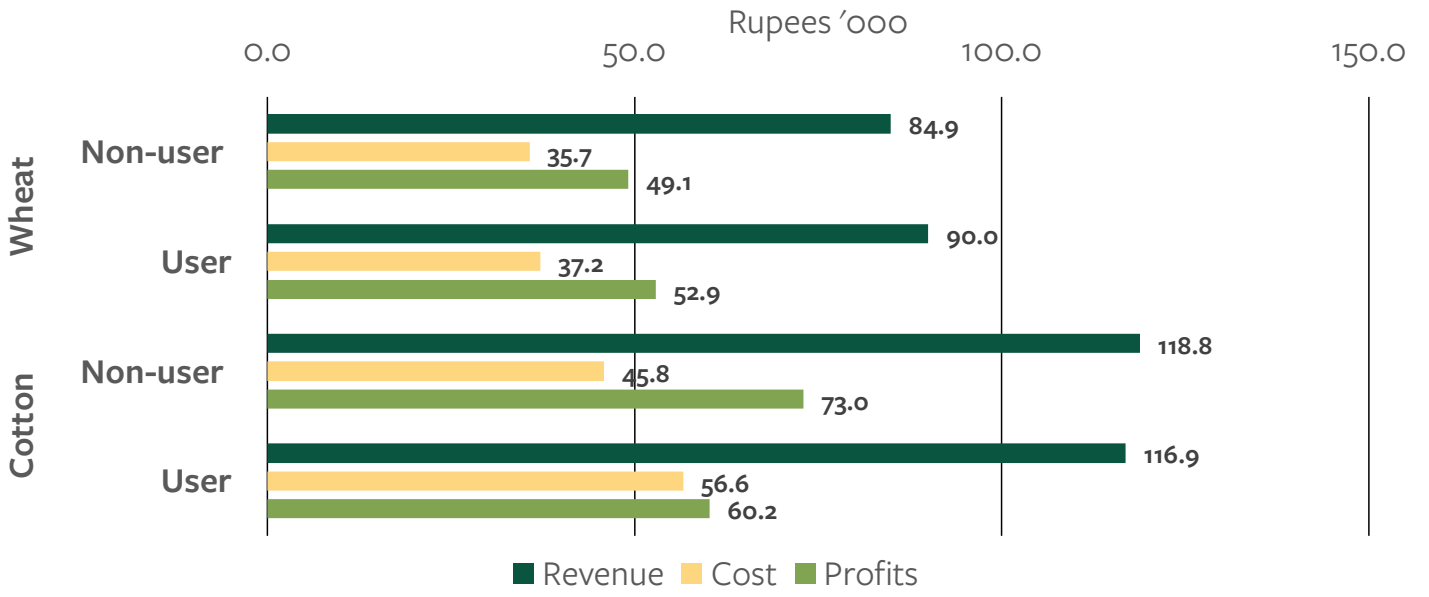
However, when we look at the farm households from two different provinces, cotton growers in Sindh are incurring lower cost and earning higher profits (PKR 4,500/acre) among the WCIS users as compared to the non-users (Figure 36). In Punjab, there are slight differences as WCIS user households are earning less profit (PKR -3,700/acre) per acre and incurring higher cost (PKR 200/acre) (Figure 37).

Figure 33 - Per acre revenue, cost and profits between non-users and users' households (full sample)



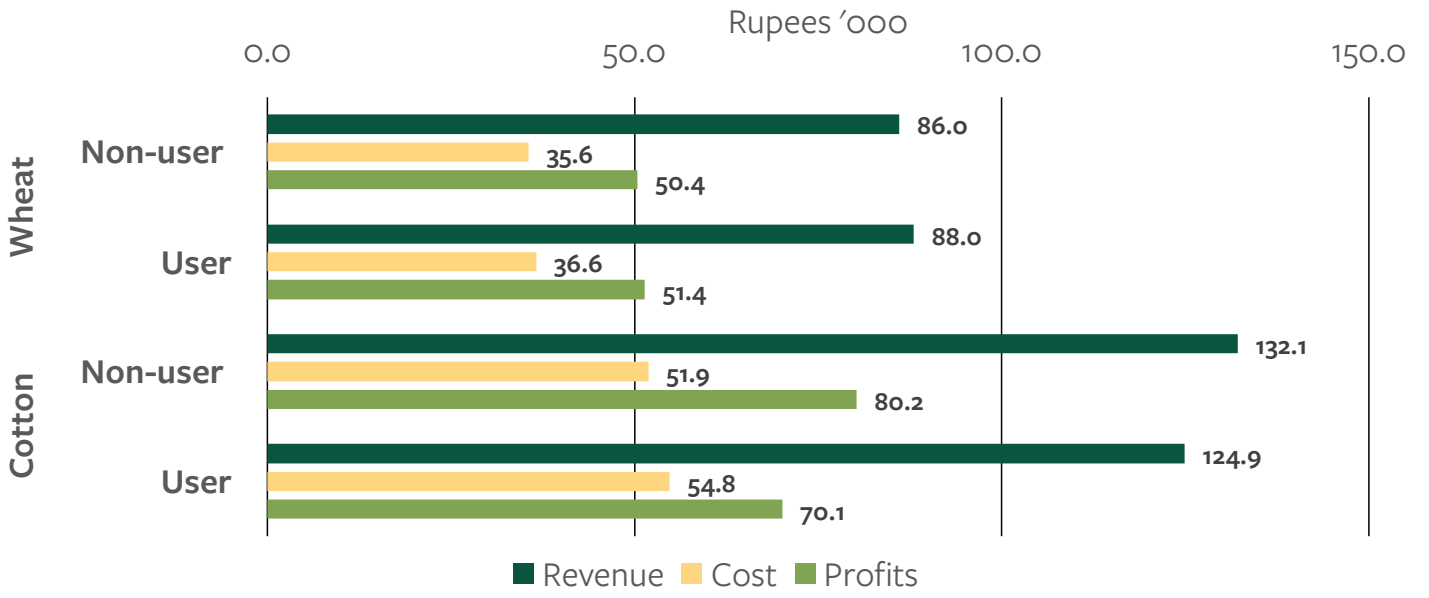
Note: Field survey, 2021

Figure 34 - Per acre revenue, cost and profits between users and non-users households (male respondents)



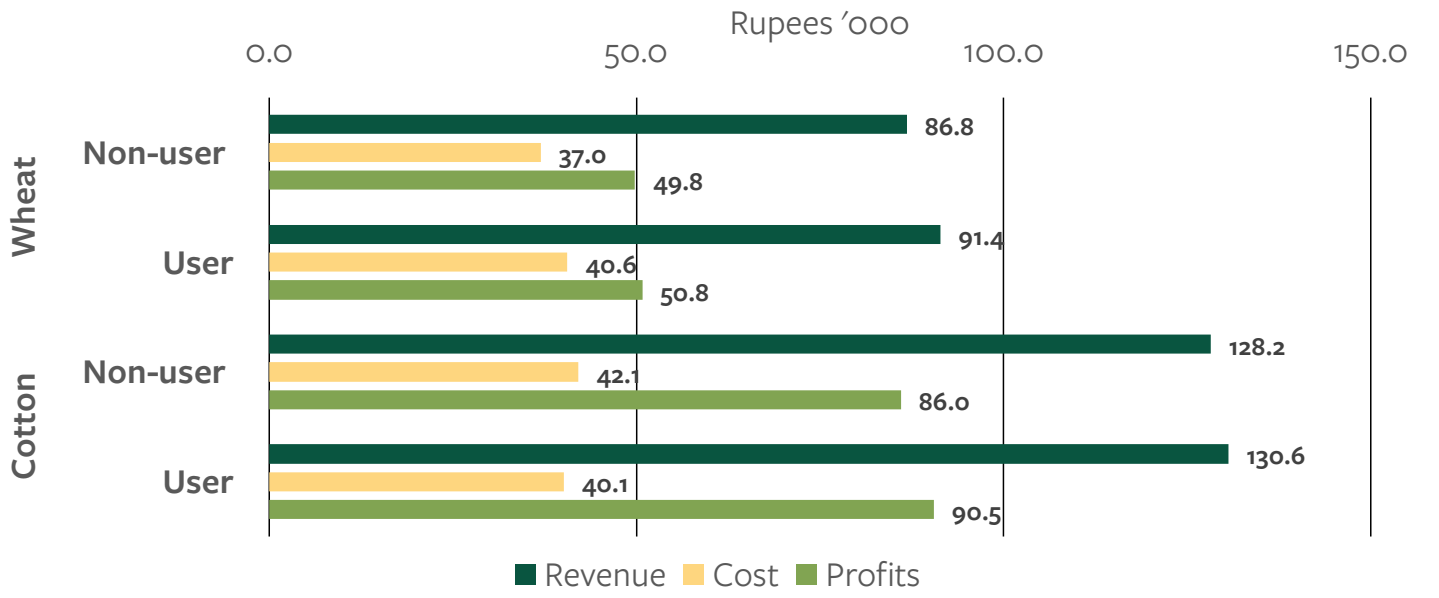
Note: Field survey, 2021

Figure 35 - Per acre revenue, cost and profits between users and non-users households (female respondents)



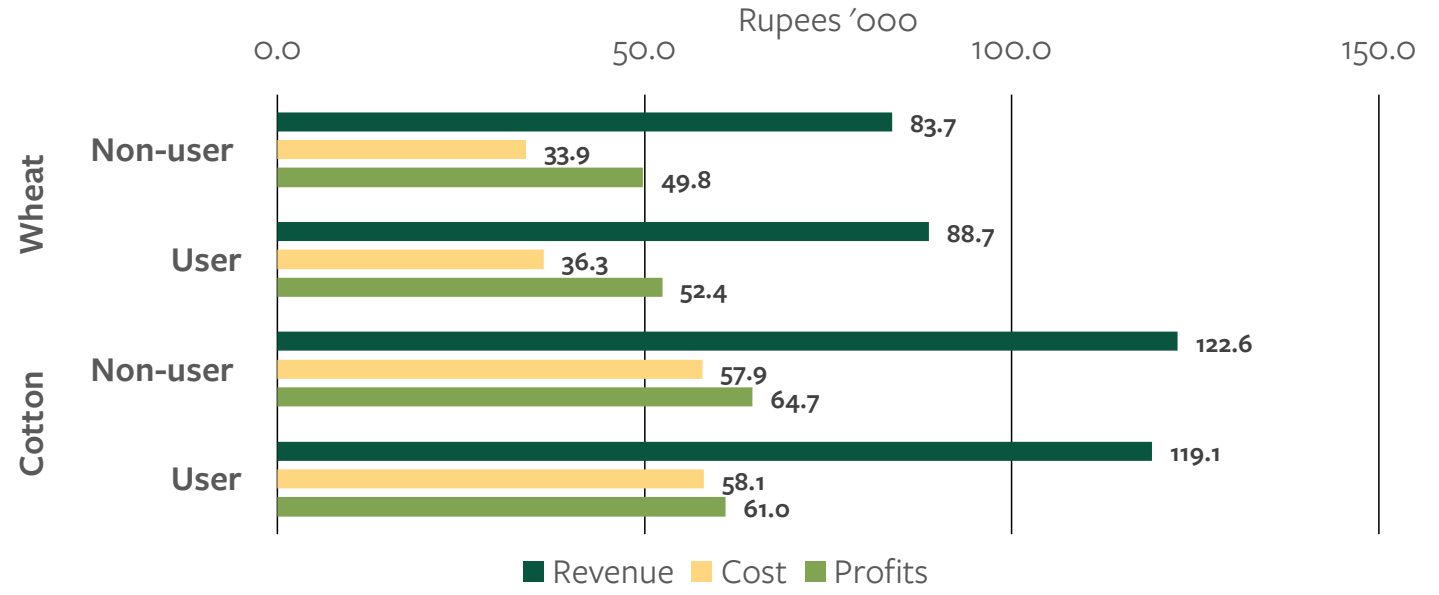
Note: Field survey, 2021

Figure 36 - Per acre revenue, cost and profits between users and non-users households (Sindh)



Note: Field survey, 2021

Figure 37 - Per acre revenue, cost and profits between users and non-users households (Punjab)



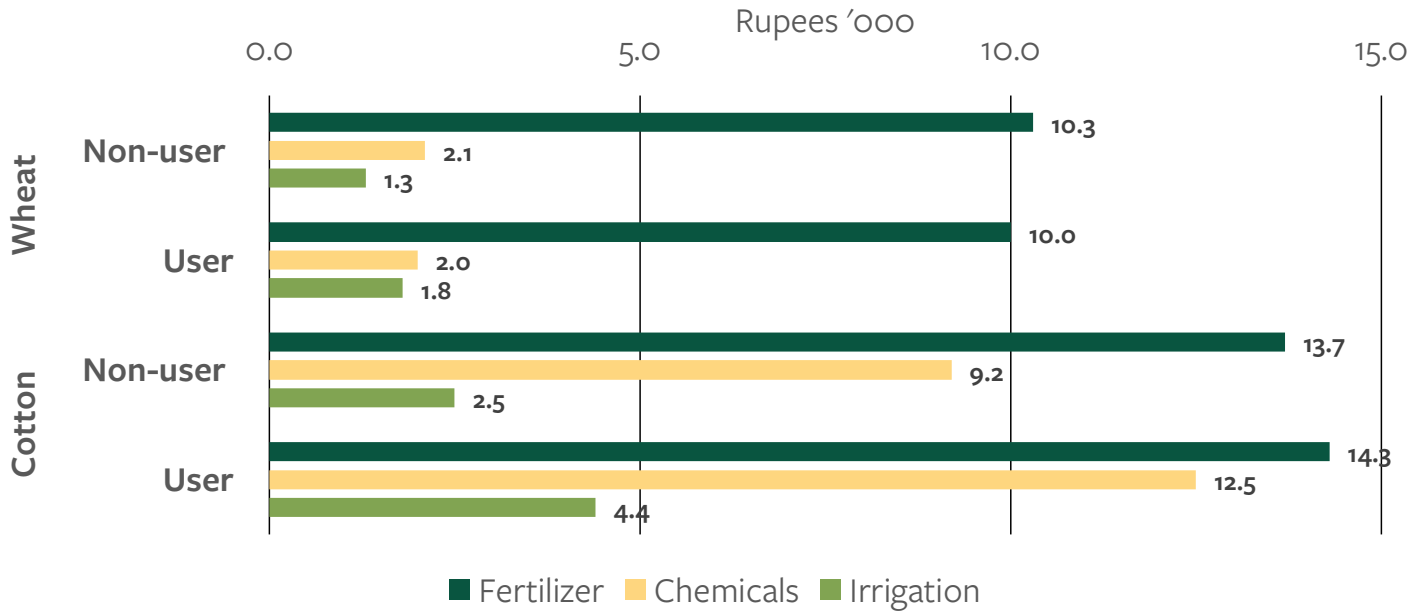
Note: Field survey, 2021

5.6.2. Input usage and the use of Agro-Met advisories

Households may make farming decisions and input usage based on the available information. Therefore, we also examine if the use of the WCIS makes any differences in terms of applying fertiliser, chemicals and using irrigation water. Since there are different types of fertilisers with different amounts of nutrient content, we converted physical amounts to expenditure on all three inputs in PKR (thousand Rupees) using reported market prices by the respondents. Figure 40 shows the per acre expenditure on three inputs (fertiliser, chemicals and irrigation water).

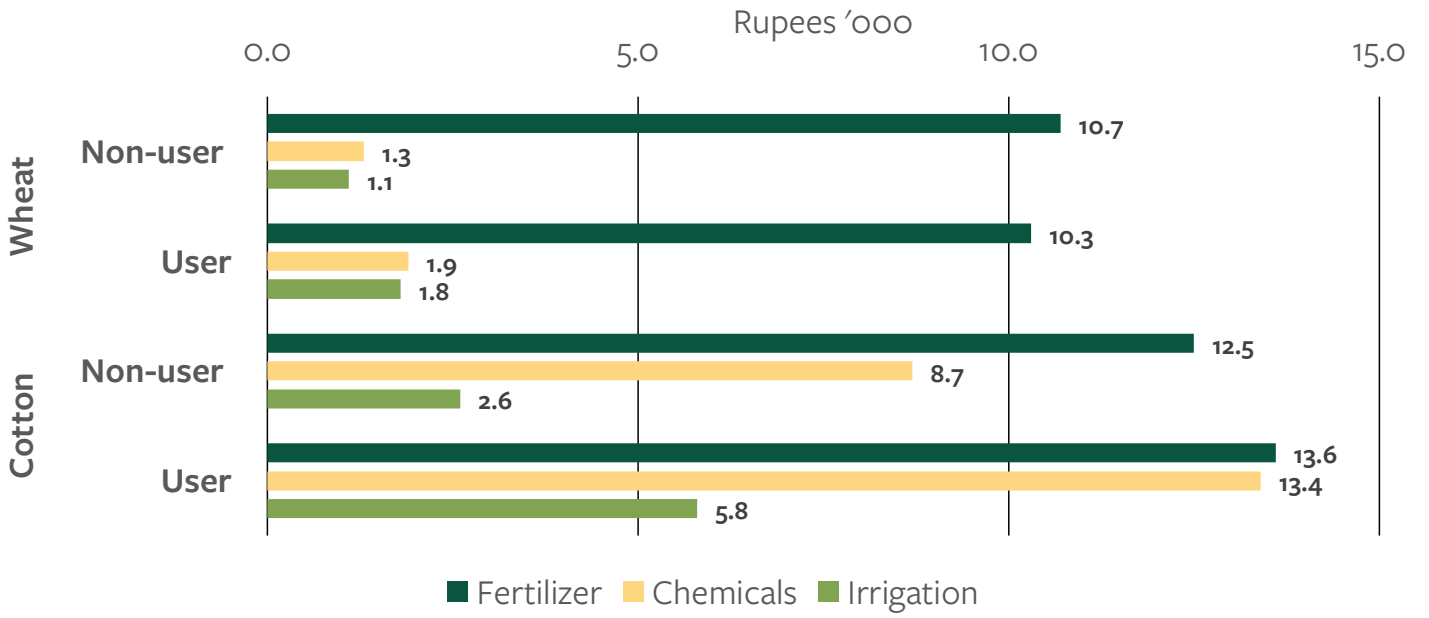
Figure 38 shows that per acre input cost is much higher for cotton crop as compared to wheat crop where the difference is much higher for chemicals. For cotton, WCIS user households incur higher per acre cost for all three inputs, while the difference is marginal in case of wheat crop. Similar pattern of input usage holds for both male and female respondents (Figure 39 and 40). In the case of Punjab province (Figure 41), farmers use more water for cotton crop as compared to farmers in Sindh (Figure 42).

Figure 38 - Per acre cost of input usage (full sample)



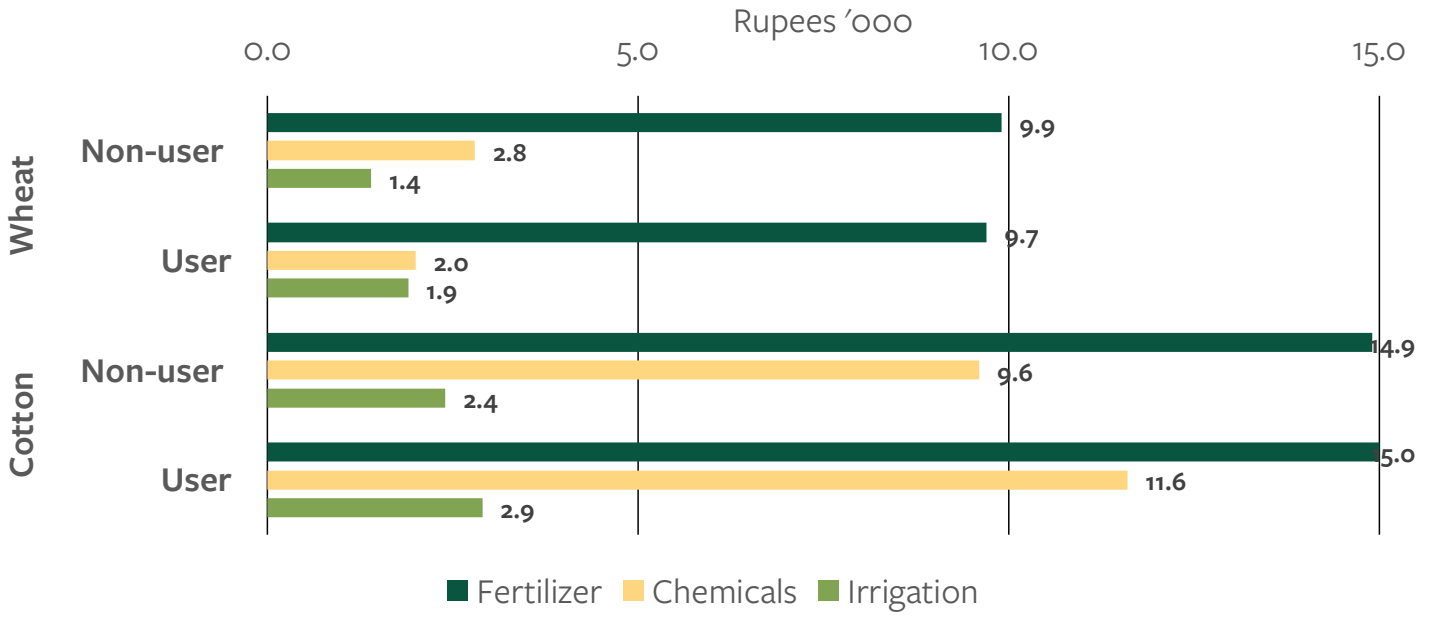
Note: Field survey, 2021

Figure 39 - Per acre cost of input usage (male sub-sample)



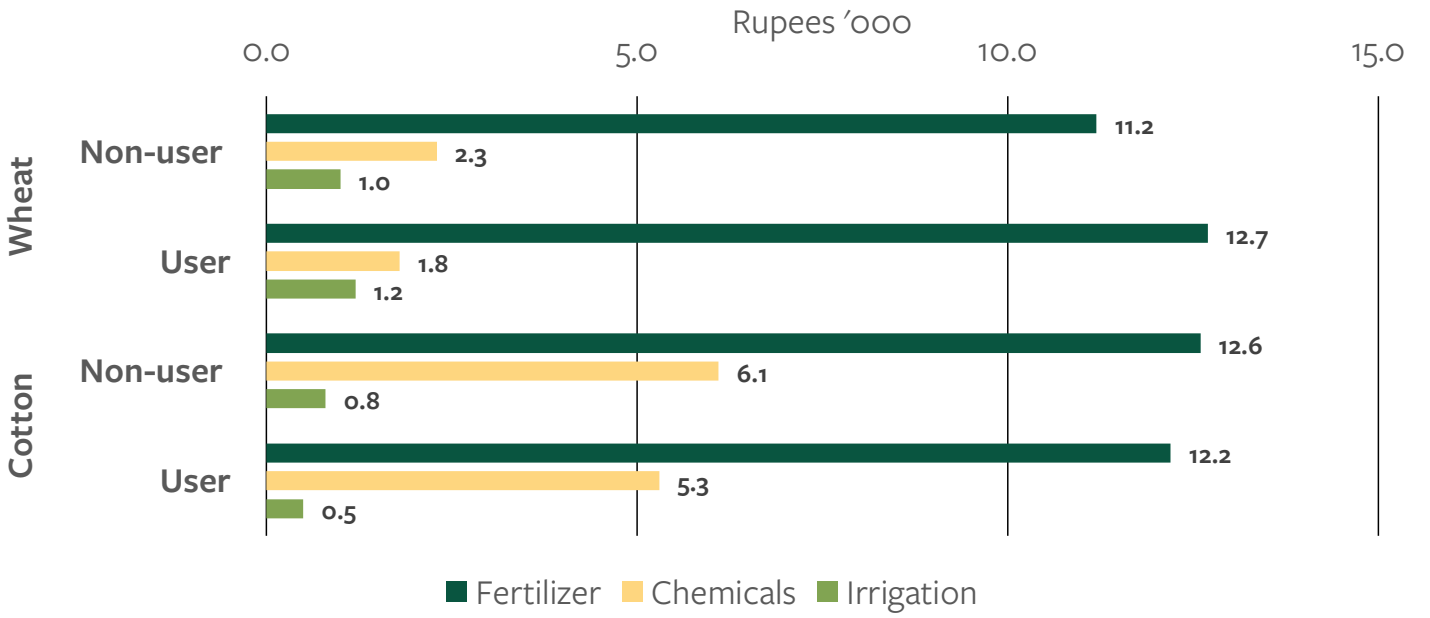
Note: Field survey, 2021

Figure 40 - Per acre cost of input usage (female sub-sample)



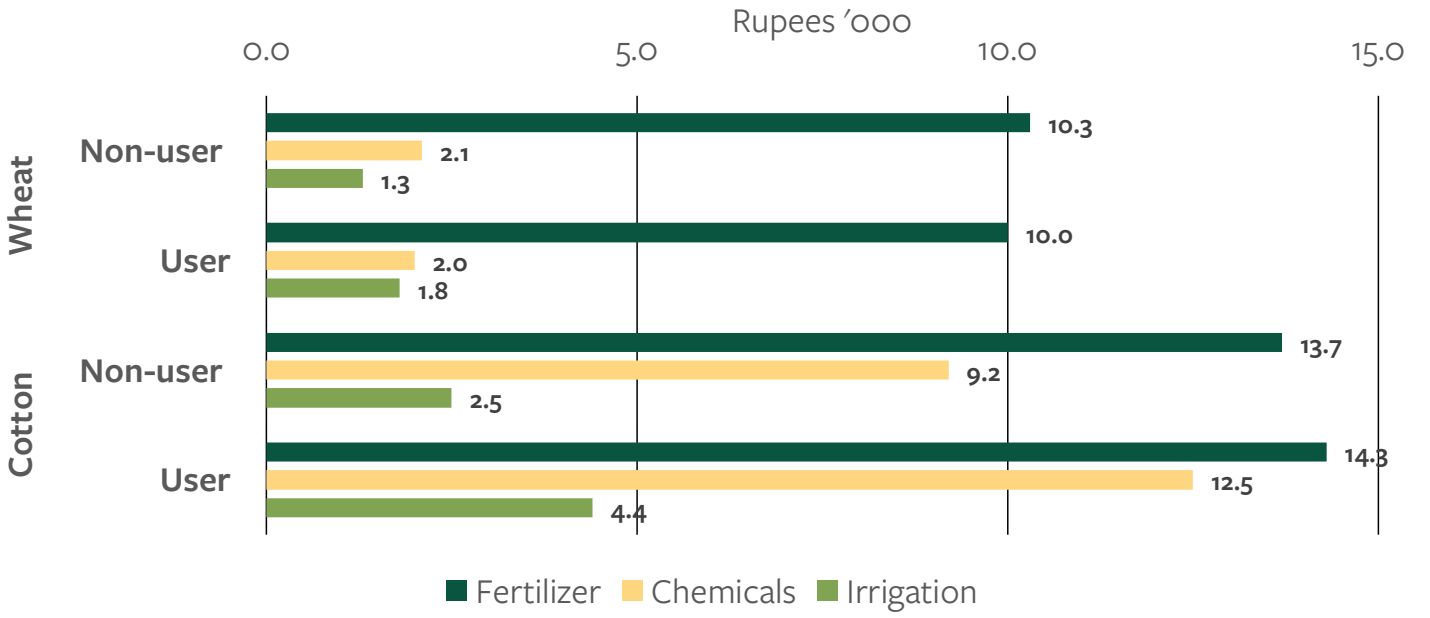
Note: Field survey, 2021

Figure 41 - Per acre cost of input usage (Sindh sub-sample)



Note: Field survey, 2021

Figure 42 - Per acre cost of input usage (Punjab sub-sample)



Note: Field survey, 2021

5.6.3. Statistical analysis

In addition to the choice that farm households make for using or not-using WCIS, they may differ in many aspects such as level of education, age, gender, farm size, family size, access to markets and information, all affecting the farm level decisions and outcomes. Therefore, we use the survey data for regression analysis where all variables that are noted above (and more) are controlled for isolating the effect of the WCIS on the farm level outcomes from other variables.

In our analysis, we developed an econometric model based on the premise that the outcomes from agriculture, Y_{ijk}, depend on the use of weather and climate service, CS_{ijk}, characteristics of the respondents, CR_{ijk}, household characteristics, HC_{ijk}, community characteristics including distance to input and output markets from the village, CC_{ijk}, agricultural practices that the households chooses (such as machine vs. manual harvesting), AP_{ijk}, information sources that the households receives related to agricultural activities, IS^{ijk}, and quality of the farmland, FQ_{ijk}, that the household cultivates.

Here i refers to a household, j refers to the community (ward), and k refers to the districts that the household lives in. Here all these variables are vectors. For example, Y_{ijk}, refers to farm households' revenue, farming cost, and profit from either wheat or cotton crop. Based on these assumptions, we estimated the following regression model:

$$Y_{ijk} = \beta_0 + \beta 0_1\, CS_{ijk} + \beta_2\, CR_{ijk} + \beta_3\, HC_{ijk} + \beta_4\, CC_{ijk} + \beta_5\, AP_{ijk} + \beta_6\, IS_{ijk} + \beta_7\, FQ_{ijk} + d_k + \mu ijk$$

Where d_k denotes district level fixed effects to control for unobserved heterogeneity that vary across the sampled districts, and μ_{ijk} refers to a white noise error term with zero mean and constant variance. These variables are summarised in Table 3, where the mean difference between WCIS user and non-user households is compared. This table also includes input usage for farming such as fertiliser, chemicals and irrigation, which are the additional outcome variables.

Table 3 - Mean difference of key economic variables by users and non-users of WCIS

	Wheat (thousand PKR)			Cotton (thousand PKR)		
Variables	**Non-Users**	**Users**	**Mean Diff**	**Non-Users**	**Users**	**Mean Diff**
Total Revenue	85.5	89.1	-3.619***	125.7	120.6	5.112**
Total Cost	35.7	36.9	-1.248**	49.0	55.7	-6.767***
Profit	49.8	52.2	-2.371**	76.8	64.9	11.879***
Cost - Fertilizer	10.3	10.0	0.255	13.7	14.3	-0.544
Cost - Chemicals	2.1	2.0	0.136	9.2	12.5	-3.383***
Cost - Irrigation	1.3	1.8	-0.560***	2.5	4.4	-1.944***

Note: All variables are measured in thousand PKR per acre.

Table 4 shows a slight difference in most of the economic variables between WCIS user and non-user farm households. For wheat crop, WCIS user households have higher revenue (PKR 3620/acre), higher cost (PKR 1248/acre) and higher profit (PKR 2371/acre) as compared to the non-user households. At the same time, their input use is not necessarily higher than the non-users except irrigation. The same pattern, however, is not there for the cotton crop, as the per acre revenue and profit are less for WCIS user households, while their cultivation cost is higher and they are using more inputs per acre (except fertiliser).

Table 4 provides mean differences between WCIS users and non-users of all the control variables listed above and used in the regression analysis. In our sample, respondents are well balanced in terms of gender of the respondent, respondent as the household head and access (distance) to market. User and non-user households are also similar in their education level except that in WCIS user groups, there are more household members with graduate level education. WCIS user households received more training and also received more extension services and more households from this group use gas as the main cooking fuel.

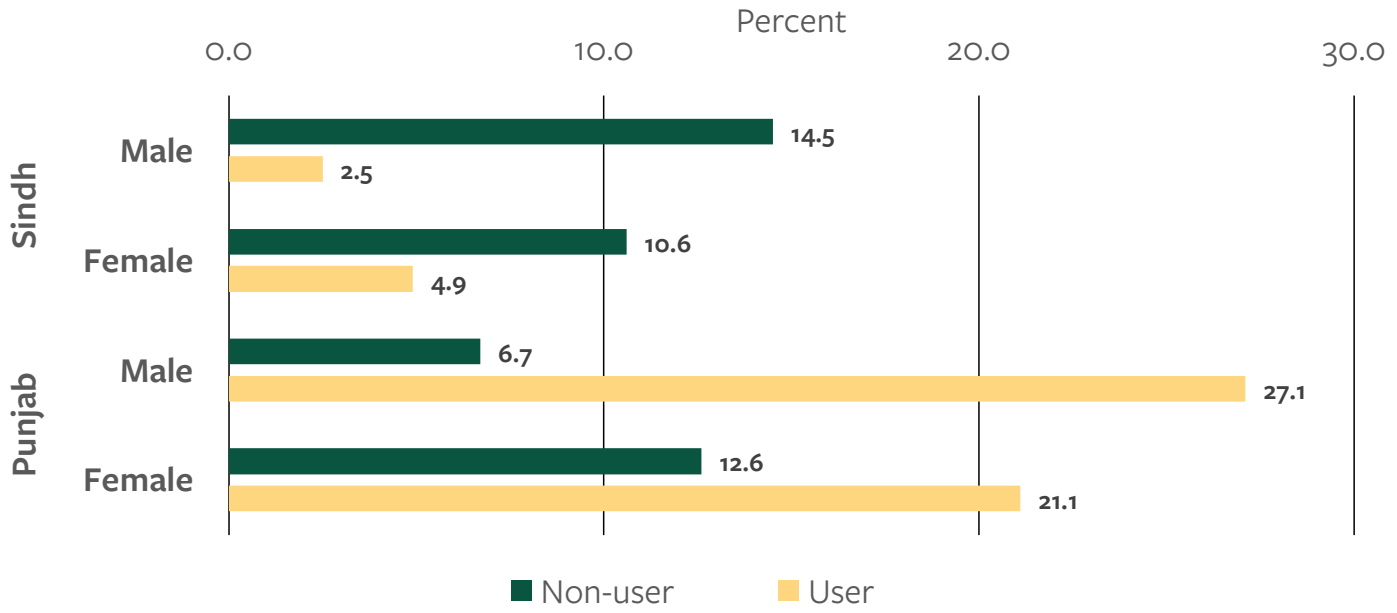
There is no statistical difference in the number of parcels of the cultivated land between WCIS user and non-user households but, these households differ significantly in terms of land holding size, warnings that they have received for any potential disasters, their perception towards climate risk (Figure 43), and information sources except cell phone (Figure 44).

Table 4 - Mean difference between users and non-users of the variables used for regression

Variable Groups	Variables	Non-Users	Users	Mean Diff
Respondent Characteristics	Respondent - Female	0.522	0.468	0.054
	Respondent- HH Head	0.489	0.432	0.057
	Climate risk perception (0/1)	0.004	0.671	-0.667***
Household Characteristics	Highest Edu at HH - Under SSC	0.191	0.171	0.021
	Highest Edu at HH - SSC	0.257	0.288	-0.031
	Highest Edu at HH - Intermediate	0.188	0.188	-0.001
	Highest Edu at HH- Graduate	0.173	0.291	-0.118***
	Agri-training received (1/0)	0.221	0.506	-0.285***
	Income other than agriculture (1/0)	0.107	0.126	-0.02
	Cooking with Gas (1/0)	0.184	0.082	0.101***
Community Characteristics	Distance to Market (km)	8.636	9.443	-0.807
	Extension service (1/0)	0.21	0.494	-0.285***
Farm Characteristics	Operational holdings (ha)	6.555	11.175	-4.620***
	Canal Irrigation (1/0)	0.415	0.091	0.324***
	Canal-Well Irrigation (1/0)	0.493	0.712	-0.219***
Agricultural Practices	Land type (fertile) (1/0)	0.596	0.488	0.107***
	Machine harvesting (1/0)	0.228	0.356	-0.128***
	No of parcels (#)	2.004	1.894	0.11
Information Sources	Cell Phone (1/0)	0.908	0.941	-0.033
	Radio (1/0)	0.331	0.626	-0.296***
	TV (1/0)	0.79	0.924	-0.133***
	Meetings attended (#)	0.54	0.871	-0.330***
	Internet (1/0)	0.143	0.353	-0.210***
Disaster Related	Drought (1/0)	0.401	0.391	0.01
	Warning (1/0)	0.32	0.812	-0.492***

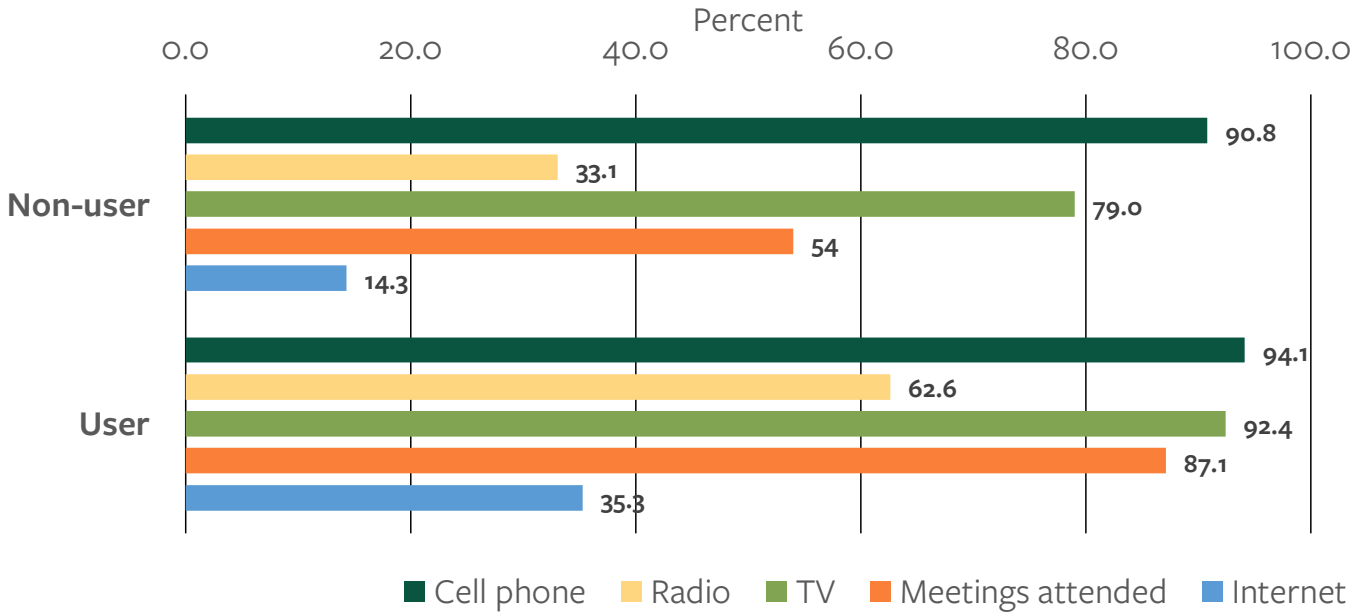
*Note: *** p<0.01, ** p<0.05, * p<0.1.*

Figure 43 - Climate risk perception among WCIS users and non-users



Note: Field survey, 2021

Figure 44 - Information sources among WCIS users and non-users



Note: Field survey, 2021

5.6.4. Impacts of weather and climate information services on profit, revenue and cost

In this section, results from regression analysis are presented. In Table 5, six different estimates are included for wheat and cotton crops, where dependent variables are profit, revenue and costs. In order to address the scale (heteroscedasticity) issue, we first apply log transformation of all dependent variables.

Our results suggests that after taking into account whole host of variables (respondent and household characteristics, farm characteristics, access to information, farm characteristics, and so on), the impact of WCIS on farm profit, revenue and costs for both crops, is insignificant both statistically and economically (the size of the estimated coefficients are very small in all models, which are around ± (2-4%) when compared with non-users' revenue, cost and profits). That means any difference in profit, revenue and costs that one can see in graphical analysis is not necessarily because of the use of WCIS alone.

For example, agricultural trainings seem to be beneficial to the cotton farmers as the profit from cotton crop is significantly higher (27.1%) and cultivation cost significantly lower (-11.3%) for the households who received agricultural trainings all else equal, while the extension service has just the opposite effect (less profit and high cost for cotton farmers). Similarly, female respondents have reported relatively higher profit and higher revenue for the cotton crop but not for the wheat crop as compared to the male respondents. Farm households who use canal irrigation seem to have earned less profit and less revenue as compared to households who use well for irrigation while farm households who have fertile soil tend to earn more profit and higher revenue but cultivation cost is similar to households whose land is less fertile.

Table 5 - Economic impact of weather and climate information services

	(1)	(2)	(3)	(4)	(5)	(6)
	Profit (PKR log)		Revenue (PKR log)		Cost (PKR log)	
VARIABLES	**Wheat**	**Cotton**	**Wheat**	**Cotton**	**Wheat**	**Cotton**
Users	**-0.04**	**-0.02**	**-0.01**	**-0.01**	**0.02**	**0.02**
	(0.03)	(0.06)	(0.01)	(0.03)	(0.02)	(0.03)
Respondent - Women	-0.01	0.19***	-0.01	0.12***	-0.01	0.04
	(0.04)	(0.05)	(0.02)	(0.02)	(0.02)	(0.04)
Distance to market	0.00*	0.01*	0.00*	0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Respondent - HH Head	-0.05	0.01	-0.02	0.00	-0.01	-0.01
	(0.04)	(0.05)	(0.02)	(0.03)	(0.02)	(0.03)

	(1)	(2)	(3)	(4)	(5)	(6)
	Profit (PKR log)		Revenue (PKR log)		Cost (PKR log)	
VARIABLES	**Wheat**	**Cotton**	**Wheat**	**Cotton**	**Wheat**	**Cotton**
Users	**-0.04**	**-0.02**	**-0.01**	**-0.01**	**0.02**	**0.02**
Highest Education - under SSC	-0.09*	-0.07	-0.05**	-0.01	-0.00	-0.01
	(0.05)	(0.06)	(0.02)	(0.03)	(0.02)	(0.04)
SSC	-0.02	0.06	-0.02	0.02	-0.00	-0.03
	(0.04)	(0.05)	(0.02)	(0.03)	(0.03)	(0.04)
Intermediate	0.01	-0.03	0.00	0.02	-0.00	0.02
	(0.05)	(0.04)	(0.02)	(0.02)	(0.03)	(0.04)
Graduate	-0.01	0.00	-0.01	0.02	0.01	-0.01
	(0.05)	(0.04)	(0.02)	(0.03)	(0.03)	(0.04)
Received - Agri training	-0.00	0.24**	0.01	0.06	0.04	-0.12**
	(0.09)	(0.12)	(0.04)	(0.06)	(0.09)	(0.05)
Income other than agriculture	0.03	-0.13**	0.03	-0.03	0.02	0.04
	(0.04)	(0.06)	(0.02)	(0.03)	(0.03)	(0.03)
Received extension service	0.02	-0.26**	0.01	-0.02	-0.01	0.21***
	(0.10)	(0.12)	(0.04)	(0.07)	(0.09)	(0.05)
Operational holding	0.00	0.00***	0.00***	0.00**	0.00	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Canal irrigation	-0.08	-0.18*	-0.07**	-0.18***	-0.02	-0.11*
	(0.08)	(0.10)	(0.03)	(0.06)	(0.04)	(0.06)
Canal-well irrigation	-0.15**	-0.14	-0.04	-0.14**	0.11***	-0.11**
	(0.06)	(0.09)	(0.02)	(0.06)	(0.03)	(0.05)
Machine harvesting	-0.00	0.12***	-0.02	0.07**	-0.04*	0.01
	(0.03)	(0.04)	(0.01)	(0.03)	(0.02)	(0.03)
No of parcels	0.01	-0.01	0.01**	0.01	0.01	0.01
	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Cooking fuel - Gas	0.00	0.01	0.00	0.02	0.00	0.05**
	(0.04)	(0.05)	(0.02)	(0.03)	(0.03)	(0.02)

	(1)	(2)	(3)	(4)	(5)	(6)
	Profit (PKR log)		Revenue (PKR log)		Cost (PKR log)	
VARIABLES	**Wheat**	**Cotton**	**Wheat**	**Cotton**	**Wheat**	**Cotton**
Users	**-0.04**	**-0.02**	**-0.01**	**-0.01**	**0.02**	**0.02**
Drought experience (past 10 years)	-0.10**	-0.07	-0.05**	-0.05*	-0.00	0.01
	(0.04)	(0.05)	(0.02)	(0.02)	(0.02)	(0.03)
Warning received?	0.05	-0.04	0.03*	-0.04	0.01	-0.03
	(0.04)	(0.05)	(0.01)	(0.03)	(0.02)	(0.03)
Soil type - fertile	0.07*	0.05	0.03**	0.02	-0.00	0.02
	(0.04)	(0.04)	(0.01)	(0.02)	(0.02)	(0.02)
Perception on climate risk - increased	0.03	0.03	0.02	0.01	-0.01	-0.02
	(0.03)	(0.07)	(0.01)	(0.04)	(0.02)	(0.03)
Cell phone	-0.06*	0.07	-0.03**	0.06*	-0.02	0.04
	(0.04)	(0.07)	(0.02)	(0.04)	(0.03)	(0.05)
Radio	-0.00	0.02	0.01	0.02	0.04**	-0.01
	(0.03)	(0.04)	(0.01)	(0.02)	(0.02)	(0.02)
TV	0.00	0.00	0.01	-0.04	0.01	-0.05
	(0.04)	(0.06)	(0.02)	(0.03)	(0.03)	(0.04)
No of meetings attended	0.02	-0.08	0.01	-0.03	0.01	0.02
	(0.04)	(0.05)	(0.02)	(0.03)	(0.02)	(0.03)
Internet	0.00	-0.02	0.01	-0.01	0.01	-0.02
	(0.03)	(0.05)	(0.01)	(0.02)	(0.02)	(0.03)
Constant	10.81***	11.39***	11.37***	11.75***	10.46***	10.48***
	(0.11)	(0.13)	(0.04)	(0.08)	(0.07)	(0.08)
Observations	612	607	612	612	612	612
R-squared	0.14	0.30	0.28	0.27	0.22	0.50

*Notes: Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Districts fixed effects are used to control for district level unobservable heterogeneity.*

5.6.5. Impacts of weather and climate information services on input usage

We also analysed the impact of WCIS on input usage. We consider three broad categories of inputs for this analysis - fertiliser, chemicals and irrigation. Instead of using physical amounts, we used monetary value/expenses on these inputs since it is often difficult to bring down to a single metric when there are varieties of fertilisers with different amounts of nutrients and so on. The regression results are reported in Table 6, where the control variables are similar to the ones used in Table 5.

Our results suggest that except for the cost of chemicals used for wheat crop, the impact of WCIS on input usage is not statistically significant. For wheat crop, the use of WCIS helps reduce cost of the chemicals by 21.3%, while accounting for all other differences among the WCIS users and the non-users. Farm households with agricultural training seem to be using less fertiliser for cotton while farmers who received extension services are using more fertiliser and chemicals for cotton crop. Also, farmers who have attended more meetings tend to use more chemicals in wheat crop.

Table 6 - Impact of climate service on inputs usage

	(1)	(2)	(3)	(4)	(5)	(6)
	Fertiliser Cost (log)		Chemicals Cost (log)		Irrigation Cost (log)	
VARIABLES	**Wheat**	**Cotton**	**Wheat**	**Cotton**	**Wheat**	**Cotton**
Users	**0.02**	**-0.02**	**-0.24*****	**0.07**	**-0.08**	**-0.17**
	(0.03)	(0.04)	(0.09)	(0.06)	(0.10)	(0.13)
Respondent - Women	-0.04	0.17***	0.29***	-0.10	0.12	-0.33*
	(0.04)	(0.06)	(0.11)	(0.07)	(0.12)	(0.17)
Distance to market	0.00	-0.00	-0.02**	-0.01*	-0.01	-0.00
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)
Respondent - HH Head	-0.02	0.01	-0.07	-0.01	-0.07	-0.27*
	(0.03)	(0.03)	(0.11)	(0.06)	(0.08)	(0.14)
Highest Education - under SSC	0.03	0.01	-0.24**	-0.02	-0.04	-0.21
	(0.04)	(0.06)	(0.10)	(0.06)	(0.10)	(0.15)
SSC	0.05	-0.01	-0.08	-0.12*	-0.01	-0.04
	(0.05)	(0.05)	(0.11)	(0.07)	(0.10)	(0.16)
Intermediate	0.04	0.05	-0.14	-0.10	-0.14	-0.16
	(0.05)	(0.06)	(0.11)	(0.07)	(0.10)	(0.15)

	(1)	(2)	(3)	(4)	(5)	(6)
	Fertiliser Cost (log)		Chemicals Cost (log)		Irrigation Cost (log)	
VARIABLES	**Wheat**	**Cotton**	**Wheat**	**Cotton**	**Wheat**	**Cotton**
Users	**0.02**	**-0.02**	**-0.24*** **	**0.07**	**-0.08**	**-0.17**
	(0.03)	(0.04)	(0.09)	(0.06)	(0.10)	(0.13)
Graduate	0.06	0.02	-0.11	-0.04	-0.14	0.01
	(0.05)	(0.06)	(0.11)	(0.06)	(0.09)	(0.14)
Received - Agri training	0.13	-0.17**	0.29	-0.13	-0.04	0.31
	(0.12)	(0.08)	(0.39)	(0.11)	(0.15)	(0.37)
Income other than agriculture	0.04	0.04	0.06	0.09	0.04	0.15
	(0.04)	(0.04)	(0.11)	(0.07)	(0.07)	(0.18)
Received extension training	-0.04	0.33***	-0.21	0.20*	0.11	-0.16
	(0.13)	(0.10)	(0.37)	(0.11)	(0.16)	(0.33)
Operational holding	0.00**	0.00**	0.01**	0.00	-0.00	0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Canal irrigation	0.07	-0.10	0.17	-0.03	-1.82***	-1.02**
	(0.06)	(0.07)	(0.15)	(0.10)	(0.18)	(0.41)
Canal-well irrigation	0.15***	-0.10	0.29**	-0.05	-0.04	-0.94**
	(0.05)	(0.06)	(0.11)	(0.09)	(0.09)	(0.41)
Machine harvesting	0.02	0.02	0.03	-0.01	-0.12***	0.06
	(0.03)	(0.04)	(0.10)	(0.05)	(0.04)	(0.14)
No of parcels	0.03*	0.01	0.03	0.00	0.00	0.02
	(0.02)	(0.01)	(0.05)	(0.02)	(0.02)	(0.04)
Cooking fuel - Gas	0.02	0.03	0.08	0.06	-0.14**	0.20
	(0.05)	(0.03)	(0.12)	(0.05)	(0.06)	(0.20)
Drought experience (past 10 years)	0.00	0.02	-0.02	0.07	-0.05	-0.23**
	(0.04)	(0.04)	(0.16)	(0.06)	(0.08)	(0.10)
Warning received?	0.03	-0.02	0.11	-0.09*	-0.03	0.01
	(0.03)	(0.04)	(0.08)	(0.05)	(0.07)	(0.10)

	(1)	(2)	(3)	(4)	(5)	(6)
	Fertiliser Cost (log)		Chemicals Cost (log)		Irrigation Cost (log)	
VARIABLES	**Wheat**	**Cotton**	**Wheat**	**Cotton**	**Wheat**	**Cotton**
Users	**0.02**	**-0.02**	**-0.24*** **	**0.07**	**-0.08**	**-0.17**
	(0.03)	(0.04)	(0.09)	(0.06)	(0.10)	(0.13)
Soil type - fertile	-0.01	0.01	-0.01	0.03	0.00	-0.01
	(0.03)	(0.04)	(0.09)	(0.04)	(0.09)	(0.12)
Perception on climate risk - increased	0.00	-0.00	0.06	-0.01	0.09	-0.14
	(0.02)	(0.03)	(0.09)	(0.06)	(0.10)	(0.13)
Cell phone	-0.03	-0.00	-0.15	0.11	0.10	-0.15
	(0.04)	(0.07)	(0.13)	(0.09)	(0.09)	(0.16)
Radio	0.04	-0.01	0.14**	-0.06	0.04	0.24*
	(0.03)	(0.04)	(0.06)	(0.05)	(0.07)	(0.12)
TV	0.00	-0.08	0.02	-0.06	0.01	-0.05
	(0.04)	(0.05)	(0.12)	(0.07)	(0.09)	(0.16)
No of meetings attended	-0.03	0.03	0.37***	0.04	-0.11	0.04
	(0.03)	(0.05)	(0.11)	(0.05)	(0.07)	(0.14)
Internet	0.02	-0.02	-0.09	-0.03	-0.01	-0.13
	(0.03)	(0.03)	(0.09)	(0.05)	(0.07)	(0.13)
Constant	9.13***	9.21***	7.14***	8.12***	7.53***	7.35***
	(0.08)	(0.12)	(0.27)	(0.12)	(0.28)	(0.50)
Observations	612	612	571	612	612	612
R-squared	0.29	0.24	0.19	0.61	0.71	0.52

*Notes: Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Districts fixed effects are used to control for district level unobservable heterogeneity.*

6. Discussion and recommendations

This section provides an overall summary and analysis of the findings structured around the four key objectives of this study followed by some key recommendations for PMD and other relevant government agencies in Pakistan.

6.1. Understanding the users' landscape and current use of PMD WCIS

All farming households surveyed are highly dependent of their farming activities making them particularly susceptible to the impacts of climate including extremes such as flooding and drought which are prominent in the case study area. In fact, many households experienced climate-related hazards in the past 10 years (2010-2020) with pests, plant diseases, rainfall and increases in temperature being those most reported. Such hazards events have led to significant impacts in their livelihoods primarily linked to a decrease in in cotton and wheat yields and household income. Many reacted to the hazard warning they received by increasing the use of pesticide (against pests and diseases) and/or increased/decreased irrigation (depending if the expected hazard rainfall or an increase in temperature). Some stated not taking any action mainly due to the late arrival of the warning and not being able to take any action but lack of funding, availability of information and lack of trust in the warning were also described as reasons for not taking action.

Warning-related information came primarily from family and friends, National TV channels, PMD SMS service and extension officers and the main perceived benefits of using such warning information as the ability to protect crops and thus increase yield as well as a more efficient use of pesticides and fungicides.

Regarding the use of WCIS across the sample of respondents, we learned that more than half of the survey respondents (56%) identified themselves as users of weather and climate information in relation to those who identified as non-users (38%). However, the number of WCIS users was relatively higher in Punjab than in Sindh (71% and 23%, respectively). Conversely, non-users of WCIS were higher in Sindh than in Punjab (77% and 29%, respectively). We also found that males tend to use more WCIS than females although the difference was not significant (58% and 53%, respectively).

For those participants currently using WCIS, the main sources of information in both Punjab and Sindh were PMD with approximately 40% using many of PMD products on a daily basis. The main product used are daily weather forecasts (50%) closely followed by farmer advisories (40%). The type of information participants used included rainfall information (heavy rain), strong winds, temperature, clouds, and typhoons. Notwithstanding, many participants also used non-PMD sources of information such as family and friends, extension services and SMS services. In fact, it transpired that many participants used more than one source of weather and climate information.

We also found that males tend to use more WCIS than females although the difference was not significant (58% and 53%, respectively).

We also examined the landscape of non-users' to help shed some light on the current challenges and barriers to the uptake and use of WCIS in that particular group. An immediate finding was that Sindh seems to be somewhat behind in the use of this type of information in relation to Punjab, particularly regarding females. Our analysis also showed that difficulty in understanding the information itself (language barriers and complexity of information) was one of the key barriers to uptake and use followed by limited access to information (particularly by females in Sindh), relevance and usefulness of information and timeliness of information. Many farmers also preferred to rely more on their own experience and, in some instances, farmers were not aware of WCIS. However, many of these farmers have means for accessing information and would be willing to use it provided if fitted their needs and alongside required conditions to help them use if adequately (**see section 6.3. below**).

Both the survey and FGDs analysis have showed that most participants (56%) use weather and climate information and updates to make decisions in key farming activities such as planting times, harvesting times, threshing times, irrigation, choice of planting varieties, use of pesticides and chemicals, and drying. In fact, there was an overall agreement that this type of information was useful throughout the various stages of farming activities (e.g. during different stages of crop development).

Overall, the main source of information are non-PMD sources such as farmers' own experience and information from family and friends (and, to a lesser extent non-PMD extension service) which account for 80/90% of farmers' using them. However, two key PMD sources - weather news on national TV and PMD SMS service – are also used by approximately 40-50% of survey respondents. However, our analysis also found that many of these participants use more than one source of WCIS information which means they are not mutually exclusive and possibly even complementary. It is important to note however, that whilst users of WCIS in Punjab seem to use a wider variety of sources of WCIS (both PMD and non-PMD sources) in Sindh users of WCIS seem to rely more on less formal non-PMD sources such as their own experience and support from family and friends.

6.2. Conditions enabling and/or constraining the use of information

Our study also aimed at understanding and identifying key barriers and challenges to the use of WCIS information as well as key conditions for enhancing existing information and increase its uptake and use by both users and non-users. These are summarised in the table 7 below.

Table 7 – Key barriers to use of WCIS information

Key barriers	Users	Non-users
Accuracy, relevance and usefulness of information	Lack of trust in information; Information is too general and hard to use and prefer area-specific information (e.g. village level)	Lack of trust in information (e.g. not believing in information; information focus on crops that are not relevant to them, difficulty understanding information
Accessibility to information	Difficult access to internet due to power cuts or speed of service; charges from mobile network	Limited access to means of information (particularly females), language barriers
Timeliness of information	The information arrives too late for them to be able to act	

Not surprisingly, key conditions required for enhancing existing WCIS information to help increase the uptake and use by users and non-users followed a similar vein t the barriers and challenges identified above. These are summarised in table 8 below.

Table 8 – Key conditions to enhance and increase uptake and use of WCIS information

Key conditions	Users	Non-users
Raising awareness, training and education about this type of information and how to use it	Educate farmers at village level on how to deal with unexpected weather conditions. Expectations that this should come from government (e.g. Agricultural department, PMD)	Awareness programmes and training e.g. free schooling at night. Training and awareness raising by female agricultural officers to female farmers. Expectations that this should be led by government
Information provided by key informants	Information to be delivered by experts such as PMD office, extension and agriculture officers, input dealer, and local educated/knowledgeable people within villages.	
Quality and understandability of information	Provide information at local level (e.g. village level); improve quality of information; Information in local languages; PMD to include information on their website for all crops according to their seasons (i.e. agronomical information, crop calendars)	Information in local languages; focus on relevant crops
Access to information means	Access to information free of charge from mobile companies	Farmers to have access to mobile telephones, radio, and state-of-the-art technology. Also access to information free of charge from mobile companies
Timely information	Provide information with enough time to act on it; broadcast information on national TV at times when farmers are available (e.g. between 12 and 2pm)	

6.3. Socio-economic benefits and costs of the services provided

The socio-economic benefits of using this type of information in their faming decisions and operations were described by the users involved in this study and ranged from helping with timely farming decisions (e.g. harvesting cotton and wheat, when to start ploughing for controlling weeds, and when to irrigate – or not), better crop management in terms of avoiding damages to crops and help protect them from pests by effectively using pesticides all of which, helps them increase crop yield and produce better quality crops.

Regarding economic benefits of using PMD WCIS products we found that, for wheat crops, weather and climate information services user households are getting slightly higher revenue (PKR 3,600/acre), higher profits (PKR 2,400/acre) and also higher cost (PKR 1,200/acre) as compared to non-user households. Whereas for cotton crop, WCIS user households are getting relatively lower revenue PKR -5,100), lower profit but incurring higher cultivation costs (PKR 6,700) per acre. However, these differences are not just because of the use of the WCIS since when we account for all other differences between WCIS user and non-user households, the effect of WCIS became statistically insignificant.

When we look at the farm households from two different provinces, cotton growers in Sindh are incurring lower cost and earning higher profits (PKR 4,500/acre) among the WCIS users as compared to the non-users. While in Punjab, we find that the WCIS user households are earning less profit (PKR -3,700/acre) per acre and incurring higher cost (PKR 200/acre). This may be due to the lack of proper understanding of the WCIS that is being provided. PMD may consider to improve the outreach of their WCIS and customise it for the needs of the farmers for its better usage.

We find that the per acre input cost in terms of fertilisers, chemicals and irrigation is much higher for cotton crop as compared to wheat crop where the difference is much higher for chemicals. The farmers of Punjab province use more water for cotton crop as compared to Sindh. We find that the similar pattern of input usage holds for both male and female respondents. Our results suggest that except for the cost of chemicals used for wheat crop, the impact of WCIS on input usage is not statistically significant. For wheat crops, the use of WCIS helps reduce cost of the chemicals by 21.3%, while accounting for all other differences among the WCIS users and the non-users.

We find that farmers who had received agriculture related training seem to have benefited more than those that had not received training. For example, cotton farmers who had agriculture training have significantly higher profits from cotton crop (27.1%) while cultivation cost is significantly lower (-11.3%). Similarly, female respondents have reported relatively higher profit and higher revenue for the cotton crop but not for the wheat crop as compared to the male respondents. Farm households with agricultural training seem to be using less fertiliser for cotton while farmers who received extension services are using more fertiliser and chemicals for cotton crop. This shows the effectiveness of training taken by farmers indicating the need for imparting continuous training adapted to the local conditions and the needs of the farmers. For example, in Africa training for cotton farmers makes use of picture blocks that tell simple stories in pictures to illustrate the content covered in training sessions to help farmers who cannot read and write to better understand and remember the information **(https://cottonmadeinafrica.org/en/trainings/).**

6.4. Recommendations for PMD

Our study highlighted a number of areas in the current provision of PMD weather and climate information services particularly those focusing on farming communities. These recommendations include:

- **Gender considerations** should be at the forefront when enhancing WCIS (e.g. ensuring the right means of access, timing of information, local languages, support by female extension officers) as well as when designing and implementing training and awareness raising activities (e.g. through female-only training events);

- **Broadcast weather news on national TV at alternative times** when farmers are available (around 12pm) and present it in local languages (e.g. Sindhi, Punjabi, Saraiki);

- **Broadcast other types of weather and climate information** with a longer lead time that allow farmers to act on it in relation to key farming operations such as spraying of fertilisers/pesticides, harvesting, irrigation, etc;

- **Include agronomical information on PMD website** for all key crops according to their seasons (e.g. crop calendars);

- **Raising awareness and implementing training activities:**

  - Through activities such as **free schooling at night and/or training events in villages;**

  - **Raise awareness of weather and climate information** for non-users as some were completely unaware of this

type of information; many also lacked trust in this type of information due to previous experiences and training could help them understand the uncertain nature of weather and climate conditions;

- **Train farmers at village level** on weather and climate information and how to deal with unexpected weather conditions; also build capacity in terms of the different types of information available from PMD as many farmers mainly use weather forecasts and/or farmer advisories and are not aware of other types of WCIS that are available;

- Explore opportunities to **enhance and expand existing extension services** (including linking with non-PMD extension services) and the role of other current key informants to ensure a coherent and robust coverage of information dissemination across villages and provide additional support to farmers (including non-users);

- Enhance **weather and climate information currently provided**, in terms of:

  - **Available in local languages to increase accessibility and understandability** of information;

  - **Higher spatial resolution** - Farmers requested information at area-specific/ village level which may not be possible but perhaps downscaling it to more refined levels of information (e.g. sub-district level) could help farmers make more informed decisions;

  - **Accurate information about volume of rain expected** at least a week ahead so they can protect their crops;

  - **Information about winds and storms** to help farmers decide when to spread fertiliser/pesticides;

  - **Need for agro-meteorological information on pests** at different stages of crop development (e.g. at the final stages of the crop).

- **Further understanding the type of WCIS information that could be most usefu**l to farmers through effective co-production processes. These processes can be aligned with training activities (i.e. take advantage of building capacity activities to enquire about farmers' needs and how to best cater for them). These would include a better understanding of:

  - The type of impacts that weather and climate conditions have in key farming activities at various stages of crop development;

  - The type of variables that would be relevant for them (considering different crops and farming activities);

  - The lead time required particularly focusing beyond weather forecasts (e.g. weekly/monthly forecasts);

  - How they would prefer to receive it (e.g. TV channels, SMS, etc) and when;

  - The type of support they require to help them effectively use this type of information in their farming activities.

- **Set up feedback mechanisms** (which can be linked to support systems for farmers e.g. extension services but also building capacity activities, SMS service, etc) to enable ongoing learning and enhancement of weather and climate information provided to farmers. Specific testing villages can be set up initially with a view of expanding to other villages and provinces in time.

Other recommendations

There were also other suggestions put forward that, although not directly related to weather and climate information, were raised by farmers due to the implications in their farming activities and outputs. Although potentially outside the scope of PMD's remit, some of these suggestions could perhaps be raised and discussed between different areas of government intervention (e.g. Pakistan Agricultural department and other ministries) with a view to improve the overall conditions and enable farmers to make more informed farming decisions. These include:

- Concerns over canal water supply issues (both in terms of accessibility and timing of when water is available) and need for government to act on it to ensure more water availability to ensure an increase in area cultivated;

- Provide farmers with information and updates (e.g. through seminars) on issues related to new seeds and fertilisers; storage of cotton; best methods for selling crops at suitable prices; marketing; information subsidies and how to obtain finance from different sources; new farming technology and machinery

- Provide financial support to farmers through e.g. subsidies on diesel, provide farmers with mobile telephones, radio, and state-of-the-art technology; access to weather and climate information free of charge from the mobile companies.

6.5. Study limitations

This study was bound by a number of limitations that constrained our finding. For example, the survey method adopted in our study, although useful to collect a substantial amount of data in a fairly quick manner, it is limited in the depth of the data collected. We aimed to address some of these shortcomings by pursuing focus group discussions (FGD) to complement the survey data.

Another limitation of our study, and something that can be pursued in future research, was the inclusion of marginalised and vulnerable groups in our analysis.

During the FGD, there were also some farmers who were busy with cotton picking at the time and thus were not willing to talk to the facilitators and/or did not talk for longer periods of time. As a result, the data collected during FGD was perhaps not as extensive and robust as we would have liked.

There were also delays in deploying the fieldwork due to the COVID19 which, although it did not affect the quality of the data, it delayed data collection on the ground.

7. Recommendations from knowledge sharing workshops

Following the conclusion of the study, ICIMOD in collaboration with PMD, the University of Leeds and the MO organised a two knowledge sharing workshops to present and discuss the main study outcomes on the use and socio-economic benefits of weather and climate information services (WCIS) in Islamabad and Multan in Pakistan.

These knowledge sharing workshops had differing audiences. While the first workshop in Islamabad was designed for the supply side of WCIS generators and top-level users of WCIS including government agencies and ministries related to agriculture, academia and research organisations; the second workshop targeted the demand side (user) of the WCIS that included progressive farmers and agricultural extension service providers including academia, state level governmental organizations from Punjab and Sindh provinces.

The main objectives of the workshops were to:

- Share key findings of the study with stakeholders and obtain feedback
- Receive recommendations for enhancing current and designing future agro-met advisories from PMD
- Discuss the study and its policy relevance
- Discuss future research needs and implementation

Below we describe the main recommendations that emerged from the two workshops.

Key recommendations from Islamabad workshop included:

- **Improvements in WCIS:** Generate need-based information and improve accuracy and lead time of WCIS to be useful for farmers. Participants also cautioned PMD about false springs that are confusing farmers and must be considered in the development of WCIS.
- **Extent of WCIS:** PMD must consider developing WCIS targeting agro-ecological zones and covering soil-moisture as an important parameter.
- **Collaborative approach:** participants called for different levels of collaboration including with (1) researchers, agricultural departments, municipal and civil aviation departments to improve the quality of WCIS (2) agricultural extension department to customize the WCIS to the requirements of the farmers and (3) telecommunication companies to disseminate WCIS more widely.
- **Further research** – horticulture, livestock and wheat (in rainfed areas) contribute to farmers' economic well-being and these must be studied.

Key recommendations from Multan workshop included:

- **Collaboration:** Similar to the Islamabad workshop, progressive farmers and other stakeholder called for collaboration among agromet service provides, research institutions, agriculture extension offices and media to provide holistic solutions for developing demand driven WCIS, customizing it for farmers and delivering equitably among all types of farmers.

- **Capacity building:** of the farmers as well as of those of extension workers to interpret WCIS, take appropriate actions. Capacity building is also necessary for introducing new and efficient cropping technologies.

- **Extent of WCIS:** farmers desired interpretational information related to the WCIS. Apart from accurate and timely WCIS, farmers requested for guidance on the recommended actions for minimizing impacts of unforeseen weather changes on their crops. They also identified that information about soil moisture and availability of surface water for irrigation are key factors that add value to WCIS. They also conveyed that the WCIS information was not comparable and requested for historic data to accompany WCIS.

- **Outreach:** The forum recommended that information dissemination should not be fully technology-driven and proven traditional means of outreach such as using loudspeakers must be explored in order to reach out to the small and poor farmers.

- **Policy support:** Many farmers cannot benefit from WCIS because they do not have the resources to take actions even when accurate information is provided with sufficient time to act. The forum recommended that farmers must be extended governmental support to take necessary actions.

The extended workshops' report can be found in **Appendix C**.

8. References

DOROSH, P., MALIK, S. J., & KRAUSOVA, M. (2010). Rehabilitating agriculture and promoting food security after the 2010 Pakistan floods: Insights from the south Asian experience. *The Pakistan Development Review, 167-192.*

FOOD AND AGRICULTURE ORGANIZATION (FAO) 2020. GIEWS Country Brief Pakistan. Available online at: https://reliefweb.int/report/pakistan/giews-country-brief-pakistan-09-december-2020.

FOOD AND AGRICULTURAL ORGANISATION (FAO) 2016. Country fact sheet on food and agriculture policy trends Pakistan: Socio-economic context and role of agriculture. Available online at: http://www.fao.org/publications/card/en/c/e2f4f2cd-6135-44d2-8cdf-c7ba67c648d5.

GORST, A.; GROOM, B.; DEHLAVI, A. (2015) Crop Productivity and Adaptation to Climate Change in Pakistan. Working Paper 189, The Centre for Climate Change Economics and Policy.

GOVERNMENT OF PAKISTAN 2022. Pakistan Economic Survey 2021-2022. Available online at: http://www.finance.gov.pk/survey/chapter_22/PES02-AGRICULTURE.pdf.

HALLEGATTE, S. 2012. *A cost effective solution to reduce disaster losses in developing countries: hydro-meteorological services, early warning, and evacuation,* The World Bank.
IPCC, 2018: *Global Warming of 1.5°C.* An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)].

MAYEE, C., MONGA, D., DHILLON, S., NEHRA, P. & PUNDHIR, P. 2008. Cotton-wheat production system in South Asia: A success story.

MIRZA NOMMAN AHMED & MICHAEL SCHMITZ, 2011. "Economic assessment of the impact of climate change on the agriculture of Pakistan," Business and Economic Horizons (BEH), Prague Development Centre, vol. 4(1), pages 1-12, January.

NAHEED, G., KAZMI, D. & RASUL, G. 2013. Seasonal variation of rainy days in Pakistan. *Pakistan Journal of Meteorology, 9.*

NOMMAN, M. A. AND SCHMITZ, M. (2011) Economic assessment of the im- pact of climate change on the agriculture of Pakistan. Business Econ. Horiz., 4, 1–12.

RAZA, A. & AHMAD, M. 2015. Analysing the impact of climate change on cotton productivity in Punjab and Sindh, Pakistan.

SHULI, F., JARWAR, A. H., WANG, X., WANG, L., & MA, Q. (2018). Overview of the cotton in Pakistan and its future prospects. *Pakistan Journal of Agricultural Research, 31(4), 396.*

STOCKER, T.F.; QIN, D.; PLATTNER,G.K.; TIGNOR, M.M.; ALLEN, S.K.; BOSCHUNG, J. ET AL. (Eds.), IPCC, 2013: Climate Change 2013: the Physical Science Basis: Contribution of Working Group Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK (2013)

SUCKALL, N. AND BRUNO SOARES, M. (2022). Evaluating the benefits of weather and climate information services in South Asia: A systematic review. *Regional Environmental Change.* https://doi.org/10.1007/s10113-022-01947-7

VENKATASUBRAMANIAN, K., TALL, A., HANSEN, J. & AGGARWAL, P. K. 2014. Assessment of India's Agrometeorological Advisory Service from a farmer perspective.

WFP PAKISTAN (2020) Sindh Flood Response Situation Report #5, 16 December 2020

WMO, 2015. Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services In: HTTPS://LIBRARY.WMO.INT/DOC_NUM.PHP?EXPLNUM_ID=3314, O. A. (ed.).

Appendix

Appendix A – Survey questions

To access the survey questions please follow the Link:

https://drive.google.com/file/d/1cvUAHXP9gtgyiXDkVNtq_kbLme9f1T2u/view?usp=sharing

Appendix B – Focus Group Discussions questions

FOCUS GROUPS DISCUSSIONS

Questions for (male and female) farmers USING weather and climate information

(Same were questions asked for both male and female FGDs)

1. **What weather and climate information do you use and how does it help with your farming activities?**
   (***Note for facilitator***: *farmers may use more than one type of information to support different activities and we want to capture the whole picture of what they use. Also, the more detail we can get on the type of information they use the better e.g. do they use daily weather forecasts for rainfall or agro-met advisories? See table 1 below with examples of W/C information by PMD*)

2. **When do you use it?** i.e. at what time of the year and for what stages of farming production?

3. **Where do you get this information from?** Both in terms of sources of information (e.g. PMD, other sources) and how you receive it (e.g. SMS, radio, TV, friends, etc)
   (***Note for facilitator***: *farmers may use more than one source of information and receive it in different ways and it would be useful to capture the whole picture of what they use.*)

4. **Could this information be improved to better suit your needs?** e.g. in terms of how the information is presented to you, how it is provided, the timing you receive it? If so, how?

5. **What are the benefits of using this information in your farming activities?** How does this information helps you?

6. **What type of barriers and/or concerns do you have when using this information?**

7. **What other information would be useful for you to have to help you in your farming activities?**

8. **Are other people in your village using this type of information?** If so, how are they using it?

9. **Any other comments or suggestions?**

Table 1 – Weather and climate information provided by PMD

- Daily weather forecasts
- 3-Days weather forecasts
- Weekly weather outlooks
- Monthly outlooks
- Farmer advisories
- Weekly Agro-met forecasts
- Seasonal Agro-met outlook (i.e. information for the next few months)
- Agro-met bulletins
- Crop reports
- Flood forecast
- Drought advisories

Questions for (male and female) farmers NOT USING weather and climate information. (*Same were questions for both male and female groups*)

1. **Are you aware of weather and climate information?** If so, can you tell us in your own words what it means to you?

2. **Do you have access to weather and climate information?**

   - **If farmer say YES** – How do you have access to it (e.g. TV, radio, SMS, friends, etc)? And what kind of information do you have access to?

   - **If farmer say NO** – Why don't you have access to this type of information?

3. **Do you understand this type of information?** Can you give us an example?

4. **In the first round of survey you told us you didn't use this type of information and we would like to know why you don't use it?**

5. **Would you like to use weather and climate information?**

   - **If farmer say YES –** ask for what purpose would they like to use it?

   - **If farmer say NO –** ask why they don't want to use it and then you can let the farmers leave the focus group discussion as the rest of the questions below will not be relevant to them.

6. **What type of weather and climate information would be useful to help you with that?**
   (***Note for facilitator*:** *farmers may want more than one type of information to support different activities and it would be useful to capture the whole picture of what they need. The more detail you can get the better e.g. do they need information about rainfall for the next few days? Or having agro-met advisories information available?*)

7. **Where would you like to get this information from?** Both in terms of sources of information (e.g. PMD, other sources) and how you prefer to receive it (e.g. SMS, radio, TV, friends, etc)

8. **What would be the main benefits of using this information?**

9. **What would be main barriers to using this information?**

10. **What would you need to be able to use this information in the future?**
    (***Note for facilitator:*** *these can include all sorts of things that can potentially help them use the information e.g. better access to weather and climate information, having training to help understanding it, having information that better fits their needs, information provided at the right time to help with their farming activities, having access to technology so they can receive the information, having access to resources so they can act on it, etc.*

11. **Where would you like to get this information from?** Both in terms of sources of information (e.g. PMD, other sources) and how you prefer to receive it (e.g. SMS, radio, TV, friends, etc)

What would be the main benefits of using this information?

12. **What would be main barriers to using this information?**

13. **What would you need to be able to use this information in the future?**
    (***Note for facilitator***: *these can include all sorts of things that can potentially help them use the information e.g. better access to weather and climate information, having training to help understanding it, having information that better fits their needs, information provided at the right time to help with their farming activities, having access to technology so they can receive the information, having access to resources so they can act on it, etc.*

- If FGD participants start talking about a lot of different aspects please ask them to tell you what would be their two top choices if they had to choose i.e. what would be the two key conditions the could help them start using the information? Ask them to explain these to you.

Appendix C – Workshops' report

WORKSHOP REPORT

Socioeconomic benefits of weather and climate services in Pakistan

2 and 4 August 2022 |
Islamabad, Multan, Pakistan

Contents

Background

About the workshop

In collaboration with the **Met Office** – the UK's national meteorological agency, the Pakistan Meteorological Department (**PMD**), and the University of Leeds (**UoL**), ICIMOD organised a two knowledge sharing workshops on the socio-economic benefits of weather and climate information services (WCIS) in Islamabad and Multan in Pakistan

In March 2021, PMD, UoL and ICIMOD initiated a joint study under the UK Aid-funded Asia Regional Resilience to a Changing Climate (**ARRCC**) programme to understand the use and evaluate the socio-economic benefits of the agro-met advisories provided by PMD, particularly focusing on cotton and wheat farmers in the Punjab and Sindh provinces where rising temperatures, more frequent flooding and prolonged droughts threaten productivity.

The knowledge sharing workshops had differing audiences. While the first workshop in Islamabad was designed for the supply side of WCIS generators and top-level users of WCIS including government agencies and ministries related to agriculture, academia and research organisations, the second workshop targeted the demand side (user) of the WCIS that included progressive farmers and agricultural extension service providers including academia, state level governmental organizations from Punjab and Sindh provinces.

Objectives

- Share key findings of the study with stakeholders and obtain feedback
- Receive recommendations for enhancing current and designing future agro-met advisories from PMD
- Discuss the study and its policy relevance
- Discuss future research needs and implementation

Expected outcomes

The workshop will share the findings of the study, solicit feedback, stimulate discussions on how to design the agro-met advisories offered by PMD to be more effective, and identify areas where farmers need support to adopt the advisories. The recommendations of the workshop are expected to influence decision-makers in developing suitable policies at various levels to support farmers in adopting the advisories and benefitting from them.

Knowledge dialogue in Islamabad, 2 Aug 2022

Proceedings

Mahr Sahibzad Khan, DG PMD, chairing the first workshop, welcomed participants and pointed out that PMD is providing WCIS services that support a range of sectors including agriculture, transport, aviation, tourism and disaster management. He emphasized that agromet services must be tailored for farmers since it is directly linked with food security and climate change mitigation and highlighted that PMD is collaborating with ICIMOD and other national and international organizations to improve

the services.

Ryan Daniel of the UK Met welcomed the participants and echoed on the importance of improving the access and quality of agromet services.

Dildar Qazmi briefed the audience about the processes adopted by PMD to develop WCIS. PMD has started developing impact based forecasting for the benefit of farmers and issues risk matrix.

Marta (UoL) and Mani Nepal (ICIMOD) presented the study finding and highlighted that more than 50% of the studied farmers used WCIS on a daily basis. However, the study did not find a significant direct relationship between use of WCISs and profits, revenue, and cost of cultivating wheat and cotton crops. WCIS users however, agreed that WCISs guided them in making important farming decisions such as improving crop quality and yield, planning for better crop management through irrigation planning, and identifying the timing for harvesting and planting for pest control.

Five speakers shared their views during a panel discussion.

Speaking about their institutional roles in contributing to generating and disseminating WCIS, **Salahuddeen** informed that PCRWR disseminates WCIS to 20,000 farmers and is targeting to reach out to 100,000 soon. Apart from dissemination, PCRWR is also engaged in active research by employing citizen science – it has provided thermometers and humidity sensors to farmers and collects temperature and humidity data to add value and prepare customized advisories at the Tehsil levels in Punjab and Sindh. Salahuddin deemed that even a 10% reduction in loss from its efforts would be a great success.

Asma briefed the audience about PMDs efforts to improve the WCIS and mechanisms to reach out to the farmers. PMD produces a range of services that include daily, weekly, monthly and seasonal outlooks for 11 agro-climatic regions of Pakistan. The seasonal outlooks targeting the winter and summer seasons considers temperate and rainfall data which are most useful for farmers. All the services are updated periodically. Asma assured that PMD would consider the requests for targeting agro-ecological zones and to downscale its services at the local level.

Husnain shared that PARC is conducting pioneering its research with national and international organizations to introduce new crop varieties that are tolerant to the impacts of climate change and variability. In his commentary, Husnain appreciated the study findings and emphasized that it was bridging an important gap between farmers and PMD by identifying the challenges and constraints of farmers in using WCIS in Pakistan. He called for more research on evaluating the benefits of WCIS to help PMD understand the information demands and recommended that the research be expanded to other districts as well.

Naveed shared his view from an econometric point of view and appreciated the study methodology and its authentic findings. He called for the study to zoom in deeper with larger sample size in order to investigate the finer deviations between the study areas and study the gender differences in their approach to using WCIS.

The participants were divided into four groups and discussions were conducted on packaging and delivering of agromet information. The following questions were discussed by the participants.

1. What are the different types of climate information products generated by PMD and other organizations

2. How are the climate services information products in particular the agromet advisory delivered to the farmers?

   - What mechanisms are available to deliver agromet advisories?

   - Can you provide some examples of best practices?

3. What are the challenges (operational, institutional, others), limitations and gaps in the delivery and use of the agromet advisory by the farmers?

4. Is there a need to package it differently than what is being done to increase the effectiveness of agromet advisories? Please provide some examples. How can farmers better access and use the provided information?

Recommendations from the Islamabad workshop

The ensuing group discussion provided the following key recommendations to the study team:

- Improvements in WCIS: Generate need-based information and improve accuracy and lead time of WCIS to be useful for farmers. Participants also cautioned PMD about false springs that are confusing farmers and must be considered in the development of WCIS.

- Extent of WCIS: PMD must consider developing WCIS targeting agro-ecological zones and covering soil-moisture as an important parameter.

- Collaborative approach: participants called for different levels of collaboration including with (1) researchers, agricultural departments, municipal and civil aviation departments to improve the quality of WCIS (2) agricultural extension department to customize the WCIS to the requirements of the farmers and (3) telecommunication companies to disseminate WCIS more widely.

- Further research – horticulture, livestock and wheat contribute to farmers' economic well-being and these must be studied.

Knowledge dialogue in Multan, 4 Aug 2022

Proceedings

Asif Ali, VC of MNSUAM, chairing the second workshop, thanked the participants for attending the workshop and appraised that the study contributes to bridging the gaps between the demand and supply of WCIS by improving the understanding of the information generators about types and timing of WCIS required by farmers.

He invited similar studies on the mango crop since it was a major cash crop and farmers are witnessing losses from variations in weather patterns. He pointed out that with accurate and timely WCIS, farmers can take long and short-term strategies to mitigate the impacts of extreme weather events on crops. He also elaborated that MNSUAM was committed to help farmers protect their food security by He invited similar studies for the mango crop since it is a major cash crop that is suffering from losses arising from variations in weather patterns. He pointed out that with accurate and timely WCIS, farmers can take long and short-term strategies to mitigate the impacts of extreme weather events on crops. He also elaborated that MNSUAM was committed to help farmers protect their food security, which ultimately leads to national food security, by conducting research on climate proof crop varieties. Noting the significant role of women farmers in agriculture, he emphasized that WCIS should be understandable and accessible by all farmers, including women, illiterate and poor farmers that do have have access to mainstream media channels such as TV and internet.

Imtiaz Waraich, Additional Secretary Agriculture advised that women play a significant role in agriculture but are somehow overlooked while disseminating WCIS. He stressed on the need for building capacities of farmers, particularly the women farmers, and the need for promoting new technologies like drip irrigation systems to counter increasing water shortages and improving yield.

Asma Jawad Hashmi stressed that PMD is persistently seeking to improve its WCIS and identified that feedback from farmers and other WCIS users was crucial in this regard. PMD is committed to providing demand-driven services and is exploring collaboration with different stakeholder to understand the types of services required for farmers. Speaking about the latest developments, she informed that PMD is developing impact based forecasts and delivering them in local languages.

Mandira Shrestha introduced the study focusing on the use and utility of WCIS by farmers. She highlighted that agromet services play an important role in reducing the risks and vulnerabilities deriving from climatic variations, especially in the Hindu Kush Himalaya region that is experiencing an increasing intensity of variations.

Marta Bruno Soares of UoL added that the study and the workshop are designed to obtain farmers' feedback as a means to improve WCIS and minimize risks for farmers

Dildar Qazmi briefed the audience about the processes adopted by PMD to develop WCIS. PMD has started developing impact based forecasting for the benefit of farmers and issues risk matrix.

Vijay Khadgi presented the study finding and highlighted that more than 50% of the studied farmers used WCIS on a daily basis. However, the study did not find a significant direct relationship between use of WCISs and profits, revenue, and cost of cultivating wheat and cotton crops. WCIS users however, agreed that WCISs guided them in making important farming decisions such as improving crop quality and yield, planning for better crop management through irrigation planning, and identifying the timing for harvesting and planting for pest control.

Recommendations of Multan workshop

Muhammad Ashfaq appraised the participants about the outcomes of the workshop in Islamabad and instigated discussions that resulted in the following recommendations:

- **Collaboration:** Similar to the Islamabad workshop, progressive farmers and other stakeholder called for collaboration among agromet service provides, research institutions, agriculture extension offices and media to provide holistic solutions for developing demand driven WCIS, customizing it for farmers and delivering equitably among all types of farmers.

- **Capacity building:** of the farmers as well as of those of extension workers to interpret WCIS, take appropriate actions. Capacity building is also necessary for introducing new and efficient cropping technologies.

- **Extent of WCIS:** farmers desired interpretational information related to the WCIS. Apart from accurate and timely WCIS, farmers requested for guidance on the recommended actions for minimizing impacts of unforeseen weather changes on their crops. They also identified that information about soil moisture and availability of surface water for irrigation are key factors that add value to WCIS. They also conveyed that the WCIS information was not comparable and requested for historic data to accompany WCIS.

- **Outreach:** The forum recommended that information dissemination should not be fully technology-driven and proven traditional means of outreach such as using loudspeakers must be explored in order to reach out to the small and poor farmers.

- **Policy support:** Many farmers cannot benefit from WCIS because they do not have the resources to take actions even when accurate information is provided with sufficient time to act. The forum recommended that farmers must be extended governmental support to take necessary actions.

In closing, PMD thanked the participants for raising pertinent issues and assured that in spite of fund and human resources constraint, PMD will make its best efforts to integrate the needs and recommendations of the forum, particularly farmers, while improving WCIS. It called for collaboration among stakeholders to address the problems jointly and contribute to improve the food security situation.

MNSUAM also thanked all participants for tabling important suggestions and offered to continue research for helping farmers deal with climatic variations and also to support PMD and other likeminded organizations for the benefit of farmers.

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