Research Article

Strengthening Smallholder Centered Agricultural Knowledge and Information System (AKIS) in Punjab, Pakistan

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Abstract | Small land holder farmers are in majority in Pakistan like other regions of the developing world. These smallholders possess limited access to agricultural knowledge and information. AKIS enables the flow and exchange of agricultural knowledge and information among different stakeholders. Present research study examined agricultural knowledge and information exchange among smallholders under AKIS in the Punjab province of Pakistan. The study employed cross-sectional survey research design. Data were collected from smallholder farmers of four randomly selected districts (Sargodha, Bhakhar, Multan and Vehari). Total sample size of the study was 400 respondents (100 smallholder farmers selected through simple random sampling procedure from each selected district). Structured interview schedule was designed for quantitative data collection. However, qualitative data were collected through interview guide. Findings revealed that smallholder farmers currently play a moderate role in agricultural knowledge (Mean = 2.92) and information exchange (Mean = 2.90), yet they aspire to significantly greater engagement (Desired Means = 3.54 and 3.45, respectively). The largest participation gaps were observed in innovator and leadership roles, indicating strong potential for farmer-led extension and participatory approaches. Farmers reported moderate knowledge levels across pre-sowing (3.03), sowing (3.04), and post-sowing practices (3.17), with comparatively stronger access to technical production information such as pest management, fertilization timing, irrigation scheduling, and harvesting. However, substantial gaps were identified in marketing, climate variation, credit and loan services, legal information, and livestock-related advisory services, reflecting an imbalance in extension priorities. Informal sources – self-experience (3.44) and fellow farmers (3.32) – emerged as dominant information channels, while formal institutions such as public extension, universities, and research departments were comparatively underutilized. Indigenous knowledge systems showed moderate reliance, with customary practices remaining influential but other traditional channels declining. The study concluded that while production-oriented advisory services are relatively strong, value chain, financial literacy, climate resilience, and integrated farm advisory components remain weak. Strengthening farmer-centered, participatory, and inclusive AKIS models that integrate indigenous knowledge with formal systems to enhance smallholder empowerment, agricultural resilience, and sustainable rural development in Pakistan.

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Introduction

The Agricultural Knowledge and Information System is defined more broadly as the actors in a network that enable the flow and exchange of agricultural knowledge and information. The system generally involves farmers, researchers, extension agents, policymakers, the private sector and other players who interact to encourage innovation and development in agriculture (World Bank, 2019). AKIS is important because it can facilitate knowledge sharing among the groups involved, allowing farmers to be addressed not just as consumers of information but also as important providers of information and knowledge. Involving farmers directly in the innovation process helps make innovations more relevant in the context of local knowledge and improves the chances of successful adoption (Spielman and Birner, 2018).

To adapt to the rapidly changing conditions, the so-called agricultural knowledge triangle has become the true driving force behind the functioning of AKIS, where farmers, the research and extension services can work together to drive innovation and system-oriented development in agriculture (Hermans *et al*., 2015). Farmers have practical knowledge and experience, both of which are critical to discovering problems and testing solutions in real-world conditions. Farmers' representation in AKIS ensures the relevance of innovations to contextual conditions and real needs (Cristóvão *et al*., 2012). The need for science and technology is ever-increasing, and researchers are producing scientific knowledge and innovations that can enhance agricultural productivity, sustainability, and resilience. Working together with farmers and extension agents, researchers can adapt the colloquium to local challenges (Leeuwis and Van den Ban, 2019). This triangular relationship makes AKIS more effective; it opens up opportunities to learn from each other and ensures that agricultural research reflects actual reality (Hermans *et al*., 2015).

If Punjab province needs to improve the knowledge base of small-scale farmers for better decision making and innovation uptake by the farmers, a well-functioning AKIS is the key. AKIS represents a network of individuals involved in agriculture, including farmers, researchers, extension services, and other agricultural stakeholders, working together to share knowledge, facilitate decision-making, and encourage the adoption of innovative agricultural practices and technologies (EU, 2021). This includes one of the original purposes of AKIS, which was to connect farmers with research organizations so that agricultural knowledge and technology is relevant to smallholder farmers. For instance, research for drought-resistant crops, integrated pest management, and sustainable irrigation techniques will not manifest potential benefit if farmers are not informed in an understandable and actionable way (Cristóvão *et al*., 2012).

Policies providing support to agriculture in Pakistan are not well aligned to the needs of small-scale farmers. While we do have organizational efforts for farm-subsidies like *Kissan* Package. In Pakistan, smallholders face enteral barriers (bureaucratic and rigid eligibility criteria) in accessing these funds (Government of Punjab, 2020), because agricultural policies are typically biased towards commercial and larger farms (Khan *et al*., 2020) less support and limited avenues exist for smallholders. Despite the growing emphasis on the Agricultural Knowledge and Information System by different development organizations experiential evidences on how small-scale farmers of the Punjab (Pakistan) actively participate within these networks remains limited. Existing research studies in Pakistan largely focus on technology adoption, agricultural extension system & performance, and policy support mechanisms, while overlooking farmers' interaction and role within AKIS. With this need, present study was designed.

Figure 1 is representing conceptual framework for the study indicating linkages among various factors.

Methodology

Research design

Cross-sectional survey research design was adopted in the present research study. The mixed-method approach enabled triangulation of findings and enhanced the validity and robustness of the results.

Sampling procedure

A two-stage sampling strategy was used to achieve a comprehensive and representative analysis. Thereafter, two divisions were randomly selected from Punjab. Out of each of the chosen divisions, two districts were purposively chosen; smallholder farmers (having land-holding up to 5 acres) have been chosen as the primary focus of the study because they depend on

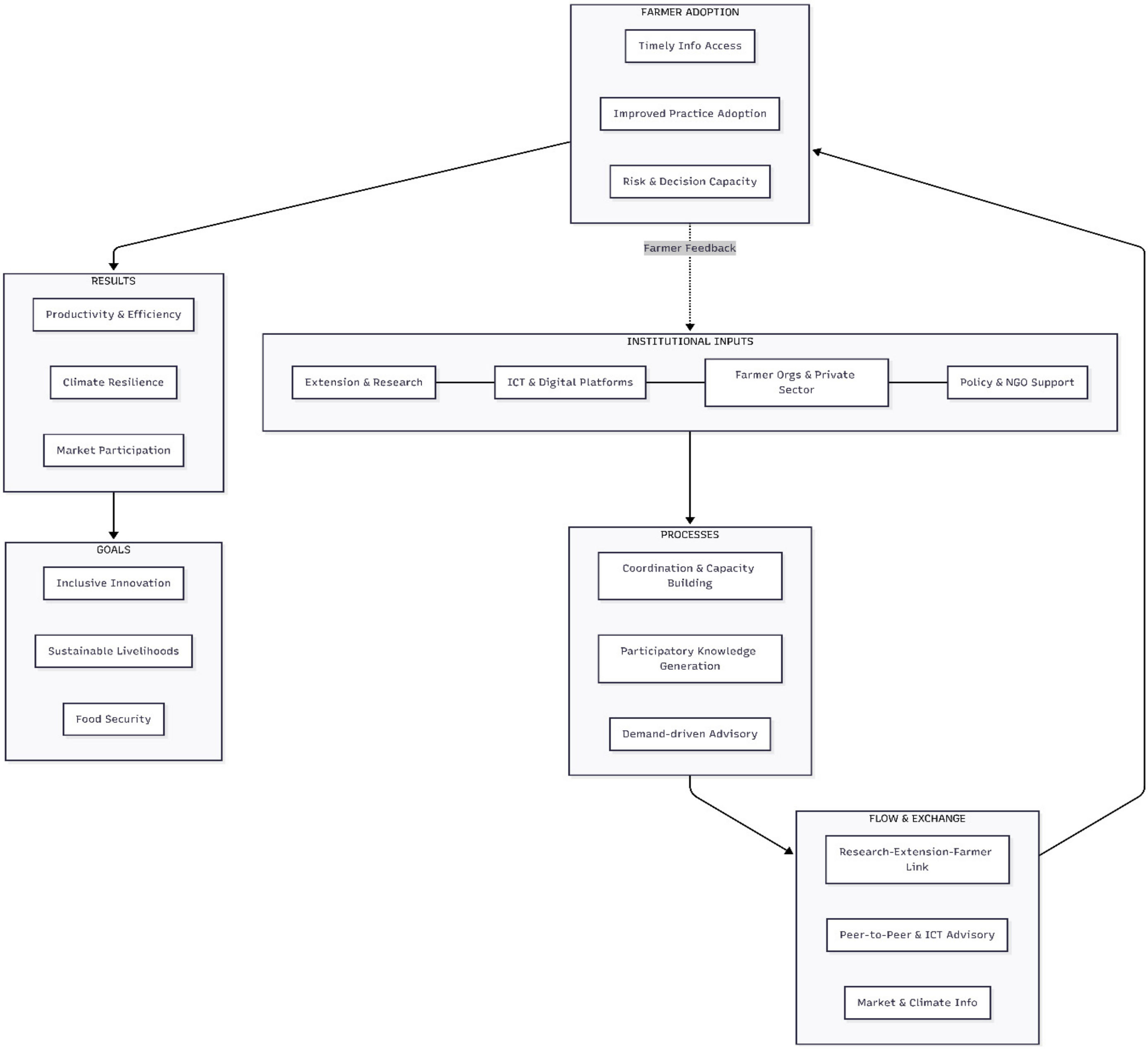

Figure 1: *Conceptual framework*

different Agricultural Knowledge and Information System channels in order to increase productivity, manage resources, and make informed farming-related decisions. In addition to agricultural stakeholders, information providers were also integrated in order to capture the barriers and facilitators of knowledge transfer in the agricultural space. In total, 400 farmers were surveyed, with a sample of 100 farmers from research districts, Sargodha, Bhakkar, Multan and Vehari as highlighted in Figure 2.

A simple random sampling technique was used to ensure that all farmers had an equal chance of being selected, thus reducing potential bias and enhancing the representativeness of the sample. Purposive sampling was used to include variety in farming types and experiences to reflect the various socio-economical, educational and technological backgrounds in Punjab's smallholder farmer setting. Likewise, simple random sampling was used to select information providers, guaranteeing that extension workers, researchers, and agricultural NGOs were unbiasedly selected.

Data collection tool and technique

Data collection involved both qualitative and quantitative information obtained using well-structured tools to aid in ensuring a robust approach. The quantitative and qualitative data collection tools used in this research was a questionnaire and an interview guide, respectively. The key tool for quantitative data collection from small-scale farmers was the questionnaire. For collecting qualitative data focus group meetings and key-informant interviews were conducted with the stakeholders. The details of these qualitative data collection meetings are given in Table 1.

Figure 2: *Map of punjab province highlighting research areas*

Table 1: *Meetings with different stakeholders*

Stakeholders/Actors involved in rural development	Number of meetings conducted
Progressive farmers (Innovators)	21
Extension field staff of public sector	12
Staff of agricultural research institutions/ stations	7
Extension field staff of private sector (Inputs supply agencies)	11
Staff of NGOs/CBOs (Community based organizations)	10
Agricultural marketing personnel	5
Dealers of grain markets (Inputs supply agencies)	10
Academia personnel	13

Quantitative data analysis was performed using SPSS for descriptive statistics whereas, for qualitative data content analysis were conducted.

Results and Discussion

The study data on the role of small farmers in the exchange of agricultural knowledge and information reveals a consistent gap between their current and desired roles across various categories (Table 2). In terms of playing a leadership role, farmers currently score 2.86 with a desired score of 3.57, indicating a gap of 0.71, suggesting they want to be more actively involved in guiding others. The role of information seeker shows a gap of 0.54, indicating a desire to more actively seek out and share information. Overall, these gaps suggest that small farmers aspire to play a more proactive and central role in the exchange of agricultural knowledge, particularly in leadership, innovation, and facilitation roles, highlighting the need for capacity-building efforts to support them in achieving these goals.

Table 2: *Role of smallholders in exchange of agricultural knowledge and information*

Exchange of agri-knowledge	Existing role		Desired role		Mean differences
	Mean	SD	Mean	SD	
Task					
Leadership role	2.86	1.446	3.57	1.406	0.71
Innovator role	2.73	1.459	3.47	1.46	0.74
Communicator role	2.93	1.505	3.48	1.479	0.55
Facilitator role	3.07	1.526	3.60	1.496	0.53
Information seeker role	2.99	1.383	3.60	1.442	0.61
Overall mean	2.92		3.54		0.62
Exchange of agri- information					
Task					
Leadership role	2.94	1.516	3.44	1.498	0.5
Innovator role	2.78	1.369	3.30	1.559	0.52
Communicator role	2.94	1.417	3.47	1.514	0.53
Facilitator role	2.90	1.411	3.56	1.467	0.66
Information seeker role	2.95	1.414	3.49	1.503	0.54
Overall mean	2.90		3.45		0.55

Scale: *5=very high, 4=high, 3=Moderate, 2=Low, 1= very low*

These findings reveal a consistent pattern across all roles, small farmers currently play a moderate role in the exchange of agricultural knowledge and information, but there is a strong desire for an enhanced role in all the aspects. This also indicates that small-scale farmers of the research areas were very ambitious and aspire to take more productive and empowered role in the existing agricultural knowledge and information mechanism. There is great and strong potential for different participatory extension and learning approaches in the form of peer learning and farmer-led innovation and information mechanism. In this situation, training programs, agricultural support systems and recognition of potential of small-scale farmers could be helpful in bridging the gap between their current and desired roles in agricultural information and delivery mechanism.

For pre-sowing practices, among the 400 respondents, farmers show a moderate level of knowledge but still express notable gaps across the board (Table 3). Land preparation has a current knowledge mean of 2.92/5.00 with a gap of 1.371, indicating that while farmers have some understanding of soil preparation, they need more precise knowledge to improve efficiency. Sowing method, with a score of 2.97 and a gap of 1.488, shows that farmers are keen to improve their techniques to ensure more efficient and productive sowing. Overall, the respondents highlight gaps in their pre-sowing and sowing knowledge, motioning the need for more targeted educational interventions to address these areas. The data indicated a moderate to moderately high level of information access to the farmers related to pre-sowing and sowing farm operations. This indicates that there is need of targeted interventions to strengthen the knowledge level of farmers. There is great potential to enhance farm productivity by improving access to information by the farmers. In this situation, strengthening of agricultural extension services on the basis of farmers needs would be helpful in bridging the gap. The overall mean scores in both categories suggest that farmers have received a moderate level of knowledge, but there is still potential for improvement. This has been concluded that farmers were moderately informed about pre-sowing and sowing farm operations, but there are still facing significant gap in it. This shows that there is dire need of participatory and targeted policy interventions to transform better access of agricultural and related information to the farmers. The same was also reported internationally by Prajapati *et al.* (2025). Research studies conducted and concluded by Anderson and Feder (2007) indicates that timely and targeted agricultural information significantly improves farmers' decision-making that ultimately enhanced their farm yields.

The data from 400 respondents on post-sowing practices highlights notable gaps between farmers' current knowledge and their desired levels across several areas (Table 4). Legal information also shows a significant gap of 1.55, suggesting that farmers require more clarity on legal matters related to farming. Other areas like transportation (1.474), vaccination (1.495), and animal husbandry (1.439) reflect farmers' needs for more knowledge on supporting their livestock and ensuring the smooth operation of their farming practices. Overall, this data shows that farmers are particularly focused on improving their knowledge in financial, technical, and environmental areas to enhance their agricultural outcomes.

Table 3: *Types of agricultural knowledge received by the smallholders*

Knowledge related to Pre-sowing practices		
Task	Mean	SD
Land preparation	2.92	1.371
Seed selection	3.32	1.302
Seed treatment	2.84	1.451
Overall Mean	3.03	
Knowledge related to sowing practices		
Tasks	Mean	SD
Plant population selection	3.00	1.306
Sowing time	3.15	1.425
Sowing method	2.97	1.488
Overall mean	3.04	

Scale: *5=very high, 4=high, 3=Moderate, 2=Low, 1= very low*

Table 4: *Knowledge related to post sowing practices*

Tasks related to post sowing practices	**Mean**	**SD**
Intercultural practices	3.28	1.411
Fertilization time	3.18	1.398
Fertilization amount	3.11	1.41
Irrigation scheduling	3.22	1.355
Disease management	3.34	1.34
Insect/pest management	3.32	1.368
Harvesting time	3.47	1.21
Storage method selection	3.28	1.413
Marketing options	3.1	1.444
Climate variation	2.81	1.435
Credit and loan	2.73	1.557
Afforestation	3.00	1.471
Weather	3.33	1.336
Post-harvest	3.48	1.312
Production techniques	3.4	1.429
Pesticides	3.48	1.425
Legal information	3.05	1.55
Animal husbandry	3.07	1.439
Transportation	2.92	1.474
Animal feed	3.09	1.41
Vaccination	2.88	1.495
Overall Mean	3.17	

Scale: *5=very high, 4=high, 3=Moderate, 2=Low, 1= very low*

This has been concluded from these findings that respondents that belong to different geographical regions of Pakistan hold a relatively better understanding about major post sowing farm operations. However, there is dire need of technical training keeping in view the socio-economics of farmers of each province to empower farming community. This will improve their farm productivity that would ultimately be helpful in sustaining their livelihoods. In connection with these findings Rivera and Qamar (2003) concluded that by developing regional/province specific agricultural knowledge and information in the local/provincial language using audio-visual aid and demonstration plots can improve the understanding and knowledge of farmers. Additionally, there is strong need of participatory monitoring tools for netter assessment of knowledge possessed by the farmers. The same was also reported by Leeuwis and van den Ban (2004).

From the standard deviation values (Table 5), we observe that pre-sowing practices, possess a relatively high level of knowledge, though there are still areas for improvement. Land preparation shows a mean score of 3.35 with a standard deviation of 1.296, indicating that most farmers have a solid understanding but with some variability in their knowledge.

Table 5: *Types of agricultural information received by the smallholders*

Information related to Pre-sowing practices		
Task	Mean	SD
Land preparation	3.35	1.296
Seed selection	3.60	1.302
Seed treatment	3.42	1.331
Overall mean	3.46	
Information related to sowing practices		
Tasks	Mean	SD
Plant population selection	3.42	1.326
Sowing time	3.59	1.286
Sowing method	3.35	1.356
Overall mean	3.45	

Scale: *5=very high, 4=high, 3=Moderate, 2=Low, 1= very low*

The areas of high/strong information access by the respondents of research areas reflected an emphasis on agronomic management through traditional extension approaches (Table 6). The same has also been reported by Anderson and Feder (2007) and FAO (2019). On the other hand, the areas of moderate to low information access by the respondents showed that although major farm operations are fully covered but value chain information and climate-smart agricultural practices were not strongly promoted (Leeuwis and van den Ban, 2004). There are some weak areas of information access. This indicates that there is limited dissemination of market related and climate resilience strategies. These areas are of critical concerns by the state department. This has been concluded from the given data in the form a table given below:

Table 6: *Information related to post sowing practices*

Tasks related to post sowing	**Mean**	**SD**
Intercultural practices	3.53	1.358
Fertilization time	3.64	1.218
Fertilization amount	3.40	1.291
Irrigation scheduling	3.63	1.325
Disease management	3.58	1.402
Insect/pest management	3.66	1.39
Harvesting time	3.53	1.352
Storage method selection	3.19	1.357
Marketing options	2.97	1.317
Climate variation	2.73	1.351
Credit and loan	2.68	1.307
Afforestation	2.79	1.308
Weather	3.28	1.245
Post-harvest	3.31	1.305
Production techniques	3.28	1.301
Pesticides	2.74	1.403
Legal information	2.78	1.36
Animal husbandry	2.90	1.366
Transportation	2.84	1.36
Animal feed	2.85	1.439
Overall Mean	3.17	

Scale: *5=very high, 4=high, 3=Moderate, 2=Low, 1= very low*

This has been concluded from the findings that although respondents (farmers) of the research areas received good levels of post-sowing information on agronomic practices, economic, environmental, and livestock-related knowledge remains weakly supported (Table 7). This calls for restructured and inclusive agricultural extension model that will integrate climate-smart agriculture, rural finance, and value chain knowledge alongside core production advice. Following recommendations are hereby suggested:

- Broaden focus of extension/rural advisory services beyond crop production
- Strengthen post-harvest & value addition services
- Promote integrated farm information systems
- Encourage participatory & contextualized agricultural extension

Table 7: *Information access level and tasks related to farming practices*

Level	Tasks related to post sowing
Strong information access	Insect/pest management
	Fertilization time
	Irrigation scheduling
	Disease management
	Intercultural practices
	Harvesting time
Moderate information access	Storage method selection
	Post-harvest handling
	Weather
Weak information access	Marketing options
	Climate variation
	Credit/loan access
	Legal information
	Afforestation
	Transportation
	Animal husbandry
	Animal Feeding
	Vaccination

Table 8: *smallholders' sources of indigenous knowledge*

Indigenous knowledge	Mean	SD
Stories	2.40	1.276
Songs	2.02	1.235
Ceremonies	2.17	1.388
Paintings	2.42	1.423
Local language proverbs	2.61	1.489
Customary practices	2.96	1.264
Overall Mean	2.43	

Scale: *5=very high, 4=high, 3=Moderate, 2=Low, 1= very low*

As shown in Table 8, farmer's sources of indigenous knowledge indicated varied reliance on traditional practices. This shows the extent to which farmers rely on various traditional sources of indigenous knowledge in their agricultural decision-making process. Customary practices have the highest mean at 2.96 with a standard deviation of 1.264, indicating they are a significant source of knowledge for farmers. Local language proverbs also play an important role, with a mean of 2.61 and a standard deviation of 1.489 (Warren, 1991; Altieri, 2004). The data also shows that there is disconnection between present youth and traditional agricultural knowledge and information sources that may be due to modernization as majority of the youth in the country is not willing to take part in farm related operations. These findings employ that formal agricultural extension system may possessed marginalized traditional knowledge and there is missed opportunity to validate this knowledge especially for sustainable agricultural practices and climate smart resilient practices.

FAO (2010) and UNESCO (2003) emphasized that indigenous knowledge is location-specific, adaptive and sustainable, making it a vital complement to scientific knowledge in the context of climate change, biodiversity, and food security. This has been concluded that indigenous agricultural knowledge remains an undervalued but culturally rich resource, especially in rural agricultural systems; it has not been systematically harnessed for agricultural innovation. The findings suggest a need to re-integrate indigenous knowledge into agricultural extension contexts to promote locally sustainable, climate-resilient farming systems. Bridging indigenous and scientific knowledge systems can empower rural communities, preserve cultural heritage, and enhance agricultural resilience. Keeping in mind these findings, this has been suggested that:

There is need to recognize and document indigenous knowledge: *Initiate community-based documentation programs to capture oral histories, practices, and ecological knowledge. Studies related to gerontology need to be concluded to involve old age people and community leaders in participatory rural appraisals and agricultural extension planning.*

There is need to integrate indigenous knowledge with formal extension system: *Develop blended learning models that combine scientific techniques with validated indigenous practices. Train extension workers to respect and incorporate indigenous knowledge, especially in areas like pest management, seasonal forecasting, and soil conservation*

Revitalize channels of cultural agricultural knowledge: *Encourage the use of folk media, such as proverbs, songs, and storytelling in awareness campaigns. Promote community-based activities to engage rural youth in* *learning about traditional agricultural knowledge*

Support inter-generational agricultural knowledge transfer: *Establish and facilitate different platforms where old age farmers share indigenous agricultural knowledge with younger generations through farmer field schools (FFS), community radio, or cultural festivals.*

Sources of agricultural information

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; Rehman *et al*., 2013). 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 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 information sources by the respondents in the targeted research areas was measured and presented below.

Table 9: *Major sources of farmers to get agricultural related information*

Sources of information	Mean	SD
Brochures and fliers	2.47	1.394
News papers	2.39	1.332
Exhibitions	2.3	1.419
Seminars	2.43	1.547
Fellow farmers	3.32	1.432
Village leaders	2.91	1.441
Religious leaders	2.39	1.407
Universities and colleges	2.27	1.443
Internet	2.46	1.436
Social media	2.55	1.451
Print media	2.41	1.424
Electronic media	2.59	1.517
Public extension department	2.43	1.518
Research department	2.54	1.445
Private services providers	3.00	1.488
NGOs	2.76	1.521
Self-experience-based knowledge	3.44	1.459

Scale: *5=very high, 4=high, 3=Moderate, 2=Low, 1= very low*

The major sources of agricultural information for farmers show significant variation (Table 9). Self-experience-based knowledge is the most relied upon, with a mean of 3.44 and a standard deviation of 1.459, indicating that farmers heavily depend on their own experiences for learning. Fellow farmers are also a key source, scoring 3.32 with a standard deviation of 1.432, highlighting the importance of peer-to-peer information exchange. Exhibitions and electronic media also show low means, suggesting that these sources have limited reach or effectiveness in delivering agricultural information.

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 inter-personal 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). This indicates 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. 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.

This has been concluded that farming community prefers to use accessible low-cost digital methods of knowledge and information sharing like social media (Table 10). Advanced ICTs are still out of range of majority of the farmers due to small size of land holdings by majority of the farmers in the research areas. Findings of the present research supported the findings reported by Aker (2011); Mittal and Mehar (2016); Misaki *et al*. (2018); Zhang *et al*. (2002); and many others. Overall, the data suggests that while some ICTs, particularly social media and the internet, are recognized by farmers, there is considerable room for enhancing the adoption of more advanced agricultural technologies.

Table 10: *ICT tools being used by the respondents*

Level of use	ICT tools
Mostly	Social media
	Internet
Moderately	Mobile apps in agriculture
	Farming automation
	Wireless technologies
Least	Remote monitoring
	Precision agricultural tools

Conclusions and Recommendations

The research findings highlight to strengthen smallholders-oriented AKIS in Punjab through shifting from fragmented and supply-driven extension services towards more integrated & demand-driven extension and advisory services. The study also demonstrates that enhanced coordination among extension agencies, research institutions, farmers organizations and private sector improves knowledge and information flow and improves accessibility to most relevant, timely, and need-based information for smallholders. These interventions assist extension reform initiatives by targeting participatory approaches, ICT-based advisory service mechanism responding to localized smallholders needs. Moreover, research findings emphasize advancement in climate smart agriculture through AKIS among smallholders. Strong linkage within advisory system improves farmers access for utilization of climate-resilient crop production practices using resource-efficient inputs, and decision-making on the basis of market and weather intelligence. By linking farmers' experience with scientific innovations in research institutions – to facilitate two-way knowledge exchange – the AKIS not only promotes sustainability productivity but also encourage context-specific solution towards climate resilience.

In a nutshell, upgraded smallholder-oriented AKIS directly empowers farmers by improving their decision making, adoptive capacity and market engagements. If the smallholders are considered as active participants generating knowledge and disseminating, the supportive system will foster inclusive innovation and developmental outcome. Consequently, institutional and policy reforms aiming modernized extension & advisory services, inclusion of climate smart agriculture practices, and improved stakeholders' collaborations are critical for constructing receptive AKIS to support sustainable agriculture, livelihoods, and food security in the region.

Novelty Statement

The current study highlights a farmers-led Agricultural Knowledge and In-formation System by assessing credible, accessible, and effective infor-mation sources within a single AKIS framework. Moreover, it presents con-text-specific policies to strengthen the farmer-led extension and innovation system in Pakistan and the developing world.

Author's Contribution

Muhammad Kaleem Abid: Conducted research to collect data and prepared initial draft of manuscript
Muhammad Yaseen: Conceived the re-search idea and su-pervised the re-search study
Muhammad Luqman: Conducted data analysis and helped in preparation of manuscript
Shoaib Nasir: Assisted in data analysis & reviewed initial manuscript
Muhammad Usman: Assisted in instru-mentation, data col-lection and reviewed the manuscript

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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