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Role of Agriculture Extension Services in Enhancing Crop Productivity: A Review of Punjab, Pakistan

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Abstract

The agricultural possibilities in Punjab remain constrained by several issues including lack of modern technologies and environmental damage alongside climate stress. The agricultural extension services enable essential communication between research institutions and farmers to spread sustainable methods and modern farming technologies alongside farmer education. Researchers analyze the Pakistani extension system development which shows a shift from official top-down control to community-based and information and communication technology-centered methods. Public and private institutions with NGOs and donor agencies are assessed about their respective roles in extension service delivery. The paper discusses the essential operating tasks of these services through technology transfer along with training components and communication approaches and input supplier relationships. Evidence shows that properly developed extension programs create substantial gains in agricultural outputs, specifically in wheat rice and cotton cultivation. The extension service continues to face crucial problems including insufficient funding while institutional connections remain weak and services remain exclusive. The paper presents recommendations that monitor institutional development and information technology advancement and standard extension services to ensure sustainable agricultural progress.

Keywords: Agriculture Extension, Services, Enhancing Crop Productivity, Punjab, Pakistan

Introduction

The agricultural heartland of Pakistan supports major economic activity which generates jobs for rural areas and ensures food security across the nation. The Pakistani province of Punjab stands as the most productive region of Pakistan by encompassing an area larger than 26 million hectares and maintaining approximately 70% of its territory as suitable for agricultural cultivation. The area produces many essential commodities including cotton as well as rice wheat and sugarcane on a large scale. The advisory serves two main purposes which include supporting sustainable farming practices while providing farmer education and modern technological implementation (Nadeem and Mushtaq, 2012). Water from the Indus River alongside its tributary streams supplies the majority of agricultural water to Punjab through its extensive canal networks. Punjab produces its main agricultural products wheat, rice, sugarcane, cotton and maize along with citrus fruits and mangoes and potato and onion vegetables. The province supplies 76% of national wheat exports together with 80% of cotton exports and 60% of sugarcane exports and 80% of rice exports which makes substantial contributions toward national agricultural production numbers (Irfan *et al.*,

2019; Davies *et al.*, 2024). Rural residents of Punjab depend on agriculture for more than 60% of their food sources and the industry supplies basic resources to food processing facilities, sugar production and textile manufacturing sectors. Punjab agriculture faces multiple challenges including limited groundwater resources, water scarcity along with soil and salt-related degradation problems, the effects of climate change and limited access to modern agricultural technologies and extension services (Naz *et al.*, 2014; Gulati *et al.*, 2021).

Importance of Crop Productivity in Ensuring Food Security

Agricultural production stands as a fundamental requirement for food security because Pakistan along with other developing countries focuses its economy on agricultural activities. Farmers attain better profits from the same land acreage because their agricultural productivity has risen, thereby maintaining important natural resources such as soil and water. Together with sustainable agriculture practice system enhances the performance of farming inputs and enables long-term agricultural practices (Abbas *et al.*, 2022; Usman *et al.*, 2025). Agricultural extension services consist of systems and initiatives that convey knowledge and expertise and technical tools to farmers and rural communities for better production enhancement and sustainable livelihoods. Agricultural extension constitutes the educational process of communication which helps farmers make knowledgeable choices about their marketing strategies, pest management and disease control methods, in addition to soil protection water conservation, livestock management and agricultural output development (Naz *et al.*, 2014; Afridi and Shrestha, 2019; Norton and Alwang, 2020). Field days coupled with demonstration trails enable farmers to acquire better farming skilss and agricultural expertise. The advisory services help farmers enter markets while also providing additional funding and developing specific agricultural support programs. Modern agricultural extension expands its outreach by implementing ICT resources which include web platforms, SMS alerts, and radio access, together with mobile applications (Khan et al., 2019; Rajalahti, 2021; Agwu et al., 2023).

Staff members make assessments of extension program components through framework evaluations and performance evaluation and identification of barriers alongside successful operational methods. Agricultural extension services fulfill their mission by linking research facilities with farm regions through innovation development that benefits farmers. Through the review process vital information becomes available which helps policymakers' researchers and practitioners to establish sustainable extension systems (Raza et al., 2020).

Historical Development of Agricultural Extension in Punjab

The last few decades have transformed Pakistan's agricultural extension system primarily through new legislation combined with institutional changes and modified agricultural growth directions. Since 1947 Pakistan has tried numerous strategies to deliver farmers sustainable agriculture solutions and information (Ashraf et al., 2019). The provincial agricultural departments supervised the first extension program through basic agricultural services supported by few employees within minimal geographic regions (CHAWLA, 2023). International donors including USAID collaborated on a significant project for integrated rural development. Integrating health, education, and agricultural services at the village level was the primary objective village aid program in 1960. Despite being creative, it lacked sustainability because of inadequate money and coordination (Ashraf *et al.*, 2019). Agricultural extension during the Green Revolution concentrated more on encouraging the use of inputs (seeds, fertilizers, and pesticides) to increase production. Crop yields were prioritized, while sustainability and farmer involvement received less attention (Reza Anik *et al.*, 2020). The T&V system, which was backed by the World Bank

during 1978-1992, established regular communication between farmers and extension agents. Its top-down methodology enhanced communication but lacked adaptability and farmer input (Afrad *et al.*, 2019). Under the 2001 Local Government Ordinance, decentralization changes gave district administrations authority over extension functions. Although response capability has increased, coordination, capacity, and funding issues persist (Ashraf *et al.*, 2019). Extension services are currently provided via some channels, including digital platforms, private input firms, non-governmental organizations, and state agencies. Farmers are increasingly being reached through television, radio, text messaging services, and mobile applications. Participatory methods, sustainable practices, and climate-smart agriculture are gaining traction (Mukherjee *et al.*, 2025).

Key Government and Non-Government Institutions Involved

Many governmental and non-governmental organizations in Pakistan support agricultural extension, which aims to increase farmers' knowledge, boost production, and encourage sustainable farming methods. These organizations are crucial to the adoption of contemporary technologies, training, research, and consulting services (Luqman *et al.*, 2013).

Government Institutions

Most agricultural extension service development and delivery within Pakistan happens through essential government organizations. Government organizations fulfill their responsibilities through farmer training organizations, pest control maintenance, input promotion, and field farm monitoring visits. As the national point of contact between research and extension. The Pakistan Agricultural Research Council (PARC) uses its partnership with provincial departments to develop innovative agricultural technology suitable for local conditions. With PARC support, NARC performs practical research across different agro-ecological zones of the country (ESCAP, 2020; Nasir *et al.*, 2021). PAES is a major extension agency in Punjab and works in close association with academic institutions and research centers. PAES promises to the farmers that they will be provided with training on the use of modern agricultural techniques and provided with an available knowledge of modern techniques of cultivation. Educational establishments, Sindh Agricultural University, PMAS Arid Agricultural University, and University of Agricultural Faisalabad (UAF) play important role in the extension system through participatory research, community extension initiatives and capacity building programs. Pakistan Meteorological Department (PMD) also provides important agro-meteorological alerts and weather forecasts. In the context of climate change, these services are particularly important to help farmers quickly decide upon irrigation, planting, harvesting, etc., and on the management of pests and diseases. (Riaz Cheema, 2018; Safdar *et al.*, 2023).

3.2 Non-Governmental Organizations (NGOs) and International Bodies

The international agencies and non-governmental organizations (NGOs) are far more crucial to the improvement of agricultural extension services in Pakistan with their financial support, capacity-building programs and their technical guidance. Through climate-smart agriculture programs CABI International (CABI) illustrates its critical position which also includes departments for pest management and soil health work. ICARDA introduced an initiative for improving agricultural productivity and resilience of Pakistan's arid territories (Mengal et al.; Khan et al., 2020).; Khan et al., 2020).

The Asian Development Bank uses its funding to increase extension capabilities which help support projects aimed at making agriculture resilient to climate changes through extended networks. IFAD and FAO with support from USAID provide technical and financial backing to advance their initiatives. Their support is essential in solving problems like food security, the

problems this brings with rural livelihoods and the problems of climate change (Canton, 2021; Phanith et al., 2023). Alongside the NGOs and donors, agritech companies and the private sector have grown increasingly more important and revolutionary players in Pakistan's agricultural extension modernization. They have laid a standard for the provision of mobile consulting services to farmers like Bakhabar Kissan, Telenor Agri Services and Digital Dera. Farmers use of these tools assures making better decisions and increasing productivity as they gain access to real-time weather data, market links and professional crop management guidance (Citaristi, 2022a;2022b).

Shifts in extension approaches

A more participative, farmer-centered method has replaced the directive, top-down model of agricultural extension in Pakistan and around the world in recent decades. This change is a result of increased recognition of the need for demand-driven, regionally relevant, and inclusive agricultural solutions (Wijeratne and De Silva, 2024).

The conventional top-down method

National or provincial research organizations that develop agricultural policy, research and innovations under the system then extension agents pass them to farming areas without much or any farmer participation. In other words, it is based on the assumption that the savvy professional knows what is best for the farmer and the requirements for the farmer. One major feature of its top-down model is the linear communication process from the government or research institutions down to extension agents and then down to the farmers. Traditionally, this strategy has helped the general public to accept the new Green Revolution technologies and practices, but often the strategy ignores the local expertise, cultural customs, and distinctive farming circumstances. In Pakistan, the conventional top-down system was widely used from the 1960s to the 1980s among other things, during the Green Revolution (Eicken *et al.*, 2021; Wijeratne and De Silva, 2024). Usually, policies and studies do not document or address concerns of farmers, indigenous practices and inventions. This strategy leads to reliance among farmers because they are considered passive information consumers, rather than active contributors to development. To make contemporary agricultural extension more relevant and effective, local knowledge should be used, communication should be two-way, and farmers should be involved in designing, implementing, and evaluating extension programs (Owais, 2020).

Participatory Extension Approaches

Participatory extension stresses are very high degree of farmer and rural community involvement in the design, implementation, monitoring, and evaluation of the extension initiative development. In participatory models, farmers are viewed as knowledgeable collaborators with insights from interactions with local actors and experiences. Farmers learn from them, but extension agents also learn from farmers' problems and solutions. Strategies like farmer field schools (FFS), participatory rural appraisals (PRA), community planning, and farm experiments are often used to promote communication, collaborative learning, and adaptation of practice to local contexts. These include building the local capacity, protecting the sustainable agricultural practices, technology, and involving people in decision making (Knook et al., 2018; Ashraf et al., 2019).

Features of the Shift

New patterns in agricultural science development transform both the roles of farmers and rural development challenges while striving for sustainability. Information is normally moved from specialists to farmers in only one direction with the conventional approach. On the other hand,

farmers are conversant on all matters and partake in conversations, give inputs, and influence change in extension planning, all through participatory approaches, which promote two way communication (Leenders *et al.,* 2019; Wijeratne and De Silva, 2024). It is currently believed that their requirements, expertise, and knowledge are crucial for creating pertinent and successful extension initiatives (Taylor and Bhasme, 2018; Liang, 2022). Participatory methods can improve social inclusion in decision-making processes, foster leadership, and bolster local capacities (Monroe *et al.,* 2022). Participatory extension promotes field solutions that are specific to local agro-ecological and socioeconomic circumstances, as opposed to the one-size-fits-all strategy of traditional approaches (Dwan *et al.*, 2019). The new strategy improves ties between development organizations, researchers, farmers, and extension agents. Participatory techniques guarantee increased ownership of procedures and results by incorporating communities at every stage. This enhances agricultural innovation and development projects' long-term viability (Adu *et al.*, 2022). To increase their reach and efficacy, contemporary participatory methodologies frequently incorporate digital tools, mobile applications, and ICT platforms to improve communication, data gathering, and knowledge distribution (Lampridi *et al.*, 2022).

Functions and Components of Agricultural Extension Services

Transfer and diffusion of technology

Its procedure entails transposing agricultural technologies, improved processes, and scientific inventions from research labs and facilities to the farmer's fields. The ultimate objectives are productivity increases, increases in farmers' incomes and sustainable agricultural development. The conventional approach to technology transfer is top-down down based on standardized advice from researchers and extension agents, according to the conventional extension approach. Extension services are giving the farm trials, demonstrations and farmer field schools priority to enable farmers to experiment with and modify technologies in response to their needs and experiences. (Taylor and Bhasme, 2018; Becerra-Encinales *et al.*, 2024). Today, modern outreach is using these platforms: digital platforms, smartphone apps, social media, and mass media (TV, radio, SMS alerts). This digital change now permits exchanges of weather predictions, pest alarms, market pricing, and best practices in real time even to underserved and rural regions (Altalb *et al.*, 2015).

Training and capacity building for farmers

Capacity building and farmer training procedures are to provide information, capacities, and self-assurance to make good choices, apply superior methods of farming, and manage their resources created to farmers (Hunt *et al.*, 2011; Kaur and Kaur, 2018). On-farm experiments, field visits, farmer field schools (FFS), peer learning, and practical training are now key components of contemporary capacity-building programs. These educational institutions encourage farmers to take ownership of the knowledge they acquire by fostering group debates, critical thinking, and experiential learning (Waddington *et al.*, 2014). For instance, capacity-building elements for gender equality, climate resilience, and sustainable agriculture are frequently included in programs funded by USAID, FAO, and IFAD (Nnachi, 2019).

Mass, group, and individual communication techniques

Communication techniques are necessary in agricultural extension since the transfer of knowledge, innovations, and skills is useful to rural communities by extension workers and research organizations. In general, these techniques can be divided into three categories, depending on the

type of content, audience, and resource, which are individual, group and mass contact methods. Although they are time-consuming and have a narrow scope, these techniques are useful when you know the patient and can tailor advice, solve problems, and build a great trust. (Shahbaz *et al.*, 2010; Nikolić *et al.*, 2020). Small and medium-sized groups of farmers who share interests or geographic areas are connected through group contact techniques. Training sessions, field demonstrations, community gatherings, and farmer field schools (FFS) (Kaur and Kaur, 2018).

Linkages with Research Institutions and Input Suppliers

Research into the creation of new agricultural technology, crop varieties, pest and disease management techniques and sustainable agricultural practices is necessary within research institutions such as universities, national research institutions for agriculture and research organizations with specialized research fields (Betru and Hamdar, 1997; Kassa and Alemu, 2016). Input providers such as seed companies, fertilizer manufacturers, as well as suppliers of agricultural machinery are equally important for a relationship. Vendors of this equipment and supplies help the farmers adopt the use of better farming methods. It also brings strong ties between the research organizations, extension services, and input suppliers and thereby it reduces the difficulty for farmers to provide the input to the suppliers and researchers, thus creating a cycle of continuous improvement (Raufu *et al.*, 2024).

Impact of Extension Services on Crop Productivity

In Punjab, Pakistan especially development services have an impact role in the change of farming methods, raising of production, and planting sustainability in the region. The success of these extension initiatives are demonstrated through case studies and empirical data, especially about initiation of better seeds, fertilizers, irrigation techniques and integrated pest management (IPM) strategies. Punjab is Pakistan’s primary agricultural province and makes up roughly 70 percent of the nation’s agricultural output (Ali and Rahut, 2013; Ali *et al.*, 2013). With important crops like wheat, rice, and cotton, Punjab is Pakistan's primary agricultural province and accounts for over 70% of the nation's agricultural output. Extension initiatives have produced measurable outcomes, and research indicates that these services, particularly when provided in a farmer-led enhanced agricultural yields (Nadeem and Mushtaq, 2012). Under the Punjab Department of Agricultural Extension’s Wheat Productivity Improvement Program, wheat production has increased by 20% because of promotion of high-yielding wheat cultivars, balanced fertilization and strategically planned irrigation. The Rice Crop Management Program, a partnership enterprise between the Rice Research Institute, likewise launched the same Alternate Wetting and Drying (AWD) approach to save water (Elahi *et al.*, 2018). The pest issue with Fall Armyworm required farmers to implement Integrated Pest Management (IPM) practices for cotton farms. Through distributing biological control agents and insect resistant cultivars and establishing crop rotation techniques as extension agents managed to decrease the use of chemical pesticides (Kumar and Rajitha, 2019).

Challenges Faced by Agricultural Extension

Agricultural extension services maintain essential roles across Punjab because they supply farmers with better methods to cultivate their lands to produce high crop yields. Several problems exist that limit the comprehensive effectiveness and achievements of this approach. The extension services face several challenges including low youth engagement and unequal gender participation and weak links between farmers and research institutions and a shortage of funds and training for staff.

Limited Resources and Funding

Success in extension services depends on effective budgeting of field visits while addressing new technology delivery methods through training and provisions of seeds and fertilizers. The limited financial resources influence what type of services are available and service quality and modern farming equipment availability for agricultural improvements. This can be attained by creating stable finance systems, strengthening the public-private cooperation, and ensuring that these funds are targeted to rural areas where their use can greatly increase the efficiency of expenditures (Farooq et al., 2010; Ashraf and Yousaf Hassan, 2021).

Insufficient capacity and training

Extension staff lacks the ability to serve various groups properly when they are not trained properly. Effective training about gender sensitive communication combined with climate-resilient strategies must become mandatory to resolve these problems. Extension service functionality can be optimized by delivering improved training to their workers. The solutions for addressing these problems include regular hands-on training seminars combined with participation in modern agricultural practices together with online instructional resource development and ongoing education about contemporary agricultural methods and communication strategies (Abbas et al., 2009).

Weak Research-Extension-Farmer Linkages

The ineffective flow of information among farmers, extension agencies, and research institutions is one of the primary problems facing Punjab's Agricultural Extension system. Because of this, the adoption of new technologies and techniques is slow, which stifles efforts to enhance the sustainability and productivity of agricultural systems. There needs to be greater integration of researchers and farmers at the grassroots level to solve this problem. This can be achieved by fostering active dialogue and feedback systems through collaborative research and extension projects so that the innovations developed truly match the needs and problems of the farmers (Kaur and Kaur, 2013; Manmeet, 2013).

Gender Disparity and Lack of Youth Engagement

The situation of women in the rural areas of Punjab is severe as they live solely under patriarchal norms. Participatory approaches to development ignore women’s active participation in agriculture as both producers and decision makers. Progressing to metropolitan areas for better opportunities, there is an alarming void of youthful vigor and innovative entrepreneurial spirit in the agricultural sector (Ali *et al.,* 2021). In addition to reviving the industry, promoting young involvement in agriculture will benefit rural communities by fostering creativity and sustainability (Hassan *et al.*, 2016). Some innovative approaches to increase the coverage, effectiveness and efficiency of extension services are being proposed. They include adopting information and communication technology (ICT), establishing public-private partnership (PPP), community and farmer led extension, participation of non-governmental organizations (NGOs) and donor coordinating projects among others, to empower farmers, increase agricultural productivity, and promote sustainable agricultural development (Davidson *et al.*, 2001; Naz *et al.*, 2014).

Integrated sustainable Solutions

Introduction of ICTs and Mobile-Based Advisory Services

Punjab’s agricultural extension systems have been transformed through the adoption of mobile advising services and the use of information and communication technology (ICT). Thanks to

digital applications, internet platforms and mobile phones, farmers are now able to get critical agricultural information at a moment's notice (Khan *et al.*, 2022). Farmers may take informed decisions about the future of their crops by using applications like AgriSmart and Kisan Call Centre which provide tailored guidance for them. Informal knowledge sharing networks can also be found via social media websites like Facebook groups and WhatsApp. Lowering the loss of crop and increasing production in particular. In the future, there is great prospect of using more specialized and efficient extension services for agriculture, by developing rural digital infrastructure (Saravanan *et al.*, 2015).

Public-Private Partnerships in Extension

These collaborations consist of representatives from government and private farming organizations alongside academic and research institutions and farmer associations. Public authorities form alliances that join their infrastructure development with policy support aspects to public-private collaborations which integrate private sector expertise in innovative technology and capital with public sector experience. Through agricultural technological progress seeds together with fertilizer and pest control techniques receive better distribution resources. As these partnerships develop, they might further be extended to include financial services, tech companies and producers of agricultural equipment (Ponnusamy, 2013; Becerra-Encinales et al., 2024).

Community-Based and Farmer-Led Extension Models

Punjab implements local-based extension procedures as solutions against the limitations of conventional extension delivery systems. The methodologies actively involve learners together with deliverers while sharing agricultural knowledge and learning procedures. Local farmers can experiment with new techniques and methods by participating in village advisory committees and farmer field schools (FFS) to share their personal experiences with other farming groups. These techniques are particularly helpful in ensuring inclusiveness and addressing local/regional challenges (Sharma; Naz et al., 2014).

Role of NGOs and Donor-Supported Projects

Non-governmental organizations and foreign donor agencies have profoundly improved Punjab agriculture extension services. The innovations provided by NGO include context-specific training, conservation methods and sustainable agricultural technologies that show better adaptability to sector requirements. Women's empowerment, water efficiency, and climate-smart agriculture projects have been undertaken under external assistance through programs from USAID and international donors like IFAD, e.g. women farmers have benefited from training programs providing them opportunities for access to markets, resources, and decision-making to learn about organic farming and resource conservation (Amir et al., 2013; Jackson, 2023).

Policy Recommendations and Future Directions

Strengthening Institutional Capacity and Financing

Institutional capacity development functions as a primary factor to build sustainable agricultural extension services over extended periods. The process ensures sufficient infrastructure and technology with effective organizational structures as well as trained personnel operate at provincial and national levels to function adequately. An institutionally developed capacity among extension personnel equips them to handle current agricultural requirements. Extension staff members will achieve increased efficiency and flexibility moving forward because they now work

stronger with research institutes along with international development partners (Yaseen et al., 2015).

Enhancing Training Programs and Use of ICTs

Practical experience in multidisciplinary trainings such as integrated pest management, organic agriculture, climate resilient agriculture and conservation practices should be made a core element of these courses. The use of information and communication technology (ICT) and extension services serves as an effective and feasible mechanism for increased knowledge transmission in addition to traditional training, providing access to relevant information at all times for farmers and extension agents, by means of mobile applications, SMS alerts, online lessons and webinars (Kamal *et al.*, 2022).

Inclusive Approaches for Women and Smallholders

Social and cultural (non-medical) and physical (dormant) problems hampering women and smallholder farming. One of the constraints in agricultural extension is the lack of participation of women and smallholder farmers (in part due to sociocultural, economic and logistical constraints) and some of these problems can be overcome by providing access to local services, establishing women-run extension units (WLUs), flexible meeting dates, gender-sensitive training modules, etc. Prioritizing low-cost and sustainable solutions that work within farmers resource limits should also be considered in extension programs catering to smallholder farmers (e. g. guidelines on appropriate irrigation techniques, low-input agriculture technologies, collective buying or marketing strategies) (Amir *et al.*, 2013; Shahbaz *et al.*, 2017; Chambers *et al.*, 2018).

Monitoring, Evaluation, and Accountability Mechanisms

Monitoring, evaluation, and accountability strategies and policies that respond to feedback can be evidence-based, and policymakers can take evidence based decisions about strategies and policies through baseline surveys, performance indicators, and outcome evaluations. This may include mechanisms to measure the performance of extension staff, frequent audits of the public sector, channels to resolve complaints about the extension system and mechanisms for farmers to provide feedback. The implementation of these strategies and policies over time can lead to more effective, farmer-centric extension systems by building trust between farmers and extension providers through implementation of digital platforms to post performance data, and implementation of real-time feedback loops (Rana, 2021).

Conclusion

The Punjab province of Pakistan depends on agricultural extension services for continuously advancing sustainable agricultural production and maintaining food security. The agricultural innovations experience improvement through the development of an open and collaborative approach after transitioning from a rigid top-down model. Extension services build sustainability through their support in teaching farmers more efficient seed choices combined with irrigation methods and pest and disease monitoring strategies. Extension services maintain limited potential because women have not received meaningful empowerment nor have they received their equitable share of land. Moreover, insufficient training together with inadequate funding and poor institutional coordination have brought them down. The issues can be resolved by establishing better institutional systems and integrating digital tools alongside inclusive planning and strengthened monitoring systems that have robust accountability protocols. The correct funding

and regulations for sustainable natural resource use will enable extension services to become the foundation of sustainable and equitable agricultural development in Punjab.

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