Research Article

Usage Patterns of Agricultural Information Sources across Agro-Ecological Zones of the Punjab, Pakistan

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Abstract | The major objective of the current study was to analyze the use, usage pattern and type of agricultural information received by the farmers of different agro-ecological zones of the Punjab, Pakistan. Current research study adopted a descriptive and correlational research design. Primary data were collected through face-to-face interviews using a validated structured interview schedule from a randomly selected sample of 500 farmers. Descriptive statistics and chi-square tests were employed for analyzing collected data. Results indicate a highly significant variation in the use of agricultural information methods by the farmers relying mainly on informal and interpersonal sources and digital media, while formal visits by Extension Field Staff (EFS) and print media are comparatively underutilized. The combined usage pattern showed that farmers mostly rely on fellow farmers and dealers of grain markets in the form of interpersonal sources. The results of chi-square statistics ($p < 0.001$) showed a significant association between agro-ecological zones and the scale of use of all agricultural information methods, indicating that farmers' preferences for interpersonal, mass media, and digital information sources vary markedly across rice-wheat, mixed, rice, cotton-mixed, and maize-wheat zones. Analysis regarding type of information received by the farmers showed that interpersonal and institutional sources (EFS visits, trainings, and demonstrations) are mainly used for plant production and protection, digital and broadcast media dominate environmental and plant protection information, while print materials and market-related sources contribute more to marketing, post-harvest, storage, and livestock management information.

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Introduction

Information plays a vital role in the development of every sector including agriculture. It underpins sustainable growth, food security, and poverty reduction around the globe (Bava *et al.*, 2014). In many developing countries, including Pakistan, agriculture remains a primary livelihood for large portions of rural populations, making effective knowledge transfer essential for both economic

and social development (Luqman *et al.*, 2025). Historically, agricultural extension services and traditional interpersonal communication methods such as visits by extension field staff, fellow farmers, and dealers of farm inputs were considered as the main sources for agricultural information for resource poor farmers (Amir *et al.*, 2024).

However, traditional agricultural information sources often struggle with reach, frequency, and relevance. Research studies in rural areas of Pakistan have shown that although extension agents remain important, many farmers still rely more heavily on neighbor-friends-relatives networks for information (Salam *et al.*, 2023). Moreover, the print media (newspapers, brochures, and journals) is less frequently utilized by many farming communities due to issues such as literacy, accessibility and cost (Akhter *et al.*, 2021). Recently, digital technologies have emerged as powerful tools in bridging these gaps. Information and Communication Technologies (ICTs), particularly mobile phones, offer scalable, cost-effective solutions for disseminating weather forecasts, pest and disease advisories, market prices, and other farm-relevant information (Awan *et al.*, 2019).

Studies from Pakistan underscore this trend as in Khyber Pakhtunkhwa province; ICT-based communication sources have shown strong potential for enabling more sustainable agricultural production via direct, tailored communication with farmers (Khan *et al.*, 2025). Digital initiatives such as customized advice via phone calls, SMS, or mobile apps have been deployed to give farmers personalized to get crop, soil and location related information and recommendations (Khan *et al.*, 2024a). Meanwhile, institutional support for digital transformation is evolving: the Punjab Directorate General of Agricultural Information promotes the use of print, electronic, and social media to distribute modern farming technologies (Mehmood *et al.*, 2022). Despite this progress, significant challenges remain. The digital divide persists in rural Pakistan: low internet penetration, limited digital literacy, and inconsistent infrastructure constrain many farmers' adoption of digital tools (Khan *et al.*, 2024b).

Additionally, agricultural extension services are often underfunded and understaffed, reducing their capacity to support both traditional and digital advisory models (Ali and Faroque, 2023). These structural and logistic constraints result in uneven access: farmers in different agro-ecological zones may rely on very different information channels depending on local connectivity, infrastructure, and institutional presence. With this background, there is a critical need to empirically assess how farmers use different agricultural information methods, including both conventional (interpersonal) and mass media (digital) sources. Understanding usage patterns, and how they vary across different agro-ecological zones, can help policymakers, extension agencies, and development practitioners optimize information delivery strategies and improve outreach efficiency. Following were the objectives of current study:

To examine the frequency and scale of use of different information sources by the farmers of different agro-ecological zones
To study the pattern of usage of different information sources by the farmers
To see the type of agricultural information received from these agricultural information sources

Methodology

Cross-sectional survey research was conducted in the present research as the data were collected for one point in time. This research design was used due to financial and time constraints for conducting this research study. The present study was conducted in the Punjab which is the most populated province of Pakistan. The province is located at 72.70° E and 31.17° N. It lies to arid and semi-arid region of Pakistan. Humidity in the Punjab province ranges from 53% to 62% depending upon the climatic variability (Govt. of Pak., 2024). Apart from that, Punjab province is distinctive in higher educational sector. Depending upon climatic factors Punjab province is divided into 14 (fourteen) agro-ecological zones as per classification defined by FAO (2019). Data were collected from five (05) purposively selected agro-ecological zones of the Punjab province. The targeted research areas are given in the following Figure 1.

Personal face-to-face method was used for the collection of information and data under the present research study. The targeted population of this research study was farmers of the Punjab province. Drawing sample out from the targeted population is refers to as sampling. Sampling procedure is one of the important and critical steps in research. In the

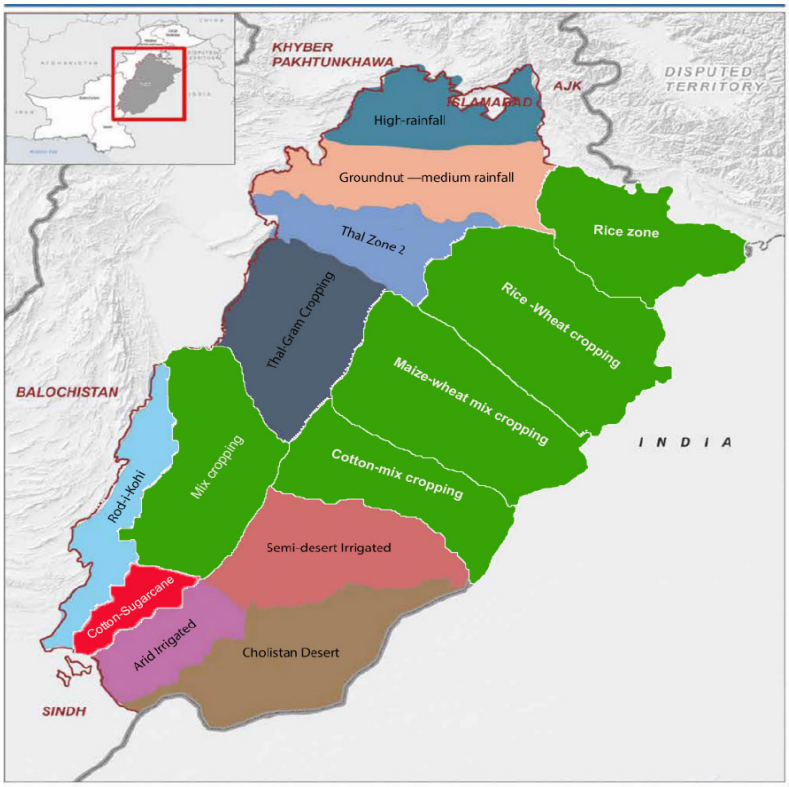

Figure 1: *Targeted research areas (Agro-ecological zones) of the Punjab, Pakistan*

field of social sciences, two major types of sampling techniques are being used as probability and non-probability. The selection of appropriate sampling in research depends upon the objectives of research. In the present research study probability (simple random) sampling procedure was adopted. The reason behind use of simple random sampling to have equal and fair opportunity available to all the participants to get selected. Simple random sampling is also good to create generalizations about a large population. In addition to probability sampling, non-probability sampling procedure was also adopted for the selection of targeted 05 (five) agro-ecological zones out from the total 14 (fourteen) of the Punjab province (targeted study province). From each cropping zone 100 farmers were randomly selected and personally interviewed for data collection. Total sample size for the current research study was 500 farmers. Structured interview schedule was used as data collection tool. Both open and close ended questions were asked to collect the information. Descriptive statistics was computed for each variable (frequency distribution for all categorical). Dependent variable of the study was mass media methods being used by the farmers (frequency of use, usefulness, time of use). Independent variables were related to socio-economic characteristics of respondents. Chi-square test of proportions was used to test the equality of proportion for different usage levels [Not at all, rarely, occasionally and mostly]. Two way contingency tables were generated for different socio economics attributes with mass media sources as dependent variable. Chi-Square test of Association was used to test the association between different socio economics attributes and mass media sources. Significance was observed at 5% level of significance.

Results and Discussion

Agriculture information methods

Information is vital for the development of an individual as well as a society (Bava *et al.*, 2014). The role of information in agricultural development cannot be ignored as it is very much crucial for sustainable improvement of agricultural production (Mittal and Mehar, 2016). But still farming is only the best solution to escape majority of the rural people out from poverty and food insecurity (Raza *et al.*, 2020). With this context, access to credible information to the farmers is very much essential for sustainable agricultural production (Mgbada, 2006). Farmers used different information sources or methods to get relevant updated agricultural knowledge that helps in boosting their farm yield through effective communication strategies. In the present study the usage of different mass media methods/sources by the respondents in the targeted research areas was

Table 1: *Frequency distribution and Chi-Square test of Equality of proportion with respect to Scale of Usage*

Agri. Information method	Scale of use				Chi-Square	p-Value
	Not At All	Rarely	Occasionally	Mostly		
Individual visit by EFS	247 (49.4)	160 (32.0)	80 (16.0)	13 (2.6)	245.424	0.000
Individual visit to office of EFS	231 (46.2)	175 (35.0)	83 (16.6)	11 (2.2)	227.968	0.000
Neighbors/fellow farmers	37 (7.4)	42 (8.4)	148 (29.6)	273 (54.6)	296.528	0.000
Dealer of grain market	48 (9.6)	19 (3.8)	128 (25.6)	305 (61.0)	396.592	0.000
Field demonstrations	21 (4.2)	145 (29.0)	232 (46.4)	102 (20.4)	185.552	0.000
Training meetings	50 (10.0)	110 (22.0)	328 (65.6)	12 (2.4)	478.624	0.000
Conferences/Seminars/Workshops	44 (8.8)	153 (30.6)	289 (57.8)	14 (2.8)	372.496	0.000
Field days/Agri. Exhibitions	117 (23.4)	131 (26.2)	243 (48.6)	9 (1.8)	219.840	0.000
Television	33 (6.6)	117 (23.4)	263 (52.6)	87 (17.4)	232.128	0.000
Radio	114 (22.8)	249 (49.8)	110 (22.0)	27 (5.4)	202.608	0.000
Internet Browsing	130 (26.0)	41 (8.2)	84 (16.8)	245 (49.0)	185.296	0.000
Smart phones/WhatsApp	129 (25.8)	18 (3.6)	64 (12.8)	289 (57.8)	336.656	0.000
Agricultural helpline	249 (49.8)	97 (19.4)	113 (22.6)	41 (8.2)	186.880	0.000
Facebook	205 (41.0)	82 (16.4)	177 (35.4)	36 (7.2)	150.992	0.000
YouTube	145 (29.0)	49 (9.8)	215 (43.0)	91 (18.2)	123.456	0.000
Books/journals/articles	378 (75.6)	60 (12.0)	41 (8.2)	21 (4.2)	688.848	0.000
Newspapers	259 (51.8)	174 (34.8)	59 (11.8)	8 (1.6)	307.216	0.000
Newsletters/Magazines	334 (66.8)	57 (11.4)	79 (15.8)	30 (6.0)	475.568	0.000
Brochures/pamphlets/posters	172 (34.4)	196 (39.2)	79 (15.8)	53 (10.6)	116.400	0.000

measured with the help of 4-point likert types scale as 1= Not at all, 2= Rarely, 3= Occasionally, and 4= Mostly. Chi-square goodness of fit test was used to test whether the frequency distributions regarding level of use of different agricultural information methods used by the respondents to get updated knowledge related to innovative agricultural technologies differ significantly. The general purpose of this statistical test was to determine the pattern of usage of different agricultural information methods/sources by the respondents to get updated agricultural knowledge related to agricultural innovations. The data in this regard is hereby presented in the Table 1.

The data presented in Table 1 indicate that high "not at all" responses of respondents was received as more than half (>50.0%) of respondents didn't use information methods/sources like books/journals, newsletters or magazines and newspapers to get agricultural related knowledge for boosting their farm productivity. The data also indicate that respondents mostly use social media platforms like YouTube, Facebook, WhatsApp, Smart phone etc. and traditional media methods like dealers of grain markets and fellow farmers for agricultural related information and knowledge. Thus, it can be generalized that the farmers mainly rely on the community and digital sources in terms of searching for the information regarding the modern innovative methods in the agriculture, whereas the printed media seems to be less relevant in the context of the modern agriculture informational sources. This also shows a shift from traditional communication methods towards digital media methods. In this regard there is need to adopt digital tools for reaching resource poor farmers by the Extension Field Staff of both public and private sector.

In connection with these findings, Memon *et al.*, 2014 reported that farmers used different conventional and non-conventional sources of information. But majority of them were using conventional sources of information. They conducted research to find out the role of mass media in the dissemination of agricultural technologies among farmers of district Jafarabad (Baluchistan). On similar lines, Akhtar *et al.* (2021) concluded that in rural areas of Pakistan farmers mostly depend upon conventional sources of information and inter-personal communication strategies for seeking updated agricultural knowledge and information. The role of inter-personal communication strategies in adopting innovative agricultural technologies by the farmers of India was

described by Das (2012). They concluded that interpersonal communication methods/sources are the most common and effective methods and sources for seeking agricultural related information and especially for adopting new and high yielding crop varieties and livestock improvement methods. The use of variety of information methods or sources by the farmers of Punjab (Pakistan) was also reported by Raza *et al.* (2020). The data presented in Table 4 also shows that farmers of the targeted research areas used demonstrations, training, meetings and conferences to get updated and innovative agricultural knowledge and information on rare and occasional basis. The result of Chi-square test shows that all the agriculture information methods or sources were not equally evaluated by the respondents. The p-value (<.001) is notably very low which indicate that these results are statistically significant.

The agricultural information sources/methods being used by the respondents to get updated agricultural knowledge (as presented in Table 1) are further classified into two main broad categories as Interpersonal Methods (conventional) and Mass Media Methods. The combined usage of these agricultural information sources were calculated by computing percentages of "occasionally (3)" and "Mostly (4)" responses received by the respondents. Out of different agricultural information sources, the sources whose combined percentage was found > 70.0% are hereby presented in the Table 2.

Table 2: *Combined usage percentage of different agricultural information methods/sources*

Category	Agri. Information Methods/ Sources	Combined usage (%)
Interpersonal (conventional)	Dealer of grain market	86.6
	Neighbors/fellow farmers	84.2
	Training meetings	68.0
	Field demonstrations	66.8
	Conferences/Seminars/Workshops	60.6
Mass media	Television	70.0
	Internet browsing	65.8
	YouTube	61.2
	Smart phones/WhatsApp	70.6

The data presented in Table 2 shows that among interpersonal (conventional) agricultural information methods/sources, dealers of respective grain markets and fellow farmers were the most commonly used sources with combined percentage 86.6 and 84.2, respectively. This indicate the significance of personal networks/connections and farmer-to-farmer extension (fellow farmers) in the study area. The effectiveness and importance of farmer-to-farmer extension was described by Nakano *et al.* (2018). On similar lines Franzel *et al.* (2019) reported that farmer-to-farmer extension is a low cost approach for promoting climate smart agricultural technologies among farmers. The data presented in the above table also shows that training methods and field demonstrations were moderately used by the respondents with combined percentage 68.0 and 66.8, respectively. These findings indicate the importance of hand-on learning through training and practical exposure are significant but slightly less accessible and prioritized by the respondents due to one or other reasons. These factors need to be explored by conducting further research studies on this particular issue. Conferences, seminars, workshops had the lowest usage (60.6%) among other interpersonal (conventional) agricultural information methods. That may be due to low accessibility for farmers of the research areas.

Among mass media information methods the usage of smart phones (70.6%) and television (70.0%) was the most leading mass media information sources. This reflects the ever growing penetration of digital technologies in rural areas of Pakistan. Internet browsing and YouTube were moderately used by the respondents with combined percentage 65.8 and 61.2, respectively. This highlights the shift towards online platforms for getting agricultural related information regarding innovative agricultural technologies. But its adoption still depends upon multiple factors like internet connectivity issues, continuous power supply issues and literacy level of farmers especially digital literacy. The overall trend of the data present in Table 2 shows that interpersonal (conventional) agricultural information sources/methods were slightly more prevalent in the study research areas. Digital tools are the emerging agricultural information sources that are competitive and convenient for the dissemination of agricultural information to the farming community. This has been suggested that a blend of both the categories of agricultural information methods (interpersonal/conventional and mass media) can maximize the reach and impact of agricultural information dissemination mechanism.

Table 3: *Chi-Square statistics regarding different information methods used by the respondents of different agro-ecological zones*

Methods	Scale of Use	Agro-Ecological Zone					Chi-Square	p-Value
		Rice-wheat	Mix	Rice	Cotton mix	Maize-wheat	77.341	0.000
Individual visit by EFS	Not At All	54 (21.90)	34 (13.80)	56 (22.70)	39 (15.80)	64 (25.90)		
	Rarely	23 (14.40)	33 (20.60)	44 (27.50)	30 (18.80)	30 (18.80)		
	Occasionally	16 (20.0)	31 (38.80)	0 (0.00)	27 (33.80)	6 (7.50)		
	Mostly	7 (53.8)	2 (15.4)	0 (0.00)	4 (30.8)	0 (0.00)		
Individual visit to office of EFS	Not At All	44 (19.0)	32 (13.90)	56(24.20)	32 (13.90)	67 (29.0)	73.687	0.000
	Rarely	35 (20.0)	31 (17.70)	41 (23.40)	41 (23.40)	27 (15.40)		
	Occasionally	18 (21.70)	34 (41.00)	0 (0.00)	25 (30.10)	6 (7.20)		
	Mostly	3 (27.30)	3 (27.30)	3 (27.30)	2 (18.20)	0 (0.00)		
Neighbors/fellow farmers	Not At All	11 (29.7)	12 (32.4)	0 (0.00)	11 (29.7)	3 (8.1)	90.490	0.000
	Rarely	14 (33.3)	9 (21.4)	0 (0.00)	8 (19.0)	11 (26.2)		
	Occasionally	26 17.6)	47 (31.8)	9 (6.1)	34 (23.0)	32 (21.6)		
	Mostly	49 (17.9)	32 (11.7)	91 (33.3)	47 (17.2)	54 (19.8)		
Dealer of grain market	Not At All	33 (68.8)	6 (12.5)	0 (0.00)	6 (12.5)	3 (6.2)	115.303	0.000
	Rarely	7 (36.8)	7 (36.8)	0 (0.00)	5 (26.3)	0 (0.00)		
	Occasionally	23 (18.0)	17 (13.3)	24 (18.8)	23 (18.0)	41 (32.0)		
	Mostly	37 (12.1)	70 (23.0)	76 (24.9)	66 (21.6)	56 (18.4)		
Field demonstrations	Not At All	8 (38.1)	4 (19.0)	0 (0.00)	6 (28.6)	3 (14.3)	97.057	0.000
	Rarely	29 (20.0)	34 (23.4)	15 (10.3)	31 (21.4)	36 (24.8)		
	Occasionally	29 (12.5)	33 (14.2)	85 (36.6)	39 (16.8)	46 (19.8)		
	Mostly	34 (33.3)	29 (28.4)	0 (0.00)	24 (23.5)	15 (14.7)		
Training meetings	Not At All	28 (56.0)	12 (24.0)	0 (0.00)	7 (14.0)	3 (6.0)	85.425	0.000
	Rarely	21 (19.1)	16 (14.5)	15 (13.6)	20 (18.2)	38 (34.5)		
	Occasionally	49 (14.9)	70 (21.3)	85 (25.9)	71 (21.6)	53 (16.2)		
	Mostly	2 (16.7)	2 (16.7)	0 (0.00)	2 (16.7)	6 (50.0)		
Conferences/ Seminars/ Workshops	Not At All	32 (72.7)	5 (11.4)	0 (0.00)	4 (9.1)	3 (3.8)	124.857	0.000
	Rarely	23 (15.0)	47 (30.7)	15 (9.8)	33 (21.6)	35 (22.9)		
	Occasionally	42 (14.5)	47 (16.3)	85 (29.4)	59 (20.4)	56 (19.4)		
	Mostly	3 (21.4)	1 (7.1)	0 (0.00)	4 (28.6)	6 (42.9)		
Field days/ Agriculture Exhibitions	Not At All	38 (32.5)	32 (27.4)	0 (0.00)	25 (21.4)	22 (18.8)	208.226	0.000
	Rarely	14 (10.7)	13 (9.9)	15 (11.5)	17 (13.0)	72 (55.0)		
	Occasionally	45 (18.5)	52 (21.4)	85 (35.0)	55 (22.6)	6 (25.0)		
	Mostly	3 (33.3)	3 (33.3)	0 (0.00)	3 (33.3)	0 (0.00)		
Television	Not At All	7 (21.2)	15 (45.5)	0 (0.00)	8 (24.2)	3 (9.1)	118.901	0.000
	Rarely	38 (32.5)	27 (23.1)	9 (7.7)	35 (29.9)	8 (6.8)		
	Occasionally	28 (10.6)	35 (13.3)	82 (31.2)	39 (14.8)	79 (30.0)		
	Mostly	27 (31.0)	23 (26.4)	9 (10.3)	18 (20.7)	10 (11.5)		
Radio	Not At All	45 (39.5)	28 (24.6)	6 (5.3)	24 (21.1)	11 (9.6)	86.500	0.000
	Rarely	34 (13.7)	35 (14.1)	73 (29.3)	40 (16.1)	67 (26.9)		
	Occasionally	15 (13.6)	28 (25.5)	18 (16.4)	27 (24.5)	22 (20.0)		
	Mostly	6 (22.2)	9 (33.3)	3 (11.1)	9 (33.3)	0 (0.00)		

Internet Browsing	Not At All	39 (30.0)	21 (16.2)	44 (33.8)	20 (15.4)	6 (4.6)	103.532	0.000
	Rarely	3 (7.3)	16 (39.0)	0 (0.00)	11 (26.8)	11 (26.8)		
	Occasionally	10 (11.9)	19 (22.6)	0 (0.00)	18 (21.4)	37 (44.0)		
	Mostly	48 (19.6)	44 (18.0)	56 (22.9)	51 (20.8)	46 (18.8)		
Smart phones/ WhatsApp	Not At All	13 (10.1)	16 (12.4)	47 (36.4)	16 (12.4)	37 (28.7)	73.884	0.000
	Rarely	7 (8.9)	3 (16.7)	0 (0.00)	8 (44.4)	0 (0.00)		
	Occasionally	13 (20.3)	18 (28.1)	0 (0.00)	16 (25.0)	17 (26.6)		
	Mostly	67 (23.2)	63 (21.8)	53 (18.3)	60 (20.8)	46 (15.9)		
Agricultural Helpline	Not At All	22 (8.8)	30 (12.0)	85 (34.1)	32 (12.9)	80 (32.1)	183.659	0.000
	Rarely	29 (29.9)	15 (15.5)	12(12.4)	21 (21.6)	20 (20.6)		
	Occasionally	31 (27.4)	45 (39.8)	3 (2.7)	34 (30.1)	0 (0.00)		
	Mostly	18 (43.9)	10 (24.4)	0 (0.00)	13 (31.7)	0 (0.00)		
Facebook	Not At All	51 (24.9)	40 (19.5)	44 (21.5)	37 (18.0)	33 (16.1)	44.042	0.000
	Rarely	11 (13.4)	14 (17.1)	12 (14.6)	17 (20.7)	28 (34.1)		
	Occasionally	32 (18.1)	29 (16.4)	44 (24.9)	36 (20.3)	36 (20.3)		
	Mostly	6 (16.7)	17 (47.2)	0 (0.00)	10 (27.8)	3 (8.30)		
YouTube	Not At All	31 (21.4)	18 (12.4)	59 (40.7)	19 (13.1)	18 (12.4)	115.629	0.000
	Rarely	8 (16.3)	12 (24.5)	0 (0.00)	7 (14.3)	22 (44.9)		
	Occasionally	36 (16.7)	39 (18.1)	41 (19.1)	46 (21.4)	53 (24.7)		
	Mostly	25 (27.5)	31 (34.1)	0 (0.00)	28 (30.8)	7 (7.7)		
Books/journals/articles	Not At All	67 (17.7)	66 (17.5)	85 (22.5)	60 (15.9)	100 (26.5)	90.420	0.000
	Rarely	20 (33.3)	9 (15.0)	15 (25.0)	16 (26.7)	0 (0.00)		
	Occasionally	5 (12.2)	19 (46.3)	0 (0.00)	17 (41.5)	0 (0.00)		
	Mostly	8 (38.1)	6 (18.6)	0 (0.00)	7 (33.3)	0 (0.00)		
Newspapers	Not At All	50 (19.3)	58 (22.4)	47 (18.1)	48 (18.5)	56 (21.6)	68.499	0.000
	Rarely	24 (13.8)	23 (13.2)	53 (30.5)	30 (17.2)	44 (25.3)		
	Occasionally	23 (29.0)	17 (28.8)	0 (0.00)	19 (32.2)	0 (0.00)		
	Mostly	3 (37.5)	2 (25.0)	0 (0.00)	3 (37.5)	0 (0.00)		
Newsletters/ magazines	Not At All	51 (15.3)	50 (15.0)	85 (25.4)	48 (14.4)	100 (29.9)	131.475	0.000
	Rarely	10 (17.5)	16 (28.1)	15 (26.3)	16 (28.1)	0 (0.00)		
	Occasionally	25 (31.6)	29 (36.7)	0 (0.00)	25 (31.6)	0 (0.00)		
	Mostly	14 (46.7)	5 (16.7)	0 (0.00)	11 (36.7)	0 (0.00)		
Brochures/ pamphlets/ posters	Not At All	34 (19.8)	24 (14.0)	44 (25.6)	24 (14.0)	46 (26.7)	115.771	0.000
	Rarely	18 (9.2)	40 (20.4)	56 (28.6)	38 (19.4)	44 (22.4)		
	Occasionally	35 (44.3)	13 (16.5)	0 (0.00)	21 (26.6)	10 (12.7)		
	Mostly	13 (24.5)	23 (43.4)	0 (0.00)	17 (32.1)	0 (0.00)		

In order to assess the association between different agricultural information sources/methods being used by the respondents and agro-ecological zones (five different data collection regions), chi-Square test of independence was used. The results of chi-square test statistics are hereby presented in Table 3.

The data presented in Table 3 shows that agro-ecological zone specific level of use of different agricultural information methods is statistically significant (p=0.000). In rice-wheat agro-ecological zone, higher use of interpersonal information source (neighour/fellow farmers) and digital information communication methods (smart phones/WhatsApp) was found. In mix cropping agro-ecological zone limited use of most of the agricultural information sources was found. However, relatively higher use of traditional print media agricultural information sources/methods (newspapers, agricultural pamphlets or brochures) was found in mix cropping zone. In cotton mix agro-ecological zone balanced

Table: 4: *Frequency distribution of respondents regarding typology of agricultural information mostly received through different agricultural information methods/sources*

Information methods/Sources	Typology of agricultural information					
	Plant production	Plant protection	Marketing	Environment	Post-harvest and storage	Livestock management
Individual visit by EFS	225 (45.0)	241 (48.2)	13 (2.6)	5 (1.0)	16 (3.2)	0 (0.0)
Individual visit to office of EFS	194 (38.8)	261 (52.2)	12 (2.4)	23 (4.6)	7 (1.4)	3 (0.6)
Neighbors/fellow farmers	126 (25.2)	244 (48.8)	0 (0.0)	26 (5.2)	47 (9.4)	57 (11.4)
Dealer of grain market	160 (32.0)	222 (44.4)	34 (6.8)	21 (4.2)	50 (10.0)	13 (2.6)
Field demonstrations	206 (41.2)	143 (28.6)	7 (1.4)	41 (8.2)	62 (12.4)	41 (8.2)
Training meetings	239 (47.8)	128 (25.6)	27 (5.4)	70 (14.0)	29 (5.8)	7 (1.4)
Conferences/ Seminars/ Workshops	227 (45.4)	80 (16.0)	36 (7.2)	71 (14.2)	40 (8.0)	46 (9.2)
Field days/ Agriculture Exhibitions	214 (42.8)	102 (20.4)	40 (8.0)	58 (11.6)	59 (11.8)	27 (5.4)
Television	51 (10.2)	71 (14.2)	17 (3.4)	279 (55.8)	43 (8.6)	39 (7.8)
Radio	58 (11.6)	75 (15.0)	28 (5.6)	263 (52.6)	49 (9.8)	27 (5.4)
Internet Browsing	36 (7.2)	89 (17.8)	34 (6.8)	250 (50.0)	45 (9.0)	46 (9.2)
Smart phones/WhatsApp	21 (4.2)	319 (63.8)	7 (1.7)	19 (3.8)	54 (10.8)	80 (16.0)
Agricultural helpline	64 (12.8)	315 (63.0)	47 (9.4)	29 (5.8)	9 (1.8)	36 (7.2)
Facebook	92 (18.4)	286 (57.2)	30 (6.0)	19 (3.8)	57 (11.4)	16 (3.2)
YouTube	56 (11.2)	282 (56.4)	23 (4.6)	58 (11.6)	48 (9.6)	33 (6.6)
Books/journals/articles	164 (32.8)	50 (10.0)	78 (15.6)	98 (19.6)	89 (17.8)	21 (4.2)
Newspapers	51 (10.2)	47 (9.4)	171 (34.2)	174 (34.8)	40 (8.0)	17 (3.4)
Newsletters/Magazines	118 (23.6)	97 (19.4)	32 (6.4)	122 (24.4)	90 (18.0)	41 (8.2)
Brochures/pamphlets/posters	83 (16.6)	104 (20.8)	45 (9.0)	91 (18.2)	158 (31.6)	19 (3.8)

n=500 Values in parentheses are percentages

use of all the traditional, interpersonal and digital agricultural information methods was found. In maize-wheat mix cropping agro-ecological zone, digital information communication method (smart phones/WhatsApp) and dealers of grain markets (interpersonal) were mostly used by the respondents. In rice agro-ecological zone limited use of all the agricultural information methods was found.

The analysis indicated a significant association between the frequency of visits by extension field staff (EFS) and agro-ecological zones, x^2 (12) 77.34, p< .001. The maize-wheat mix zone had the highest proportion of farmers who reported not receiving visits at all (25.9%), followed by the rice zone (22.7%), rice-wheat (21.90%) and cotton mix (15.8%) zones. Rare visits were most frequently observed in the Rice zone (27.5%) and the mix zone (20.6%). Farmers reporting occasional visits were primarily from the rice zone (38.8%), with other zones showing lower proportions, such as 33.8% in the cotton mix zone and 7.5% in the maize-wheat mix zone. Mostly frequent visits were uncommon across all zones, with the rice-wheat mix zone exhibiting the highest proportion (53.8%), followed by the cotton mix zone (30.8%). These results highlight significant differences in the frequency of EFS visits across agro ecological zones, emphasizing variability in outreach and support provided to farmers. Highest chi-square ($\chi 2$) value (in case of field days/agricultural exhibitions = 208.226) shows highly unequal usage pattern across agro-ecological zones. In case of conferences/seminars/ workshops high chi-square ($\chi 2$) value (124.857) shows low usage in most of the agro-ecological zones with occasional usage in rice zone. Similarly, in case of print media agricultural information sources like posters/brochures and pamphlets relatively high chi-square ($\chi 2$) value (115.771) indicate that significant variation in occasional and rare usage across all the agro-ecological zones. From these findings, it is clear that there is declining usage of print media agricultural information methods and most of the farmers shift towards adoption of digital, dynamic and more interactive agricultural information tools to update their agricultural related knowledge. In this context, different agricultural mobile applications have been

launched in Pakistan to empower farmers through digital initiatives. Top ranked digital agricultural applications in Pakistan are Bakhabar Kissan, Ricult Pakistan, Kisan Zar Zameen, Kissan Bazaar and Agri. Smart. Similar findings were also reported by Ajadi *et al*. (2016) from Nigeria. In Ethopia also, Shitaye *et al*. (2024) reported the actors influencing smallholder farmers' access to agricultural information. Previous research studies conducted in Pakistan also noted the significance of extension contacts and interpersonal sources in delivering agricultural information, especially in rural areas where other media are limited (Yaseen *et al*., 2016).

Typology of agricultural information received

Farmers received a wide variety of agricultural related information from different information delivery methods and sources as mentioned in the Table 4. The major farm related areas for which farmers received updated information are "plant production practices", "plant protection practices", "marketing of agricultural/farm produce", "environment/weather", "post-harvest/processing/storage of agricultural produce" and "livestock management and production practices". The data in this regard were collected for different information delivery methods and presented in the Table 4.

The data presented in Table 4 shows that respondents mostly used Extension Field Staff as agricultural information source to get information related to plant production practices (45.0%) and plant protection practices (48.2%). While visiting office of Extension Field Staff, respondents mostly get information related to plant production practices (38.8%) and plant protection practices (52.2%). For getting information related to plant protection practices and livestock management practices, respondents mostly used neighbor/fellow farmers as interpersonal information source as reported by 48.8% and 11.4% of respondents, respectively. Respondents rarely used neighbor/fellow farmers as interpersonal information source for marketing of agriculture produce and environment/weather related information. Dealers of grain markets interpersonal information source was mostly and significantly used for plant production related information (44.4%) and information related to agricultural marketing. Respondents rarely used dealers of grain markets as information source for seeking information related to livestock production practices and environment/weather related information.

The data shows that respondents primarily used demonstrations (method and result) as interpersonal communication source for seeking information concerning plant production (41.2%) and protection practices (28.6%). Respondents moderately used demonstrations as information source to get environment/weather and post-harvest/processing/storage related information. Respondents (50.0%-55.8%) predominately used radio, television and internet browsing to get environment/weather related information. Farmers of the targeted research areas mostly used smart phones/WhatsApp for seeking information related to plant protection practices (63.8%) and livestock management practices (16.0%). Facebook and YouTube were also being used as agricultural information source for seeking information related to plant protection practices as reported by 57.2% and 56.4% of respondents, respectively. Respondents rarely used Facebook and YouTube as agricultural information source for getting information related to agricultural marketing and environment/weather.

Print media (books/journals/articles, newspapers and newsletters) information sources were mostly used for getting information related to agricultural marketing, environment/weather and plant production practices as reported by 34.2%, 34.8% and 32.8% of respondents, respectively. It is important to mention here that newspapers as print media agricultural information source were used in a balanced pattern agricultural marketing and environment/weather related information. Respondents, primarily used agricultural brochures, pamphlets/posters for seeking information related to post harvest/processing/storage (31.6%) and plant protection related practices (20.8%). The general trend of the data shows that farmers of the targeted research areas heavily rely on interpersonal information sources (visit of EFS and field demonstrations) and online digital platforms for getting information regarding plant production and plant protection related practices. In case of environment/weather related information, respondents mostly rely on mass media information methods (radio, television and internet browsing). For seeking information related to marketing of agricultural produce, respondents mostly rely on dealers of respective grain markets and newspapers and newsletters. In order to get information concerning

livestock management practices, respondents, significantly depends upon neighbors/fellow farmers and use of smart phones (WhatsApp).

Conclusions and Recommendations

Findings of the study showed a clear preference for practical, peer-based and ICT-enabled agricultural information sources over conventional information methods. The data also showed that farming community mostly relied on interpersonal conventional information sources for getting updated agricultural related information especially dealers of grain market and fellow farmers. This indicates that peer networks and trusted market based information sources remain the dominant among farming community. Other informal interpersonal communication and information channels were reported as equally important showing the significance of participatory and experiential learning approaches. Among mass media information sources, majority of the farmers relied on ICT based information sources for getting in time and user-friendly agricultural related information. Findings of the study highlighted that geographical and ecological conditions shape the information-seeking behavior of farmers, reinforcing the need for zone-specific extension strategies. Each information method has a specific content orientation, and farmer's access different sources strategically depending on their information needs. This has been suggested that there is a need for extension services to strengthen community-based and digital outreach strategies to better align with farmers' actual information-seeking behaviors. Overall, the data suggests a dual preference structure where farmers continue to value trusted interpersonal sources while increasingly embracing digital media, underscoring the need for extension systems to integrate community-based and ICT-driven communication strategies for more effective dissemination of agricultural advisory information. This also suggested the need of content-specific extension strategies, integrating interpersonal, ICT, mass media, and print sources to deliver comprehensive agricultural advisory services.

Novelty Statement

This study provides a comprehensive, zone-wise analysis of agricultural information-use patterns in Punjab, Pakistan, by integrating agro-ecological context with farmers' communication behavior. It also demonstrates that farmers' reliance on interpersonal, institutional, mass media and digital sources varies significantly across agro-ecological zones, and those different types of agricultural information flow through distinct communication pathways.

Author's Contribution

Muhammad Luqman: Supervision and finalized the paper
Adeel Mustafa: Data collection and Methodology
Muhammad Yaseen: Prepared initial draft of paper
Muhammad Usman: Data curation, writing - review and editing
Tahir Munir Butt: Designed survey research instrument

Generative AI and AI-assisted technology statement
The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest
The authors have declared no conflict of interest.

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