



3rd International Conference Food Security and Value Chain Systems: *Innovative Pathways for Sustainability and Resilience*

(ICFSVC-2026)

BOOK OF ABSTRACTS

- Food Security and Sustainable Agriculture
- Climate Change and Environmental Challenges
- Agribusiness, Value Chains and Markets
- Innovation and Digital Agriculture
- Knowledge Sharing, Education and Community Empowerment

ISBN-978-969-23812-2-2



February 11 - 12, 2026



3rd International Conference
**Food Security and Value Chain
Systems:**
Innovative Pathways for Sustainability and Resilience
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MNS University of Agriculture Multan

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Faculty of Social Sciences and Humanities
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Introduction

MNS-University of Agriculture, Multan (MNS-UAM) established in 2012, is a fast-growing public sector university. During the short period of its existence, the University has made rapid progress in terms of expansion of its academic programs, students, enrolment, physical infrastructure, campus network, and hiring of highly qualified and experienced academic and administrative staff. MNSUAM has been recognized as one of the fastest-growing academic institutions in the country. The vision of the university is to develop a world-class university in agricultural and allied sciences by providing effective systems and leadership for professional learning, research, entrepreneurship, and community service.

The Faculty of Social Sciences and Humanities was established in 2017 at MNS-UAM. Keeping in view the current scenario of the world and our own country for ensuring food security, improving quality of life, alleviation of poverty, and overall development in the rural areas. The faculty has three departments i.e. Department of Agricultural and Resource economics, Department of Agribusiness and Entrepreneurship Development and Department of Outreach and Continuing Education. The Faculty of Social Sciences and Humanities is aware of changing scenarios of the sector and emerging challenges of the rural economy of Pakistan and is committed to equip young social and agricultural scientists and agribusiness specialists with updated knowledge and the latest research skills enabling them to handle economic, social, and environmental challenges in achieving the goal of sustainable rural development.

The faculty is currently running undergraduate and postgraduate degree programs in Agricultural & Resource Economics, Farm Management, Agribusiness, Sociology, Economics with Data Science and Agricultural Extension along with short courses under continuing education. Competent faculty and excellent skills are the basic strengths of the faculty to produce technically sound graduates to meet industrial and community requirements.



The Agriculture
ECONOMIST
LEADING AGRICULTURAL
ECONOMICS MAGAZINE
ISSN: 2104-8803





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3rd International Conference

Food Security and Value Chain Systems:

Innovative Pathways for Sustainability and Resilience

The 3rd International Conference on Food Security and Value Chain Systems (ICFSVC-2026), organized at Muhammad Nawaz Shareef University of Agriculture, was of significant scientific and policy relevance, particularly for emerging economies confronting the dual challenge of ensuring food security while strengthening efficient and resilient value chain systems. Held under the theme "Innovative Pathways for Sustainability and Resilience," the conference provided a dynamic platform for researchers, policymakers, development practitioners, and industry stakeholders to exchange ideas, present research findings, and explore transformative approaches for sustainable agri-food systems. As emerging economies continue to face pressures from climate change, population growth, and resource constraints, the conference emphasized the urgent need for climate-smart agriculture, resilient supply chains, digital innovations, and sustainable food distribution mechanisms. The discussions and collaborations fostered during the conference are expected to support the development of policies and technologies that enhance agricultural productivity, reduce post-harvest losses, promote value addition, and improve market access for smallholder farmers. By focusing on sustainable value chain development, the conference also highlighted the importance of creating economic opportunities and improving rural livelihoods through better integration of agricultural markets and agribusiness systems. The conference helped align stakeholders across emerging economies by providing a platform to:

1. Share initiatives and experiences in addressing food insecurity, climate change impacts, and rural poverty.
2. Facilitate the exchange of information, best practices, knowledge, and skills generated through research and development activities.
3. Create awareness about the role of emerging economies in promoting inclusive, resilient, and sustainable agri-food systems while strengthening community resilience against climate change threats.

The 3rd ICFSVC-2026 had a meaningful academic and societal impact by fostering international collaboration, promoting innovative strategies, and encouraging sustainable practices in food security and agricultural value chain systems. The conference highlighted the importance of integrating scientific research, technological innovation, and policy frameworks to strengthen food systems and support sustainable economic growth in developing regions. The insights, research outputs, and policy recommendations emerging from the conference are expected to influence policymakers, researchers, and practitioners in advancing food security initiatives and building resilient agricultural systems.





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The geo-strategic position of Muhammad Nawaz Shareef University of Agriculture makes it particularly well suited to address these challenges. Located in South Punjab—one of Pakistan’s most important agricultural regions—the university serves as an emerging hub for agricultural research, rural development, and policy engagement. Its accessibility from across the country and strong connections with rural communities, agribusiness sectors, government departments, and policy think tanks enable the university to actively contribute to addressing regional and national agricultural challenges. Considering these advantages, the university continues to take a leading role in organizing international platforms that address global as well as regional concerns in food security and sustainable agriculture.

The Faculty of Social Sciences and Humanities, MNSUAM played an active role in advancing the conference theme by promoting interdisciplinary dialogue on the drivers, costs, and outcomes of current and future food security systems. The conference facilitated discussions that helped policymakers, researchers, practitioners, and community stakeholders better understand the complex environmental, nutritional, agricultural, demographic, socio-economic, political, technological, and institutional factors shaping food security. In line with the theme “Innovative Pathways for Sustainability and Resilience,” particular emphasis was placed on exploring innovative research approaches, climate-smart solutions, sustainable value chains, and data-driven technologies. Interactions among participants highlighted how emerging global trends such as climate change, urbanization, green economic transitions, and digital agriculture can be leveraged to strengthen resilient and sustainable agri-food systems for the future.

Themes:

- Food Security and Sustainable Agriculture
- Climate Change and Environmental Challenges
- Agribusiness, Value Chains, and Markets
- Innovation, Technology, and Digital Agriculture
- Knowledge Sharing, Education, and Community Empowerment



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The Role of Financial Performance on Stock Prices: An Empirical Study of Basic Materials Companies Listed on the Indonesian Stock Exchange 2022 – 2024

Anida Almirah Syahid¹, Sabrian Oehoedoe¹, Muh. ¹, Muh. Fajar Alamsyah Razak¹, Nur Patmasari¹, Anisah Nadya¹, Mohammad Shiddiq¹

¹Sekolah Tinggi Ilmu Ekonomi Enam-Enam Kendari, Indonesia

Correspondence to anidalmirahsy@gmail.com

Abstract

Financial performance plays a significant role in influencing stock prices, as it reflects a firm's economic condition and operational effectiveness, thereby shaping investor expectations and market valuation. Previous empirical studies indicate that financial ratios related to profitability and capital structure affect stock price movements in the Indonesian capital market. Research across various sectors listed on the Indonesia Stock Exchange highlights the continued relevance of financial performance indicators, particularly during the post-pandemic period of 2022–2024. This study aims to analyze the effect of financial performance, as measured by Return on Assets (ROA), Return on Equity (ROE), and Debt to Equity Ratio (DER), on the stock prices of agricultural companies in the Basic Materials sector listed on the Indonesia Stock Exchange during the period 2022–2024. This study adopts a quantitative approach using secondary data from annual financial statements and stock prices of agricultural companies in the Basic Materials sector listed on the Indonesia Stock Exchange 2022 - 2024. Financial performance is measured using ROA, ROE, and DER. Multiple linear regression analysis is used to examine their effects on stock prices. The results indicate that financial performance exhibits differing effects on stock prices among agricultural companies in the Basic Materials sector. Return on Assets (ROA) does not show a significant effect on stock prices, suggesting that asset utilization efficiency is not a primary consideration for investors. In contrast, Return on Equity (ROE) has a positive and significant effect, indicating that higher returns to shareholders are positively valued by the market. Meanwhile, Debt to Equity Ratio (DER) does not significantly influence stock prices, reflecting limited investor sensitivity to leverage levels during the study period. This study concludes that financial performance selectively influences stock prices of agricultural companies in the Basic Materials sector. Return on Equity (ROE) positively affects stock prices, reflecting investor preference for shareholder returns. In contrast, Return on Assets (ROA) and Debt to Equity Ratio (DER) show no significant effect, likely due to the capital-intensive nature of the agricultural industry and relatively stable leverage levels. Companies are encouraged to strengthen shareholder returns, while future research should examine additional influencing factors.

Keywords: Financial performance, stock price, agriculture companies, basic materials sector & capital market



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Community Empowerment through the Participatory Local Social Development (PLSD) Framework to Increase Rural Income and Reduce Poverty in Food Value Chain Systems in Namu Village, Southeast Sulawesi.

Sri Rachmawati Rachman¹, Anggi Tri Pratiwi¹, Noor Ian Afrianto¹,

¹Sekolah Tinggi Ilmu Ekonomi Enam Enam Kendari, Indonesia

Correspondence to rachmawatysri1@gmail.com

Abstract

Rural poverty in coastal areas remains a persistent challenge due to limited economic opportunities, weak integration into food value chains, and low community participation in development planning. Namu Village, a coastal village in Southeast Sulawesi, experiences a high incidence of poverty despite its significant local food and tourism potential, with 167 residents classified as extremely poor. Participatory Local Social Development (PLSD), developed by Yutaka Ohama, emphasizes community participation, local norms, organization, and resource utilization as foundations for sustainable development. This study situates PLSD within local food value chain systems to enhance rural income and reduce poverty at the village level. This study aims to analyze and operationalize a PLSD-based community empowerment model to strengthen local food value chains, increase rural household income, and reduce poverty in Namu Village, Southeast Sulawesi. The study adopts a qualitative descriptive design. Data were collected through focus group discussions (FGDs), in-depth interviews, field observations, and document analysis. Primary data were obtained from FGDs with Namu Village residents, and with representatives from the provincial, district, and sub-district governments, as well as the village head and officials. Secondary data were sourced from the National Integrated Social and Economic Data (Data Terpadu Sosial Ekonomi Nasional) of Namu Village (2025), slum settlement area data, and the village demographic profile. Thematic analysis was used to identify patterns in participation, resource utilization, and food value chain integration. The findings indicate that the PLSD framework plays a significant role in strengthening community empowerment at the village level. FGDs reveal that, beyond limited awareness of local potential, rural livelihoods in Namu Village are constrained by insufficient access to markets, particularly in reaching consumers outside the village. This limits the value-added potential of local products despite the availability of diverse resources, including plantation commodities such as cashew nuts, nutmeg, coconut, and cloves; fishing activities predominantly undertaken by men; and handicrafts produced by women using agel plants and coastal shells as souvenirs of Namu Tourism Village. Within this context, PLSD emphasizes community participation, local norms, organizational strengthening, and effective resource utilization as foundations for sustainable development. Through capacity-building initiatives that enhance community knowledge and skills, villagers are enabled to manage local resources more independently. The implementation of PLSD strengthens institutional capacity, improves market linkages, and expands access to information and capital, thereby supporting better integration into local food value chain systems, increasing rural income, and contributing to sustainable poverty reduction. This study concludes that the Participatory Local Social Development (PLSD) framework effectively strengthens community empowerment by enhancing local capacities, institutional roles, and market integration, thereby supporting increased rural income and poverty reduction. To sustain these outcomes, it is recommended that local governments



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institutionalize PLSD principles within village development planning, strengthen collaboration between communities and market actors, and support value chain upgrading through targeted capacity-building and market access programs. Integrating empowerment-oriented interventions with local economic policies is essential to achieving inclusive and sustainable rural development.

Keywords: Participatory Local Social Development; Community Empowerment; Food Value Chain; Rural Income; Poverty Reduction



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Analysis of Increasing the Knowledge of Paddy Farmers through the use of Agricultural Technology in North Konawe Regency

Indira Yuana¹, Muh. Nur¹, Ichsanuddin Akbar¹, Kusman Paluala¹,

¹STIE Enam Enam Kendari

Correspondence to indirayuana09@gmail.com

Abstract

Increasing the knowledge of paddy farmers in North Konawe Regency is an important factor in supporting the productivity and sustainability of the agricultural sector. Adequate knowledge allows farmers to understand proper cultivation techniques, efficient land management, and optimal control of plant pests and diseases. In facing the challenges of climate change, limited resources, and the demands of increasing food production, farmers are required to be able to adapt to the development of science and technology. The use of agricultural technology is one of the strategies that can increase the capacity of farmers to manage farming in a more efficient, modern, and sustainable manner, so as to be able to increase production and the welfare of paddy rice farmers. This study aims to analyze in depth the improvement of knowledge of paddy rice farmers through the use of agricultural technology in North Konawe Regency, covering aspects of understanding, application, and adaptation of technology in rice cultivation activities, as well as identifying factors that affect the level of adoption of agricultural technology by farmers in North Konawe Regency. This study uses a qualitative descriptive approach to gain an in-depth understanding of increasing the knowledge of paddy rice farmers in North Konawe Regency through the use of agricultural technology. Data collection was carried out through field observation to directly observe rice farming practices, in-depth interviews with rice farmers to explore their experiences, perceptions, and levels of understanding of agricultural technology, as well as focus group discussions (FGD) involving farmers and employees of the North Konawe Regency Food Crops and Livestock Service. The data obtained were analyzed descriptively to identify patterns, meanings, and factors that influence the improvement of farmers' knowledge. The results of the study show that the use of agricultural technology by paddy farmers in North Konawe Regency makes a real contribution to improving knowledge and technical capabilities in farm management. The use of agricultural tools and machinery, such as hand tractors and planting machines, increases farmers' understanding of efficient land management and the determination of proper planting time. The application of cultivation technology, including the use of superior varieties, legowo row planting systems, and balanced fertilization, strengthens farmers' knowledge in increasing productivity and crop quality. In addition, the use of digital-based agricultural information, such as weather apps and price information, helps farmers in planting planning and decision-making. However, the level of technology adoption still varies and is influenced by limited access to information, low levels of formal education, and the suboptimal intensity of agricultural assistance and extension in the region. The use of agricultural technology by paddy farmers in North Konawe Regency has proven to contribute positively to the improvement of knowledge and technical capabilities in farm management. The use of agricultural tools and machinery, the application of cultivation technology, and access to digital-based agricultural information increase farmers' understanding of planting planning, land management, fertilization, and agricultural decision-making. However, the level of technology adoption is still uneven due to limited access to information, low education levels, and lack of mentoring. Strengthening of counseling, continuous training, and regional policy support is needed to expand the adoption of agricultural technology evenly and sustainably.

Keywords: Farmer Knowledge, Rice Fields, Agricultural Technology, Extension, Kabupaten Konawe Utara





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The Effect of Competence on Employee Performance

Sulistiani Syafitri¹, Sakti Saputra Alvian¹, Gusti Ayu Putri Sukreni¹

¹Faculty of Economics and Business, Halu Oleo University

Abstract

Competence refers to an individual's ability to perform tasks based on knowledge, skills, and professional behavior aligned with job demands. It represents what employees bring into their work and how they apply their expertise effectively. Previous studies have shown that competence has a positive relationship with employee performance. Employee performance itself is a crucial indicator of organizational success, particularly in state-owned enterprises such as PT PLN UPDK. This study emphasizes the importance of competence in enhancing employee performance and supporting organizational development. This study aims to examine and analyze the effect of employee competence on employee performance at PT PLN UPDK Kendari, and to determine whether competence has a positive and significant influence on performance. The study employed a quantitative research approach. The population consisted of 43 permanent employees of PT PLN UPDK Kendari, all of whom were used as research samples through saturated sampling. Data were collected using questionnaires measured with a Likert scale. The analysis technique used was Partial Least Squares (PLS) with the assistance of WARP PLS 7.0 software to test the effect of competence on employee performance. The results indicate that employee competence has a positive and significant effect on employee performance. Descriptive analysis shows that employees generally have high levels of competence, particularly in knowledge and skills. Employee performance was also rated positively, with quality being the strongest aspect. The PLS analysis revealed a path coefficient of 0.34 with a p-value < 0.01, indicating a significant relationship. The coefficient of determination (R^2) was 0.1156, meaning that competence explains 11.56% of the variance in employee performance. These findings confirm that higher competence leads to better employee performance. The study concludes that competence significantly and positively influences employee performance. Employees with competencies aligned to their roles tend to perform better. Therefore, organizations should prioritize competence development through training, skill enhancement, and proper job placement. It is recommended that management continuously improve employee competencies to optimize performance and support organizational goals.

Keywords: competence, employee performance



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The Role of Human Resource Management in Achieving Sustainable Agriculture Indonesia

Andi Adawiah¹, Ibrahim¹, Andi Zulkifli Nusri¹, Puji Rahmah¹, Irfan Ahmad Baig², Umar Ijaz Ahmed²

¹Magister of Management Department, Management Department, Informatics Engineering Department, Management Department, Universitas Lamappapoleonro Soppeng, Indonesia,

²Faculty of Social Science & Humanities, MNS University of Agriculture, Multan, Pakistan,

Correspondence to aadawiah@unipol.ac.id

Abstract

Sustainable agriculture has become a strategic priority in Indonesia due to increasing environmental pressures, climate change, population growth, and the need to ensure long-term food security. As an agrarian country, Indonesia relies heavily on the agricultural sector not only as a source of food supply but also as a major contributor to employment and rural livelihoods. However, conventional agricultural practices have often resulted in environmental degradation, inefficient resource use, and social inequality, which threaten the sustainability of the sector. In Indonesia, challenges such as limited access to training, low levels of education, uneven institutional support, and weak coordination among stakeholders continue to hinder the development of agricultural human resources. Therefore, understanding how HRM contributes to sustainable agriculture is essential for designing effective strategies to strengthen human capital in the agricultural sector. This study examines the role of Human Resource Management in achieving sustainable agriculture in Indonesia, focusing on its contribution to human resource development and sustainability outcomes. This study aims to analyze the role of Human Resource Management in supporting sustainable agriculture in Indonesia by examining how human resource development, training, motivation, and institutional support contribute to the adoption of sustainable agricultural practices, improved productivity, and long-term environmental, economic, and social sustainability. This study adopts a qualitative descriptive research approach to explore the role of Human Resource Management in achieving sustainable agriculture in Indonesia. Data was collected through a combination of literature review, in-depth interviews, and field observations. Primary data was obtained from interviews with farmers, agricultural extension officers, and relevant stakeholders involved in agricultural development. Secondary data were collected from academic journals, government publications, policy documents, and reports related to HRM and sustainable agriculture in Indonesia. The data were analyzed using thematic analysis to identify key patterns and themes related to HRM practices and sustainability in the agricultural sector. The findings of this study showed that Human Resource Management plays a significant role in promoting sustainable agriculture in Indonesia. HRM practices such as training and capacity building were found to improve farmers' knowledge and skills in sustainable farming techniques, including soil conservation, efficient water use, and environmentally friendly pest management. In addition, motivation, leadership, and institutional support were identified as important factors influencing farmers' willingness to adopt sustainable practices. Effective agricultural extension services and collaborative farmer groups contributed positively to knowledge sharing and collective action. However, the study also revealed several challenges, including limited access to continuous training, unequal distribution of extension services, and insufficient integration of sustainability principles into HRM policies at the local level. Effective agricultural extension services and collaborative farmer organizations were shown to play an important role in facilitating knowledge sharing, collective learning, and coordinated action among farmers. This study concludes that Human



Resource Management is a crucial factor in achieving sustainable agriculture in Indonesia. Effective HRM practices enhance the capacity, motivation, and performance of agricultural human resources, thereby supporting environmental protection, economic resilience, and social well-being. Strengthening HRM systems in the agricultural sector is essential to ensure the long-term sustainability and competitiveness of Indonesian agriculture. Therefore, it is recommended that the government should strengthen HRM policies in agriculture by expanding access to continuous training and education on sustainable agricultural practices.

Keywords: Human, Resource, Management, Sustainable, Agriculture



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February 11 - 12, 2026
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Digital Marketing Strategies for Small-Scale Agricultural Products in Makassar, South-Sulawesi Province, Indonesia.

Muchlis Abbas¹, Puji Rahmah¹, Arnida¹, Tamrin Meda¹, Asri Nur Muin², Umar Ijaz Ahmed³

¹Magister of Management Department, Management Department, Universitas Lamappapoleonro Soppeng, Indonesia, Entrepreneurship Department, Universitas Handayani, Indonesia.

²Department of Management, STIE YPUP, Indonesia.

³Department of Agricultural and Resource Economics, Faculty of Social Science & Humanities, MNS University of Agriculture, Multan, Pakistan

Correspondence to muchlis@unipol.ac.id

Abstract

The rapid development of digital technology has significantly transformed marketing practices across various economic sectors, including agriculture. For small-scale agricultural producers, digital marketing offers new opportunities to expand market reach, increase product visibility, and improve income levels. In urban areas such as Makassar, where digital adoption and internet penetration continue to grow, digital platforms have become increasingly important for connecting small-scale farmers with consumers. Despite this potential, many small-scale agricultural producers in Makassar still rely on traditional marketing channels, such as local markets and intermediaries. Limited digital literacy, lack of marketing skills, and inadequate access to digital infrastructure remain major challenges. This study aims to analyze the digital marketing strategies applied to small-scale agricultural products in Makassar by examining the use of digital platforms, online marketplaces, and social media as marketing tools, as well as evaluating their effectiveness in expanding market reach, enhancing customer engagement, increasing sales performance, and supporting the long-term sustainability of small-scale agricultural businesses. This study employs a descriptive qualitative research approach. Data were collected through observations and documentation. Primary data were obtained through semi-structured interviews to explore marketing practices, digital platform usage, and perceived benefits and challenges. Secondary data were collected from academic literature, government reports, and online sources related to digital marketing and agricultural product marketing. Data analysis was conducted using thematic analysis to identify patterns and key themes related to digital marketing strategies and their effectiveness. The results of the study indicated that the implementation of digital marketing strategies forms a continuous and interrelated pattern in enhancing the competitiveness of small-scale agricultural products in Makassar. The use of social media and digital marketplaces serves as the initial stage that enables producers to conduct promotional activities and interact directly with consumers more effectively. These digital marketing activities contribute to increased consumer trust and expanded market reach. The subsequent impact of this process is reflected in higher sales and repeat purchases, which ultimately strengthen product competitiveness. However, the effectiveness of this pattern is still influenced by limitations in digital skills, product quality consistency, and distribution and logistics constraints, which need to be addressed to optimize the benefits of digital marketing in a sustainable manner. The use of digital marketplaces and online delivery services contributed to expanded market reach and increased sales. Producers who actively managed digital content and customer interactions experienced higher consumer trust and repeat purchases. However, several challenges were identified, including limited digital skills, inconsistent product quality, and logistical constraints related to distribution and delivery. This study concludes that digital marketing strategies are essential for



enhancing the market access and business sustainability of small-scale agricultural products in Makassar. Effective use of social media and online marketplaces enables producers to reach a wider consumer base, reduce dependence on intermediaries, and increase sales performance. However, the success of digital marketing largely depends on digital literacy, product consistency, and logistical support. Therefore, it is recommended that Local governments and related institutions should provide digital marketing training and capacity-building programs for small-scale agricultural producers. Furthermore, small-scale producers should be encouraged to adopt integrated digital marketing strategies, combining social media, online marketplaces, and branding techniques.

Keywords: Digital, Marketing, Small-Scale, Agricultural Products, Makassar



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The Role of Accounting Information Systems in Supporting Digital Agriculture Innovation in Indonesia

Jamauddin¹, Anni Suryani¹, Sitti Hartini Rachman¹, Siti Intan Nuraini¹, Siska Widya Sari¹

¹Doctoral in Management, Accountant Department, STIE AMKOP, Indonesia.

Correspondence to jamaluddinbatailyas@gmail.com

Abstract

The agricultural sector plays a vital role in Indonesia's economic development by providing employment, supporting rural livelihoods, and ensuring food security. Accounting Information Systems (AIS) serve as an essential tool for managing financial and operational information within agricultural enterprises. Through accurate, timely, and integrated information, AIS support planning, budgeting, cost control, and performance evaluation. In the context of digital agriculture, AIS enable agribusinesses to assess the financial feasibility of technological investments, monitor operational efficiency, and enhance transparency and accountability. Despite the increasing importance of digital agriculture in Indonesia, many agricultural enterprises—particularly small and medium-sized agribusinesses—face challenges in adopting and optimizing Accounting Information Systems. This study aims to To comprehensively analyze the role of Accounting Information Systems in supporting digital agriculture innovation in Indonesia by examining how system integration, information quality, and real-time financial reporting facilitate technology adoption, innovation-driven decision-making, and operational efficiency in agricultural enterprises. This study employs a qualitative descriptive research approach based on a comprehensive literature review. Data were collected from secondary sources, including academic journals, government reports, policy documents, and publications from national and international organizations related to accounting information systems and digital agriculture. A content analysis technique was used to examine the relationship between AIS implementation and digital agriculture innovation. The analysis focused on key dimensions such as information quality, system integration, decision support capability, and organizational readiness. Relevant case examples from Indonesian agricultural enterprises were also reviewed to support the analysis. The findings of this study indicate that Accounting Information Systems play a crucial role in supporting digital agriculture innovation in Indonesia. AIS enhance financial planning, budgeting, and cost management, enabling agricultural enterprises to evaluate and adopt digital technologies more effectively. Integrated AIS improve data accuracy and timeliness, which are essential for managing complex and technology-driven agricultural operations. Furthermore, AIS contribute to improved transparency and accountability through standardized financial reporting and real-time performance monitoring. These features support strategic decision-making and reduce financial risks associated with digital innovation. However, the study also identifies several challenges, including limited access to digital infrastructure, insufficient accounting and technological skills, high implementation costs, and resistance to organizational change, particularly among small-scale agricultural enterprises. This study concludes that Accounting Information Systems play a significant role in supporting digital agriculture innovation in Indonesia by improving financial management, decision-making quality, and operational efficiency. Effective AIS implementation enables agricultural enterprises to better manage resources, assess investment feasibility, and strengthen their innovation capacity. Therefore, it is recommended that Agricultural enterprises should adopt integrated and user-friendly Accounting Information Systems tailored to digital agriculture needs. Furthermore, capacity-building programs should be strengthened to improve accounting, digital, and technological literacy among agricultural stakeholders.

Keywords: Accounting, Systems, Supporting, Digital Agriculture, Innovation





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Digital Business Transformation as a Strategy to Enhance National Food Security in Indonesia

Hasrullah Liong Misi¹, Ahmad Fauzan¹, El yana¹, Inayah¹

¹Digital Business Department, STIE AMKOP, Indonesia

Correspondence to dgruppa63@gmail.com

Abstract

In Indonesia, challenges related to food availability, accessibility, affordability, and sustainability remain significant due to population growth, climate change, distribution inefficiencies, and structural issues in the agricultural sector. These challenges have been further intensified by global disruptions, such as economic volatility and supply chain shocks. In recent years, the rapid development of digital technology has transformed various sectors of the economy, including agriculture and food systems. Digital business transformation through e-commerce platforms, digital supply chains, agritech startups, data-driven farming, and online marketplaces—has emerged as a promising strategy to improve efficiency, transparency, and inclusiveness within the food sector. Digital platforms enable direct connections between farmers, distributors, and consumers, reduce transaction costs, and minimize post-harvest losses. This study aims to comprehensively analyze the role of digital business transformation in supporting national food security in Indonesia by examining how digital technologies, platforms, and business models contribute to improving food availability, accessibility, distribution efficiency, and sustainability across the food system. This study employs a qualitative descriptive research approach with a literature-based analysis. Data were collected from secondary sources, including academic journals, government reports, policy documents, industry publications, and reports from international organizations related to food security and digital transformation. The analysis focuses on identifying patterns, trends, and relationships between digital business practices and food security dimensions, such as availability, access, utilization, and stability. A content analysis method was applied to examine how digital technologies and business models contribute to improving food system performance in Indonesia. In addition, comparative analysis was used to assess best practices and relevant case examples from digital agribusiness initiatives. The findings of this study indicate that digital business transformation plays a significant role in supporting national food security in Indonesia. Digital platforms facilitate more efficient food distribution by shortening supply chains and connecting producers directly with consumers, thereby reducing price disparities and food waste. E-commerce and digital marketplaces improve market access for farmers and food-based micro, small, and medium enterprises (MSMEs), leading to increased income and economic resilience. Furthermore, the use of digital technologies such as data analytics, mobile applications, and digital payment systems enhances production planning, inventory management, and price transparency. Agritech innovations support farmers in accessing real-time information on weather, inputs, and market demand, contributing to increased productivity and sustainability. However, the study also identifies several challenges, including unequal digital infrastructure across regions, limited digital literacy among farmers, data integration issues, and regulatory constraints. These challenges may hinder the optimal contribution of digital business transformation to food security if not addressed comprehensively. This study concludes that digital business transformation has strong potential to support national food security in Indonesia by improving efficiency, inclusiveness, and sustainability within the food system. Digital business models



contribute positively to food availability and accessibility through enhanced distribution networks, improved market connectivity, and increased farmer empowerment. Therefore, it is recommended that the government should strengthen digital infrastructure and internet connectivity, particularly in rural and agricultural areas. Furthermore, capacity-building programs should be implemented to improve digital literacy among farmers and food sector actors.

Keywords: Human, Resource, Management, Sustainable, Agriculture Indonesia



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Sustainable Agricultural Entrepreneurship as a Strategy for Economic and Environmental Resilience in Indonesia

Rezvanny Maricar¹, Ahmad Fakhri¹, Trianda¹, Ulfiah Salsabila¹

¹Entrepreneurship Department, STIE AMKOP, Indonesia.

Correspondence to vannymaricar@gmail.com

Abstract

Agriculture plays a crucial role in Indonesia's economy by providing employment, supporting rural livelihoods, and ensuring food availability. These challenges threaten both economic stability and environmental sustainability, particularly for smallholder farmers who dominate Indonesia's agricultural landscape. In response to these challenges, sustainable agricultural entrepreneurship has emerged as a strategic approach to strengthen economic and environmental resilience. Sustainable agripreneurs integrate entrepreneurial innovation with environmentally responsible agricultural practices, such as organic farming, efficient resource management, and climate-smart agriculture. Through value creation, market-oriented strategies, and sustainable business models, agricultural entrepreneurship can enhance income diversification, reduce vulnerability to external shocks, and promote environmental conservation. This study aims to comprehensively analyze the role of sustainable agricultural entrepreneurship in strengthening economic resilience in Indonesia by examining how entrepreneurial innovation, sustainable business models, and value-added agricultural activities contribute to income diversification, employment generation, and the ability of farming communities to withstand economic shocks. This study employs a qualitative descriptive research approach based on a literature review and conceptual analysis. Data were collected from secondary sources, including academic journals, government publications, policy documents, and reports from national and international organizations related to sustainable agriculture, entrepreneurship, and environmental resilience. The analysis was conducted using thematic content analysis to identify patterns and relationships between sustainable agricultural entrepreneurship and resilience outcomes. The study focuses on economic indicators such as income diversification and market access, as well as environmental indicators such as resource efficiency, soil conservation, and biodiversity preservation. The findings of this study indicate that sustainable agricultural entrepreneurship plays a significant role in enhancing both economic and environmental resilience in Indonesia. Economically, sustainable agripreneurs contribute to income stability by diversifying agricultural products, adding value through processing and branding, and expanding market access through cooperatives and digital platforms. From an environmental perspective, sustainable entrepreneurial practices—such as organic farming, integrated farming systems, agroforestry, and climate-smart agriculture—support soil fertility, water conservation, and biodiversity protection. These practices reduce environmental degradation while increasing long-term productivity. However, the study also identifies several challenges, including limited access to financing, inadequate entrepreneurial and technical skills, uneven digital and physical infrastructure, and regulatory constraints. These factors limit the scalability and sustainability of agricultural entrepreneurship initiatives, particularly among smallholder farmers. This study concludes that sustainable agricultural entrepreneurship represents an effective strategy for strengthening economic and environmental resilience in Indonesia. By integrating entrepreneurship with sustainable agricultural practices, agripreneurs enhance rural income, improve environmental quality, and increase the adaptive capacity of agricultural systems to economic and ecological shocks. Therefore, it is recommended that The government should strengthen policies and incentive programs that support sustainable agricultural



entrepreneurship, particularly for smallholder farmers. And then Capacity-building programs should be expanded to improve entrepreneurial skills, sustainability knowledge, and technological adoption.

Keywords: Sustainable, Agricultural Entrepreneurship, Strategy, Economic Environmental, Resilience



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February 11 - 12, 2026
MNS University of Agriculture Multan

Digital Agriculture as a Component of the Digital Economy: Economic Implications

Nurfaisah Baharuddin¹, St Hatidja¹, Kurniawaty¹, Fani Rahmasari¹, Mauhud Arkan Fauzan¹

¹Management Department, Doctoral in Management Department, STIE AMKOP, Indonesia.

Correspondence to nurfaisah.baharuddin@gmail.com

Abstract

Agriculture, traditionally characterized by labor-intensive and resource-based activities, is increasingly influenced by digital technologies such as precision farming, Internet of Things (IoT), big data analytics, artificial intelligence, and digital platforms. This transformation, commonly referred to as digital agriculture. Digital agriculture plays an important role as a component of the digital economy by enhancing productivity, improving market access, reducing transaction costs, and increasing efficiency across agricultural value chains. Through the integration of digital tools, farmers and agribusinesses can make data-driven decisions, optimize resource use, and respond more effectively to market demand. These changes have substantial economic implications, particularly in terms of income generation, competitiveness, and structural transformation within the agricultural sector. To analyze the role of digital agriculture within the digital economy framework by assessing its impact on agricultural innovation, institutional adaptation, efficiency of production systems, and the resilience of the agricultural sector. This study employs a qualitative descriptive research approach based on a literature review and conceptual analysis. Data were collected from secondary sources, including academic journals, government publications, policy documents, and reports from national and international organizations related to sustainable agriculture, entrepreneurship, and environmental resilience. The analysis was conducted using thematic content analysis to identify patterns and relationships between sustainable agricultural entrepreneurship and resilience outcomes. The study focuses on economic indicators such as income diversification and market access, as well as environmental indicators such as resource efficiency, soil conservation, and biodiversity preservation. The findings of this study indicate that sustainable agricultural entrepreneurship plays a significant role in enhancing both economic and environmental resilience in Indonesia. Economically, sustainable agripreneurs contribute to income stability by diversifying agricultural products, adding value through processing and branding, and expanding market access through cooperatives and digital platforms. From an environmental perspective, sustainable entrepreneurial practices—such as organic farming, integrated farming systems, agroforestry, and climate-smart agriculture—support soil fertility, water conservation, and biodiversity protection. These practices reduce environmental degradation while increasing long-term productivity. However, the study also identifies several challenges, including limited access to financing, inadequate entrepreneurial and technical skills, uneven digital and physical infrastructure, and regulatory constraints. These factors limit the scalability and sustainability of agricultural entrepreneurship initiatives, particularly among smallholder farmers. This study concludes that sustainable agricultural entrepreneurship represents an effective strategy for strengthening economic and environmental resilience in Indonesia. By integrating entrepreneurship with sustainable agricultural practices, agripreneurs enhance rural income, improve environmental quality, and increase the adaptive capacity of agricultural systems to economic and ecological shocks. Therefore, it is recommended that The government should strengthen policies and incentive programs that support sustainable agricultural entrepreneurship, particularly for smallholder farmers. And then Capacity-building



programs should be expanded to improve entrepreneurial skills, sustainability knowledge, and technological adoption.

Keywords: Sustainable, Agricultural Entrepreneurship, Strategy, Economic Environmental, Resilience



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February 11 - 12, 2026
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Economic Policy and Digital Agriculture Innovation for Sustainable Development

Umi Farida¹, Nurfaishah Baharuddin¹

¹Magister of Management Study Program, Department of Management, STIE AMKOP, Indonesia
Correspondence to farida.unm@gmail.com

Abstract

Sustainable development has become a central objective of economic policy in many countries, particularly in the context of increasing environmental challenges, food security concerns, and economic inequality. The agricultural sector plays a strategic role in achieving sustainable development, as it contributes to economic growth, employment, and rural welfare while also directly interacting with natural resources. However, traditional agricultural practices often face limitations related to low productivity, inefficient resource use, and vulnerability to climate change. The integration of digital technologies—such as precision farming, data analytics, digital platforms, and smart supply chain system has the potential to enhance productivity, improve resource efficiency, and reduce environmental impacts. This study aims to To analyze the role of economic policy in promoting digital agriculture innovation through the evaluation of regulatory framework and institutional arrangements that support the adoption of digital technologies in the agricultural sector. This study employs a qualitative-descriptive and analytical approach. Data are collected through a comprehensive review of academic literature, government policy documents, and reports from international organizations related to economic policy, digital agriculture, and sustainable development. In addition, secondary data from national statistics and development agencies are analyzed to support the discussion. The analysis focuses on identifying policy instruments, innovation mechanisms, and sustainability indicators. A thematic analysis method is used to examine the relationship between economic policy frameworks and digital agriculture innovation, while a comparative analysis is applied to assess best practices and policy implications. The findings indicate that economic policy plays a crucial role in accelerating digital agriculture innovation. Supportive policies—such as investment incentives, digital infrastructure development, and innovation-friendly regulations—significantly encourage the adoption of digital technologies in the agricultural sector. Digital agriculture innovation contributes positively to productivity growth, cost efficiency, and income generation, particularly for small and medium-scale farmers. Moreover, the integration of digital solutions improves environmental sustainability by optimizing resource use, reducing waste, and minimizing the environmental footprint of agricultural activities. However, the study also identifies several challenges, including unequal access to digital infrastructure, limited digital literacy among farmers, and insufficient coordination among policy institutions. This study concludes that the alignment between economic policy and digital agriculture innovation is essential for achieving sustainable development. Effective economic policies can create an enabling environment for digital innovation, leading to improved economic performance, environmental sustainability, and social inclusion in the agricultural sector. Without strong policy support, the potential benefits of digital agriculture for sustainable development may not be fully realized. Therefore, it is recommended that strengthening economic policies that support digital infrastructure development in rural areas and enhancing policy incentives for investment in digital agriculture technologies and innovation.

Keywords: Economic, Policy, Digital, Agriculture, Innovation



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Digital Agriculture Innovation and Economic Development in Indonesia

St Hatidja¹, Jamaluddin¹, Nurfaishah Baharuddin¹

¹Management Department, Doctoral in Management Department, STIE AMKOP, Indonesia.

Correspondence to sthatidja68@gmail.com

Abstract

Agriculture remains a key sector in Indonesia's economic development, contributing to growth through digital technologies (IoT), big data analytics, artificial intelligence, and digital agricultural platforms. Digital agriculture innovation plays an increasingly important role in supporting economic development by improving resource allocation, reducing production and transaction costs, and expanding market access for farmers and agribusinesses. Through digital platforms, farmers can access real-time information on weather, inputs, prices, and market demand, enabling more informed decision-making and greater economic resilience. Moreover, digital agriculture supports value chain integration and encourages entrepreneurship and innovation in rural areas. These challenges may affect the extent to which digital agriculture contributes to inclusive and sustainable economic development. This study aims to comprehensively analyze the role of digital agriculture innovation in supporting economic development in Indonesia by examining how the adoption of digital technologies, data-driven farming practices, and digital platforms contributes to increased agricultural productivity, income growth, market efficiency, and inclusive rural economic development. This study employs a qualitative descriptive research approach based on a literature review and secondary data analysis. Data were collected from academic journals, government reports, policy documents, and publications from international organizations related to digital agriculture and economic development. The analysis was conducted using thematic content analysis to identify relationships between digital agriculture innovation and economic outcomes. Key indicators analyzed include productivity growth, cost efficiency, income diversification, and market access. Relevant case studies and empirical findings from Indonesia were used to support the analysis. The findings of this study indicate that digital agriculture innovation contributes positively to economic development in Indonesia. The adoption of digital technologies enhances agricultural productivity through improved input management, precision farming practices, and data-driven decision-making. Digital platforms facilitate better market access, reduce information asymmetry, and improve price transparency, leading to increased income for farmers and agribusiness actors. Furthermore, digital agriculture innovation supports rural economic development by promoting entrepreneurship, creating employment opportunities, and strengthening agricultural value chains. However, the study also identifies several challenges, including limited access to digital infrastructure in rural areas, low digital literacy among farmers, high technology adoption costs, and regulatory barriers. These constraints may limit the scalability and inclusiveness of digital agriculture innovation. This study concludes that digital agriculture innovation plays a significant role in supporting economic development in Indonesia. By improving productivity, efficiency, and market integration, digital agriculture contributes to income growth, competitiveness, and structural transformation within the agricultural sector. Therefore, it is recommended that the government should strengthen digital infrastructure and internet connectivity in rural and agricultural areas. Furthermore, capacity-building programs should be expanded to improve digital literacy and technological skills among farmers and agribusiness actors.

Keywords: Digital, Agriculture, Innovation, Economic, Indonesia



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Digital Marketing Strategies for Dragon Fruits in Makassar City

Muh. Fadhel G Bata Ilyas¹, Gunawan¹

¹Management Department, Doctoral in Management Study Program, Sekolah Tinggi Ilmu Ekonomi
AMKOP, Indonesia

Correspondence to fadhelgunawanbi@gmail.com

Abstract

The advancement of information and communication technology has significantly transformed marketing practices across various sectors, including agriculture. Digital marketing has become an effective strategy for promoting agricultural products, expanding market reach, and improving communication. For horticultural products such as dragon fruit, which are highly perishable and sensitive to market price fluctuations, effective marketing strategies are essential to maintain product value and income stability for producers. In Makassar City, dragon fruit products are cultivated and marketed by small-scale farmers and micro-entrepreneurs. Despite increasing consumer interest in healthy and fresh fruit, the marketing of dragon fruit still faces several challenges, including limited market access, dependence on traditional distribution channels, price volatility, and low product differentiation. To examine the role of digital marketing strategies in promoting dragon fruit products in Makassar City and to evaluate their contribution to market expansion, consumer awareness, and the economic performance of dragon fruit businesses. This study adopts a qualitative descriptive research design. Primary data were collected through semi-structured interviews with dragon fruit farmers, traders, and small agribusiness owners operating in Makassar City. Observations of digital marketing activities on social media platforms and online marketplaces were also conducted to assess marketing practices and content strategies. Secondary data were obtained from academic literature, government publications, and digital marketing reports related to agricultural marketing. Data analysis was carried out using thematic analysis to identify patterns related to platform utilization, marketing effectiveness, customer interaction, and perceived benefits of digital marketing strategies. The findings reveal that digital marketing strategies play a significant role in enhancing the marketing performance of dragon fruit products in Makassar City. Social media platforms—particularly Instagram, Facebook, and WhatsApp—are the most widely used tools due to their accessibility, low cost, and broad user base. Online marketplaces further support market expansion beyond local consumers. Digital marketing improves product visibility, facilitates direct communication with customers, and increases transparency in pricing and product quality. Respondents reported increased consumer awareness and improved sales performance after adopting digital marketing strategies. However, several challenges persist, including limited digital marketing skills, inconsistent content management, lack of branding strategies, and minimal use of data analytics to evaluate marketing performance. This study concludes that digital marketing strategies offer substantial potential to enhance the competitiveness and market reach of dragon fruit products in Makassar City. The effective use of social media and online marketplaces enables producers and traders to access wider markets, strengthen consumer engagement, and improve sales outcomes. Therefore, it is recommended that Dragon fruit producers and traders should enhance their digital marketing capabilities through continuous training and skill development. And Local governments and agricultural institutions should provide structured digital then, marketing training programs tailored to horticultural products.

Keywords: Digital, Marketing, Strategies, Dragon, Makassar





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Collaborative Governance in Police Oversight Systems: Internal and External Synergy of The South Sulawesi Regional Police

Andi Asmar Alimuddin¹, Ansar²

¹Faculty of Social Sciences and Law, Universitas Negeri Makassar

²Doctoral in Management Study Program, Sekolah Tinggi Ilmu Ekonomi AMKOP, Indonesia

Correspondence to andiasmar02@gmail.com

Abstract

The Indonesian National Police (Polri) continue to face demands for structural, cultural, and instrumental reform. These demands converge on the vision of establishing a Presisi institution—one that is Predictive, Responsible, and Transparent with Justice. Challenges in modern oversight arise because issues of police accountability and ethics often constitute wicked problems, i.e., complex issues that cannot be resolved within the confines of a single organization. The limitations of government, driven by a series of changes in the implementation of New Public Management ideas, demonstrate an inability to address severe problems beyond organizational boundaries. Collaborative Governance (CG) offers the necessary framework to manage the complexity. This study aims to analyze the implementation of the Collaborative Governance (CG) model within the oversight system of the South Sulawesi Regional Police through synergy between internal and external actors. The focus of the investigation is the implementation of CG, examined through three dimensions: (1) Communication, (2) Resources, and (3) Implementers' Attitudes. The type of research employed is qualitative with a descriptive approach, aimed at producing a systematic, factual, and accurate description of the implementation of Collaborative Governance (CG) in the police oversight system at the South Sulawesi Regional Police (Polda Sulawesi Selatan). This approach is relevant because police oversight involves complex social interactions and policy processes, requiring an in-depth case study. The research locus is the South Sulawesi Regional Police, involving internal oversight actors (Itwasda, Propam) and external oversight actors (Kopolnas, Ombudsman RI West Sulawesi Representative, and media/community representatives). The implementation of Collaborative Governance (CG) in the oversight of the West Sulawesi Regional Police (Polda Sulbar) is analyzed using Van Meter and Van Horn's variables Communication and the Principle of Principled Engagement. At the strategic level, the initiation of communication by the West Sulawesi Police Chief (Kapolda Sulbar) with various community elements and the media demonstrates a strong commitment to Principled Engagement, which serves as a fundamental foundation of CG. Resources and the Principle of Capacity for Joint Action Resource analysis indicates that the Capacity for Joint Action at Polda Sulbar is still hindered by a serious deficit in internal resources. Implementers' Attitudes (Disposition) and the Principle of Shared Motivation Implementers' attitudes reflect the disposition (willingness) of actors to collaborate. The leadership of Polda Sulbar has shown a positive disposition, evidenced by initiatives to synergize with the media and the commitment to respond to pressures from Kopolnas. However, low public participation reflects a failure to cultivate a sense of ownership and Shared Motivation at the community level. The implementation of Collaborative Governance (CG) in the oversight system of the South Sulawesi Regional Police (Polda Sulawesi Selatan) can be concluded to be at a transitional CG stage. Internal synergy (Itwasda, Propam) and external synergy (Kopolnas, Ombudsman, media) have been formalized and demonstrate strong Principled Engagement. Therefore, it is recommended that Polda Sulbar prioritize budget reallocation for the training and recruitment of professional human resources, particularly forensic auditors, IT/cyber



personnel, and data managers within internal oversight units (Itwasda and Propam). The formalization of partnerships with expert institutions (BPKP, BPK) for auditor training should be enhanced into a continuous certification program.

Keywords: Collaborative, Governance, Police, Oversight, South-Sulawesi



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February 11 - 12, 2026
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Transformation Of Information Technology-Based Management Information System Policies in Police Recruitment

Andi Sirajuddin¹, Ramli¹

¹Faculty of Social Sciences and Law, Doctoral in Public Administration Study Program, Universitas Negeri Makassar, Indonesia

Correspondence to abdisira501@gmail.com

Abstract

The rapid development of information and communication technology in the 21st century has fundamentally transformed human life, including governance and public administration. This phenomenon, often referred to as the Fourth Industrial Revolution (Industry 4.0) and now progressing toward Society 5.0. Requires public organizations to move away from the rigid, slow, and opaque traditional bureaucratic paradigm toward an agile, efficient, and transparent Digital Governance paradigm. Public demands for bureaucratic reform within the Indonesian National Police (Polri) have intensified, particularly. The lingering stigma of past recruitment processes, perceived to be rife with practices of Corruption, Collusion, and Nepotism (KKN), presents a significant challenge that must be addressed. The primary focus of this study is to evaluate the success of the implementation of the Information Technology-Based Management Information System in Police Recruitment, examined through three dimensions: (1) communication, (2) resources, and (3) implementers' attitudes. These three dimensions are adopted from the Van Meter and Van Horn model. The type of research employed in this study is qualitative, aiming to describe the implementation of the online selection system for police candidates at the West Sulawesi Regional Police. A qualitative approach was chosen because it allows for an in-depth exploration of phenomena, an understanding of the meaning behind numerical data, and the capture of the dynamics of interactions among actors involved in policy implementation. The focus of the investigation is the implementation of the information technology-based management information system in police recruitment, examined through three dimensions: (1) communication, (2) resources, and (3) implementers' attitudes. The study showed that communication aspect of the online selection system implementation at the West Sulawesi Regional Police (Polda Sulawesi Barat) reveal a complex dynamic. Although the Indonesian National Police (Polri) is known as an organization with a strict Command and Control structure, the implementation of information technology introduces new communication challenges that have not been fully addressed. Based on interviews with research informants and field observations, it can be concluded that communication is less effective at certain levels. There is often a lack of understanding of information from senior leadership down to implementers. In the context of Polri recruitment, strategic policies are formulated by the Human Resources Staff (SSDM) at the National Police Headquarters in Jakarta. These policies are then disseminated to Polda Sulbar via Telegram Letters (TR) containing instructions and guidance (Jukrah). At the Polda level, this information is generally well understood by top officials (Karo SDM, Kabag Dalpers). The implementation of the online selection system at the West Sulawesi Regional Police, viewed from the communication aspect, has not been fully effective across all levels. In terms of resources (human, financial, and technological), implementation still faces a significant gap between the system's requirements and field realities. From the perspective of implementers' attitudes, there are a dualism between integrity commitment and resistance to adaptation. Therefore, it is recommended to develop more effective two-way communication channels, such as a 24-hour AI-based digital helpdesk or





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Visionary Leadership Innovation in The Midst of Bureaucratic Reform (A Case Study of The South Sulawesi Regional Police)

Dedi Surya Dharma¹, Rifdan¹

¹Faculty of Social Sciences and Law, Doctoral in Public Administration Study Program, Universitas Negeri Makassar, Indonesia

Correspondence to dedisuryadharma04@gmail.com

Abstract

South Sulawesi, as the largest and most populous province in Eastern Indonesia, presents unique demographic and sociological challenges for law enforcement institutions. With an egalitarian yet critical society and the potential for communal conflict, the South Sulawesi Regional Police (Polda Sulsel) are required to demonstrate a high level of organizational agility. Within this constellation of challenges, leadership emerges as a determining variable. Empirical data indicate that during the period 2023–2025, Polda Sulsel achieved performance outcomes that were anomalous compared to national trends. The objective of this study is to analyze the characteristics of visionary leadership implemented by the Chief of the South Sulawesi Regional Police (Kapolda Sulsel). Furthermore, the study assesses the extent to which these innovations have been effective in enhancing the Community Satisfaction Index (CSI) and the performance of equitable law enforcement. This study adopts a qualitative approach using a case study method. The data are derived from documentary and literature research, including policy documents, performance reports, media publications, and academic literature. Data analysis is conducted through three interrelated stages: data reduction, data display, and conclusion drawing. The collected data are classified according to key thematic categories—leadership, digital innovation, cultural innovation, and impact—and their validity is examined through source triangulation, by comparing policy statements with their implementation in practice. The analysis further integrates quantitative data (Community Satisfaction Index statistics) to strengthen the qualitative arguments. Bureaucratic reform at the South Sulawesi Regional Police (Polda Sulsel) demonstrates that with a clear vision, strong integrity, and relentless innovation, a police institution can transform into a trusted, professional, and community-loved public service. Therefore, it is recommended that Regular technology audits of the 13 existing applications are necessary to ensure data security, user-friendly interfaces, and data integration across applications (interoperability) to prevent overlapping functionalities. Furthermore, conduct extensive socialization and education for rural communities on how to use police service applications, while providing hybrid service alternatives for areas with limited internet access.

Keywords: Visionary, Leadership, Innovation, Bureaucratic, Police



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February 11 - 12, 2026
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Digital-Based Public Service Innovation: The Effectiveness of Electronic Traffic Law Enforcement (ETLE) in Traffic Bureaucratic Reform at the South Sulawesi Regional Police

Monalisa Sadra¹, Andi Kasmawati¹

¹Faculty of Social Sciences and Law, Doctoral in Public Administration Study Program, Universitas Negeri Makassar, Indonesia

Correspondence to monazadra3549@gmail.com

Abstract

The paradigm of public service delivery in Indonesia is currently undergoing a fundamental transition, shifting away from the traditional, rigid, and hierarchical Weberian bureaucratic model. The Indonesian National Police, as the frontline institution responsible for maintaining public security and order, faces substantial pressure to undertake institutional reform. The South Sulawesi Regional Police with Makassar City serving as the epicenter of economic and social activities in Eastern Indonesia, represents both a strategic area and a “living laboratory” for the implementation of this technology. The dense, dynamic, and often disorganized traffic conditions in Makassar pose distinct challenges to conventional policing methods. The objective of this study is to provide an overview of the effectiveness of the Electronic Traffic Law Enforcement (ETLE) system in supporting bureaucratic reform within the South Sulawesi Regional Police. The scope of the research is limited to the implementation of the ETLE system within the jurisdiction of the South Sulawesi Regional Police. This study employs a qualitative approach using a descriptive-analytical method. The qualitative approach was selected due to its ability to explore in depth the understanding of complex social phenomena, policy implementation processes, and the perceptions of the actors involved. Data for this study were collected through documentation review techniques and extensive secondary data analysis. The data sources include official documents and reports, statistical data, and scholarly journal articles. Data analysis was conducted using the interactive model proposed by Miles and Huberman, which consists of three main activities: data reduction, data display, and conclusion drawing. The implementation of the Electronic Traffic Law Enforcement (ETLE) system in Makassar did not occur overnight; rather, it evolved through a prolonged and challenging process. At present, the Traffic Directorate (Ditlantas) of the South Sulawesi Regional Police operates a comprehensive digital surveillance ecosystem consisting of three main technological variants that complement one another to address existing enforcement gaps : First, Static ETLE serves as the backbone of the surveillance system. Second, Mobile Handheld ETLE utilizes specially modified smartphones directly. Third, Mobile On-Board ETLE consists of advanced cameras mounted on police patrol vehicles. The implementation of ETLE system has become a key indicator and a flagship innovation in the assessment of the Integrity Zone (ZI) toward Corruption-Free Areas (WBK) and Clean and Service-Oriented Bureaucracy Areas (WBBM) within the South Sulawesi Regional Police. The successful development of an integrated ETLE system, which has even been adopted as a national role model by the Traffic Corps of the Indonesian National Police (Korlantas Polri), has earned high scores in the aspects of “Strengthening Oversight” and “Improving the Quality of Public Services. In conclusion, the implementation of the Electronic Traffic Law Enforcement (ETLE) system within the South Sulawesi Regional Police represents a fundamental and innovative leap in the history of traffic bureaucratic reform. The system has successfully transformed the nature of law enforcement from a manual and transactional approach into one that is digital and transparent. Therefore, it is recommended that



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improvements be made to the vehicle registration database, inter-agency data integration, and verification mechanisms to ensure sustainable and efficient enforcement outcomes.

Keywords: Digital-Based, Public Service, Effectiveness, ETLE, Police



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February 11 - 12, 2026
MNS University of Agriculture Multan

Digital Technology-Based Public Administration Innovation For Sustainable Food Security (Phenomenological Study In Makassar City, Indonesia)

Muhammad Kholidinna Qasabandiyah¹, Wahira¹, Jasruddin¹, Andi Cudai Nur¹

¹Faculty of Social Sciences and Law, Doctoral in Public Administration Study Program, Universitas Negeri Makassar, Indonesia

Correspondence to muhammadkholidinnaqasabandiyah@gmail.com

Abstract

Food security has become an increasingly urgent strategic issue in the 21st century. Global population projections, which are expected to exceed 9.7 billion by 2050. In the global context, Indonesia's food security condition remains suboptimal. The 2022 Food Security Statistics indicate that Indonesia ranked 69th out of 113 countries in the Global Food Security Index (GFSI), with a score of 59.2, which remains lower than that of several other Asian countries. In addition, the food supply chain in Makassar continues to face classic challenges, including distribution systems that are highly dependent on weather conditions and logistical infrastructure. This study aims to identify and describe the forms of public administration innovation in the utilization of digital technology to support food security in Makassar City, as well as to identify the factors that support and hinder the implementation of digital technology-based public administration innovation in the food security sector of Makassar City. This study employs qualitative data obtained from primary and secondary data. Primary data were collected through in-depth interviews, field observations, and documentation involving various actors engaged in the digital technology-based food security ecosystem. The main informants were drawn from government institutions, including the Food Security Office, the Communication and Informatics Office as the administrator of the Electronic-Based Government System (SPBE) and the war room, the Regional Development Planning Agency. In addition, data were also collected from business actors and stakeholders within the food supply chain, such as food distributors, market managers, and Agritech or agro-digital actors relevant to the process of food digitalization. This study showed that Makassar City has implemented various digital innovations to strengthen food security through the real-time integration of food stock, distribution, and price data via a digital food dashboard, supported by the utilization of IoT and big data technologies for monitoring, forecasting, and decision-making through the Food Information System (SIPG) and the Makassar War Room. These innovations enhance transparency, public access, and accountability in food distribution, while also strengthening the capacity of local governments to respond more rapidly and in a data-driven manner to price fluctuations and potential supply chain disruptions. The implementation is supported by strong leadership commitment, a developing Smart City ecosystem, and cross-sector collaboration; however, it still faces challenges in the form of uneven digital infrastructure in hinterland areas, low digital literacy among farmers and small business actors, and limited availability of detailed data on food production, distribution, and consumption. This study concludes that Makassar City has adopted significant digital technology-based public administration innovations to strengthen food security. These innovations have improved distribution effectiveness, price transparency, and cross-sector coordination. However, implementation gaps remain, particularly in digital literacy, infrastructure availability, and the provision of granular data. Optimizing digital innovation requires an integrated strategy that includes strengthening systems and infrastructure, enhancing human resource capacity, fostering cross-sector collaboration, implementing data-driven monitoring, and improving public communication. Through these strategies,



Makassar City can maximize the potential of digitalization to achieve sustainable food security, in line with the national Nawacita agenda and the Sustainable Development Goals (SDGs).

Keywords: Digital, Technology-Based, Innovation, Sustainable, Food Security



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Enhancing Yield, Water Productivity and Profitability of Bell Pepper through Soilless Cultivation Systems under Partially Controlled Greenhouse in South Punjab

Sabahat Rasool¹, H Nazar Faried¹*, Ali Asad Bahar¹, Khurram Ziaf², Kashif Razzaq¹, Mohsin Bashir², Atyab Amjad¹, Asif Rasool¹, M. Mazhar Iqbal³

¹Department of Horticulture, Muhammad Nawaz Shareef University of Agriculture, Multan-Pakistan

²Department of Soil and Environmental Sciences, College of Agriculture, University of Sargodha

³Institute of Horticultural Sciences, University of Agriculture, Faisalabad-Pakistan

*Correspondence to nazar.farid@mnsuam.edu.pk

Abstract

Water scarcity, soil degradation, and rising production costs threaten the economic sustainability of vegetable production in semi-arid regions. Soilless greenhouse cultivation offers a viable pathway to enhance productivity while improving farm profitability and resource-use efficiency. This study assessed economic viability of three soilless cultivation systems - Trough (TS), Grow Bag (GBS), and Dutch Bucket System (DBS) for bell pepper (*Capsicum annuum* L.) production under partially controlled greenhouse in South Punjab, Pakistan. Two commercial bell pepper hybrids, 'Red Jet' and 'Bachata' (F1), were evaluated using a split-plot CRD with three replications. Detailed cost-benefit analysis was conducted by estimating fixed costs, operational costs, gross returns, net income, and benefit-cost ratio (BCR) for each system. Yield performance and water productivity were integrated to determine overall economic feasibility. Results revealed that the Trough System (TS) combined with 'Red Jet' F1 cultivar produced the highest marketable yield (9.75 kg m⁻²) and net income (4,390 PKR), resulting in the most favorable BCR (1.63), driven by superior water productivity, efficient fertigation, and lower recurring substrate replacement costs. Although the Grow Bag System incurred relatively lower initial investment and enhanced fruit biochemical quality, its higher running costs reduced overall profitability compared to the trough system. The Dutch Bucket System showed intermediate economic performance. Overall, soilless capsicum production is economically viable under semi-controlled greenhouse conditions, with the trough system as the most cost-effective option for commercial adoption. The study provides practical evidence to support investment decisions, value-chain upgrading, and climate-smart horticulture in water-limited regions.

Keywords: Economic viability, Soilless cultivation, Bell pepper, Greenhouse horticulture, Water productivity, Value chain sustainability



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Seaweed Bio-Stimulants for Economic Resilience Against Salinity in Cherry Tomato

Asif Rasool¹, Ali Asad Bahar¹, Hafiz Nazar Faried^{1, *}, Sami Ullah¹, Kashif Razzaq¹, Mohsin Bashir², Atyab Amjad¹

¹Department of Horticulture, MNS University of Agriculture, Multan

²Office of Research, Innovation and Commercialization, MNS University of Agriculture, Multan

³Institute of Horticultural Sciences, University of Agriculture, Faisalabad,

*Correspondence to nazar.farid@mnsuam.edu.pk

Abstract

Salinity stress is a major constraint to sustainable food production in dryland agriculture, reducing crop productivity, resource-use efficiency, and farm profitability. Cherry tomato (*Solanum lycopersicum* L. var. *cerasiforme*), a high-value horticultural crop, is highly sensitive to salinity during early seedling development, resulting in poor establishment and reduced yield potential. Sustainable biological approaches are therefore needed to strengthen climate-resilient vegetable production systems. This study evaluated the effectiveness of seaweed-based bio-stimulants in improving salinity tolerance and physiological performance of cherry tomato under partially controlled dryland conditions. Cherry tomato seedlings were exposed to four salinity levels (0, 50, 100, and 150 mM NaCl) with and without application of a 15% seaweed extract bio-stimulant. Growth traits, chlorophyll content, gas exchange parameters, and antioxidant enzyme activities were assessed to determine plant responses under saline conditions. Increasing salinity significantly reduced plant height, biomass accumulation, root growth, chlorophyll content, photosynthetic activity, and stomatal conductance, while increasing oxidative stress indicators. However, plants treated with seaweed bio-stimulants maintained better growth, higher chlorophyll retention, and improved gas exchange across all salinity levels. Biochemical analysis showed that bio-stimulant application enhanced antioxidant defense by increasing superoxide dismutase (SOD) and catalase (CAT) activity, helping plants maintain cellular stability under stress. Principal component analysis further confirmed positive associations between bio-stimulant treatment and improved physiological traits under salinity stress. The findings demonstrate that seaweed-based bio-stimulants can improve stress tolerance, crop establishment, and input-use efficiency in saline environments. Economically, this technology has strong potential to reduce production losses, improve crop quality and marketability, and support sustainable vegetable value chains in dryland regions. Adoption of bio-stimulant-based management practices may contribute to climate-smart agriculture, improved farmer resilience, and long-term food security in Pakistan.

Keywords: salinity stress, bio-stimulant, seaweed extract, dryland agriculture, antioxidant enzymes, cherry tomato, sustainable development, saline-alkali soil



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Evaluation of seed coating treatments to enhance seed germination and seedling growth of alfalfa

Usama Shabbir¹, Muhammad Amir Bakhtavar^{1*}, Shahid Iqbal¹, Muhammad Baqir Hussain²

¹Institute of Plant Breeding and Biotechnology, Muhammad Nawaz Shareef University of Agriculture Multan, Pakistan.

²Department of Soil and Environmental Science, Muhammad Nawaz Shareef University of Agriculture Multan, Pakistan.

Correspondence to amir.bakhtavar@mnsuam.edu.pk

Abstract

Alfalfa is a protein rich fodder crop that is widely grown in Pakistan and across the globe. Livestock industry is dependent on alfalfa fodder as it contains high protein, minerals and vitamins. Availability of quality seeds is the key for increasing alfalfa fodder yield and livestock production. High seed germination, uniform and vigorous crop stand of alfalfa can be achieved by applying various seed enhancement techniques such as seed coating. In this study seed coating treatments were optimized in the lab and selected treatments were further evaluated in the wire house. Various treatment combinations were made including talcum as filler and carboxymethyl cellulose (CMC) as binders. Various doses of gibberellic acid were added to improve seedling growth. The experiment was conducted at Seed and Plant Testing Lab and research block of MNS-University of Agriculture Multan, in Completely Randomized Design (CRD) with three replications. Data of seed germination, germination energy, mean germination time, time to radical emergence, emergence index, vigor index, shoot length, root length, fresh seedling mass, dry seedling mass and abnormal seedlings were recorded. Seed coating with (1% CMC) and GA (50 ppm) resulted in higher germination, germination index and germination energy. Maximum shoot length, root length, vigor index, seedling fresh and dry mass were recorded for seed coating comprising 1% CMC and 50 ppm GA. While lowest results for these parameters were showed by treatment having 0.5% CMC as binder and 150 ppm gibberellic acid. In wire house experiment, maximum emergence, emergence energy, emergence index, seedling vigor index and shoot length were found in 1% CMC with 50 ppm GA. Therefore, seed coating with CMC as binder, gypsum as filler and gibberellic acid as plant growth regulator is recommended for improving seed germination and seedling growth of alfalfa.

Keyword: Alfalfa, emergence, germination, seed enhancement, seed coating, seedling growth, vigor



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Impact of different nitrogen levels on seed yield and quality of wheat under drought conditions

Muneeb Ali Khan¹, Muhammad Amir Bakhtavar^{1*}, Shahid Iqbal¹, Rao Muhammad Ikram²

¹Institute of Plant Breeding and Biotechnology, Muhammad Nawaz Shareef University of Agriculture Multan, Pakistan.

²Department of Agronomy, Muhammad Nawaz Shareef University of Agriculture Multan, Pakistan.

Correspondence to amir.bakhtavar@mnsuam.edu.pk

Abstract

Drought affects crop yield by reducing photosynthesis and stunted growth due to limited water availability. Proper nitrogen application is considered a key factor to achieve higher yield of wheat as it plays an essential role in crop growth and development. Optimizing nitrogen under drought stress can improve wheat seed yield and quality. A field study was being conducted at MNS University of Agriculture, Multan to assess the impact of different nitrogen doses on growth, seed yield and quality of wheat under drought stress conditions. Wheat varieties (Akbar-19 and FSD-2008) were planted during 2nd week of November 2023. Experiment was laid out by RCBD split-split plot arrangement. Different drought levels were placed in the main plots while wheat varieties were placed in sub plots keeping nitrogen doses in sub-sub plots. Overall, normal watering combined with higher fertilizer (140 kg/ha) gave the best results in both varieties. FSD-2008 consistently performed better than Akbar-19, especially in 1000 grain weight (37.6 g per hectares), grains per spike (47), and total grain yield (4994 kg per hectares). Additionally, Akbar-19 performed better in various seed quality parameters such as shoot length (7.95 cm at 90 kg ha⁻¹), root length (4.59 cm on skipping irrigation at grain filling stage), shoot fresh weight (1.98 g at 90 kg ha⁻¹) and Root dry weight (0.41 g at normal conditions). The maximum drop in performance was observed when watering was skipped during the grain filling stage at 90 kg ha⁻¹.

Keyword: Growth, photosynthesis, germination, vigor, viability



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 – 12, 2026
MNS University of Agriculture Multan

Towards Climate Resilient Irrigation: A Review of Adaptive Strategies for Agricultural

Sana Nafees¹, Maaz¹, M. Khurram¹, Huzaifa Rauf¹, Nida Maqbool¹

¹Institute of Environmental Science and Engineering (IESE), School of Civil and Environmental Engineering (SCEE), National University of Science and Technology (NUST), Islamabad, Pakistan
Correspondence to nidamaqbool@iese.nust.edu.pk

Abstract

Agriculture currently accounts for approximately 70% of global freshwater usage but faces escalating threats due to growing water scarcity and the accelerating impacts of climate change. Global hydrological cycles are facing significant disruption, which undermines the reliability of groundwater and surface resources through increased drought frequency and altered precipitation patterns. These challenges necessitate urgent adaptive strategies to transition agricultural systems toward Climate Resilient Irrigation. This study aims to systematically analyze adaptive strategies for transitioning agricultural systems toward Climate Resilient Irrigation. It seeks to establish a comprehensive conceptual framework that integrates technological, agronomic, and managerial adaptations to address the challenges posed by disrupted hydrological cycles and water scarcity. This review conducts a systematic analysis of adaptive strategies within the agricultural sector. The methodology involves the development of a conceptual framework that synthesizes diverse approaches, including technological innovations, agronomic techniques, and managerial reforms. This framework is used to evaluate how these integrated strategies can mitigate the impacts of unreliable water resources caused by climate change. The study identifies critical technological innovations, such as the transition from surface to pressurized irrigation systems including drip irrigation, alongside precision agriculture tools including evapotranspiration modeling and soil moisture sensors. Agronomic evaluations show that strategies like Deficit Irrigation and Partial Root-Zone Drying successfully maximize crop water productivity. Additionally, the review highlights the necessity of institutional reforms, specifically the formation of Water User Associations, and the increasing utilization of non- conventional water resources such as treated wastewater. To ensure long-term environmental sustainability and food security, future research must focus on the Water-Energy-Food nexus. The review recommends the integration of digital technologies, including Artificial Intelligence, and the adoption of agrivoltaics. These innovations are essential for ensuring the continued resilience of agricultural systems in the face of climate instability.

Keywords: Climate Resilient Irrigation; Water Scarcity; Adaptive Strategies; Water Use Efficiency; Precision Agriculture; Deficit Irrigation; Water-Energy-Food



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February 11 - 12, 2026
MNS University of Agriculture Multan

Sustainable Agriculture as a Pillar for Global Food Security

Kiran Kareem Bukhsh¹, Ramsha Akram¹

¹Faculty of Food and Home Sciences, MNS University of Agriculture, Multan, Pakistan

Correspondence to kirankareem0@gmail.com

Abstract

Food security is a complex issue to resolve as it cannot be limited to demographics, education, location or income. As the global population continues to grow, the demand for food is rising exponentially. Sustainable agriculture is one of the possible ways to ensure that everyone have access to safe, healthy and nutritious food. It enhanced not only productivity but also maintain environment and natural resources. Sustainable agriculture approaches such as crop rotation, agroforestry and integrated pest management can increase yield without damaging the land. These practices not only enhance farm productivity but also play an important role in long term food security by promoting resilience and health of the agricultural ecosystem. To ensure food security through sustainable agriculture a partnership is required among diverse stakeholders. It is crucial that policy makers, corporate leaders and farmers collaborate in developing policies that support sustainable agriculture. Furthermore, it is also necessary to develop innovative methods that balance productivity with environmental sustainability.

Keywords: Food security, Sustainable agriculture, Population, Crop rotation



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February 11 - 12, 2026
MNS University of Agriculture Multan

Food Industry Wastewater Remediation Via Advanced Oxidation Techniques

Kaif Ul waris¹, Samreen Iqbal², Rukhsar Rasool³, Khadija Zaman², Areeba Khalid², Sana Ashraf⁴, Shafia Aslam², Muhammad Saad Rubbani⁵

¹Department of Chemistry, University of Chakwal, Pakistan

²Department of Chemistry, University of Agriculture Faisalabad, Pakistan

³School of Natural Sciences, National University of Sciences and Technology, Islamabad.

⁴Department of Botany, University of Agriculture, Faisalabad, Pakistan

⁵Department of Agronomy, University of Agriculture, Faisalabad, Pakistan

Correspondence to khadijazaman416@gmail.com

Abstract

The food processing sector produces substantial quantities of wastewater marked by elevated organic content, suspended particulates, fats, oils, greases, nutrients, and persistent contaminants, creating significant environmental and public health risks when released without proper treatment. Traditional wastewater treatment technologies frequently exhibit limited effectiveness in fully eliminating resistant organic pollutants and lowering chemical oxygen demand to permissible standards. Within this framework, advanced oxidation techniques (AOTs) have attracted considerable interest as efficient and environmentally sustainable solutions for treating food industry effluents. This research examines the capability of advanced oxidation processes to degrade and mineralize complex organic contaminants present in food manufacturing wastewater. The main aim is to evaluate the performance of various AOTs, including ozonation, Fenton and photo-Fenton processes, photocatalytic systems, electrochemical oxidation methods, and integrated hybrid approaches, in enhancing effluent quality and complying with regulatory discharge requirements. The methodological approach involves a comprehensive review of available laboratory-scale and pilot-scale investigations, focusing on operational parameters, oxidation performance, reaction kinetics, and the formation of transformation by-products. The results indicate that advanced oxidation techniques successfully generate highly reactive oxidizing species, such as hydroxyl radicals, which accelerate the decomposition of recalcitrant compounds and markedly improve wastewater biodegradability. In summary, AOTs constitute a robust and adaptable strategy for food industry wastewater management, providing high contaminant removal efficiency and strong compatibility with biological treatment processes. Future outlooks emphasize process refinement, development of energy-efficient reactor configurations, integration with conventional treatment technologies, and large-scale deployment to promote environmentally responsible and resource-efficient food processing operations.

Keywords: Wastewater remediation, Advanced Oxidation Techniques (AOT), Food processing.



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February 11 - 12, 2026
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High-Value Phenolics from Olive Industry Waste Via Green

Saiqa Saadat ¹, Yasmeen Bano ², Ahmad Saleem ², Hafsa Sarwar ², Abdul Rasheed ³

¹Department of Food Science and Technology, University of Agriculture, Faisalabad, Sub-Campus Burewala, Pakistan.

²Department of Food Science and Technology, University of Agriculture, Faisalabad, Sub-Campus Burewala, Pakistan.

³Department of Food Science and Technology, The Islamia University of Bahawalpur, Pakistan.

Correspondence to yasmeen@uaf.edu.pk

Abstract

Olive pomace is the main by-product of olive oil production. It has gained increasing attention as a valuable source of bioactive compounds rather than an agro-industrial waste. It contains phenolic compounds, including hydroxytyrosol, tyrosol, and secoiridoid derivatives, along with dietary fiber and minor lipid fractions. Conventional solvent extraction methods are not very sustainable due to high solvent consumption and thermal degradation of sensitive compounds. Green extraction techniques such as ultrasound-assisted extraction, enzyme-assisted extraction, microwave-assisted extraction, and supercritical fluid extraction have been widely used for the recovery of bioactive compounds from olive pomace. Due to reduced solvent use and processing time, these techniques improve the extraction efficiency. Phenolic recovery due to cell wall disruption in Ultrasound-assisted extraction, whereas enzyme-assisted extraction improves compound release by hydrolyzing structural polysaccharides. Supercritical carbon dioxide extraction combined with co-solvents enables the selective recovery of thermo-labile compounds under mild conditions. Extracts obtained through green technologies have shown strong antioxidant capacity and biological activity. The valorization of olive pomace through sustainable green extraction aligns with circular economy principles by transforming by-products into a high-value resource. The integration of green extraction techniques represents an environmentally responsible approach for utilizing olive pomace in food and pharmaceutical applications. The valorization of olive pomace through green extraction technologies directly contributes to SDG 12, responsible production, industry, and innovation, and SDG 9 infrastructure by promoting waste reduction and resource efficiency.

Keywords: Olive Pomace, Green extraction, Bioactive compounds, Valorization, Sustainability, Agro-waste



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February 11 – 12, 2026
MNS University of Agriculture Multan

Assessing Future Climate Risks to Wheat Production in Punjab, Pakistan Using Advanced Machine Learning Approaches

Samra Naseem¹, Atif Akbar², Ghulam Murtaza³

¹Department of Statistics, Muhammad Nawaz Shareef University of Agriculture Multan, Pakistan.

²Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan.

³School Education Department, Government of the Punjab, Pakistan.

Correspondence to samra.naseem@mnsuam.edu.pk

Abstract

Climate change is increasingly threatening agricultural productivity in Pakistan through rising temperatures, shifting precipitation patterns, recurrent heatwaves, and extreme flood events. Punjab, the country's largest wheat-producing province, is particularly susceptible due to its strong dependence on climate-sensitive winter rainfall, extensive groundwater extraction, pronounced agro-climatic gradients, and the concentration of wheat cultivation in regions already operating near thermal and water stress thresholds. These factors collectively increase the risk of climate-induced yield instability. This proposed study will investigate the impact of climate variability and future climate scenarios on wheat yield across five major wheat-producing districts of Punjab Bahawalpur, Multan, Rahim Yar Khan, Sargodha, and Faisalabad using secondary data covering the period 1998–2024. Annual wheat yield ($t\ ha^{-1}$) will be derived from district-level production and harvested area data obtained from the Punjab Agriculture Department, while monthly climatic variables including maximum and minimum temperature, rainfall, relative humidity, and wind speed will be sourced from the Pakistan Meteorological Department (PMD). The analysis will focus on the wheat-growing season (October–April), which represents critical crop growth and grain formation stages and is highly sensitive to climatic fluctuations. Advanced machine learning techniques Random Forest, Extreme Gradient Boosting (XGBoost), Support Vector Machines, and Artificial Neural Networks will be employed to model nonlinear climate–yield relationships. Future wheat yield responses will be assessed under three climate conditions: Baseline, Hot–Dry, and Warm–Wet, to identify region-specific vulnerabilities and potential adaptation pathways. The anticipated findings are expected to reveal substantial spatial heterogeneity in climate impacts, with southern districts likely facing greater yield losses due to heat and moisture stress, while comparatively cooler districts may exhibit more resilient responses under moderate warming. This research aims to support climate smart agricultural planning, contribute to Sustainable Development Goals (SDGs) 2, 13, and 15, and enable policymakers to design targeted, data-driven adaptation strategies. Limitations related to soil health and CO₂ fertilization effects are acknowledged and will be addressed in future model refinements.

Keywords: Climate change; Wheat yield; Machine learning; Punjab; Food security



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February 11 - 12, 2026
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Enhancing Wheat Yield and Farmer Resilience in Flood-Affected Southern Punjab, Pakistan: University-Industry Collaborative Initiative

M. Ishtiaq¹, Usman Jamshaid², Tanveer Ahmed³, Umair Waqas⁴, Ali Haider⁴

Punjab, Pakistan: University-Industry Collaborative Initiative

¹Department of Entomology, MNS University of Agriculture, Multan

²Department of Outreach and Continuing Education, MNS University of Agriculture, Multan

³Department of Entomology, MNS University of Agriculture, Multan

⁴Department of Clinical Medicine, FVAS, MNS University of Agriculture, Multan

Correspondence to m.ishtiaq@mnsuam.edu.pk

Abstract

Pakistan where ~80% of the population depends on agriculture, suffered heavy monsoon flooding from June–Sept 2022, which severely damaged crops and livelihoods. In its flood-prone southern districts (Rajanpur, Dera Ghazi Khan), an estimated 33 million people were affected and 8.3 million acres of farmland inundated. To support climate resilience, a collaborative initiative by MNS University of Agriculture Multan and Evyol Group provided, targeted support to farmers. Teams surveyed crop losses and supplied critical inputs (improved wheat seed, fertilizers, pesticides) on credit for the Rabi season, alongside on-farm guidance. Field trials identified best practices, sowing wheat in late October–early vs November maximized yields versus lower yields from earlier or delayed planting), and reduced seeding rates and balanced fertilization improved efficiency and grain quality. Use of the newly released rust-resistant variety Bhakkar Star completely prevented leaf and yellow rust (confirmed tolerant to local rust strains), unlike adjacent susceptible fields. Planting mustard as a trap border markedly enhanced natural enemies (lacewings, ladybird beetles, syrphid flies) for aphid bio-control. The interventions yielded strong outcomes, contract farmers wheat yields rose from ~36 to ~46 maunds/acre on an average (one farmer reached 62 maunds/acre), and on-farm purchase prices paid above market rates boosted incomes. A public-health component addressed flood-related disease risks (water- and vector-borne illnesses commonly surge after floods) through free medical camps and awareness training. Home gardening kits (vegetable seeds and nurseries) improved household nutrition and extra income. These results demonstrate that integrating applied research sowing date optimization, resistant varieties, eco-friendly IPM, with community outreach and private-sector support can significantly improve productivity, health, and livelihoods in climate-vulnerable farming communities.

Keywords: Evyol group, Resilience, Flood effected, Gardening kit, IPM



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February 11 - 12, 2026
MNS University of Agriculture Multan

Climate-Resilient Integrated Pest Management as an Innovative Pathway for Sustainable

Hafiz Ali Raza¹, Inam Irshad¹, Hafiz Ali Raza¹, Inam Irshad¹

¹Institute of Agricultural Extension Education & Rural Development, UAF Department of Soil & Environmental Sciences, UOS

Correspondence to razaa0617@gmail.com

Abstract

Climate change poses a serious threat to agricultural sustainability and food security, particularly for climate-sensitive crops such as sugarcane. Increasing temperatures, irregular rainfall patterns, and heightened pest and disease incidence have significantly affected sugarcane productivity in Pakistan. These challenges are further aggravated by the excessive and indiscriminate use of chemical pesticides, leading to environmental degradation and reduced farm resilience. In this context, integrated pest management (IPM) offers an innovative and sustainable pathway to enhance climate resilience in sugarcane production systems. This study aimed to assess farmers' perceptions and adoption of IPM and climate change adaptation strategies in District Rahim Yar Khan, Punjab, Pakistan. Using a structured interview schedule, primary data were collected from sugarcane farmers to evaluate their awareness, adoption behavior, and constraints related to climate-resilient pest management practices. Descriptive statistics and inferential analyses were employed to examine the association among the socio-economic characteristics, adoption of IPM and climate adaptation strategies. The findings revealed that the majority of farmers exhibited low adoption of IPM practices due to limited technical knowledge, particularly regarding pest identification and the application of cultural, mechanical, and biological control methods. Similarly, climate change adaptation practices were poorly adopted, mainly due to insufficient awareness of recommended climate-smart agricultural practices. However, variables such as age, education, farm size, farming experience, and access to information sources showed a significant association with farmers' adoption of IPM and climate adaptation strategies. The study highlights the need for strengthening extension services, promoting farmer education and enhancing knowledge-sharing mechanisms to support climate-resilient agriculture. The adoption of IPM under changing climate conditions can contribute significantly to sustainable sugarcane production, environmental protection and long-term food security. Mass awareness campaigns and the effective use of media and digital tools are recommended to accelerate the dissemination of climate-smart IPM innovations.

Keywords: Climate change adaptation; integrated pest management; sustainable agriculture; sugarcane production; farmer perception.



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February 11 - 12, 2026
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A study on the Role of Gut Microbiota in Food-Based Allergies

Hafiz Muhammad Ishaq¹

¹Department of Pathobiology and Biomedical Sciences, Faculty of Veterinary and Animal Sciences, Muhammad Nawaz Shareef University of Agriculture, Multan, Pakistan.

Correspondence to hafiz.ishaq@mnsuam.edu.pk

Abstract

The meta-analysis was conducted between August 2023 and July 2024, and included 30 research studies investigating the gut microbiota-food allergy relationship. There is recent evidence that the human gut microbiome is changing in terms of its composition and function as food allergies are increasing. Gut microbes and the host have a central regulatory role in the immune system. Microbiotics from the mother in early life (via vaginal delivery and breastfeeding) contribute to the establishment of a healthy gut microbiota and immune system. On the other hand, antibiotics have been associated with imbalance of microorganisms and increased incidence of allergy. Changes in the diversity or abundance of intestinal microorganisms may affect oral tolerance. Microbial components have a role in interacting with pattern recognition receptors on immune cells affecting immune responses and perhaps enhancing sensitivity towards food antigens. Conversely, some short-chain fatty acids that are produced by gut bacteria during the fermentation of dietary fiber have been shown to have protective properties against food allergies, as they promote immune regulation and the maintenance of intestinal barrier function. Probiotics have been of interest as both a prevention and treatment strategy for food allergies. The introduction in animal models and clinical trials of certain beneficial microorganisms (e.g., some *Clostridia* species) has been proved to decrease or prevent allergic responses. This meta- analysis highlights the important role of gut microbiota in the development and modulation of food allergies. Although probiotics' anti-allergic properties and the intricate connections between the gut microbiota and immune system are not yet fully understood. More research is required to understand the factors that affect microbiota–host interactions and intestinal immunity and to identify the safety, efficacy and best practice for incorporating probiotics into standardized treatments in food allergies.

Keywords: Food antigens; Gut microbiota; Probiotics; Immune tolerance; Short-chain fatty acids.



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February 11 - 12, 2026
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Climate Change and Emerging Food Safety Risks: A Meta-Analysis of Recent Research

Dr. Hafiz Muhammad Ishaq¹

¹Department of Pathobiology, Faculty of Veterinary and Animal Sciences, Muhammad Nawaz Shareef University of Agriculture, Multan, Pakistan.

Correspondence to hafiz.Ishaq@mnsuam.edu.pk

Abstract

To explore current trends in food safety concerns related to climate change, we analyzed 40 research reports from January 2024 to December 2025. In recent decades, climate change has emerged as one of the great challenges of the world. It is defined by changes in climate and a sustained increase in global temperature. The effects of climate change on food safety and food security are evident. The safety of the food supply chain is at risk via several routes due to environmental variability and variation of climate conditions. Because of these changes, foodborne pathogens can occur more frequently, live longer, and be more virulent, creating an increased risk for foodborne disease. Furthermore, the toxicity and activity of different microorganisms can change in response to environmental changes. Concerns about chemical hazards are also increasing. Myco- and pesticide residues and heavy metals in food can be affected by climate-related factors. New and emerging food safety challenges include rising temperatures, less rain in some areas and increasing occurrences of extreme weather events. Some of these are water scarcity for irrigation, use of more pesticides as a result of pest resistance, loss of cold chain due to heat stress and water pollution after floods. These can result in food poisoning, food poisoning infections, antimicrobial resistance and the deposits of heavy metals in the human organism. The effect of extreme climate events and natural disasters on food safety may be direct or indirect on different stages of food production, processing and distribution. This study illustrates the link between climate change and new threats to food safety. It also addresses the issues of mitigation and adaptation to the challenges of global warming and environmental change.

Keywords: Food safety; Climate change; Adaptation; Mitigation; Food hazards.



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February 11 - 12, 2026
MNS University of Agriculture Multan

From Nutrition to Risk: Heavy Metals and Mineral Imbalance in Meat Across Diverse Supply Chains

Hamza Rehman¹, Amir Ismail¹, Muhammad Aqeel¹

¹Department of Food Safety and Quality Management, Faculty of Food Science & Nutrition, Bahauddin Zakariya University (BZU), Multan, Pakistan

Correspondence to hamzarehmanqazi@yahoo.com

Abstract

One of the food security aspects of developing nations where rapid urbanization is taking place is quality control of food that is produced out of animals either concerning the safety or the nutritional value of such food. The study involved the analysis of the concentration of the chosen heavy metals including Lead (Pb), Cadmium (Cd) and Arsenic (As) and the essential mineral elements including Iron (Fe), Zinc (Zn), Sodium (Na), Potassium (K) and Calcium (Ca) in meat and the edible organs present in the major markets in Multan, Pakistan. A total of one hundred and sixty-two samples were sampled in three sources of supply-chain (local markets, supermarkets, and industrially processed outlets) and had three animal species (mutton, beef, chicken) and three tissues (muscle, liver, kidney). The samples were digested in normal wet-digestion procedures and identified using Atomic Absorption Spectroscopy (AAS). The analysis revealed that Pb, Cd and as contamination was found to be high especially in the local market samples and kidney as well as liver organs. Lead levels were above the Codex limit 0.1 mg/kg) in virtually all samples and some offal tissues had cadmium levels that were above recommended limits (0.05-0.1 mg/kg). This trend was equally followed by the amounts of arsenic on mutton and beef kidneys which reported the highest accumulation levels. Heavy metal loading in terms of the species was mutton then beef then chicken with variation in the feeding systems, exposure to the environment and the way of production. In fact, all the necessary minerals were located in favorable levels with Fe, Zn and K showing distributions as would be anticipated in the body maximum in liver and kidney. However, there were high amounts of sodium in some of the samples which indicated potential dietary problems. These findings indicate a two-fold issue: due to high levels of the bioavailable nutrients, meat, on top of its adverse impacts on human health, which is attributed to the existence of harmful metals, aids in the endangerment of nutritional security in the most susceptible populations. The results suggest the significance of an improved surveillance, feed, environmental management, and improved regulation of all meat supply chains.



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Climate-Resilient Agriculture: Integrating Precision Technologies and Policy Reforms to Achieve Zero Hunger Goals

Ramsha Akram ¹, Umar Farooq ¹, Aliza Batool ¹, Syed Muhammad Naqi Abbas ¹, Fiza Noor ¹,
Munnaza Riaz ¹

¹Faculty of Food and Home Sciences, MNS University of Agriculture, Multan, Pakistan

Correspondence to email ramshaakram19@gmail.com

Abstract

Climate change is potentially an existential threat to international food security, and it is estimated that by mid-century, the effect of irregular weather patterns, drought, and flooding will cause a reduction of up to 20 percent in yield in tropical areas. The study of the publication Climate-Resilient Agriculture: Integrating Precision Technologies and Policy Reforms to Achieve Zero Hunger Goal is the response to this crisis, as it proposes a synergistic approach in terms of strengthening agricultural productivity, equity, and sustainability. The paper critically summarizes innovations in precision measures like AI-based irrigation, drone-based surveillance of crops, and CRISPR-based drought-resistant breeds that have a strong policy framework to withstand uncertainties in the environment. The most important actions are the implementation of real-time soil and water analytics with the help of satellite imagery and IoT sensors so that farmers can reduce input levels by 30% and ensure that maximum yields are obtained. These solutions give power to the small farmers who are the main producers of food in the developing countries via the available online platforms that forecast pest attacks and help to plan their crops optimally. In addition to technology, policy reform focuses on subsidies of resilient seeds, microfinance of agroecological transition, and international trade agreements to promote food sovereignty over export monocultures. Based on the UN SDG 2 indicators, the case studies of sub-Saharan Africa and South Asia have been analyzed using case study with integrated strategies to overturn the hunger trends through nutritional diversity and halving post-harvest losses. Issues such as digital divides and regulatory silos are criticized and they suggest that people and companies come together in partnerships and capacity-building to create scalable impact. The net effect is the ultimate integration towards zero hunger in 2030, which will result in the establishment of resilient agroecosystems that can feed 10 billion people equitably.

Keywords: Food sovereignty, Weather patterns, Microfinance, Silos, Partnerships.



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Circular Economy in Pakistan's Food Systems: Innovations for Waste Reduction

Ahmad Saleem ¹, Yasmeen Bano ¹, Hafsa Sarwar ¹, Ayesha Syed ², Muhammad Yousaf ³, Mehak Fatima ², Abdul Rasheed ⁴

¹Department of Food Science and Technology, University of Agriculture, Faisalabad, Sub-Campus Burewala, Pakistan.

²National Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan.

³School of Agriculture and Biology, Shanghai Jiao tong University, Shanghai city, China.

⁴Department of Food Science and Technology, The Islamia University of Bahawalpur, Pakistan.

Correspondence to yasmeen@uaf.edu.pk

Abstract

Pakistan loses large volumes of edible food and biomass at each stage of the value chain, from harvest and processing to retail and households representing both a food security challenge and an economic loss for farmers and cities. National analyses estimate very high annual wastage in staple and perishable commodities, indicating a large untapped opportunity for recovery and reuse. Circular economy approaches adapt proven techniques to recover value from this stream. Green processing and valorization (e.g., enzymatic and fermentative bio-processing, targeted extraction of bio-actives, spray-drying) can convert fruit, vegetable and cereal residues into ingredients for animal feed, functional foods, or nutraceutical, improving farm incomes and reducing disposal burdens. Complementary pathways locally scaled food waste bio-refineries, composting for soil restoration, and redistribution of surplus edible produce can close nutrient loops while delivering low carbon energy and soil fertility benefits. Pilot projects combining these approaches show technical feasibility for Pakistan's agro-industrial context. To translate technology into impact, Pakistan needs concerted policy support, investments in cold chain and decentralized processing, and clear food safety pathways for by product reuse. Equity and consumer acceptance must guide design so recycled value products reach smallholders and low income consumers rather than only high value markets. National policy briefs and programme reviews outline these priorities and propose practical road maps. Adopting circular models can reduce waste, recover economic value for rural and urban communities, and help meet SDG 12, SDG 2 and SDG 13 provided innovations are scaled with strong governance, public private partnerships, and targeted finance.

Keywords: Circular economy, Food waste valorization; Bio-refinery, Agri-food.



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Early Childhood Nutrition and Long-Term Health Concerns

Hafsa Sarwar¹, Yasmeen Bano², Ahmad Saleem¹, Rameen Sajid¹, Abdul Rasheed², Uswah Hareem¹, Warda Nayab¹

¹Department of Food Science and Technology, University of Agriculture, Faisalabad, Sub-Campus Burewala, Pakistan.

²Department of Food Science and Technology, The Islamia University of Bahawalpur, Pakistan.

Correspondence to yasmeen@uaf.edu.pk

Abstract

Early childhood is a critical time when good nutrition shapes growth, learning, and long-term health. Poor nutrition during the first 1,000 days (pregnancy through 24 months) is linked to stunted growth, delayed brain development, more infections, and diminished school and work outcomes later in life. Children who face under-nutrition early are also at higher risk of overweight, diabetes, and heart disease in adulthood. Improving mothers' diets before and during pregnancy, supporting exclusive breastfeeding for the first six months, introducing safe and age-appropriate complementary foods, and providing essential vitamins and minerals all reduce the harms of early under-nutrition. These measures are most effective when programs reach the poorest families, respect local foods and customs, and are delivered through community and health services that families already use. Combining nutritional counseling, food support, and micro-nutrient distribution with routine maternal and child health services increases coverage and keeps costs manageable. When implemented well, early nutrition programs reduce child illness, improve developmental outcomes, and lower the future burden of chronic disease, delivering benefits for individuals and societies. Investing in early nutrition is therefore both a moral and practical choice. By preventing under-nutrition and interrupting biological pathways to long-term disease, such investments support SDG 2 and SDG 3. They also contribute to education and economic goals by improving children's ability to learn and be productive adults.

Keywords: Under-nutrition, Maternal health, Early childhood nutrition, First 1000 days



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Agro-Industries' Contributions to Realizing Soil's Potential as a Carbon Sink

Khadija Zaman¹, Samreen Iqbal¹, Sana Ashraf², Rukhsar Rasool³, Najma Farid⁴, Muhammad
Saad Rubbani⁵, Kaif Ul Waris⁶

¹Department of Chemistry, University of Agriculture, Faisalabad, Pakistan

²Department of Botany, University of Agriculture, Faisalabad, Pakistan

³School of Natural Sciences, National University of Sciences and Technology, Islamabad.

⁴Department of Material Sciences and Engineering, Hohai University, Nanjing, China

⁵Department of Agronomy, University of Agriculture Faisalabad, Pakistan

⁶Department of Chemistry, University of Chakwal, Pakistan

Khadija Zaman khadijazaman416@gmail.com

Correspondence to sanashraf254@gmail.com

Abstract

The sectors of energy utilization, production efficiencies, motor vehicle competence, and renewable energy sources have been a focus for innovations to minimize greenhouse gases. Recently, farmers have recognized that their cultivation methods significantly impact climate change. By adopting simple yet effective practices like conservation tillage, facilitated by tools like chemical sprays and Roundup Ready crops, they can substantially reduce atmospheric carbon dioxide amplification. Conservation tillage minimizes soil disturbance through minimal or no tillage. Implementing precision farming equipment enables real-time tracking, and data analytics optimizes resource allocation (e.g., fertilizers), boosting crop yields (10-20% ↑), reducing pesticide use, and enhancing sustainability. Harnessing agro-industrial techniques boosts soil's carbon capture capacity, contributing to a sustainable future and combating climate change, while enhancing Soil Organic Carbon (SOC) levels. For instance, Conservation tillage can increase soil organic carbon by 10-15 %, cutting Carbon Dioxide (CO₂) emissions by 50%. In future, agro-industrial methods shall propel eco-friendly soil management worldwide. Incorporating AI-drive accuracy farming enhance the health of soil plus Carbon Dioxide sequestration. This adds substantially towards international environmental objectives which guide path towards carbon dioxide balanced outlook.

Keywords: Agro-industries, Sustainability, Organic Carbon, Conservation tillage, Greenhouse gases.



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
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Climate Change-Driven Groundwater Projections for an Irrigated Aquifer in the Indus Basin

Dr. Muhammad Saifullah¹, Prof. Dr. Irfan Ahmad Baig²

Conference track: Food Security & Sustainable Agriculture

¹Assistant Professor, Faculty of Agricultural Engineering MNS University of Agriculture, Multan

²Dean, Faculty of Social Sciences and Humanities, MNS University of Agriculture, Multan

Engr. Muddasar Masood, Junior Water Expert in FAO Funded Project at MNS University of Agriculture, Multan.

Correspondence to muhammad.saifullah@mnsuam.edu.pk

Abstract

It is projected that climate change will result in change of temperature and precipitation patterns across the Asian continent, which will influence the recharging of groundwater and the irrigation demand. These changes are dangerous to the water security of the agricultural regions that rely on ground water. Learning about the long-term groundwater response when the climate changes in the future is critical to the planning of sustainable resources. This paper assesses the future state of groundwater within the Khanewal area using a combination of climate forecasts and a calibrated groundwater Vistas model. To assess the long-term impacts of projected climate change on groundwater recharge and availability up to the year 2099. Future trends in recharge and evapotranspiration were estimated by using bias adjusted RCP climate projections of temperature and precipitation. An already calibrated groundwater model was projected up to 2099, starting with the historical period (2013-2020). Simulations in the future were run using climate driven variations in both recharge and water demand with observed abstraction patterns to determine possible groundwater stress. According to model estimates, ground water recharge is going to decrease slowly with warmer climatic conditions and there will be an increase in the evaporative losses. The simulated groundwater levels are decreasing in intensity in areas which are highly irrigated, especially at the extended dry season. Both regions that are already on moderate levels of stress are expected to shift to high-risk zones in case abstraction is not addressed. The findings point to the interactive impacts of climate change and groundwater pumping on the sustainability of aquifers. DTW for the study area at September 2040, 2070 and 2099 is presented in Figure 1 below.

Keywords: Climate change, Groundwater projections, RCP climatic projection, Recharge dynamics, Water sustainability



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February 11 - 12, 2026
MNS University of Agriculture Multan

Assessment of Water, Energy, and Carbon Fluxes in a Cotton-Wheat System Under Climate Change

Muhammad Saifullah ¹, Muhammad Zeeshan Hussain ¹

¹Department of Agricultural Engineering, MNS-University of Agriculture, Multan.

Correspondence to muhammad.saifullah@mnsuam.edu.pk

Abstract

The sustainable agricultural management under climate change necessitates the integrated assessment of water, energy, and carbon fluxes at the field scale. This study employs the eddy covariance flux tower technique to quantify the evapotranspiration, surface energy balance, and CO₂ exchange in the cotton-wheat cropping system and evaluate responses under projected warming scenarios. Continuous measurement of turbulent fluxes, alongside air temperature, net radiation, soil heat flux and moisture were used to analyze the seasonal flux dynamics. Results reveal crop-specific difference in the water use and carbon exchange, with elevated temperatures increasing evaporative demand and modifying CO₂ flux patterns. Scenario analysis indicates that future warming may intensify irrigation requirements and affect the system's carbon balance. EC-based observations integrated with scenario assessment offer critical insights for climate-resilient and sustainable irrigation management.

Keywords: Climate change impacts, Sustainable agriculture, Eddy covariance flux tower, Water-energy-carbon dynamics, Irrigation management



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February 11 - 12, 2026
MNS University of Agriculture Multan

Empowering Women for Gender-Inclusive Food Security in the Developing World

Nighat Raza^{1,*}, Alina Sadaf¹

¹Department of Food Science and Technology, MNS-University of Agriculture, Multan, Pakistan

Correspondence to nighat.raza@mnsuam.edu.pk

Abstract

Food security is a concern in regions with low gender equality. Gender inequalities affect output and economic stability. Women contribute to farm labor, family nutrition, and resource management in developing regions. The issues faced by women include unequal distribution of land, finances, developmental resources, and education opportunities. These are the challenges that hinder the growth of the agricultural economy, hence causing food insecurity. The importance of including both males and females in food security and agricultural economic development projects is highlighted in the present study. Women-inclusive policies show that when combined with interventions in the form of education, financial inclusion, and social protection, gender-inclusive policies can even boost agricultural productivity by 40 percent. It aims to explore how approaches can improve gender equality in food security and sustainability. This research paper explores the connection between the role of women and food security with a specific focus on policymaking and the adoption of measures that work towards the improvement of training and skill development of women. It aims at determining successful strategies for enhancing the involvement of women in agricultural production and the regional economy. The study shows that gender-inclusive policies, especially the enhancement of access to farming inputs, land resources, and education for women, can significantly enhance food security in the developing world. This can result in more crop production and good family nutrition. The possibility of fair gender involvement in policy-making processes on food production and food security has the promise of increasing productivity levels and ensuring food security in the region. The research also focuses on the aspect of women's inclusion and the mitigation of gender disparity in the local agricultural sector in a region. It seeks to advise governments, organizations, scientists, and researchers to develop policies that empower women and enhance equal rights.

Keywords: Food security, gender equality, women empowerment, agricultural productivity, gender-inclusive policies, sustainable agriculture



The Impact of Food Waste on Food Insecurity in Pakistan: Causes, Consequences, and Solutions

Zafar Ahmad Siddiqui¹

¹ISRA University, Hyderabad

Correspondence to: Zafar414@yahoo.com

Abstract

Food waste is an alarming global concern, and for developing nations like Pakistan, it carries severe socioeconomic consequences. Globally, nearly 1.3 billion tons of food are wasted each year (FAO, 2023), while in Pakistan, an estimated 40% of the total food produced, approximately 36 to 40 million tons annually, is wasted (Pakistan Institute of Development Economics, 2024). Meanwhile, over 26 million Pakistanis face moderate to severe food insecurity (World Food Program, 2025). This dual reality of excess and deprivation exacerbates poverty, child malnutrition, and ecological strain. This study investigates the scale and drivers of food waste in Pakistan and how it directly contributes to food insecurity. It aims to propose evidence-based strategies to reduce waste, improve distribution, and enhance food availability for vulnerable communities. A three-pronged approach was adopted. Quantitative data from PBS, FAO, WFP, and UNDP analyzed to assess national trends. Surveys and focus groups conducted in Sindh and Punjab with 600 respondents (Farmers, distributors, retailers, and users etc.). Case studies of successful food redistribution programs like Rizq (Lahore) and Saylani Welfare Karachi). 38% of food is wasted at the consumer level (households, weddings, hotels). 20-25% post-harvest losses due to poor storage, transport, and packaging. 80% of restaurants reported discarding large volumes of edible food daily. Child stunting rates in food-insecure regions reach 40% (UNICEF 2022). Only 5% of surplus food is currently recovered and redistributed. Food waste is both a cause and symptom of broader systemic inefficiencies in Pakistan. While the agricultural sector is robust, lack of infrastructure, awareness, and regulatory mechanisms leads to massive loss, even as millions go hungry.

Keywords: Food Waste, Food Insecurity, Pakistan, Sustainable Agriculture, Cold Chain, Hunger, Policy, Redistribution, Public Awareness.



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February 11 - 12, 2026
MNS University of Agriculture Multan

Impact of Awareness on Smoking Behavior

Prof. Dr. Nasir Nadeem¹, Alia Hassan², Khadija Syed³

¹Department of Agricultural and Resource Economics, MNS University of Agriculture, Multan

²Department of Pathobiology and Biomedical Sciences, Muhammad Nawaz Shreef University of Agriculture, Multan

³Department of Agribusiness and Entrepreneurship Development, MNS University of Agriculture, Multan
Correspondence to: nasir.nadeem@mnsuam.edu.pk

Abstract

This study examines the correlation between smoking awareness initiatives and changes in smoking behavior patterns among different demographic groups. The research analyzes how exposure to health education campaigns, warning labels, and anti-smoking interventions influences smoking prevalence, cessation rates, and prevention of initiation. The findings aim to provide evidence-based recommendations for optimizing awareness strategies to achieve meaningful behavioral changes in tobacco consumption. This cross-sectional study was conducted in urban areas of Tehsil Alipur, Muzaffargarh District, using a structured questionnaire adapted from the WHO Global Youth Tobacco Survey. A sample of 297 participants was selected through convenience sampling at the district level and simple random sampling within urban areas, with data analyzed using descriptive statistics and Chi-square tests. The study examines the correlation between smoking awareness initiatives and behavioral changes among different demographic groups to provide evidence-based recommendations for tobacco control strategies. Results revealed a statistically significant association between awareness levels and quit intentions with 66.3% of high-awareness individuals intending to quit compared to only 20.3% of low-awareness participants. The findings demonstrate that enhanced health risk awareness significantly increases smoking cessation intentions, supporting the implementation of targeted educational interventions and comprehensive tobacco control policies. The study conclusively demonstrates that health risk awareness is a critical determinant of smoking cessation behavior, with higher awareness levels significantly associated with increased quit intentions among smokers.

Keywords: Impact, Awareness, Smoking, Behavior



Climate Modulation and Emerging Infectious Diseases, and Food Security: A Meta-Analytical Study

Hafiz Muhammad Ishaq¹

¹Department of Pathobiology, Faculty of Veterinary and Animal Sciences, Muhammad Nawaz Shareef University of Agriculture, Multan, Pakistan.

Correspondence to hafiz.ishaq@mnsuam.edu.pk

Abstract

Between October 2024 and August 2025, we carried out a meta-analysis of 35 research studies on emerging infectious diseases (EIDs) and food security. The results identify a close relationship between climate change and the transmission of infectious diseases and the stability of food systems. As a result of natural habitat loss, environmental changes caused by man, climate change, etc., there is a greater possibility for pathogens to spread from one species to another and from one area to another. Emerging infectious diseases pose a direct and indirect risk to food security. These reduce agricultural yields, food systems and public health, and consequently access to safe, nutritious food. With the absence of strengthening the preventive actions, the economic cost of EIDs is likely to increase substantially in the next few decades, and could even reach the national and global gross domestic product in both food secure and food insecure countries. In response to this challenge, one has to think outside the boxes and adopt an ecological worldview, one which was proposed by the Stockholm Paradigm. A pathogen-centred perspective offers a new definition of risk by considering whether and how pathogens invade real or potential fitness spaces. Where habitats overlap, there are more chances for pathogens to be exchanged and diseases arise. A document – assess – monitor – act approach is a structured system for identifying and managing risks of EID. This strategy focuses on the systematic gathering, analysis and dissemination of data, to generate information that can be used to act. Achieving effective risk management requires a coordinated set of interventions and collaborative efforts between scientists, public health officials and policy makers, food system stakeholders and local communities. The Stockholm Paradigm and the DAMA framework complement each other in achieving food security, equitable access to nutritious food, timely response to medical needs and responsible management of the environment. The need to strengthen these integrated strategies is crucial to safeguard human health and global food systems in a changing climate.

Keywords: Climate change; Emerging infectious diseases; Food security; DAMA framework; Stockholm Paradigm.



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
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Impact of nutritional health consultancy centre on polycystic ovary syndrome Females in Fateh Pur, Punjab, Pakistan

Hafiz Muhammad Ishaq¹

¹Department of Pathobiology, Faculty of Veterinary and Animal Sciences, Muhammad Nawaz
Shareef University of Agriculture, Multan, Pakistan

Correspondence to hafiz.ishaq@mnsuam.edu.pk

Abstract

Polycystic Ovary Syndrome (PCOS), a prevalent reproductive endocrine disorder, is strongly linked to insulin resistance. This study investigated the current and future role of nutritional consultancy in managing PCOS, particularly in the Layyah region of South Punjab, where awareness is low. A mixed-methods approach was employed, involving 220 women (18–32 years). In the qualitative phase, 200 participants received nutritional consultancy, while 20 did not. Baseline data revealed 81.5% of participants were overweight or obese (a major PCOS contributor), 34.7% experienced back pain, and 33.7% reported acne and hair fall. Following dietary interventions, 32.7% reported over 50% symptom improvement, with 61.8% achieving at least 80% improvement. Furthermore, 90% were satisfied with weight management and symptom control guided by dietitians, and 10.92% believed nutritional therapy was more effective than Glucophage. Crucially, 76.2% lacked prior knowledge of nutrition's role in PCOS. In the quantitative component, hormonal evaluations (LH and FSH) in a subset of 21 participants showed statistically significant improvements ($p = 0.0001$) after dietary counselling, indicating a restoration of normal hormonal profiles and reinforcing the effectiveness of nutritional therapy. These findings highlight the critical need to expand access to qualified dietitians and promote nutrition-based management strategies for PCOS.

Keywords: PCOS, FSH, LH , nutrition, hormone, consultancy



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February 11 - 12, 2026
MNS University of Agriculture Multan

Combating Climate Change Through Adopting Sustainable Practices

Muhammad Ashfaq¹, Muhammad Saeed Ahmad², Usman Ali¹, Tariq Jamil¹

¹NBS, The University of Faisalabad, Pakistan

Correspondence to dean.nbs@tuf.edu.pk

Abstract

This paper examines how industries worldwide are adopting green policies and sustainable practices to combat climate change, reduce environmental impacts, and enhance organizational resilience. Focusing on key sectors like manufacturing, energy, transportation, agriculture, and services, it explores how green strategies are integrated into core operations. The role of Human Resource Management (HRM) is emphasized, highlighting its contribution in fostering green behaviors, delivering sustainability-focused training, and aligning HR practices with environmental goals. The paper also addresses industry-specific challenges, showcases success stories, and distills lessons learned, offering actionable insights to support global climate resilience through strengthened green initiatives.

Keywords: Green Policies, Sustainable Practices, Organizational Resilience



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February 11 - 12, 2026
MNS University of Agriculture Multan

Climate Smart Agriculture as a Pathway to Resilient Food Security in Pakistan

Muhammad Hanzla¹

¹MNS University of Agriculture, Multan

Correspondence to 2020-uam-077@mnsuam.edu.pk

Abstract

Agricultural food systems in Pakistan are increasingly vulnerable as climate change continues to reshape environmental and production conditions. Rising temperatures, changing rainfall patterns, frequent floods and droughts, and declining soil and water resources are placing sustained pressure on crop productivity and rural livelihoods. These challenges demand adaptive approaches that can safeguard food availability while enhancing farmers' capacity to respond to climate-related risks. Climate-Smart Agriculture (CSA) offers an integrated framework that links productivity improvement with climate resilience and environmental sustainability. This study examines the potential of climate-smart agricultural practices in strengthening food security under changing climatic conditions in Pakistan. The analysis highlights key interventions, including the adoption of stress-tolerant crop varieties, resource-efficient irrigation systems, soil and water conservation practices, balanced nutrient management, and the use of climate-based advisory services for informed farm decision-making. Particular attention is given to the applicability of these practices across Pakistan's diverse agro-ecological regions, many of which are highly exposed to climate extremes. The study also identifies major constraints to CSA adoption, such as limited institutional capacity, financial barriers, and gaps in extension and climate information services. The findings indicate that wider adoption of climate-smart practices can enhance farm-level resilience, reduce vulnerability to climate shocks, and contribute to stable and sustainable food production. Overall, climate-smart agriculture represents a viable pathway for achieving resilient food security in Pakistan under ongoing climate and environmental change.

Keywords: Climate Change; Environmental Change; Climate-Smart Agriculture; Food Security; Agricultural Resilience



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February 11 - 12, 2026
MNS University of Agriculture Multan

Integrating Precision Dairy Farming and Circular Economy for Sustainable Livestock Systems in Pakistan

Imam Bux ¹, Jasmin Arif Shah ², Zaheeruddin Mirani ³

¹Department of Agriculture Technology, Faculty of Agriculture, Universiti Putra Malaysia, Selangor, 43400, Malaysia.

²Department of Agriculture Technology, Faculty of Agriculture, Universiti Putra Malaysia, Selangor, 43400, Malaysia.

³Department of Agricultural Education Extension, Sindh Agriculture University, Tando Jam
Correspondence to zamirani@sau.edu.pk

Abstract

Rapid global population growth has intensified the challenge of food insecurity, making the dairy sector vital for economic stability and food demand. While Precision Dairy Farming (PDF) and Circular Economy (CE) principles offer innovative pathways for sustainability, their implementation in developing regions relies heavily on farmer acceptance. This study examines the determinants of adopting PDF and CE practices to enhance the resilience of dairy operations in the Tharparkar district, Pakistan. Using a quantitative approach based on Rogers' Diffusion of Innovations theory, data were collected from 460 dairy farmers via stratified random sampling. The study assessed the correlation between adoption rates and five key attributes: relative advantage, compatibility, complexity, trialability, and observability. The results indicate strong positive correlations between these factors and the adoption of innovative technologies. Specifically, farmers' perception of compatibility ($r = 0.574$) and observability ($r = 0.676$) played significant roles in their willingness to adopt sustainable systems. The findings demonstrate that fostering a resilient dairy system requires not just technological availability, but strategies that address farmer perceptions. These insights provide a roadmap for policymakers to promote innovation-driven, precision-based farming, ultimately supporting broader goals of environmental sustainability and economic viability.

Keywords: Precision Dairy Farming, Adoption Behavior, Circular Economy, Tharparkar



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February 11 - 12, 2026
MNS University of Agriculture Multan

Climate-Resilient Agriculture: Integrating Precision Technologies and Policy Reforms to Achieve Zero Hunger Goals

Ramsha Akram ¹, Umar Farooq ¹, Aliza Batool ¹, Fiza Noor ¹, Munnaza Riaz ¹

¹Faculty of Food and Home Sciences, MNS University of Agriculture, Multan, Pakistan

Correspondence to ramshaakram19@gmail.com

Abstract

Climate change is potentially an existential threat to international food security, and it is estimated that by mid-century, the effect of irregular weather patterns, drought, and flooding will cause a reduction of up to 20 percent in yield in tropical areas. The study of the publication & Climate-Resilient Agriculture: Integrating Precision Technologies and Policy Reforms to Achieve Zero Hunger Goal is the response to this crisis, as it proposes a synergistic approach in terms of strengthening agricultural productivity, equity, and sustainability. The paper critically summarizes innovations in precision measures like AI-based irrigation, drone-based surveillance of crops, and CRISPR-based drought-resistant breeds that have a strong policy framework to withstand uncertainties in the environment. The most important actions are the implementation of real-time soil and water analytics with the help of satellite imagery and IoT sensors so that farmers can reduce input levels by 30% and ensure that maximum yields are obtained. These solutions give power to the small farmers who are the main producers of food in the developing countries via the available online platforms that forecast pest attacks and help to plan their crops optimally. In addition to technology, policy reform focuses on subsidies of resilient seeds, microfinance of agroecological transition, and international trade agreements to promote food sovereignty over export monocultures. Based on the UN SDG 2 indicators, the case studies of sub-Saharan Africa and South Asia have been analyzed using case study with integrated strategies to overturn the hunger trends through nutritional diversity and halving post-harvest losses. Issues such as digital divides and regulatory silos are criticized and they suggest that people and companies come together in partnerships and capacity-building to create scalable impact. The net effect is the ultimate integration towards zero hunger in 2030, which will result in the establishment of resilient agroecosystems that can feed 10 billion people equitably.

Keywords: Food sovereignty, Weather patterns, Microfinance, Silos, Partnerships.



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February 11 - 12, 2026
MNS University of Agriculture Multan

From Wayward Fields to a Way Forward: Socioeconomic Drivers and Farmers' Willingness to Revive Cotton in Pakistan

Sami Ullah¹, Irfan Ahmad Baig¹

¹Muhammad Nawaz Shareef University of Agriculture, Multan

Correspondence to sami.ullah@mnsuam.edu.pk

Abstract

Cotton has traditionally been a fundamental component of Pakistan's agricultural and industrial sectors; however, its production has consistently declined due to a combination of institutional, economic, and environmental factors. This study examines the root causes of this decline and explores potential strategies for revitalizing cotton farming by analyzing farmer's willingness to expand acreage under improved conditions. Primary data were collected from cotton-growing regions in Punjab, Sindh, and Baluchistan and analyzed using an ordered probit model. The findings revealed that shortages in inputs, substandard seed and pesticide quality, labor scarcity, and the presence of alternative crops negatively affect farmer's decisions to invest in cotton cultivation. Conversely, access to weather information, agricultural extension services, and varietal diversity positively influence the likelihood of expanding cotton acreage. Notably, in emerging geographical zones, such as Baluchistan, farmers exhibit a greater propensity to increase cotton acreage compared to established areas, highlighting the potential for geographic diversification. Furthermore, farmers demonstrated a significant willingness to pay for improved inputs and services, indicating an untapped demand and a desire to re-engage under favorable conditions. This study offers policy recommendations aimed at reversing the decline in cotton production by focusing on the input markets, extension services, and regional support strategies. This study contributes an innovative perspective to the discourse on cotton in Pakistan by identifying constraints and recognizing opportunities, thereby shifting the focus from problem documentation to revival strategies.

Keywords: Cotton revival, ordered probit, Farmer willingness, Input quality, Extension services



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Impact of RO Wastewater Irrigation on Soil Properties and Plant Growth

Muhammad Aqeel ¹, Amir Ismail ¹, Sameem Javed ¹, Hamza Ur Rehman ¹, Aliza Batool ², Amna Iqbal ¹, Mumtaz Hussain ¹, Muhammad Yasir ¹

¹Department of Food Safety & Quality Management, Faculty of Food Science and Nutrition, Bahauddin Zakariya University, Multan, Pakistan

²Department of Food Science and Technology, Faculty of Food and Home Sciences, MNS University of Agriculture, Multan-Pakistan

Correspondence to aqeelraza538@gmail.com

Abstract

The problem of freshwater scarcity and the rising demand for food production worldwide underscore the need to find alternative water sources for sustainable food production. Even though reverse osmosis (RO) desalination continues to grow rapidly, it generates considerable volumes of reject water (Reverse osmosis wastewater), which, in most cases, is disposed of in the environment through sewage and waste systems. This research paper examines the agronomics and environmental safety of reusing RO wastewater as an irrigation medium on some of the vegetable crops, e.g., Bitter gourd (*Momordica charantia*), Green chili (*Capsicum annuum*), and Tomato (*Solanum lycopersicum*), under semi-arid field conditions in the southern part of Punjab in Pakistan. An exclusive examination of RO wastewater showed that it had a near-neutral pH of 6.875-7.5 and a moderate electrical conductivity of 1.3–1.9 dS m, and could be considered marginally suitable for irrigation according to the FAO standards. Field experiments with various RO wastewater concentrations (100, 75, and 50 percent) revealed that a moderate concentration (75 percent) did not alter plant height, fruit production, or chlorophyll index compared to freshwater irrigation. It also prevented the salinity accumulation and accumulation of trace metals in root zone. Physicochemical properties of the soil were not dramatically altered throughout the growing season, which means that the environment was safe in the short term and that agricultural reuse might be local. The results indicate that freshwater consumption and savings in crop production could be increased with apt utilization of RO wastewater, and thus enhance water-use effectiveness. The process of converting waste into a valuable crop material makes the operations of the circular economy possible. Overall, RO waste water reuse is a low-cost, climate flexible and scalable method that fits the SDGs Sustainable Development Goals), and contributes to the establishment of less water-intensive and more resilient water-deprived regions food systems.

KeyWords: Utilization of RO (Reverse Osmosis) Waste Water, Sustainable Irrigation, Saline Water reuse, Climate resilient Agriculture.



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February 11 - 12, 2026
MNS University of Agriculture Multan

Assessing Farmers' Willingness to Adopt and Future Demand Estimation of Hybrid Wheat Varieties in Punjab, Pakistan

Nabiha Arshad¹, Irfan Ahmad Baig¹, Dr. Umar Ijaz Ahmed¹, Dr. Muhammad Ali Imran¹

¹MNS- University of Agriculture, Multan

Correspondence to nabihaarshad111@gmail.com

Abstract

Wheat is the most important staple crop in Pakistan, contributing significantly to national food security and rural livelihoods. Despite its importance, Pakistan faces persistent yield gaps compared to other wheat-producing countries, largely due to smallholder-dominated farming, resource constraints, and slow adoption of modern technologies. Hybrid wheat has been introduced as a potential solution for yield enhancement and resilience under changing climatic conditions. However, its adoption in Pakistan remains low, and limited research exists on the socioeconomic, institutional, and economic factors influencing farmers' willingness to adopt hybrid wheat. This study was therefore designed to evaluate the determinants of hybrid wheat adoption, assess farmers' willingness to pay, identify barriers to adoption, and project future demand under varying subsidy scenarios. The research was conducted using primary data collected from 240 wheat growers across the major wheat-producing regions of Punjab, including Faisalabad, Multan, Bahawalpur, and Muzaffargarh. A purposive sampling technique was employed to categorize farmers into control and treatment groups, distinguishing those cultivating open-pollinated varieties (OPVs), hybrid wheat, and other hybrid crops. Data were gathered through structured questionnaires and interviews. Analytical methods included descriptive statistics to profile socioeconomic characteristics, gross margin and benefit-cost ratio (BCR) analyses to compare economic returns between hybrid and OPV wheat, and econometric model such as binary logistic regression model are used to determine adoption drivers and willingness to pay. Subsidy simulations were also performed to estimate potential future demand for hybrid wheat seed. The results revealed that hybrid wheat adoption is influenced by multiple factors, including farm size, soil fertility, household size, education, and farming experience. Institutional support, especially agricultural extension services, significantly increased adoption likelihood, while high seed costs and weak market demand perceptions reduced willingness to pay. However, barriers such as high input costs, limited seed availability, and social influence from neighboring farmers remain major constraints. Subsidy simulations showed that even modest financial support could substantially increase both adoption rates and cultivated area, highlighting the importance of policy incentives.

Keywords: Willingness to pay, Binary Logistic Regression Model, Hybrid wheat, Open Pollinated Varieties, Future Demand



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Gendered Dimensions of Climate Change Adaptation in Maize Farming: Evidence from Punjab, Pakistan

Shoaib Akhtar ¹, Muhammad Asad ur Rehman Naseer ¹, Muhammad Faisal ², Maryam Nawaz ¹,
Ashir Kamal ¹, Haseeb Raza ³

¹Department of Agricultural Business and Marketing, Bahauddin Zakariya University, (60800) Multan, Pakistan.

²Department of Economics, University of Mianwali

³Department of Agribusiness and Entrepreneurship Development, MNS Multan, Pakistan.

Correspondence to haseebrizvi00@yahoo.com

Abstract

Climate change is increasingly affecting agricultural production in Pakistan, particularly maize farming systems that are highly sensitive to temperature fluctuations and rainfall variability. In Punjab, women are actively involved in maize production activities; however, their role in farm level adaptation decisions and the challenges they face in responding to climate risks remain inadequately documented. This study aims to analyze climate change adaptation strategies adopted by maize farmers and to examine gender-specific constraints influencing women's adaptive capacity. The study is based on primary data collected from 400 maize growing households across major maize-producing districts of Punjab. Farmers' perceptions of climate change and adaptation responses were first examined using descriptive statistics. A multivariate probit model was then employed to analyze the determinants of adopting multiple adaptation strategies simultaneously, including changes in sowing time, use of improved seed varieties, irrigation adjustments, and increased input application. The results indicate that most farmers have experienced rising temperatures and increasingly erratic rainfall over the past decade. Econometric findings show that women's participation in farm level decision making significantly increases the likelihood of adopting low cost and knowledge-based adaptation strategies. In contrast, limited access to landownership, credit, extension services, and climate information significantly constrains women's adaptive responses. The study highlights the need for gender responsive climate and agricultural policies that strengthen women's access to productive resources, extension support, and climate information to enhance the resilience of maize farming systems in Punjab, Pakistan.

Keywords: Climate change adaptation; gender inequality; agricultural livelihoods; development policy; Pakistan



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Integrating Climate-Smart Practices for Food and Nutrition Security

Munnaza Riaz¹, Umar Farooq¹, Ramsha Akram¹, Syed M. Naqi Abbas¹

¹ Faculty of Food and Home Sciences, MNS University of Agriculture, Multan (Pakistan)

Correspondence to munnazariaz206@gmail.com

Abstract

Climate change significantly affects crop production, rainfall distribution, and the frequency of extreme weather events, making agriculture highly vulnerable and increasing the susceptibility of local food systems. These climatic variations influence food availability, utilization, and the nutritional quality of crops, thereby increasing the risk of micronutrient deficiencies, particularly among rural populations dependent on plant-based diets. As a result, managing food and nutrition security (FNS) has emerged as a critical global challenge, especially in developing countries where conventional agricultural practices remain dominant. This study aims to examine the role of climate-smart agricultural practices in improving food and nutrition security among farming households by enhancing productivity, dietary diversity, and resilience to climate change. The study is based on a comprehensive review and synthesis of existing research articles, reports, and empirical studies focusing on climate-smart agriculture and food and nutrition security. Relevant literature was analyzed to identify key climate-smart agricultural practices and their documented impacts on food availability, dietary diversity, and household food security indicators such as the Household Dietary Diversity Score (HDDS). The findings indicate that the adoption of climate-smart agricultural practices positively influences food and nutrition security outcomes. Practices such as crop diversification, crop rotation, intercropping, cultivation of drought-resistant crops, soil and water conservation, minimum or zero tillage, mulching, and the application of organic manure were associated with improved dietary quality and food security. Households adopting these practices exhibited higher HDDS and food consumption scores, reflecting improved access to diverse and nutritious foods and greater resilience to climate-related shocks. Climate-smart agriculture plays a vital role in strengthening food systems, enhancing climate resilience, and reducing food insecurity. To achieve sustainable food and nutrition security, the widespread adoption of CSA should be promoted through effective agricultural extension services, capacity building, and strong stakeholder support. Policymakers should prioritize CSA-focused strategies to ensure long-term agricultural sustainability and improved livelihoods for farming communities.

Keywords: Climate-smart agriculture; Dietary diversity scores; Food and nutrition security; Greenhouse gas emission; Sustainable farming technique.



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Evaluation of Genetic Variability, Heritability, and Genetic Advance for Yield in Exotic Spring Wheat (*Triticum aestivum* L.) Germplasm

Muhammad Irfan ¹, Dr. Shahzadi Mahpara ², Shaista Suleman ²

¹Department of Plant Breeding and Genetics, Ghazi University Dera Ghazi Khan, Pakistan

²Department of Plant Breeding and Genetics, College of Agriculture, University of Sargodha, Pakistan

Correspondence to irfankhan2606@gmail.com

Abstract

Wheat (*Triticum aestivum* L.) plays a vital role in global food systems, yet yield improvement remains a continuous challenge due to limited genetic diversity in cultivated varieties. The evaluation of exotic germplasm offers an effective approach to broaden the genetic base and identify high-performing genotypes adaptable to diverse environments. A clear understanding of genetic variability and the inheritance of yield-related traits is essential for developing efficient selection strategies in wheat breeding programs. The objectives of this study were to assess genetic variability among exotic spring wheat lines, estimate heritability and genetic advance of important agronomic traits, and identify key traits associated with grain yield to support effective selection in wheat improvement programs. The experiment was conducted at the University of Sargodha using 49 exotic spring wheat lines obtained from CIMMYT, along with a locally adapted check cultivar. The trial was laid out in a lattice design with two replications. Observations were recorded for major phenological, morphological, and yield-related traits. Statistical analyses were performed to determine variability among genotypes, estimate heritability and genetic advance, and analyze phenotypic and genotypic correlations using standard quantitative genetic methods. Significant differences were observed among genotypes for all studied traits, indicating the presence of considerable genetic variability within the evaluated germplasm. Grain yield showed positive and meaningful associations with plant height, peduncle length, number of tillers per unit area, and maturity duration, highlighting their importance in yield improvement. High heritability combined with high genetic advance was recorded for grain yield and tiller number, suggesting that these traits are primarily governed by additive genetic effects and can respond effectively to selection. Some traits exhibited high heritability but lower genetic advance, implying environmental influence. Several exotic lines consistently outperformed the local check, demonstrating their adaptability and yield potential under local conditions. The findings demonstrate that exotic spring wheat germplasm possesses valuable genetic potential for yield enhancement. Traits with high heritability and genetic advance should be prioritized in selection-based breeding programs. Promising lines identified in this study may be utilized as parental material for future hybridization. Multi-environment testing is recommended to confirm yield stability and facilitate the development of improved wheat cultivars. These genotypes are suggested to further use in crossing to produce high yielding filial generation.

Keywords: Genetic variability; Heritability; Yield components; Wheat breeding



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February 11 - 12, 2026
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Strengthening Food Security through Capacity Building, Empowerment, and Inclusion: Insights from Technical Education and Agricultural Extension for Sustainability

Dr. Neelam Chaudhary¹, Dr. Rao Sabir Sattar¹

¹University of Agriculture, Faisalabad, Pakistan

Correspondence to neelam.chaudhary@uaf.edu.pk

Abstract

Knowledge dissemination and capacity building through formal education, technical and vocational training and extension services are realized as important drivers in order to achieve food security and resilience of agri-food systems. Human capital development is considered as a strategic approach by a number of global institutions, like IFAD, FAO, and ILO to mitigate persistent challenges such as rural poverty, youth unemployment, lower agricultural productivity and vulnerabilities due to climate change. Nevertheless, ineffective training frameworks, insufficient extension outreach activities and organizational constraints still make it difficult to transfer technical knowledge and skills efficiently. This review aims to systematically specify and explore empirical studies and institutional reports to assess and evaluate the direct and indirect impact of capacity development, extension modes, youth engagement and women inclusion on enhancing livelihoods and ensuring food security across agri-food value chain systems. This critical analysis is drawn on pragmatic studies, regular peer-reviews and reports from international organizations made on need assessment and impact evaluations published up to 2025. The sources of information include studies on farmer training, youth participation in agribusiness, extension service delivery and rural skills development across the world continents, especially Africa and Asia. Employing a narrative review methodology, the analysis integrates quantitative findings- such as pre- and post-training assessments and technology adoption rates with qualitative evidence derived from extension personnel interviews and policy analyses, in order to identify recurring patterns, outcomes and gaps. The literature review consistently demonstrates that skill development and training programs significantly improve technical knowledge and competency of farmers, adoption trends of improved agricultural practices, entrepreneurship capacities and income-generating opportunities. Youth and women intrigued and involved positively influence their empowerment through active participation in agribusiness, productivity and increased employment possibilities, though access to resources like finance, land and extension support services remain main obstacles. Extension education and training systems using pluralistic approaches— lead farmers, farmer field schools, printed guides and digital tools including mobile phones and radio—are shown to be effective in disseminating agricultural knowledge. Institutional reports highlight the significance of demand-driven training models, continuous professional development of extension workers and alignment of curricula with market needs and climate change circumstances. Overall, this review concludes that integration of skill development, extension services and empowerment of youth and women is fundamental to building resilient and inclusive food systems, contributing to improved productivity and hence to enhanced household food security. However, strengthening institutional capacity, scaling adoption of digital innovations, following pluralistic extension models and reshaping equitable and inclusive access to resources are critical for sustainable outcomes. Policymakers are encouraged to align national strategic programs with IFAD, FAO and ILO frameworks to ensure knowledge sharing and empowerment to promote food security, inclusive growth and effective knowledge translation into practice.

Keywords: Capacity Building, Agricultural Extension, Empowerment, Inclusive Growth, Food Systems





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Role of Digital Agriculture in Enhancing Food Security and Sustainable Farming

Muhammad Afzal Anjum¹, Abdul Rehman¹, Muhammad Waqas¹, Hanan Yousaf¹

¹Department of Plant Breeding and Genetics, UAF- Constituent College, Burewala

Correspondence to muhammadafzalanjum097@gmail.com

Abstract

Rapid population growth, climate variability, and declining soil fertility continue to threaten agricultural productivity and global food security. Digital agriculture provides a transformative solution by integrating advanced technologies to enhance productivity, sustainability, and data driven decision-making. The rapid advancement of tools such as the Internet of Things (IoT), artificial intelligence (AI), big data analytics, remote sensing, and precision farming has significantly reshaped traditional agricultural practices. These technologies enable real-time monitoring of soil health, crop growth, weather conditions, and pest dynamics, allowing more precise and efficient use of inputs such as water, fertilizers, and pesticides. AI is increasingly applied in mutation breeding, selection processes, environmental control, trait data management, and automated plant scanning. AI supports scientists, researchers, breeders, and students by improving data analysis, problem-solving, and learning efficiency. Digital agriculture helps reduce resource wastage, lower production costs, and minimize environmental impacts while improving crop yield and quality. Data-driven platforms also support predictive modeling and risk management, enabling farmers to respond proactively to climate and market variability. Additionally, drones, satellite imagery, and smart machinery enhance field-level management and operational efficiency. Despite its potential, challenges such as limited digital literacy, high initial investment, data privacy concerns, and unequal access especially in developing regions remain significant. Addressing these barriers through policy support, capacity building, and infrastructure development is essential to fully realize the benefits of digital agriculture.

Keywords: Digital agriculture, Artificial intelligence, Precision farming, Food security, Sustainable agriculture



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Nabiha Arshad ¹, Prof. Dr. Irfan Ahmad Baig ¹

¹MNS- University of Agriculture, Multan

Correspondence to nabihaarshad111@gmail.com

Abstract

Wheat is the most important staple crop in Pakistan, contributing significantly to national food security and rural livelihoods. Despite its importance, Pakistan faces persistent yield gaps compared to other wheat-producing countries, largely due to smallholder-dominated farming, resource constraints, and slow adoption of modern technologies. Hybrid wheat has been introduced as a potential solution for yield enhancement and resilience under changing climatic conditions. However, its adoption in Pakistan remains low, and limited research exists on the socioeconomic, institutional, and economic factors influencing farmers' willingness to adopt hybrid wheat. This study was therefore designed to evaluate the determinants of hybrid wheat adoption, assess farmers' willingness to pay, identify barriers to adoption, and project future demand under varying subsidy scenarios. The research was conducted using primary data collected from 240 wheat growers across the major wheat-producing regions of Punjab, including Faisalabad, Multan, Bahawalpur, and Muzaffargarh. A purposive sampling technique was employed to categorize farmers into control and treatment groups, distinguishing those cultivating open-pollinated varieties (OPVs), hybrid wheat, and other hybrid crops. Data were gathered through structured questionnaires and interviews. Analytical methods included descriptive statistics to profile socioeconomic characteristics, gross margin and benefit-cost ratio (BCR) analyses to compare economic returns between hybrid and OPV wheat, and econometric model such as binary logistic regression model are used to determine adoption drivers and willingness to pay. Subsidy simulations were also performed to estimate potential future demand for hybrid wheat seed. The results revealed that hybrid wheat adoption is influenced by multiple factors, including farm size, soil fertility, household size, education, and farming experience. Institutional support, especially agricultural extension services, significantly increased adoption likelihood, while high seed costs and weak market demand perceptions reduced willingness to pay. However, barriers such as high input costs, limited seed availability, and social influence from neighboring farmers remain major constraints. Subsidy simulations showed that even modest financial support could substantially increase both adoption rates and cultivated area, highlighting the importance of policy incentives.

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February 11 - 12, 2026
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Consumer Preferences and Willingness to Pay for Value-Added Fish Products in Muzaffargarh District

Khizar Ilyas¹, Prof. Dr. Nasir Nadeem¹, Prof. Dr. Mubashir Mehdi¹, Mr. Abd Ur Rehman¹

¹Muhammad Nawaz Shareef University of Agriculture Multan

Correspondence to khizarilyas624@gmail.com

Abstract

In regions such as Muzaffargarh, Pakistan, where fisheries are a vital source of livelihood and nutrition, value-added fish products present a significant opportunity to enhance food security, reduce waste, and boost local incomes. However, their success in the market relies on a thorough understanding of local consumer behavior. This study investigates consumer preferences and willingness to pay (WTP) for value-added fish products in Muzaffargarh District. Using a quantitative approach with 352 respondents, data were analyzed through Principal Component Analysis (PCA) and a Binary Logit Model. The findings reveal a strong consumer preference for these products, with taste, freshness, ease of preparation, discounts, and flavors being the main factors influencing choice. Despite this positive outlook, a notable affordability gap remains. WTP is heavily influenced by socioeconomic factors, with education and income playing key roles; higher income, educated males are significantly more willing to pay a premium. The market demonstrates high price sensitivity, with demand mainly at the lowest price points, and features such as certification or attractive packaging tend to have a limited impact on WTP. The study concludes that the potential for the value-added fish sector is limited not by a lack of interest but by the difficulty of aligning product value with consumers' purchasing power. Recommendations are made for producers and policymakers to bridge this gap through targeted pricing, education, and quality assurance.

Keywords: Value-Added Fish Products, Consumer Preferences, Willingness to Pay (WTP), Principal Component Analysis, Binary Logit Model



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February 11 - 12, 2026

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Physiological and Growth Responses of Maize to Foliar Applied Bio-Stimulants and Micronutrients under Drought Stress

Waseem Hassan ¹, Rehab Noor ¹, Muhammad Waseem ²

¹ Department of Soil and Environmental Sciences, Muhammad Nawaz Shareef University of Agriculture Multan

² Institute of Plant Breeding and Biotechnology, Muhammad Nawaz Shareef University of Agriculture Multan

Correspondence to waseem.hassan@mnsuam.edu.pk

Abstract

Maize (*Zea mays* L.) is an important crop to the global food security as well as agro-based economies; almost 97 percent of the total crop production in Pakistan is made up of maize. Nevertheless, its production is constantly compromised by abiotic stresses especially drought that is increasing in intensity and extent due to climate change. Bio stimulants are chemicals that includes natural plant growth regulators, amino acids and peptides that enhance natural plant activities, have been promising in terms of enhancing plant growth and stress resistance. The effects of bio stimulants in drought conditions could offer synergistic effects when used together with micronutrients like zinc, copper, iron, manganese, and boron. Each of which is of significance in the processes of enzymatic activity, membrane stability, photosynthesis, and reproductive development. The main objective of the research was investigating physiological and agronomic characteristics of maize hybrids to foliar application of bio-stimulants in conjunction with micronutrients under drought stress. The experiment of pot was carried out under Completely Randomized Design (CRD) having five combinations of bio-stimulants and micronutrients (Zn, Fe, B, Cu, and Mn) in the treatment. The data about Emergence (%), Emergence index (%), catalase (CAT), Peroxidase (POX) and Superoxide Dismutase (SOD) under drought stress was recorded. Seeds with foliar application of zinc showed a highest decrease in emergence percentage by 59.25% when subjected to drought stress conditions in contrast to normal water supply (74.07%). The foliar application with bio stimulants and manganese exhibited a highest decrease in emergence index by 29.63% when subjected to drought stress conditions than normal water supply conditions (55.55%). Seeds with Boron foliar application showed a marked increase in catalase activity by 10.62 U min⁻¹ mg⁻¹ protein when subjected to drought stress conditions than normal water supply. Seeds with iron application showed a remarkable increase in peroxidase activity by 14.78 U min⁻¹ mg⁻¹ protein when exposed to drought stress conditions than control water application (23.30 U min⁻¹ mg⁻¹ protein). Under normal conditions of water application, foliar application of copper resulted in highest increase in superoxide dismutase activity by 45.10 U min⁻¹ mg⁻¹ protein compared to the control (HP). Micronutrients and biostimulants applied to the foliar were used to increase drought tolerance and water use efficiency that enhanced growth, physiological performance and yield of maize.

Keywords: Maize, Drought, Bio stimulants, Micronutrients, Nutrient management, Foliar Application



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February 11 - 12, 2026
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Fuel, Forex, and Food Security: Assessing the Impact of Oil Prices and Exchange Rate Volatility on Rice Production in SAARC Economies

Saba Saleem¹, Ameen Ullah²

¹ Institute of Agriculture and Resource Economics, University of Agriculture Faisalabad.

² Department of Agriculture Economics, Balochistan Agriculture College, Quetta, Pakistan.

Correspondence to abasial530@gmail.com/ameenullah.pk@yahoo.com/kakaruaf@yahoo.com

Abstract

The impact of oil prices and exchange rate volatility on rice production in selected SAARC economies, Pakistan, Bangladesh, India, Afghanistan, and Sri Lanka, is analyzed using panel data covering the period from 1985 to 2023. Given the central role of rice in ensuring food security across South Asia, understanding how macroeconomic fluctuations influence agricultural output remains a critical policy concern. Rice production is modeled as the dependent variable, while international oil prices, exchange rates, fertilizer consumption, and temperature are incorporated as key explanatory variables. To ensure the robustness of the empirical analysis, several panel unit root tests, including Levin, Lin and Chu, I'm, Psarian Shin, and ADF Fisher chi-square, are employed, with results indicating that all variables are stationary at first difference. The Hausman specification test supports the use of a fixed effects model over pooled OLS and random effects alternatives. Empirical findings reveal that oil prices, exchange rates, and fertilizer use exert a statistically significant influence on rice production across SAARC countries, while temperature also demonstrates a significant impact. These results underscore the sensitivity of rice output to energy prices and currency movements, highlighting their implications for regional food security. The findings offer important policy insights, suggesting that stabilizing macroeconomic conditions and supporting input accessibility can enhance rice production and contribute to sustainable agricultural development in the SAARC region.

Keywords: SAARC countries, Oil Prices, Exchange rates, Temperature, Fertilizer use, Rice Production



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February 11 - 12, 2026
MNS University of Agriculture Multan

Productivity and Economic Analysis of Groundnut in Different Rainfall Conditions of the Pothwar Region of the Punjab

Dr. Arshed Bashir ¹, Rashed Saeed ², and Dr. Irfan Mahmood ²

¹Director, (PARC) Social Sciences Research Institute, Faisalabad.

²Senior Scientific Officer, (PARC) Social Sciences Research Institute, Faisalabad

Correspondence to arshadparc@gmail.com

Abstract

Groundnuts (also known as peanuts) are seeds from *Arachis hypogaea* and are a part of the legume family. It is main cash crop of summer season in the Pothwar region of the Punjab. The Pothwar tract has more climatic variability due to more diversity in temperature and rainfall. The meager output of groundnut in area may be attributed to production challenges such as rainfall variability, drought, poor soil fertility, traditional farming with little mechanization and weak extension services. Keeping in view the economic importance of groundnut in the rural economy of the region, the present study was conducted with the objective of productivity and economic analysis with respect to three different rainfall conditions of the belt. Primary data through structured questionnaire was collected during 2024-25 from 100 groundnut growers representing three rainfall zones on the basis of annual rainfall (lower, medium and high). Descriptive and partial budgeting techniques were used to analyze and report the collected data. Groundnut was the major kharif crop covering about 41 percent area of the total cropped area. Kharif fodder followed by maize were the other important crops covering 6.4 and 1.3 percent of the total cropped area respectively. The remaining (49.1 percent) area was kept as fallow. Overall, non-recommended variety of groundnut i.e Desi/334 was the dominant occupying about 39 percent of the total groundnut area. While a recommended variety BARI- 2016 was the second dominant variety covering 30 percent groundnut area. However, 20.4 percent area was occupied by the other recommended varieties. Farmers of the high rainfall area applied 33.8 kilograms seed against recommended seed rate of 40 kilogram on per acre basis. However, the farmers of medium and low rainfall zones applied 27.0 and 28.6 kilogram respectively. The farmers of high rainfall zone got higher yield (404.0 kilograms per acre) as compared with low rainfall farmer (361.4 kg/ac) and medium rainfall farmers (349.3 kgs/ac). Similarly, the net return obtained by high rainfall zone farmers was Rs. Rs. 70206.4 ac- 1. The net return on per acre basis in low and medium rainfall zones was Rs. 4784.9 and 42809.1 ac- 1. Similarly, the benefit cost ratio of 1:1.92 in high rainfall zone was comparatively more than other two zones. The reason able benefit cost ratio for groundnut production in Pothwar region of the Punjab suggests its wide cultivation as well as value addition for higher returns. However, scope still exists for improving its yield with recommended seed rate and other production practices because farmers are gaining about 60 percent less yield than the potential. The agriculture extension department should extend advisory services particularly focusing on guiding groundnut farmers for adopting recommended seed rate, approved varieties and good agricultural practices to harness the maximum benefits from groundnut.

Keywords: Economic Analysis, Groundnut, Productivity, Punjab, Rainfall



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February 11 - 12, 2026
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Towards A Zero Waste Future: The Development of Ecofriendly Crockery To Reducing the Plastic Waste

Fatima Sohail¹, Ayesha Mazhar¹, Tahani Haseeb¹

¹Jinnah University for Women,

Correspondence to fatimasohail750@gmail.com

Abstract

Edible crockery is an emerging sustainable alternative to single use plastic tableware, created from natural and food-grade materials such as wheat bran, rice and corn. These products are safe to consume, biodegradable and leave no waste after use. The concept responds to rising concerns about plastic pollution and the need for environmentally responsible dining options. By aligning with zero-waste and circular economy principles, edible crockery presents a practical approach to reducing environmental impact while offering consumers a greener and more responsible choice. This study aims to explore the development of edible crockery using natural ingredients, evaluate its functional performance and assess its potential as a sustainable replacement for disposable plastic tableware. The preparation process involved mixing wheat bran, rice flour and corn based ingredients to form a uniform dough. After allowing the dough to rest, it was shaped into different crockery forms using molds. The shaped pieces were then baked at controlled temperatures to achieve the desired firmness and durability. Once cooled, the finished edible crockery was evaluated for texture, usability and overall performance. The developed edible crockery showed strong potential as a reliable substitute for disposable tableware. It retained its structure during food service without leaking or becoming soggy, demonstrating adequate resistance to moisture and heat. Being fully biodegradable, it greatly contributes to reducing plastic waste and limiting environmental pollution. Sensory responses indicated that users found the product unique, appealing and convenient. Positive feedback on its functionality and eco-friendly nature highlighted growing consumer interest in sustainable dining solutions. Overall, the results suggest that edible crockery is both practical and market ready, with significant promise for environmentally conscious consumers and the broader hospitality sector. Edible crockery represents an innovative step toward greener consumption practices by combining practical utility with environmental responsibility. Its complete biodegradability and edible nature eliminate waste entirely, turning disposable tableware into a zero-waste solution. With rising demand for eco-friendly products, this concept can play a key role in promoting sustainable dining habits. Further improvements in flavor, texture and large scale production are recommended to enhance consumer acceptance and commercial viability.

Keywords:

Edible crockery, biodegradable tableware, sustainability, zero-waste, eco-friendly products



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February 11 - 12, 2026
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Ensuring Food Security by Implementing Sustainable Agricultural Practices

Aqsa Solangi¹, Jam Ghulam Murtaza Sahito² and Altaf Hussain Solangi³

¹Department of Agricultural Economics, Sindh Agriculture University, Tanodjam KCAET,

²Khairpur Mir's Sindh Agriculture University, Tandojam

³Institute of Crop Sciences, Chinese Academy of Agricultural Sciences, Beijing

Correspondence to solangiaqsa838@gmail.com

Abstract

Worldwide, food and agriculture production systems are confronted with previously unprecedented challenges due to the growing population's need for food, rising rates of malnutrition and starvation, the negative effects of climate change, overuse of natural resources, loss of biodiversity, and food loss and waste. These issues may make it tougher for the world to meet its current and future food needs. The prospect of climate-smart agriculture practices (CSA) represents a desire to enhance the integration of climate awareness and agricultural development. It seeks to accomplish both food security and more broad development objectives in the face of a shifting climate and rising food demand. However, the dietary diversity is a concept that considers not only food quantity but also food quality. This study explores that natural resource managers take on a variety of responsibilities as part of their role as conservation scientists and explores that they may create and conduct scientific research in addition to analyzing and researching scientific data to help them make decisions. They might also design project budgets and policies that adhere to best practices and environmental regulations. The findings indicate that higher levels of education, farming experience and larger farm size have a positive effect on food security and sustainable agriculture. In contrast, financial limitations, restricted access to credit, and reliance on off-farm income serve major obstacles to this adoption. The research emphasizes that millions of people worldwide suffer from hunger, crop failures, and rising food costs brought on by inequality, conflict, and climate change. It is more important than ever to guarantee that everyone has access to wholesome, reasonably priced food. For there to be no hunger in the future, it is crucial to comprehend the problems and take action on sustainable solutions.

Keywords: Food security, sustainable agriculture, climate-smart agriculture (CSA), natural resources management.



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February 11 - 12, 2026
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Does Livelihood Capital Matter in Farmers' Adoption of Sustainable Crop Residue Management Practices Emerging Evidence from Pakistan?

Muhammad Haseeb Raza ¹, Shoaib Akhtar ², Muhammad Faisal ³

¹ Department of Agribusiness and Applied Economics, MNS University of Agriculture, Multan

² Department of Agriculture Business and Marketing, Bahaudin Zakariya University, Multan

³ Department of Economics, University of Mianwali, Pakistan.

Correspondence to haseeb.raza@mnsuam.edu.pk , Shoaibakhtar@bzu.edu.pk

Abstract

The sustainable management of crop residue is crucial for enhancing agricultural productivity and reducing carbon emissions in agriculture sector. However, the adoption rate of sustainable crop residue management practices (SCRMPs) at the farm level is low and the impact of livelihood capitals has received little attention. For this purpose, a survey was conducted from three agro-ecological zones of Punjab, Pakistan, and a multivariate probit approach was employed to analyze the impact of farmers' livelihood capitals, which are calculated by employing an entropy-TOPSIS approach, on farmers' decisions on the use of different practices. Results indicate that different livelihood capitals categories exert different influences on the adoption of SCRMPs. Particularly, social, financial, human, natural and physical capitals have significant and positive relationship with the use of crop residues in biogas plants. Social, financial, human, and physical capitals have significant and positive relationships with the use of crop residues for on-farm purposes. The results revealed that farmers were becoming more and more interested in using sustainable crop residue management practices despite several challenges. The majority of farmers are currently using crop residue for their animal feed, though more than 50% of farmers are willing to use it as a bio-fertilizer, also for energy purposes in biogas plants. These results hold true for a wide range of countries with notable spatial variations in livestock density, particularly for those with ambitions to use crop waste more sustainably and effectively. The findings of the study recommend that improving crop residue on-farm use requires enhancing rural households' livelihood capitals through a combination of appropriate crop residue management practices.

Keywords: livelihood capital, sustainable crop residue management practices, bio-fertilizer, Pakistan



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Digital Platforms and Inclusive Innovations: Transforming Agricultural Value Chains for Reduced Food Loss and Enhanced Farmer Incomes in Developing Markets

Mr Umair Zulfiqar¹, Muhammad Adeel Sattar¹

¹University of Agriculture Faisalabad

Correspondence to sattaradeel61@gmail.com

Abstract:

The agricultural value chains need to achieve their maximum efficiency because this leads to reduced post-harvest losses and increased income for smallholder farmers and improved market competitiveness of developing economies. The traditional supply chain system produces operational difficulties because it suffers from broken logistics networks and restricted capacity to create value and hidden information and it prevents smallholder farmers from participating in the system, which results in food waste that reaches 30 to 40 percent in some areas and weakens financial returns. The new digital commerce innovations together with contract farming and cooperative and processing technology developments create new opportunities for establishing market systems that include all participants. The research investigates how these technological solutions help smallholder farmers connect with sustainable supply chains in both local and regional systems that operate in resource-limited areas of Punjab Pakistan which depend on grain and horticultural production. The primary objective is to assess innovations in digital platforms, contract farming, and value addition for enhancing agribusiness value chains. The research will evaluate how these methods decrease food waste and increase farmer profits while supporting entrepreneurship development and cooperative growth and providing smallholders with equal access to markets. The study uses a mixed-methods framework by analyzing secondary data from reports which include data from FAO and ADB and Punjab Agriculture Department initiatives and conducting case studies on digital platforms which include e-Mandi-like systems and direct-to-market apps and contract farming systems within Punjab. The research integrates agricultural stakeholders who include farmers and cooperatives and agribusinesses with quantitative metrics that measure loss reduction and income changes through survey data. Value chain mapping identifies logistical and processing and marketing bottlenecks while comparative analysis evaluates inclusive innovations against traditional systems for efficiency and equity. Farmers can connect with buyers through digital marketplaces and mobile applications which eliminate the need for middlemen and enable farmers to receive 20-30% higher payments according to pilot studies. Through contract farming and digital cooperatives, farmers can obtain better agricultural inputs, meet higher quality standards, and gain access to more accurate market information which results in 15-40% reduction of post-harvest losses through improved transportation methods and refrigerated storage systems. Businesses can enhance their market position through value-added processing methods which include solar-powered storage and product traceability systems. Women and youth receive empowerment through inclusive business models which provide entrepreneurship training and cooperative development programs that enable them to achieve higher income levels which reach as high as 25% in some Punjab programs. Digital literacy gaps and infrastructure limitations present challenges, but scaled platforms maintain operational stability during market fluctuations while blockchain projects enhance supply chain transparency and establish trust. Agribusiness value chains obtain substantial benefits through digital and inclusive innovations which decrease operational losses while boosting income levels and advancing sustainability practices. The



programs create business opportunities through cooperative development and equitable market systems which are vital for advancing rural economic growth. The recommendations need digital infrastructure development through policy support together with literacy program funding and contract farming and cooperative operations and public-private partnerships and specific financial backing for smallholder-inclusive systems. The government can use its digital agriculture programs from Punjab to expand these models which will improve agricultural competitiveness and food security throughout the country. The organization needs to focus on assessing equity impacts because it will help them achieve results which will benefit all participants in the value chain

Keywords: Agribusiness value chains, Digital platforms, Food loss reductions, Supply chain efficiency, Inclusive Market system



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February 11 - 12, 2026
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Determinants of Home Garden Commercialization among Vegetable Growers in Kombo North District, West Coast Region, The Gambia

Mortala Boye¹, Lamin KM Fatty¹

¹Agricultural Economics and Extension Unit, School of Agriculture and Environmental Sciences
University of The Gambia

Corresponding to moboye@utg.edu.gm

Abstract:

The shift from traditional farming practices to more commercially oriented approach has been in the limelight of agribusiness development discourse. This study aimed to examine the determinants and extent of vegetable commercialization among home garden vegetable growers in Kombo North District, West Coast Region, The Gambia. Primary data was collected using semi-structured questionnaire involving 140 home garden vegetable growers. Household Commercialization Index (HCI) was employed to evaluate the extent of commercialization of vegetable products. Factors influencing commercialization were analyzed using the Tobit regression model. The analysis reveals that 39 % of the respondents were semi-commercialized, 33% indicated subsistence, and 20.7% were moderately commercialized. The Tobit regression model indicates that sex, access to transport, credit, market information, and membership in a farmer association significantly and positively influenced growers' decision to commercialize vegetable produce. The study recommends that improving access to essential farming supplies could enhance the commercialization of home gardens. Additionally, developing gender-specific intervention programs is vital for ensuring that both men and women can participate equally in vegetable production and marketing. Furthermore, providing smallholder farmers with regular market information and supporting farmers' cooperatives may facilitate their entry into markets and increase their market participation, ultimately leading to fair returns

Keywords: Home garden, commercialization, home garden growers, West Coast Region, Tobit model



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February 11 - 12, 2026
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Nutrition Knowledge Gaps, Fast Food Consumption, and Health Outcomes among Female Youth in Pakistan

Sawera Malik¹

¹Department of Sociology, The Women University Multan

Corresponding to saweram343@gmail.com

Abstract:

Fast food-related dietary changes with high intake of fast food are becoming a major public-health problem in developing nations, especially in Pakistan. The changing of food environments, the aggressive marketing policies, peer pressure, and the increased availability of processed foods have all contributed to the change in the dietary habits of young people with important consequences to health, well-being and long-term sustainability of food systems. The current study aims at exploring the eating habits and associated health and well-being consequences of fast foods among young female university students, a group that is highly vulnerable to the risks of poor health caused by poor diet. The quantitative research design was adopted and a simple random sampling approach was used to sample 200 female students of the Women University Multan. The self-administered questionnaire was used to collect the data by evaluating the frequency of fast food intake, accessibility, dietary preference, health outcomes, nutrition awareness, and perceived well-being. The SPSS was used to perform descriptive and inferential statistical tests. The findings imply that 80.0% of the sampled individuals stated that they have easy access to fast food in their residential locations and 40.5% ate fast food one or twice a week. Taste was the main factor in the preference of fast food by 60.0% of the respondents. About half (48.0%) admitted that obesity has a negative impact on their general health and 35.5% admitted to changes in the menstrual cycle. In addition, 38.0 per cent had the feeling that the consumption of fast food had a negative effect on their general well-being and a significant number of them were neutral or unsure about formal nutritional education. The paper brings out the overlap of dietary behavior and women health and gap in knowledge in nutritional awareness. These results highlight the strong necessity to focus on nutrition education, health programs in universities, and community-oriented awareness efforts to encourage people to make healthier food choices. Not only is it important to address the issue of fast-food consumption among young women to achieve personal health but also to promote sustainable food systems and human capital development and, consequently, to be aligned with the overall goals of food security and community empowerment.

Keywords: Fast Food Consumption; Women's Health; Nutritional Awareness; Dietary Behavior; Health and Well-Being



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February 11 - 12, 2026
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Does Digital Credit Enable Sustainable Farming? Evidence on Soil and Water Management Adoption among Smallholders in Pakistan

Irfan Mahmood¹, Arshed Bashir¹, Rashed Saeed¹, Sobia Naheed¹

¹Pakistan Agricultural Research Council

Corresponding to irfan.mahmood@parc.gov.pk

Abstract:

Smallholder agriculture in developing countries faces increasing challenges due to climate change, water scarcity, soil degradation, and limited access to formal financial services. In Pakistan, these constraints significantly restrict farmers' capacity to invest in sustainable agricultural management practices (AMPs) that enhance productivity and resource efficiency. While recent studies highlight the role of digital finance in improving financial inclusion, empirical evidence on how e-credit influences the adoption of multiple soil and water management practices remains limited. Addressing this gap is crucial for promoting climate-resilient and resource-efficient farming systems in vulnerable agrarian economies. This study examines the role of e-credit in influencing small farmers' adoption of key soil and water management practices in Punjab, Pakistan. It further analyzes complementarities among practices and evaluates how e-credit affects the intensity of adoption of multiple agricultural management practices. The study uses cross-sectional data collected from 420 smallholder farmers across four regions of Punjab through a multistage random sampling technique. A Multivariate Probit (MVP) model is employed to analyze the simultaneous and interdependent adoption decisions of four practices: precision land levelling, crop residue incorporation, sustainable irrigation water use, and crop rotation. To assess adoption intensity, an Ordered Probit model is applied, capturing farmers' likelihood of adopting multiple practices. The models control for socioeconomic, institutional, and farm-level characteristics to ensure robust inference. The results reveal that e-credit adoption significantly increases the likelihood of adopting precision land levelling, crop residue incorporation, and sustainable irrigation practices, while showing a negative association with crop rotation, reflecting short-term productivity preferences. Strong complementarities are observed among precision land levelling, residue management, and sustainable irrigation, confirming joint adoption behavior. The Ordered Probit results further indicate that e-credit substantially enhances the probability of adopting three or more practices simultaneously. Farm size, education, farming experience, awareness of AMPs, access to certified seed, soil testing facilities, and mechanization positively influence both adoption and adoption intensity. Conversely, off-farm employment reduces engagement in labor- and management-intensive practices. The findings underscore e-credit as a critical enabler of sustainable and climate-smart agriculture among smallholders. By easing liquidity constraints, e-credit not only promotes individual practice adoption but also facilitates bundled adoption of complementary soil and water management practices. Policy efforts should focus on expanding digital credit access, strengthening institutional support services, and enhancing farmers' awareness and technical capacity. Integrating e-credit with extension programs can accelerate the transition toward resource-efficient and resilient agricultural systems in Pakistan and similar developing economies.

Keywords: digital credit, sustainable agriculture, smallholders, Pakistan



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February 11 - 12, 2026
MNS University of Agriculture Multan

Managing Irrigation Water Conflicts under Increasing Water Scarcity: Policy Evidence from Punjab, Pakistan

Komal Azhar¹, Usman Azhar¹

¹Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad

Corresponding to komalazhar@uaf.edu.pk

Abstract:

Climate change, population pressure, and ineffective water management practices have led to water scarcity and this has been a major challenge to the sustainability of agriculture. Frequent conflict among farmers is a result of increasing competition on the limited irrigation water which threatens agricultural productivity and lives in the countryside. This paper explores the key reasons behind irrigation water conflicts and analyzes the methods of dealing with the conflict in two districts of Punjab, Pakistan, that is, Sargodha and Sahiwal. It was used to collect primary data through a structured questionnaire on 300 farming households. Socio-economic characteristics were evaluated with the help of descriptive analysis, and the most significant factors affecting the choice of conflict management strategies by farmers were determined with the use of a logistic regression model. The findings indicate that the lack of education, small land areas, low incomes, and years of farming experience are important factors that influence the reaction of farmers to irrigation conflicts. The perceived water scarcity and farm attributes are also highly related to the perceived water scarcity and farm characteristics in adoption of cooperative, negotiated or formal conflict resolution approaches. The paper has emphasized the role of good water management, knowledge among farmers, and institutional facilitation of irrigation conflicts. Sustainable irrigation practices, enhanced water delivery systems and enhanced local conflict management institutions are necessary to improve the agricultural resilience and equitable water utilization in water-deprived areas.

Keywords: Water Scarcity, Irrigation Conflicts, Conflict Management, Agricultural Policy, Sustainable Water Use



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February 11 - 12, 2026
MNS University of Agriculture Multan

Poetics of Ecological Belonging: Community-Based Resilience in Gary Snyder's Prayer for the Great Family

Aimen Batool¹, Mamoon Asif², Saima Umer²

¹Lecturer, MNSUAM

²Lecturer, NUML

Corresponding to aimen.batool@mnsuam.edu.pk

Abstract:

This paper examines Gary Snyder's "Prayer for the Great Family" as a poetic articulation of ecological ethics and community-based resilience in the context of contemporary climate change and environmental challenges. Drawing on Arne Naess's Deep Ecology and Jane Bennett's Vibrant Materialism, the study argues that Snyder's poem offers a conceptual framework for reimagining human-nature relationships essential for fostering sustainable and resilient communities. Through the lens of biospheric egalitarianism, the poem affirms the intrinsic value of all beings—human, non-human, and elemental—thereby challenging anthropocentric worldviews that underpin ecological degradation and climate crises. Snyder's inclusive notion of the "Great Family" positions humans as embedded participants within ecological systems rather than external managers, a perspective that resonates strongly with community-based approaches to environmental stewardship and climate adaptation. Complementing this ethical stance, Bennett's Vibrant Materialism illuminates the poem's representation of matter—land, water, animals, and atmospheric forces—as active and agentic. Such an outlook is particularly relevant to climate resilience, as it foregrounds the interdependence of ecological systems and human communities. The paper further interprets the poem's concluding emphasis on consciousness—"in our minds so be it"—as a call for ecological awareness as the foundation of collective resilience. Ultimately, this study contends that "Prayer for the Great Family" contributes to climate discourse by envisioning resilience not merely as infrastructural adaptation, but as a culturally and ethically grounded practice rooted in ecological belonging, mindfulness, and shared responsibility.

Keywords: Ecological Kinship, Climate Resilience, Deep Ecology, Posthuman Ecocriticism, Community-Based Environmental Ethics.



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Rural Women's Contribution to Household Food Security in Agrarian Communities: A Cross-Sectional Study from Rural Punjab, Pakistan

Dr. Madiha Naz¹, Dr. Nouman Khaliq², Dr. Sadaf Mahmood¹, Dr. Naveed Farah¹, Dr.
Muhammad Idrees¹

¹Assistant professor, Department of Rural Sociology, University of Agriculture Faisalabad.

²Associate professor, Department of Sociology, Riphah International University Faisalabad.

Corresponding to madiha.naz@uaf.edu.pk

Abstract

Food insecurity remains a pressing development issue in many low- and middle-income countries. In Pakistan's rural communities, women bear substantial responsibility for ensuring household food security through food production, access, utilization, and overall resource management. Despite their vital contributions, there is limited empirical research exploring the role of rural women in household-level food security in the Pakistani context. This study aims to examine the extent of rural women's involvement in various dimensions of household food security in agrarian communities of Punjab, Pakistan. A cross-sectional quantitative survey was conducted in three purposively selected districts of Punjab. Data were collected from 420 rural households using a structured interview schedule and random sampling technique. Both descriptive and inferential statistics, including binary logistic regression, were applied to analyze the data. Findings showed that 49% of households were food insecure, while 51% were food secure. Women played a significant role across all dimensions of food security. In terms of availability, 67% of women contributed as farmers and laborers. For access, 57.4% acted as food buyers, and 23% were engaged in wage-based income generation particularly vital for low-income households. In food utilization, 75% of women were involved in food preparation, processing, and distribution. However, only 15.2% had substantial knowledge of nutritional needs. Additionally, 40.5% of the women were illiterate, and the majority (39.8%) were between 25–35 years of age. The binary logistic regression analysis indicated that women's participation in food production, indigenous knowledge, income contribution, age, education level, household size, and asset ownership were significant predictors of household food security. The study concludes that rural women play a pivotal role in ensuring household food security. However, their contributions are often constrained by limited resources, education, and institutional support. Policy interventions should focus on empowering women through income-generating activities, nutritional education, and improved access to resources. Strengthening women's capacities will enhance household food security outcomes and contribute to broader rural development goals.

Keywords: Rural women, food security, agriculture, Punjab, Pakistan



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Gendered Livelihoods and Household Food Security: Evidence from Rural Agricultural Communities in Punjab

Dr. Madiha Naz¹, Dr. Nouman Khaliq², Dr. Sadaf Mahmood¹, Dr. Naveed Farah¹, Dr. Muhammad Idrees¹

¹Assistant professor, Department of Rural Sociology, University of Agriculture Faisalabad.

²Associate professor, Department of Sociology, Riphah International University Faisalabad.

Corresponding to madiha.naz@uaf.edu.pk

Abstract:

Climate change poses significant risks to food security by affecting agricultural productivity, market stability, and household well-being. In rural Pakistan, women are central contributors to household food systems—engaged in crop production, livestock management, food purchasing, cooking, and food preservation. Their contributions help ensure food availability, access, and utilization, especially under conditions of climate stress and resource scarcity. Despite this, their work remains undervalued and inadequately supported. This study explores how rural women contribute to household food security within the context of changing climate and livelihood vulnerabilities in agrarian communities of Punjab, Pakistan. This study aims to examine the extent and determinants of rural women's contributions to household food security, with a specific focus on climate-responsive livelihood activities in agrarian communities of Punjab, Pakistan. A cross-sectional quantitative survey was conducted in three purposively selected rural districts of Punjab. Data were collected from 420 rural households through a structured interview schedule using random sampling. Both descriptive statistics and inferential statistics, including binary logistic regression, were applied to analyze the data and identify predictors of household food security. Findings revealed that 49% of households were food insecure, while 51% were food secure. Women demonstrated substantial involvement across key dimensions of food security: Food Availability: 67% of women participated in agricultural labor, livestock care, and home-based food production, which helped sustain household food supplies under climate variability. Food Access: 57.4% were responsible for purchasing food, while 23% contributed to household income through wage labor, home-based work, or seasonal farm employment. Food Utilization: 75% managed food preparation, preservation, and intra-household distribution; however, only 15.2% demonstrated adequate nutritional knowledge, largely due to 40.5% illiteracy among respondents. Binary logistic regression analysis identified women's involvement in food production, indigenous knowledge, income contribution, age, education, household size, and asset ownership as significant predictors of household food security. The study concludes that rural women are central to sustaining climate-resilient household food security. However, their roles are constrained by limited access to land, income opportunities, agricultural training, and nutritional awareness. To enhance food security outcomes, policy interventions should: Promote women's access to climate-smart agricultural training. Strengthen livelihood diversification and income-generating opportunities. Improve access to nutrition education and women-friendly extension services. Ensure gender-equitable access to land, credit, and agricultural inputs. Empowering rural women is critical not only for household food security but also for building inclusive, climate-resilient, and socially just rural development pathways.

Keywords: Rural women, climate-smart agriculture, food security, livelihoods, Punjab, Pakistan.



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February 11 - 12, 2026
MNS University of Agriculture Multan

Harnessing The Power of Precision Technologies: Advancing Towards a Sustainable and Efficient Future Livestock and Dairy Farming

Muhammad Ashraf¹, Anita Mehboob²

¹Department of Livestock Management, University of Agriculture, Faisalabad, Sub-Campus Toba Tek Singh, Pakistan.

²Department of Zoology University of Baltistan, Skardu, Pakistan

Corresponding to tariq7337@gmail.com

Abstract

The global livestock and dairy industry is facing increasing pressure to improve productivity, sustainability, and animal welfare. The livestock and dairy industry has undergone a revolutionary transformation in recent years, with precision agriculture emerging as a cornerstone for sustainable and efficient production. Precision livestock and dairy production (PLDP) is an emerging approach that utilizes data analytics, sensors, and other technologies to optimize animal management and production decisions. This review highlights recent advancements in PLDP, including the use of wearable sensors, machine learning algorithms, and artificial intelligence to monitor animal health, behavior, and productivity. PLDP has the potential to revolutionize the livestock and dairy industry by improving animal welfare, reducing environmental impacts, and increasing profitability. The emergence of cutting-edge sensors, artificial intelligence (AI), and machine learning (ML) algorithms has propelled PLDP forward. These technologies enable continuous monitoring of individual animals, providing real-time insights into their physiological parameters, behavior, and environmental conditions. By analyzing this vast trove of data, farmers can gain a deeper understanding of their animals' needs and this information can be used to make more informed decisions about animal management, such as adjusting feed rations, administering medications, and selecting breeding animals. PLDP is already having a significant impact on the livestock and dairy industry. For example, wearable sensors are being used to monitor the health of dairy cows and detect early signs of mastitis, a costly and debilitating disease. Machine learning is being used to optimize feed rations for beef cattle, reducing feed costs and improving animal growth rates. PLDP is also being used to improve the welfare of animals, such as by using sensors to monitor the temperature and humidity in barns and adjusting ventilation systems accordingly. The adoption of PLDP is being driven by a number of factors, including the increasing availability of data, the decreasing cost of sensors and computing power, and the growing demand for sustainable and ethically produced food. PLDP has the potential to transform the livestock and dairy industry by making it more efficient, sustainable, and humane.

Keywords: Innovative Approaches, Livestock/ Dairy, Scientific Progress, Precision Production, Sustainability



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February 11 - 12, 2026
MNS University of Agriculture Multan

Obesity as a Mediating Pathway to Ischemic Heart Disease in Pakistan: Implications for Nutritional Security and Sustainable Food Systems

Umar Ijaz Ahmed¹, Muhammad Akash Khan²

¹Department of Agricultural and Resource Economics, MNS University of Agriculture Multan

²Faculty of Veterinary and Animal Sciences, MNS University of Agriculture Multan

Corresponding to umar.ijaz@mnsuam.edu.pk

Abstract

Rapid urbanization, dietary transitions, and sedentary lifestyles have intensified obesity prevalence in Pakistan, posing serious challenges to nutritional security and sustainable food systems. Obesity is increasingly recognized as a critical driver of non-communicable diseases, particularly ischemic heart disease (IHD), which significantly burdens public health and economic productivity. To examine the direct and indirect effects of obesity on ischemic heart disease and assess the mediating roles of hypertension, diabetes, and dyslipidemia in the context of nutritional security. A prospective observational study was conducted among clinically diagnosed IHD patients at tertiary healthcare facilities in Pakistan. Obesity was assessed using body mass index, waist circumference, waist-hip ratio, and abdominal fat indicators. Biochemical markers including lipid profile, blood glucose, C-reactive protein, and blood pressure were analyzed. Obese individuals showed significantly higher prevalence of ischemic heart disease, elevated blood pressure, dyslipidemia, hyperglycemia, and inflammatory markers compared to non-obese individuals. Hypertension, diabetes, and dyslipidemia partially mediated the relationship between obesity and IHD. Obesity acts as a critical link between poor nutritional patterns and ischemic heart disease. Integrated strategies focusing on nutrition-sensitive agriculture, dietary diversification, and preventive health interventions are essential.

Keywords: Obesity, Nutritional Security, Ischemic Heart Disease, Metabolic Risk, Sustainable Food Systems



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February 11 - 12, 2026
MNS University of Agriculture Multan

Climate Change, Urbanization, and the Persistence of Dengue: Evidence from Surveillance and Control Gaps in Pakistan

Umar Ijaz Ahmed¹, Muhammad Taha Kamran²

¹Department of Agricultural and Resource Economics, MNS University of Agriculture Multan

²Faculty of Veterinary and Animal Sciences, MNS University of Agriculture Multan

Corresponding to umar.ijaz@mnsuam.edu.pk

Abstract

Dengue fever is one of the fastest-growing climate-sensitive vector-borne diseases in developing countries. Climate variability, rapid urbanization, and weak public health infrastructure have intensified dengue transmission dynamics in Pakistan. To examine the role of climate change and surveillance gaps in the persistence of dengue and assess implications for climate-resilient public health systems. A mixed-methods approach was used, combining retrospective dengue surveillance data with a cross-sectional Knowledge, Attitudes, and Practices (KAP) survey of 300 respondents in Muzaffargarh District, Pakistan. Results reveal significant underreporting and delays in passive surveillance systems. Rising temperatures and altered rainfall patterns expanded Aedes mosquito breeding habitats, while insecticide resistance and low community engagement weakened vector control efforts. The study highlights the need for climate-informed surveillance, community-based vector control, and strengthened health systems to enhance resilience against dengue under changing climatic conditions.

Keywords: Climate Change, Dengue Fever, Surveillance Systems, Vector Control, Public Health



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February 11 - 12, 2026
MNS University of Agriculture Multan

Economic and Policy Constraints to the Adoption of Unmanned Aerial Vehicle (UAV) Technology in Smallholder Agriculture: Evidence from South Punjab, Pakistan

Umar Ijaz Ahmed¹, Muhammad Zohaib Faheem²

¹Department of Agribusiness and Entrepreneurship Development, MNS University of Agriculture, Multan

²Department of Agricultural and Resource Economics, MNS University of Agriculture, Multan

Corresponding to umar.ijaz@mnsuam.edu.pk

Abstract

Unmanned Aerial Vehicles (UAVs) have gained policy attention as a precision agriculture tool capable of improving productivity, reducing input waste, and supporting climate-smart farming systems. However, adoption among smallholder farmers in developing countries remains limited, raising important economic and institutional questions. To analyze the economic, policy, and institutional factors influencing the adoption of UAV technology among smallholder farmers in South Punjab, Pakistan. Primary data were collected from 200 smallholder farmers across selected tehsils of District Multan using a structured questionnaire. Descriptive statistics, reliability analysis, and principal component analysis were employed to identify and rank adoption constraints. The findings reveal that high initial investment costs, limited access to credit, and uncertainty regarding returns on investment are the dominant economic barriers. Policy and institutional constraints, including weak extension services, lack of targeted subsidies, regulatory uncertainty, and limited public-private partnerships, further inhibit adoption. The study highlights market failures related to information asymmetry, credit access, and risk. Policy interventions focusing on service-based UAV models, digital extension, credit facilitation, and regulatory clarity are recommended to promote inclusive adoption and accelerate digital transformation in smallholder agriculture.

Keywords: Digital Agriculture, UAV Adoption, Agricultural Policy, Technology Economics, Smallholder Farmers



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February 11 - 12, 2026
MNS University of Agriculture Multan

Food Insecurity in South Punjab, Pakistan: Structural Drivers and Sustainable Agricultural Pathways

Umar Ijaz Ahmed¹, Maryam Tahir²

¹Department of Agricultural and Resource Economics, MNS University of Agriculture, Multan

²Department of Agribusiness and Entrepreneurship Development, MNS University of Agriculture, Multan

Corresponding to umar.ijaz@mnsuam.edu.pk

Abstract

Food insecurity continues to be an issue in South Punjab, Pakistan, despite the fact that it contributes significantly to food production at a national level. Climate change and inefficiencies within food production systems have created a shortage of nutritious food among households. To identify drivers of food insecurity in South Punjab and examine sustainable agriculture options for enhancing food security. The research relied on primary survey data obtained at the household level from some districts in South Punjab. The analysis based on descriptive statistics and food security measures explored the availability, access, utilization, and stability components for food security. Results show that water scarcity, soil deterioration, and climate change have negatively impacted productivity and earnings. Lack of access to inputs, credit, extension services, and markets hinders food availability. Lower dietary diversity among households signifies low food utilization. Vulnerable groups include small farmers and female-headed households. The research emphasizes the importance of climate-smart agriculture, crop diversification, extension services, and market access. It also emphasizes nutrition and inclusion as ways to develop a food system with resilience and overcome the issue of food insecurity within South Punjab.

Keywords: Food Insecurity, Sustainable Agriculture, Climate-Smart Farming, South Punjab, Rural Livelihoods



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February 11 - 12, 2026
MNS University of Agriculture Multan

Economic Significance of SMEs in Labor Absorption: An Empirical Analysis from a Semi-Urban District in Pakistan

Azhar Iqbal¹

¹Ph.D. Scholar (Agricultural Economics) MNS Agricultural University Multan, Pakistan

Corresponding to azhar001979@gmail.com

Abstract

This study investigates the contribution of Small and Medium Enterprises (SMEs) to employment generation in the district of Khanewal, Pakistan, by integrating descriptive evidence with econometric modeling. SMEs in the region are primarily concentrated in the manufacturing and trading sectors and operate with modest initial capital, yet they demonstrate substantial capacity for labor absorption. Descriptive findings reveal that most SMEs employ between 5 and 20 workers, with employment levels increasing across the business life cycle—from formation to current operations—indicating their sustained role in generating livelihood opportunities. The econometric analysis provides robust empirical support for the employment-enhancing role of SMEs. Results from the multiple regression model show that SME income has a strong and statistically significant positive effect on employment ($\beta = 0.26694$, $p < 0.001$), confirming that enterprise growth directly increases labor force participation. Education of workers ($\beta = 0.30462$, $p < 0.001$) also positively influences employment, underscoring the importance of human capital within SME operations. Conversely, longer working hours and greater distance from urban centers exhibit negative associations with employment, indicating structural and locational constraints that shape labor participation decisions. Overall, the findings affirm that SMEs are a critical driver of employment generation in semi-urban and rural economies. Strengthening SME ecosystems through enhanced access to finance, skill development, infrastructure, and targeted policy support can amplify their employment effects and contribute to inclusive economic growth in Pakistan.

Keywords: SMEs; Employment Generation; Labor Force Participation; Rural Economy; Economic Growth



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February 11 - 12, 2026
MNS University of Agriculture Multan

Estimation of supply and demand elasticities for wheat crop in Pakistan

Shabnum Soomro¹, Jam Ghulam Murtaza Sahito²

¹M.Sc. Scholar, Department of Agricultural Economics, Sindh Agriculture University, Tandojam

²Professor, Khairpur College of Agriculture and Management Sciences, Khairpur Mir's

Corresponding to shabnumsoomro0202@gmail.com

Abstract

This paper examines the supply and demand elasticities of wheat in Pakistan, an essential element of the nation's food security and economic structure. Wheat constitutes 1.8% of Pakistan's Gross Domestic Product (GDP) and 9.2% of agricultural value added, positioning the country as the ninth-largest wheat producer globally. Approximately 38.5% of the population is engaged in the agricultural sector, with 66-70% relying on it for their livelihoods. The demand for wheat demonstrates typical price inelasticity, which is influenced by ongoing population growth and resultant production shortfalls. Currently, around 53 million individuals live in poverty, and the unemployment rate is approximately 16%, issues further intensified by the COVID-19 pandemic's impact on food security. The objectives of this study are threefold: to estimate the price elasticity of the wheat crop, to estimate the price elasticity of demand for the wheat crop, and to understand the changes in supply and demand along with their implications. Utilizing time series data from 2000-01 to 2021-22 obtained from the Household Integrated Economic Surveys (HIES) and the Agricultural Statistics of Pakistan, the study employs the Nerlovian partial adjustment model to calculate supply elasticities, while the Linear Approximate Almost Ideal Demand System (LA-AIDS) model is utilized to estimate demand elasticities. The dataset includes pertinent variables such as wheat production, wholesale prices of wheat and competing crops, irrigated area, rainfall, temperature, and fertilizer prices. The findings indicate that both supply and demand for wheat are inelastic, revealing a limited responsiveness of farmers and consumers to price fluctuations. Specifically, all variables within the supply and demand models, including input prices such as urea and DAP, as well as the budget shares for related food items, demonstrate inelastic behavior. In light of these findings, it is recommended that the government explore alternative policy measures beyond merely increasing wheat prices. Strategies should focus on enhancing production efficiency, introducing innovative wheat varieties, and diversifying food sources to reduce reliance on wheat and improve overall food security.

Keywords: Price, Elasticity, Market, Response, Demand-supply



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Creating a Health-Boosting Probiotic Chocolate Spread Using an Innovative Approach

Ayesha mazhar¹, Malaika kiran², Hafiza Madiha², Kulsoom Ibrahim²

¹Bs Food Science and Technology

²Department of Food Science and Technology

Corresponding to ayeshamazhar586@gmail.com

Abstract

This research investigates the novel use of hazelnuts and yogurt powder to create a nutritious and probiotic-rich chocolate spread. Hazelnuts, which are known for their healthy fats and minerals, and yogurt powder, which provides probiotics, are combined to create a spread that is high in bioactive compounds, including beneficial probiotics, which have potential health benefits. The goal of this study is to contribute to sustainable food practices by turning nutritious ingredients into a value-added product. The probiotic chocolate spread was characterized by different parameters like proximate, phytochemical, microbial analysis. In which we have the moisture content around $12.87\% \pm 0.02$, Ash content $0.73\% \pm 0.15$, shows little change from trial to trial and indicates a stable mineral composition and precise formulation. The fat content stayed largely unchanged. With a mean fat percentage of $34.53 \pm 0.25\%$. This indicates a balanced approach between health functions and palatability, as it is somewhat lower than classic chocolate spreads. Hazelnuts and milk solids were added to a probiotic spread supplemented with *Lactobacillus plantarum*, which showed a protein content of $7.42 \pm 0.11\%$. With a slight variance of 350.63 ± 0.25 , this viscosity number indicates the product's consistency and spreadability, guaranteeing a creamy and even application. By providing insight into the development of functional foods with potential health benefits, this study contributes to the expanding field of sustainable food innovation. The obtained yogurt powder and hazelnut mixture improve the nutritional profile and probiotic capacity of the chocolate spread formulation. The microbiological analysis revealed that the probiotic chocolate spread contained 111.00 ± 3.61 CFU/g of beneficial bacteria. This implies that the spread contains a robust probiotic population, which is advantageous for supporting the digestive system and gut health. Consumer panels evaluate the sensory qualities of the chocolate spread to ensure acceptability. A nutritional analysis is also performed. The results show that chocolate spreads fortified with hazelnut and yogurt powder have higher probiotic activity than conventional chocolate spreads. The analysis confirms the presence of bioactive compounds that are responsible for the health benefits observed. According to the sensory evaluation, the chocolate spread has a pleasant taste and texture

Keywords: Probiotic, hazelnuts, chocolate spread, good for gut health



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Towards a zero-waste future: The development of eco-friendly crockery to reduce plastic waste

Fatima Sohail¹, Ayesha Mazhar², Tahani Haseeb²

¹Bs Food Science and Technology

¹Department of Food Science and Technology

Corresponding to fatimasohail750@gmail.com

Abstract

Edible crockery is an emerging sustainable alternative to single use plastic tableware, created from natural and food-grade materials such as wheat bran, rice and corn. These products are safe to consume, biodegradable and leave no waste after use. The concept responds to rising concerns about plastic pollution and the need for environmentally responsible dining options. By aligning with zero-waste and circular economy principles, edible crockery presents a practical approach to reducing environmental impact while offering consumers a greener and more responsible choice. This study aims to explore the development of edible crockery using natural ingredients, evaluate its functional performance and assess its potential as a sustainable replacement for disposable plastic tableware. The preparation process involved mixing wheat bran, rice flour and corn based ingredients to form a uniform dough. After allowing the dough to rest, it was shaped into different crockery forms using molds. The shaped pieces were then baked at controlled temperatures to achieve the desired firmness and durability. Once cooled, the finished edible crockery was evaluated for texture, usability and overall performance. The developed edible crockery showed strong potential as a reliable substitute for disposable tableware. It retained its structure during food service without leaking or becoming soggy, demonstrating adequate resistance to moisture and heat. Being fully biodegradable, it greatly contributes to reducing plastic waste and limiting environmental pollution. Sensory responses indicated that users found the product unique, appealing and convenient. Positive feedback on its functionality and eco-friendly nature highlighted growing consumer interest in sustainable dining solutions. Overall, the results suggest that edible crockery is both practical and market ready, with significant promise for environmentally conscious consumers and the broader hospitality sector. Edible crockery represents an innovative step toward greener consumption practices by combining practical utility with environmental responsibility. Its complete biodegradability and edible nature eliminate waste entirely, turning disposable tableware into a zero-waste solution. With rising demand for eco-friendly products, this concept can play a key role in promoting sustainable dining habits. Further improvements in flavor, texture and large-scale production are recommended to enhance consumer acceptance and commercial viability.

Keywords: Edible crockery, biodegradable tableware, sustainability, zero-waste, eco-friendly products



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Development of a Functional Focaccia Soft Bread with Spinach Powder and other Nutritious Ingredients

Yumna Ateeq¹, Ayesha Mazhar¹, Maryum sheikh¹

¹Bs Food science and technology

Corresponding to jalalyumna11@gmail.com

Abstract

The growing consumer demand for nutritious, affordable, and health-promoting food products, this study presents the development of functional soft focaccia bread enriched with spinach powder and other nutrient-rich ingredients. Spinach was selected for its high content of iron, fiber, vitamins A, C, and K, folate, and antioxidants, making it a valuable addition to functional bakery formulations. The incorporation of spinach powder aimed not only to enhance the nutritional profile of the bread but also to introduce natural color and a mild earthy flavor that complements traditional focaccia. Additional wholesome ingredients were used to improve the bread's functional properties, targeting benefits such as better digestive health, antioxidant support, and overall dietary enrichment. The formulation process focused on maintaining the soft texture and sensory qualities expected in focaccia, ensuring consumer acceptance while delivering enhanced health value. This innovative product offers a practical, cost-effective alternative to conventional bread, contributing to balanced nutrition in everyday diets. In recent years, there has been a growing shift in consumer preferences toward functional foods that combine nutritional value with sensory appeal and convenience. Bread, being a staple food in many cultures, offers an ideal platform for fortification with health-enhancing ingredients. This study focuses on the development of a functional soft focaccia bread formulated with spinach powder and other nutritious components to improve its health impact, quality, and consumer acceptability. The results demonstrate that the developed focaccia bread possesses favorable nutritional and sensory characteristics. The low moisture content (2.62%) indicates good shelf stability and reduced risk of microbial spoilage. Ash content (1.29%) suggests the presence of essential minerals, contributed partly by spinach powder and whole grain flours. The minimal fat content (0.42%) makes the bread a suitable option for health-conscious consumers, and its neutral pH confirms that it is safe and non-acidic for consumption. The inclusion of spinach powder likely added to the nutritional profile without affecting the overall palatability of the product. Sensory evaluation results, with scores consistently above 7, indicate strong consumer acceptance in terms of taste, texture, appearance, and overall quality. This suggests that the incorporation of nutritious ingredients did not compromise the sensory appeal of the bread. The study successfully developed a functional focaccia soft bread enriched with spinach powder and other nutritious ingredients. The bread exhibited desirable nutritional attributes, such as low fat and good mineral content, and was well-received during sensory evaluation. This product shows promise as a health-oriented bakery item and could be beneficial for consumers seeking nutritious and functional food alternatives.

Keywords: Fiber rich, focaccia bread, functional, bakery product, better digestive



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Economic Viability of Extracting Eucalyptus Essential Oil Under Steam Distillation Method in Pakistan

Rashed Saeed¹, Dr. Arshed Bashir², Dr. Naveed Ahmad³

¹(PARC) Social Sciences Research Institute, Faisalabad

²Director, (PARC) Social Sciences Research Institute, Faisalabad.

³Horticulturist, Horticultural Research Sub-Station for Floriculture and Landscaping, AARI, Faisalabad

Corresponding to rashedkasuri@gmail.com

Abstract

Essential oils used by medicinal purposes are volatile compounds naturally found in medicinal and aromatic plants. Essential oils are gaining popularity locally as well as internationally because of higher economic returns from processing of raw herbal/medicinal plants and their subsequent use from cosmetics to aromatherapy and wellness sectors. Despite enjoying a rich and diverse flora of almost 5700 species of medicinally important plants, Pakistan is net importer of essential oils. Here limited awareness of farmers and the processors about essential oils as well as lack of infrastructure including inadequate access to market are some of the challenges hindering developments in medicinal plants for essential oils. Present research aimed at providing practical and comprehensive financial and technical knowledge to potential processors about eucalyptus essential oil that has huge demand in cosmetic, perfumery, and aromatherapy. Eucalyptus essential oil from plant leaves was extracted during year 2025 in LPG fueled small but commercial steam distillation unit having 500 litre water holding capacity. Whole economic analysis was conducted based on current market input/output prices to factually guide the potential processors/entrepreneurs of essential oils. Eucalyptus leaves purchased locally for Rs.25 per Kg were handed over to Pak Herbal Dispensary - a local herbs processing facility for distillation of essential oil. According to technical extraction results, 470 ml of pure essential oil was extracted from 60 Kg dried leaves while consuming 6 Kg LPG in one 4-hours distillation round. Cost benefit analysis based on monthly estimates of eucalyptus essential oil reveals that processors can earn a gross profit around Rs.77162/ month by producing 11.7 Litre oil to sell in wholesale market for Rs.20000/ Litre by daily running one distillation round. Moreover, profitability analysis of essential oil reveals that business can return around 50% gross profit on initial small investment of up to one million having 1 year pay back period. It was quite obvious from technical and economic analyses that eucalyptus leaves which are normally a waste or less valued byproduct of timber industry in Pakistan when used for essential oil purposes can return a handsome economic value to the farmers, processors. In the nutshell, any potential investor can start this business with little initial investment of less than one million to be returned to the investors within 1 year of working. Based on reasonable economic viability of eucalyptus essential oil extraction in the country, government should promote essential oil business especially among youth and eucalyptus farmers by special inclusion of essential oil business in its loan schemes. Similarly, private sector should come forward to promote essential oil industry on large scale to cater the local demands form consumers as well as export essential oils to the developed big overseas markets. Moreover, it is equally important to explore competitiveness of local essential oils for international markets.

Keywords: Benefit-Cost Analysis, Essential Oil, Eucalyptus, Steam Distillation, Pakistan





3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Effects of Acidified Sunflower Meal-Based Diets on Nutrient Utilization, Hematological Indices and Body Carcass of *Cirrhinus Mirigala* Juvenil

Maliha Sarfraz¹, Tayyba², Khalid³

¹University of Agriculture Faisalabad, Constituent College Toba Tek Singh, Punjab, Pakistan

²University of Agriculture Faisalabad, Constituent College Toba Tek Singh, Punjab, Pakistan, Fatima

³University of Agriculture Faisalabad, Constituent College Burewala, Punjab, Pakistan

Corresponding to maliha.sarfraz@uaf.edu.pk

Abstract

With potential advantages for sustainable aquaculture, sunflower meal (SFM) has become a viable alternative protein source in aquafeeds. Objective: This study uses fingerlings of *Cirrhinus mrigala* fed SFM-based diets to examine the effects of dietary supplementation techniques on nutrient consumption and body composition measurements. Methodology: SFM will be added in different percentages to fish meal to provide experimental meals at doses of 0, 1, 2, 3, and 4 gkg⁻¹. The pellets will be supplemented with an indigestible marker, chromium oxide. For 60 days, the fingerlings will be fed their basic diet twice a day at a rate of 4% live body wet weight; their waste will be collected and kept for additional chemical analysis. There were 240 healthy Juveniles of *C. mrigala* were divided into four treatment groups at random and given the corresponding diets for eight weeks in a controlled environment. Results: This study examines how juvenile *Cirrhinus mrigala*'s body composition and nutrient utilization are affected when acidified sunflower meal (ASM) is added to their diets. Increasing amounts of ASM (0%, 10%, 20%, and 30%) were added to four experimental diets to partially replace traditional protein sources. The results demonstrated that adding up to 20% ASM improved body composition and nutrient use, as seen by greater levels of crude protein and fat ($p < 0.05$). A 30% inclusion level, however, had a detrimental effect on body composition and nutrient absorption. Conclusion: Sunflower meal's nutritional profile was improved by the acidification process, which was successful in lowering anti-nutritional elements. The findings indicate that up to a 20% inclusion level of ASM in the meals of *C. mrigala* juveniles can be added successfully without affecting their body composition or nutrient absorption.

Keywords: *C. mrigala*, Sunflower meal, nutrition, growth, hematological



Social Capital and Entrepreneurial Intentions among Women Farmers in Punjab, Pakistan

Rimsha Zaheer¹, Dr. Mubashir Mehndi¹

¹Department of Agribusiness and Entrepreneurship Development, Muhammad Nawaz Sharif University of Agriculture, Multan, Pakistan

Corresponding to rimshazaheer22331@gmail.com

Abstract

Entrepreneurship is an important driver of economic development, innovation, economic competition, and social mobility in societies, particularly in rural areas. Women business owners are regarded as successful due to their intense drive and capacity for efficient economic growth. However, women are tied up with strong social and cultural norms, which may hinder them from achieving their aim to be entrepreneurs. This study investigated women's intention to engage in entrepreneurial activities by analyzing their intention in the light of social capital theory. For this purpose, data was collected from 120 rural women of Punjab province through a purposive sampling technique. Quantitative techniques guided the key factors affecting rural women in generating new businesses, which were further explored using the order probit model to assess the direct impact of social capital on women's entrepreneurial intentions at the community's wider level. The results showed that Participation in the local community (PLC) and feeling of trust and safety (FTS) have significantly increased the intention of rural women. The findings suggested that entrepreneurship programs in rural communities can be successful and more effective if the development agencies focus on neighborhood connection along with friend and family support.

Keywords: Entrepreneurial Intention, Rural women, Social Capital, Local economic development



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Climate Change and Environmental Stress as Drivers of Food Insecurity, Malnutrition, and Public Health Risks in Pakistan

Tahira Sadaf¹, Ayesha Rouf¹, Zaki², Rauf²

¹Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan,

²Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan

Corresponding to tahira.sadaf@uaf.edu.pk

Abstract

Climate change is increasingly shaping environmental conditions that determine how food is produced, distributed, and consumed, with direct consequences for nutrition and public health. In Pakistan, rising temperatures, shifting rainfall patterns, and more frequent extreme events such as droughts, floods, and heatwaves are placing pressure on crop yields, livestock health, and fisheries, while also disrupting transport, storage, and market functioning. These shocks reduce the stability of food supplies and contribute to price volatility, which can quickly translate into poorer diet quality, especially for low-income households that already spend a large share of their income on food. Environmental stresses also interact with existing structural constraints, including water scarcity, groundwater depletion, soil degradation, and declining ecosystem services, making it harder for farmers and food value chains to adapt. At the same time, climate-related changes can intensify health risks by worsening water contamination, increasing food safety challenges, and creating conditions that support the spread of vector-borne and diarrhoeal diseases, particularly after extreme weather events. Urbanisation adds further pressure through higher demand for processed and convenience foods, growing waste streams, and increased exposure to air pollution and heat stress, which can indirectly influence dietary practices and health outcomes. This discussion frames climate change as more than an agricultural problem: it is a food systems and public health challenge that requires coordinated responses across sectors. Strengthening resilience depends on climate-informed planning, improved water and land management, climate-smart and diversified livelihoods, reliable early warning and risk financing, and social protection measures that help households maintain adequate diets during shocks. By linking environmental disruption to diet quality and health outcomes, this section highlights why climate action and food policy must be designed together if nutrition security is to be protected in a rapidly changing climate.

Keywords: climate change; environmental degradation; food systems; nutrition security; food insecurity; public health; water scarcity; extreme weather; agricultural resilience; social protection



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Sustainable mitigation of nitrogen gaseous emissions and leaching losses using coated-urea fertilizers coupled with organic amendments in a rice-wheat cropping system

Ghulam Murtaza¹, Tajammal Hussain², Munir Hussain Zia³

¹Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad, Pakistan.

²Soil and Water Testing Laboratory, Gujranwala, Punjab, Pakistan

³Research and Development, Fauji Fertilizer Company (Pvt.) Ltd, Pakistan

Corresponding to wasim.javed@uaf.edu.pk

Abstract

Excessive use of nitrogenous fertilizers for crop intensification has negative environmental impacts, including emissions of nitrous oxide (N₂O) and ammonia (NH₃), and nitrate (NO₃⁻) leaching. The study evaluated the effects of various locally available coated-urea fertilizers on N emissions under both aerated and submerged conditions in a wheat-rice cropping system. The incubation study revealed that all coated-urea fertilizers significantly reduced NH₃ (15.84%, 13.87%, 13.04%, and 12.11%) and N₂O (16.03%, 15.10%, 12.92%, and 11.56%) emissions with neem-coated urea, nutraful urea, biomaterials-coated urea, and zabardast urea products, compared to standard urea, respectively at 65% WHC. Similar reductions were observed with these coated fertilizers at 100% WHC, where emission losses were comparatively higher. Lysimeter experiments further tested the most efficient coated-urea fertilizers during the cultivation of rice and wheat, with/without compost and biochar amendments. Neem-coated urea and nutraful urea achieved the highest reductions in NH₃ volatilization (13.8% and 14.0%), N₂O emissions (15.3% and 14.9%), and NO₃⁻ leaching (6.97% and 10.3%), respectively, during rice, and similar reductions were recorded with these coated fertilizers in wheat crop. Moreover, neem-coated urea increased partial N factor productivity (PFPN) and partial N balance (PNB) in rice (10.04%, 20.12%) and wheat (7.92%, 21.61%). The compost application along with standard urea and coated fertilizers, significantly enhanced N₂O and NH₃ losses; on contrary biochar application in all cases reduced N emissions. Integrated use of neem-coated urea and biochar reduced NH₃ (26.16% and 28.57%) and N₂O (24.28% and 28.04%) emissions and NO₃⁻ leaching (23.53% and 14.55%) under rice and wheat crops, respectively. As Pakistan is committed to halving N waste by 2030 under the Colombo Declaration, neem-coated urea seems to be the best option for minimizing N losses and enhancing NUE.

Keywords: Nitrogen use efficiency; Coated urea; Biochar; NH₃ volatilization; N₂O emissions; NO₃ leaching



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Building Climate-Resilient Agricultural Value Chains: A Transformative Agenda for Pakistan

¹Mahmood Ahmad, ²Puja Bhetwal, ³Rummana Basit Mir, ⁴Arifa Younas

¹Director, Climate Policy Research Unit, Abdus Salam Research Unit and CTA, Yunus/Rizq Knowledge Hub, AIT, Bangkok

²Food Chain Specialist, Research Associate, Climate Policy Research Unit, Based in Nepal.

³Soil and Crop scientist / Team Leader, RIZQ/CPRU

⁴Natural Resource Management Specialist, CPRU

Corresponding to mahmood.ahmad@rizq.org

Abstract

Pakistan's agricultural sector, historically driven by industrial and input-intensive production systems, faces mounting challenges under accelerating climate change. Key crop value chains including wheat, rice, maize, cotton, sugarcane, oilseeds, mango, and potato are increasingly exposed to extreme weather events, water scarcity, soil degradation, rising energy costs and market volatility. These systemic stresses undermine productivity, threaten farmer livelihoods and pose a severe challenge to national food security. Addressing these challenges requires a paradigm shift from conventional linear and extractive value chains toward climate-resilient, circular, and regenerative agri-food systems that enhance both economic viability and environmental sustainability. This study aims to analyse climate vulnerabilities and structural gaps across major agricultural value chains in Pakistan and to propose a transformative agenda for building more climate-resilient, regenerative, and market responsive agri-food systems. The paper employs a mixed-methods value chain and market analysis framework, combining secondary data review, policy analysis, and insights from field-based pilots conducted by the Climate Policy Research Unit and its partners. Climate risk mapping has been integrated across production, processing, transport, and market nodes to identify systemic vulnerabilities and resilience opportunities. Qualitative assessments incorporate cross-cutting dimensions including youth participation, governance, and private-sector engagement for a holistic evaluation of both technical and institutional constraints within existing value chains. The analysis reveals that climate-resilient and regenerative agriculture indeed offers a viable and scalable pathway to enhance profitability and inclusion across Pakistan's agrifood sector. Significant improvements in said resilience can be achieved through three interwoven pillars one is more resilient value chain infrastructure including upgraded irrigation systems, climate-proofed feeder roads, and improved storage and cold-chain facilities, second is climate-smart production and agribusiness, including regenerative practices, climate-smart agri-inputs, improved mechanisation and digital advisory services; and third is a more enabling environment for climate-friendly markets that feature improved market access, climate-aligned standards, green finance, ICT integration, and traceability. The study also highlights emerging opportunities related to agricultural carbon footprints and carbon credit markets as mechanisms for future net-zero commitments. Transforming Pakistan's agricultural value chains requires aligned, coordinated action across its various agri-infrastructure, production systems and market institutions. Developing climate-resilient and regenerative value chains can simultaneously enable greater climate adaptation, climate mitigation and more inclusive economic growth. The paper recommends the establishment of a Climate-Smart Agri-business Forum to



align public policy, private investment, research, and farmer-led innovation. Such a platform can catalyze scalable solutions, mobilize green finance, and help institutionalize climate-resilient practices across high-priority agricultural value chains.

Keywords: Climate-resilient agriculture, Value chains, Regenerative agriculture, Climate-smart markets, Pakistan



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February 11 - 12, 2026
MNS University of Agriculture Multan

Strengthening Food Security through Capacity Building, Empowerment and Inclusion: Insights from Technical Education and Agricultural Extension for Sustainability

Dr. Neelam Chaudhary¹, Dr. Rao Sabir Sattar²

¹Assistant Professor, Professional Training and Skill Development Centre, University of Agriculture, Faisalabad, Pakistan

²Assistant Professor, Institute of Agricultural Extension, Education and Rural Development, University of Agriculture, Faisalabad, Pakistan

Corresponding to neelam.chaudhary@uaf.edu.pk

Abstract

Knowledge dissemination and capacity building through formal education, technical and vocational training and extension services are realized as important drivers in order to achieve food security and resilience of agri-food systems. Human capital development is considered as a strategic approach by a number of global institutions, like IFAD, FAO, and ILO to mitigate persistent challenges such as rural poverty, youth unemployment, lower agricultural productivity and vulnerabilities due to climate change. Nevertheless, ineffective training frameworks, insufficient extension outreach activities and organizational constraints still make it difficult to transfer technical knowledge and skills efficiently. This review aims to systematically specify and explore empirical studies and institutional reports to assess and evaluate the direct and indirect impact of capacity development, extension modes, youth engagement and women inclusion on enhancing livelihoods and ensuring food security across agri-food value chain systems. This critical analysis is drawn on pragmatic studies, regular peer-reviews and reports from international organizations made on need assessment and impact evaluations published up to 2025. The sources of information include studies on farmer training, youth participation in agribusiness, extension service delivery and rural skills development across the world continents, especially Africa and Asia. Employing a narrative review methodology, the analysis integrates quantitative findings—such as pre- and post-training assessments and technology adoption rates with qualitative evidence derived from extension personnel interviews and policy analyses, in order to identify recurring patterns, outcomes and gaps. The review of literature consistently demonstrates that skill development and training programs significantly improve technical knowledge and competency of farmers, adoption trends of improved agricultural practices, entrepreneurship capacities and income-generating opportunities. Youth and women intrigued and involved positively influence their empowerment through active participation in agribusiness, productivity and increased employment possibilities, though access to resources like finance, land and extension support services remain main obstacles. Extension education and training systems using pluralistic approaches—lead farmers, farmer field schools, printed guides and digital tools including mobile phones and radio—are shown to be effective in disseminating agricultural knowledge. Institutional



reports highlight the significance of demand-driven training models, continuous professional development of extension workers and alignment of curricula with market needs and climate change circumstances. Overall, this review concludes that integration of skill development, extension services and empowerment of youth and women is fundamental to building resilient and inclusive food systems, contributing to improved productivity and hence to enhanced household food security. However, strengthening institutional capacity, scaling adoption of digital innovations, following pluralistic extension models and reshaping equitable and inclusive access to resources are critical for sustainable outcomes. Policymakers are encouraged to align national strategic programs with IFAD, FAO and ILO frameworks to ensure knowledge sharing and empowerment to promote food security, inclusive growth and effective knowledge translation into practice.

Keywords: Capacity Building, Agricultural Extension; Empowerment; Inclusive Growth; Food Systems



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February 11 - 12, 2026
MNS University of Agriculture Multan

Evaluation of Genetic Variability, Heritability, Genetic Advance for Yield in Exotic Spring Wheat (*Triticum aestivum* L.) Germplasm

Muhammad Irfan¹, Dr. Shahzadi Mahpara²

¹Department of Plant Breeding and Genetics Ghazi University Dera Ghazi khan, Pakistan, 32200

²Department of Plant Breeding and Genetics Ghazi University Dera Ghazi khan, Pakistan, 32200

Corresponding to irfankhan2606@gmail.com

Abstract

Wheat (*Triticum aestivum* L.) plays a vital role in global food systems, yet yield improvement remains a continuous challenge due to limited genetic diversity in cultivated varieties. The evaluation of exotic germplasm offers an effective approach to broaden the genetic base and identify high-performing genotypes adaptable to diverse environments. A clear understanding of genetic variability and the inheritance of yield-related traits is essential for developing efficient selection strategies in wheat breeding programs. The objectives of this study were to assess genetic variability among exotic spring wheat lines, estimate heritability and genetic advance of important agronomic traits, and identify key traits associated with grain yield to support effective selection in wheat improvement programs. The experiment was conducted at the University of Sargodha using 49 exotic spring wheat lines obtained from CIMMYT, along with a locally adapted check cultivar. The trial was laid out in a lattice design with two replications. Observations were recorded for major phenological, morphological, and yield-related traits. Statistical analyses were performed to determine variability among genotypes, estimate heritability and genetic advance, and analyze phenotypic and genotypic correlations using standard quantitative genetic methods. Significant differences were observed among genotypes for all studied traits, indicating the presence of considerable genetic variability within the evaluated germplasm. Grain yield showed positive and meaningful associations with plant height, peduncle length, number of tillers per unit area, and maturity duration, highlighting their importance in yield improvement. High heritability combined with high genetic advance was recorded for grain yield and tiller number, suggesting that these traits are primarily governed by additive genetic effects and can respond effectively to selection. Some traits exhibited high heritability but lower genetic advance, implying environmental influence. Several exotic lines consistently outperformed the local check, demonstrating their adaptability and yield potential under local conditions. The findings demonstrate that exotic spring wheat germplasm possesses valuable genetic potential for yield enhancement. Traits with high heritability and genetic advance should be prioritized in selection-based breeding programs. Promising lines identified in this study may be utilized as parental material for future hybridization. Multi-environment testing is recommended to confirm yield stability and facilitate the development of improved wheat cultivars. These genotypes are suggested to further use in crossing to produce high yielding filial generation.

Keywords: Genetic variability; Heritability; Yield components; Wheat breeding



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 – 12, 2026
MNS University of Agriculture Multan

Determinants of Growers' Intentions to Adopt Blockchain Technology in Pulses Supply Chains

Manal Saddique¹, Abdul Ghafoor², Burhan Ahmad³, Hammad Badar⁴, Adnan Adeel⁵

¹Graduate Researcher

²Director, Institute of Business Management Sciences

³Associate professor, Institute of Business Management Sciences

⁴Associate professor, Institute of Business Management Sciences

⁵Lecturer, Institute of Business Management Sciences

Corresponding to manalsaddique70@gmail.com

Abstract

Global food production and sustainability rely on the agriculture sector which directly impact food security. Pakistan's agricultural sector's productivity is strongly linked to the country's growing economy and stability. Pulses, as an important crop in Pakistan have inefficient supply chains with unstable production, poor market connections, and declining farmer interest. Blockchain technology has the ability to reform and create a sustainable pulses supply chain by facilitating direct connections between stakeholders. Creative solutions to food safety, security, transparency, and product traceability are provided by integrating it into agri-food supply chains. The objective of this research is to investigate the key factors influencing growers' intentions to adopt blockchain technology in pulses supply chains. The study employed an extended Unified Theory of Acceptance and Use of Technology (UTAUT) model, incorporating Perceived risk as an additional predictor and perceived cost as a moderating variable. A pre-tested questionnaire and a hybrid purposive–convenience sampling strategy were used to gather data from 204 pulse growers in Bhakkar and Chakwal, Punjab, Pakistan. The study employed SPSS for descriptive analysis and SmartPLS-based PLS-SEM for structural model evaluation and hypothesis testing. The findings revealed strong receptiveness when informed. PLS-SEM analysis confirmed all UTAUT constructs significantly influenced adoption intention, with effort expectancy as the strong predictor. Perceived risk negatively impacted adoption intention while perceived cost moderated certain relationships by amplifying the negative impact of perceived risk and the positive effect of facilitating conditions. The findings validate the extended UTAUT model in agriculture and provide practitioners, policymakers, and technology developers with targeted insights to address cost sensitivity, build trust, and enhance facilitating conditions for blockchain adoption into traditional supply chains. Future research should validate and extend this study's framework through longitudinal, cross-cultural assessments of blockchain adoption drivers and their real-world supply chain impacts.

Keywords: Blockchain technology, Agricultural supply chains, Pulses growers, Technology adoption intention, UTAUT model



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February 11 - 12, 2026
MNS University of Agriculture Multan

Deforestation Trends and Environmental Degradation in South Asia

Zeeshan Yousaf¹, Dr Muhammad Imran²

¹Department of Media Creative Art & Global Political Studies, Emerson University Multan

²Department of Media Creative Art & Global Political Studies, Emerson University Multan

Corresponding to zeeshanyousaf345@gmail.com

Abstract

Deforestation has emerged as a serious environmental challenge in South Asia, driven by population growth, agricultural expansion, urbanization, and weak forest governance. The rapid loss of forest cover has intensified environmental degradation, resulting in soil erosion, biodiversity loss, disrupted water cycles, and increased vulnerability to climate change. As forests play a vital role in maintaining ecological balance and supporting livelihoods, understanding deforestation trends is essential for sustainable development and environmental protection in the region. The study aims to examine deforestation trends in South Asia, assess their environmental impacts, and identify key drivers contributing to forest degradation. It also seeks to highlight policy gaps and suggest sustainable forest management strategies. This study adopts a qualitative and descriptive research approach based on secondary data analysis. Data are collected from reports published by FAO, World Bank, regional environmental agencies, and peer-reviewed academic journals. Trend analysis is used to examine changes in forest cover over time, while content analysis helps assess environmental impacts and policy responses. Comparative insights across South Asian countries are also incorporated to identify common challenges and best practices in forest conservation. The findings indicate a consistent decline in forest cover across South Asia, with varying rates among countries. Agricultural expansion, illegal logging, infrastructure development, and fuelwood dependency emerged as major drivers of deforestation. The study reveals that forest loss has significantly contributed to soil degradation, increased flood risks, declining biodiversity, and reduced carbon sequestration capacity. Weak enforcement of environmental regulations and limited community participation further exacerbate forest degradation. However, countries implementing afforestation programs, community forestry, and conservation policies have shown relatively improved outcomes. The results highlight the urgent need for coordinated regional efforts to address deforestation and mitigate its environmental consequences. Deforestation continues to pose a major threat to environmental sustainability in South Asia. Addressing this challenge requires strengthening forest governance, enforcing environmental laws, and promoting community-based forest management. Regional cooperation, investment in afforestation, and the use of sustainable energy alternatives can help reduce pressure on forest resources. Integrating environmental conservation into development planning is essential to ensure long-term ecological stability and climate resilience.

Keywords: Deforestation, Environmental Degradation, Forest Governance, South Asia, Sustainability



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Creation of a Nutrient-Enriched, Sustainable Plant-Based Kabab Mix Powder Using Bottle Gourd Peels (*Lagenaria siceraria*) and Kidney Beans (*Phaseolus vulgaris*)

Malaika Kiran¹, Hafiza Madiha¹, Ayesha Mazhar¹, Khadija Aijaz¹

¹Department of Food Science and Technology, MNS University of Agriculture Multan

Corresponding to malaikakiran522@gmail.com

Abstract

The goal of the current study was to create a plant-based kabab mix with rice flour, kidney bean powder, and bottle gourd peel powder as the primary ingredients. The goal of this project was to create a healthy, affordable, and eco-friendly kabab mix that could be used in place of kababs made with beef. Rice flour was added to enhance binding and texture, kidney bean powder was chosen as a plant protein source, and bottle gourd peel powder was utilized to boost nutritional fiber and decrease food waste. The created kabab mix was assessed based on its general acceptability, texture, appearance, and cooking behavior. According to the findings, the produced kababs had good nutritional content and sensory quality, making them appropriate for vegetarians and health-conscious people.

Keywords: Plant based, fiber-rich, protein, powder mix, consumer preferences



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Stubble Burning, Farmers' Risk Perception and Farmer Field School in Punjab, Pakistan

Aswad Razzaq¹, Dr. Yasir Mehmood¹

¹MNS University of Agriculture, Multan

Correspondence to aswad.razzaq.ch@gmail.com

Abstract

Globally stubble burning is used as agricultural practice where stubble which remains after harvesting, such as wheat, rice etc., are intentionally subjected to burn, which causes substantial environmental and health challenge. Five billion metric tons of residues related to agriculture are produced annually over the world, with a significant portion being burned. The study in hand was conducted to explore the relation between farmer field school and stubble burning behavior of farmers in Punjab, Pakistan. This study also explored possible other factors which enhance or reduce this approach, along with farmer's own risk perception associated with stubble burning. The objectives are to access to farmer field school influence Farmer's decision to burn crop residue, to do farmers believe that burning crops can contribute to air pollution (such as smog) in districts of Punjab, Pakistan?, to do farmers perceive risk of stubble burning as something injurious to health? The method is a multistage sampling technique was used to select the farmers from the Punjab, three districts from the list were selected based on the agricultural importance: Rahim Yar Khan, Rajanpur and Sheikhpura. From three districts, two locations (from each district) were surveyed. The selection method was deemed appropriate because most households in these villages have a temporary housing structure with no formal address and reliable public or private census data do not exist. The authors randomly chose 204 households that could be interviewed keeping the cost and timeframe of this study into consideration. In final stage, the respondents were randomly selected applying the random walk method. The questionnaire included demographic profiles, farm size, knowledge and attitudes about crop residue management. The results show that a strong negative correlation exists between FFS (SD= 0.35) and Stubble Burning ($r = -.614$, $p < .01$), indicating that higher adoption of farmer field schools is associated with significantly reduced burning activity.

Moderate negative relationships exist between Stubble Burning and variables that are measuring risk perception ($r = -.544$, $p < .01$), ($r = -.513$, $p < .01$) and ($r = -.543$, $p < .01$). Another strong negative correlation is observed between Stubble Burning and Availability of Alternative Strategies ($r = -.539$, $p < .01$) indicating important factor contributing to Stubble Burning. Awareness of air pollution shows strong positive correlations with environmental risks ($r = .646$, $p < .01$) and health risks ($r = .628$, $p < .01$), information through multiple sources also participated in shaping perception ($r = .704$, $p < .01$). Recommendations are although there is a significant positive effect of FFS but roughly half of the farmers are still burning stubble with or without perceiving risk. Strengthening farmers' air-pollution awareness requires integrating cognitive-risk communication into FFS. Government Policies are playing their role to some extent but there is a need of more deliberate. Embedding visual cues (e.g., pollution heat maps), and peer-modelling can elevate risk perception associated with residue burning. FFS should adopt experiential learning, on-farm pilots of residue-management technologies, and decision-support tools. Multi-stakeholder coordination is essential to transform farmer intentions into sustained adoption of non-burning alternatives.

Keywords: Stubble Burning, Risk Perception, Farmer Field School, Farmers, Crop Residue





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February 11 - 12, 2026
MNS University of Agriculture Multan

Soybean production and marketing scenario in Pakistan

Irfan Mahmood¹,

Sobia Naheed¹, Irfan Mahmood¹, Arshad Bashir¹, Rashid Saeed¹

¹Pakistan Agricultural Research Council, Social Sciences Research Institute, Faisalabad

Corresponding to irfanparc@gmail.com

Abstract

Pakistan's heavy reliance on imported soybean meal for its poultry industry, with 2.5 MMT imported in FY 2022-23, underscores a critical gap in domestic production. This study analyzes the nascent soybean farming sector to understand its potential as a viable import-substitution and income-generating crop for Pakistani farmers. This study aims to assess the farm-level economics and marketing dynamics of soybean cultivation in Pakistan, focusing on cost structures, profitability, and disposal patterns across the autumn and spring growing seasons. Primary data were collected in 2024 via personal interviews using a pre-tested schedule. The sample comprised soybean growers from both the autumn and spring seasons. The analysis focused on socio-economic indicators, varietal adoption, seed sourcing, cost of production, marketing channels, and final use of the produce. The study reveals two distinct production scenarios. Cultivation is recent, with most farmers adopting after 2021. Autumn cultivation is dominated by smallholders (64.3%) who primarily sell their entire crop to a single mill (Jadeed Mill). Spring cultivation involves larger farm sizes, with 17.6% being large farms, and a more diversified market where Mumtaz Feed Mill is a major buyer (41.2%). Seed sources and popular varieties differ significantly between seasons. The crop is used for both human consumption (51.6% of respondents) and animal feed, with spring growers utilizing a wider variety of food products. Crucially, profitability diverges sharply: the Benefit-Cost Ratio (BCR) for autumn is 1.69, while spring cultivation is markedly more profitable with a BCR of 3.05, yielding an overall BCR of 2.66. Soybean cultivation in Pakistan is profitable, particularly in the spring season, demonstrating strong potential for reducing import dependence. To capitalize on this, concerted efforts are needed to educate farmers on high-performing, season-specific varieties and improved agronomic practices. Policy should support spring cultivation through targeted extension services, ensure reliable seed supply chains from institutions like AARI and the University of Faisalabad, and develop diversified market linkages beyond a few major mills to enhance farmer bargaining power and sector resilience.

Keywords: Soybean, production, marketing, oil seed, value addition



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February 11 – 12, 2026

MNS University of Agriculture Multan

A Voice-Driven AI Advisory System for Wheat Farmers in Pakistan

Ayman Asif¹, Mr. Aziz Ur Rehman²

¹Institute of Computing, Muhammad Nawaz Sharif University of Agriculture Multan, Pakistan

²MS Computer Science, Muhammad Nawaz Sharif University of Agriculture Multan, Pakistan

Corresponding to 2020-uam-1807@mnsuam.edu.pk

Abstract

Wheat crop cultivators in Pakistan struggle with inability to access relevant agricultural advice because of less literate populations, poor agricultural extension, and a lack of connectivity. To address this, our proposed work aims to bridge this gap by developing an AI-assisted voice advice system with a radio talking voice interface, which will allow wheat crop cultivators to take informed decisions. Our project aims to incorporate elegant hardware solutions with AI-assisted voice analysis and predictive advice capabilities. The proposed research will focus on designing and developing an advisory device with voice capabilities and AI-assisted functions in order to provide personalized and multiple language support to wheat growers, improve usability with a button interface, and make predictions in critical crop management domains. The system is based on a microcontroller with a speaker, microphone, and two buttons for easy interaction. AI-assisted components include speech recognition (VOSK) with rules and lightweight ML algorithms for intent identification, and TTS engines for spoken advisories in real time using Coqui TTS. The advisories relate to wheat diseases, irrigation, fertilization, crop protection, and crop harvest and have been compiled from authentic extension literature. The system recommends actions based on queries from farmers using predictive logic. The system can handle Urdu, Punjabi, and Sindhi languages with accent normalization and noise-insensitive preprocessing. The initial field tests have proven that interaction with this device using voice commands and buttons is quite comfortable for farmers. The AI-enabled device is able to detect queries accurately and respond in a reliable manner on functions related to leaf rust, stem rust, yellow rust, irrigation timings, fertilizer application, and pest control. The participants were satisfied with voice interaction and established that voice interaction reduced dependency substantially on different advisory services. Predictive functions enabled them to have a better vision of future dangers and address them proactively. The device performed well in a noisy village environment, which proved it to be efficient and feasible in a rural setup. Acceptance among farmers at a higher level shows a great possibility of a simplified multilingual advisory system in improving production and overcoming crop losses. The voice advisory device using AI assistance provides a good tool for inclusive delivery of personalized crop advice to less literate wheat cultivators in rural villages. The device with simple hardware components, AI-assisted predictive advice, and support for local languages will help in ensuring usability, accuracy, and an inclusive approach. Future research directions include developing content for other crops and contexts, incorporating image diagnostics, and working with extension services for scaling up. Thus, AI-assisted digital agriculture solutions have a good chance of ensuring enhanced smallholder productivity and resilience with AI-assisted digital tools.

Keywords: Voice-Based Advisory, Wheat Farming, Rural Farmers, Digital Agriculture, Agricultural Extension



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February 11 - 12, 2026
MNS University of Agriculture Multan

Food Security in Climate Change: The role of Climate and Sustainable Agricultural Systems

Saba Javed¹, Aliya Qaiser²

Corresponding to Aliyaqaiser321@gmail.com

Abstract

Food security has been one of the most alarming issues in the world, mainly in the light of climate change, population increase, and degradation of resources. Sustainable agriculture has become an essential way towards the stability in food supply and preserving natural resources, as well as sustaining rural livelihood. Sustainable agriculture can help meet the resilience to environmental shock through combining climate-smart production technologies, digital technologies, resource-efficient production systems, and nature-based solutions, and improve long-term food security. The strategy targets productivity, environmental, and social inclusion in order to generate resilient agricultural-food systems. The objectives of this study are to: explore sustainable agricultural practices as a way of sustaining food security; discuss how climate-smart and technology-driven agriculture practices can be used in enhancing agricultural productivity; and analyze the environmental and socio-economic benefits of adopting sustainable agricultural practices as a way of attaining a stable food system in the long-run. The research has been conducted on a multidisciplinary and extensive literature review of available literature, international case studies, and the current development trends in frameworks of sustainable agriculture and food security. It is a systems-based analysis, which encompasses the knowledge of agricultural economics, environmental science, climate studies and rural development to evaluate the relationship between sustainability practices and food security outcomes. The review suggests that sustainable agricultural practices are very effective in increasing food security by enhancing productivity, efficiency in utilizing the resources, and reducing vulnerability to climate risks. Combinations of climate-intelligent methods, precision farming, and nature-based solutions help to reduce environmental effects, enhance resilience, and be able to benefit even smallholder farmers. The results show that there is a high possibility of scalable adoption in both the developing and the developed economies with relevant policies and institutional frameworks. This study has concluded that sustainable agriculture is a functional and effective approach of providing long-term food security amidst changing climatic and socio-economic conditions in the short run. There must be strengthened investments in capacities to project farming, digital and climate-resilient infrastructure, enabling policies, and localized research. A collaborative approach between policymakers, researchers, farmers, and the private sector has been recommended in an attempt to improve sustainable innovation and resilience in the global agri-food systems.

Keywords: Food security, sustainable agriculture, climate change adaptation, agricultural resilience, resource-efficient farming, Agri-food sustainability



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February 11 - 12, 2026
MNS University of Agriculture Multan

Livelihood Diversification and Household Food Security under Climate Stress: A Study of District Bahawalpur

Hina Shahid¹, Dr Farkhanda Anjum¹, Dr. Ayesha Batool¹, Abdul Manan¹, Rabia Munir¹, Naseer Ahmad¹, Lariab Javed¹

¹University of Agriculture Faisalabad

Corresponding to soc2k1430@gmail.com

Abstract

Climate change poses considerable threats to family food security in arid and semi-arid regions, where agricultural livelihoods are especially susceptible to climatic variability. Bahawalpur District, characterized by recurring droughts, rising temperatures, and water scarcity, presents a vital backdrop for investigating adaptive livelihood alternatives. This quantitative study investigates the influence of livelihood diversification in improving household food security during periods of climate stress. Primary data were gathered by a structured household survey, and food security outcomes were assessed using standard indices of food availability, access, and stability. Livelihood diversification was determined by combining farm, off-farm, and non-farm revenue streams. The findings show a strong positive association between livelihood diversification and household food security. Households that engaged in several revenue-generating occupations reported higher food consumption, greater income stability, and lower vulnerability to climate-induced shocks than households that relied only on agriculture. The data also show gender differences in impacts, as households with women participating in off-farm and non-farm activities had higher food access and nutritional diversification. Youth participation in non-agricultural livelihoods was also shown to improve adaptation capacity by lowering reliance on climate-sensitive farming. However, access to diversification options remained unequal, owing to insufficient education, financing availability, and market access. The study suggests that livelihood diversification is an important option for improving climate-resilient family food security in susceptible regions like Bahawalpur. It underlines the need of inclusive policies that combine climate-smart agriculture with fair livelihood possibilities to boost resilience, minimize social vulnerability, and promote sustainable and just food systems.

Keywords: Agriculture, Livelihood, Food Systems, Climate Resilience, Family



From Soil to Mind: Metaphorical Perceptions of Primary School Children Regarding Agricultural Processes

Halil Özcan Özdemir¹, Feriha Bükel²

¹Kırşehir Ahi Evran University, Faculty of Agriculture Department of Agricultural Economics, Division of Farm Management

²Kırşehir Ahi Evran University, Faculty of Health Sciences Department of Child Development

Corresponding to hoozdemir@ahievran.edu.tr

Abstract

The aim of this study is to examine the metaphorical perceptions of primary school children aged 6-10 regarding agricultural processes (soil, seeds, production, water, and food) and to explore how these perceptions are related to their attitudes toward agriculture. The primary school period represents a critical developmental stage during which children are able to establish cause–effect relationships concerning environmental issues, begin to develop value-based judgments, and meaningfully conceptualize the notion of sustainability. The study is designed within a qualitative research framework. Data will be collected through metaphor elicitation prompts (e.g., “Agriculture is like ... because ...”), agriculture-themed drawings, and short semi-structured interviews. The collected data will be analyzed using content analysis, and the metaphors will be categorized under the themes of labor, responsibility, life cycle, human–nature relationship, and food security. Existing literature indicates that primary school children conceptualize agriculture not merely as a productive activity, but also within the broader contexts of human–nature interaction, the value of labor, and social responsibility. Accordingly, it is expected that the findings of this study will reveal that children’s attitudes toward agriculture are largely protective, value-oriented, and sustainability-focused. The results are anticipated to contribute to the structuring of climate-smart agriculture education at the primary school level, the development of interdisciplinary curricula, and the promotion of child-centered sustainable food policies.

Keywords: Metaphorical perception, agriculture, children’s attitudes, sustainability



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February 11 - 12, 2026
MNS University of Agriculture Multan

Impact of Social Media on Health Literacy Among University Students

Nadeem Akhtar¹, Dr. Muhammad Ali Imran¹

¹MNS University of Agriculture, Multan

Corresponding to maharnadeem5566@gmail.com

Abstract

The study objectives will be to investigate the connection between health literacy and social media use among the students in Multan, Pakistan, who are aged 18-30 and enroll in various classes. To gather the information, the topical surveys will be applied. This research is devoted to the concept of how the health literacy of university students in Multan, Pakistan, is influenced by social media. Three hundred undergraduate students, ranging in age from 18 to 30, from a wide range of academic disciplines, participated in the cross-sectional survey used for the study. A stratified random sample technique was used to make sure the participants were truly representative of the student population overall. The survey assessed students' health literacy using current technology. They were assessed on their usage of social media, knowledge, attitude, behavior, and capacity to critically assess health information. Statistical methods like ANOVA and association tests were used to look at the data. The study says that Facebook, YouTube, and WhatsApp may help people learn more about some aspects of health. The study says that health lessons should be personalized for each student, and teaching digital literacy is very important for helping students understand and use online health information better. The cross-sectional design of the study and the fact that the data were self-reported are some of its flaws. Because of this, more long-term research is needed to find the real cause-and-effect links. to college campuses, both public and private. Several types of random selection were used to ensure that the participants were an equitable sample of all students. The poll was created with pre-existing instruments. It evaluated students' knowledge, attitudes, behaviors, and capacity to critically analyze health information in order to determine their degree of health literacy. Furthermore, it evaluated how they used social media. ANOVA and correlation tests were among the statistical tests used to assess the data. The social media platform used determined the level of health literacy. To improve their well-being, it is still essential that kids learn about health and make sure they understand the facts. The cross-sectional methodology of the study and the fact that the data were self-reported are two of its flaws. Therefore, more long-term study is needed to fully understand the real cause-and-effect connections, which means more long-term Research is needed to understand the true cause-and-effect relationships.

Keywords: Social Media Usage, Health Literacy, Health Information Awareness, Digital Health Assessment



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February 11 - 12, 2026
MNS University of Agriculture Multan

Farmer's Perception and Adaptation Strategies Apropos Climate Change: Impact and Implications on Small Ruminants in Balochistan, Pakistan

Wakeel Ur Rehman¹, Prof. Dr. Nasir Nadeem¹, Dr. M Haseeb Raza¹ and Mam Samra Naseem¹

¹MNS University Multan, Pakistan

Corresponding to Wakeel.rehman@mnsuam.edu.pk

Abstract

Agriculture and livestock production systems are suffering because of climate change. Livestock production is the biggest land use sector in the world, making it susceptible to climate change. One of the nation's most at risk from climate change is Pakistan, which has had several natural disasters and climate shocks that have had a negative effect on its livestock producers and agricultural industry. Climate change induced devastating floods are becoming more regular in Pakistan especially in Balochistan. Especially the 2022 floods are excellent. The food security of Balochistan is threatened by climate change, making it one of Pakistan's most susceptible provinces. Primary data will be collected from 400 livestock farmers through well-structured questionnaire interviews, focus group discussions (FGDs) using face to face surveys in 2 districts of Balochistan. This study will investigate the farmers' perception about climate change and drivers of adaptation strategies of small ruminants' farmers. Second, this study will add to existing literature by Quantifying the economic impacts of extreme climate scenarios on small ruminants' production in Balochistan. Third, this study will also evaluate the impact of climate change on small ruminant farmers' livelihood vulnerability in Balochistan. By examining these dynamics, the research seeks to contribute to evidence-based policymaking for enhancing climate resilience and sustainable development in livestock farming communities. The findings will not only strengthen academic discourse but also serve as a decision-making tool for policymakers, Government agencies, and local institutions to design evidence-based interventions aimed at building climate resilience, ensuring food security, and promoting sustainable development in vulnerable livestock farming communities of Balochistan.

Keywords: Climate change, Adaptation, Livestock, Vulnerability, Agricultural resilience, Balochistan



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February 11 - 12, 2026
MNS University of Agriculture Multan

Fresh Jaman Fruit Supply Chain in Punjab: Identification of Fruit Losses, Management of Losses after Harvest, and Value Addition

Dr. Sami Ullah¹, Kashif Razzaq¹, Sajid Ali², Ishtiaq A. Rajwana², Umar Ijaz Ahmed³, Shafa Nayab¹

¹Department of Horticulture, MNS-University of Agriculture, Multan

²Department of Horticulture, Bahauddin Zakariya University, Multan

³Department of Agricultural and Resource Economics, MNS-University of Agriculture, Multan

Corresponding to sami.ullah1@mnsuam.edu.pk

Abstract

Globally, jaman, java plum, is a tree fruit thriving in Tropical to Sub-tropical regions. The fruit crop is a minor/underutilized fruit of Pakistan, mostly jaman trees are cultivated as boundary walls or shelter belts for fruit orchards in the country, however, few commercial orchards have been found Faisalabad region of Punjab. Nevertheless, it is very popular among the fruit growers and consumers owing to its high nutritive, medicinal value and wide range of application in processing industry. Currently, jaman fresh fruit industry is facing various challenges including higher fruit losses after harvest due to improper handling of fruit during harvest, transport and at retails and during processing. Moreover, higher perishability short shelf life and incidence of diseases after harvest make it more prone to post harvest losses. A comprehensive research study was executed with the sole objective to study and manage fruit postharvest losses along the fresh fruit supply chains of jaman fruit. Initially several R&D activities were undertaken involved quantifying of post-harvest losses along the fresh fruit supply chain and introduction of some selected intervention based previous study learnings. Moreover, several experiments were executed with the objectives to manage postharvest quality losses of fresh jaman fruit after harvest with the application of pre- and postharvest applications fruit ripening delaying chemical. Moreover, during this duration value added products, jaman fruit pulp leather and jam were also developed and checked for proximate and sensory attributes. Additionally, market study and consumer survey for the developed value added products from jaman fruit. The study demonstrated strong consumer familiarity and cultural acceptance of jaman fruit, alongside significant interest in value-added products such as fruit leather and jam. Packaging preferences emphasized medium-sized units with affordable price ranges, indicating favorable market potential. Postharvest quality assessments revealed that citric acid (CA) treatments, particularly at 2 MM, effectively minimized weight loss, maintained TSS, delayed acidity reduction, and preserved ascorbic acid content compared to the control. Moreover, combined pre- and post-harvest citric acid applications were most effective in retaining nutritional quality and regulating juice pH during storage. Collectively, these findings highlight both the commercial viability of jaman fruit-based products and the efficacy of organic acid treatments in enhancing postharvest shelf life and consumer acceptance.

Keywords: Fresh jaman fruit, Supply chain, consumers preferences, value added products, jaman leather



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February 11 - 12, 2026
MNS University of Agriculture Multan

Awareness and Understanding of Palliative Care Principles Among Medical Students in South Punjab

Prof. Dr. Nasir Nadeem¹, Abdul Mughees Ahsan¹

¹Department of Agricultural and Resource Economics

Corresponding to nasir.nadeem@mnsuam.edu.pk

Abstract

Palliative care plays a crucial role for individuals with severe health conditions. Medical students need to grasp the concept of quality-of-life care and its components to effectively assist these patients. However, the extent of awareness regarding this type of care among prospective doctors in South Punjab remains unclear. The primary aim was to evaluate the understanding of palliative care and its elements among medical students in South Punjab. The research employed a cross-sectional design with simple random sampling to gather data, involving a total of 303 participants. The Palliative Care Knowledge Scale (PaCKS) was utilized to collect responses, with each participant's answers being assigned a numerical value. A total score was then calculated for each participant based on their PaCKS responses. Data analysis involved descriptive statistics, including median, IQRs, frequencies, and percentages. The Kolmogorov-Smirnov test was used to assess data normality, while the Mann-Whitney U and Kruskal-Wallis tests were applied to compare PaCKS scores across different variable groups. All data analysis was conducted using the Statistical Package for Social Sciences (SPSS). Demographic analysis revealed no significant differences in PaCKS scores concerning gender, city of residence, or family income. Additionally, overall knowledge scores did not show notable improvement from the fourth year to the final academic year. There is an urgent need for comprehensive palliative care education for medical students. This education should address common misconceptions and enhance practical and communication skills. Increased clinical training will also help close the gap between public and private medical colleges.

Keywords: Palliative care, medical students, South Punjab, Palliative Care Knowledge



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February 11 - 12, 2026
MNS University of Agriculture Multan

Economic Stressors Associated with Zoonotic and Non-Zoonotic Parasites in Sustainable Aquaculture

Rimsha Jamil¹, Muhammad Imran²

¹Department of Zoology wildlife and Fisheries University of Agriculture Faisalabad

²Department of Parasitology, University of Agriculture Faisalabad

Corresponding to rimshajameel1996@gmail.com

Abstract

Sustainable aquaculture contributes significantly to world food security, livelihoods and economic stability, and is notable especially in the developing world, where fish farming helps sustain small-scale producers. Nevertheless, the problem of parasitic diseases continues to be a challenge to productivity and sustainability. Zoonotic and non-zoonotic parasites cause diseases in fish, reduce food safety, and raise costs of production by lowering growth, mortality, treatment, and market value. The economic aspects of parasitic infections are also exacerbated by the environment-related shifts in climate conditions that promote the spread and maintenance of parasites in the aquaculture environments. The current paper seeks to evaluate the economic burden of zoonotic and non-zoonotic parasitic infections on sustainable aquacultural systems, as well as discuss their effects on fish productivity and market value, and emphasize what they imply on food safety and economic resilience in climate-smart aquaculture. The detection of major zoonotic and non-zoonotic parasites was done by conducting parasitological surveys of selected aquaculture systems by using standard microscopic and molecular diagnostic methods. The data on Fish mortality, growth performance, treatment cost and market losses were gathered and evaluated. The economic effects were estimated by finding out the direct losses (poisoned yield, death) and indirect losses (managerial expenses, trade and consumer safety issues) linked to parasitic infections. The results indicated that parasitic infections had a strong relationship with economic losses in aquaculture farming. Zoonotic parasites were further hazards because of food safety and market limitations, and non-zoonotic parasites were the main dangers to production efficacy and profitability. Parasitism was identified as a key economic stressor in sustainable aquaculture through increased management expenditures, and lower growth rate and market preference of fish products were associated with higher infection prevalence.

Keywords: Aquaculture, Zoonotic parasites, non-zoonotic parasites, Economic stressors, Sustainability



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February 11 - 12, 2026
MNS University of Agriculture Multan

Towards Climate Resilient Irrigation: A Review of Adaptive Strategies for Agricultural Underwater Scarcity

Dr. Nida Maqbool¹, Sana Nafees¹, Maaz¹, Muhammad Khurram¹, Huzaifa Rauf¹

¹Assistant Professor, Institute of Environmental Science and Engineering (IESE), School of Civil and Environmental Engineering (SCEE), National University of Science and Technology (NUST), Islamabad, Pakistan

Corresponding to nidamaqbool@iese.nust.edu.pk

Abstract

Agriculture accounts for approximately 70% of global freshwater usage, faces escalating threats from growing water scarcity and the accelerating impacts of climate change. This review systematically analyzes adaptive strategies designed to transition agricultural systems toward Climate Resilient Irrigation. The study examines the disruption of global hydrological cycles, which undermines the reliability of surface and groundwater resources through altered precipitation patterns and increased drought frequency. To address these challenges, the review establishes a conceptual framework that integrates technological, agronomic, and managerial adaptations. Key technological innovations discussed include the shift from surface to pressurized irrigation systems, such as drip irrigation, and the adoption of precision agriculture tools like soil moisture sensors and evapotranspiration modeling. Agronomic strategies, including Deficit Irrigation and Partial Root-Zone Drying, are evaluated for their ability to maximize crop water productivity. Furthermore, the paper highlights the necessity of institutional reforms, such as the formation of Water User Associations and the utilization of non-conventional water resources like treated wastewater. Finally, the review identifies future research directions, emphasizing the Water-Energy-Food nexus and the role of digital technologies including Artificial Intelligence and agrivoltaics in ensuring long-term food security and environmental sustainability.

Keywords: Climate Resilient Irrigation; Water Scarcity; Adaptive Strategies; Water Use Efficiency; Precision Agriculture; Deficit Irrigation; Water-Energy-Food



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February 11 - 12, 2026
MNS University of Agriculture Multan

Screening of Rice Genotypes for Resistance against Bacterial Leaf Blight and Sheath Blight under Field Conditions

Sana-e-Mustafa¹, Muhammad Sabar¹, Rana Ahsan Raza Khan¹, Muhammad Ijaz¹ and Syed Ali Zafar¹, Misbah Riaz¹, Tahira Bibi,¹ Ammara Athar¹ and Hira Saher¹

¹Rice Research Institute, Kala Shah Kaku

Correspondence to Sanamustafa45@gmail.com

Abstract

Rice yield is affected by a number of diseases among which bacterial leaf blight (BLB); caused by *Xanthomonas oryzae pv oryzae* and sheath blight (caused by *Rhizoctonia solani*) are one of the oldest and most severe ones. The introduction and widespread cultivation of high yielding cultivars having narrow genetic base was led to increased susceptibility to diseases such as bacterial blight. Phenotypic assessments were conducted using standard disease scoring systems. Promising genotypes exhibiting high levels of resistance were further analysed using molecular markers linked to ShB and BLB resistance genes. Selected resistant lines were then employed in back cross breeding with elite but susceptible cultivars to combine desirable agronomic traits with disease resistance. This study aimed to evaluate the resistance of rice germplasm against sheath blight and bacterial leaf blight (BLB) and to utilize these resistant lines in a back cross breeding program for developing superior rice varieties. A total of thirty (30) rice lines were screened under field conditions, and the results indicated a variation in resistance levels among the tested lines. For sheath blight, two exotic lines (Tetop and TKM6) exhibited resistance, characterized by significantly lower lesion lengths and disease severity indices compared to the susceptible control. Similarly, 04 lines namely; IRBB21, IRBB23 IRBB58 and IRBB66 lines showed resistance to BLB, with minimal lesion lengths and disease progression. These resistant lines were then employed in a back cross breeding program aimed at developing new rice varieties with enhanced disease resistance. The initial crosses involved using the resistant lines as donors and a high-yielding, but disease-susceptible, variety as the recurrent parent. Subsequent back cross generations (BC₁F₁, BC₂F₁, etc.) will be screened for disease resistance and agronomic performance, with selection for desirable traits being carried out at each generation. In conclusion, the screening experiment effectively identified rice lines resistant to sheath blight and bacterial leaf blight, which will be successfully used in a back cross breeding strategy. This approach holds potential for developing new rice varieties that combine high yield with enhanced disease resistance, contributing to sustainable rice production.

Keywords: *Xanthomonas oryzae pv. Oryzae*, stability, Recurrent parent, Back-cross, germplasm



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February 11 - 12, 2026
MNS University of Agriculture Multan

Development of a Climate-Resilient, Bacterial Leaf Blight-Resistant, Extra-Long Grain Basmati Rice Variety through Marker-Assisted Breeding

Muhammad Sabar¹, Sana-e-Mustafa¹, Rana Ahsan Raza Khan¹, Muhammad Ijaz¹, Syed Ali Zafar¹, Misbah Riaz¹, Tahira Bibi¹ and Hira Saher¹

¹Rice Research Institute, Kala Shah Kaku

Correspondence to muhammadsabar@gmail.com

Abstract

Rice (*Oryza sativa* L.) is a major staple food crop, providing nutrition to more than half of the world's population and contributing significantly to food security and rural livelihoods. Among rice types, Basmati holds a premium position due to its extra-long slender grains, unique aroma, and superior cooking quality, characteristics that are strongly influenced by specific agro-ecological conditions of the traditional Basmati-growing regions of Punjab, Pakistan. However, productivity of traditional Basmati cultivars is increasingly constrained by biotic stresses, particularly bacterial leaf blight (BLB), lodging susceptibility, and delayed maturity, challenges that are further intensified under changing climatic conditions. To address these limitations, a climate-resilient, early-maturing, lodging-resistant, extra-long grain Basmati rice line, PKBB15-116 (Super Gold), was developed through marker-assisted backcross breeding by introgression the BLB resistance gene *Xa21* from IRBB60 into the Super Basmati background. The candidate line was evaluated from 2014 to 2018 through observational plots, station yield trials, regional adaptability trials, hotspot testing, micro-plot trials, and National Uniform Rice Yield Trials across major rice-growing regions of Pakistan. Results demonstrated that PKBB15-116 consistently outperformed commercial checks, including Super Basmati and Basmati 515, with an average yield advantage of 10–17%, coupled with stable performance across environments. The variety exhibited strong resistance to bacterial leaf blight, moderate resistance to major insect pests, improved stem stiffness, early maturity (≈ 105 days), and superior grain quality attributes, including extra-long slender grains, high head rice recovery, and excellent cooking quality. Economic analysis indicated substantial yield gains and potential national-level savings due to reduced BLB-related losses. Overall, the development of PKBB15-116 represents a significant advancement toward green and sustainable rice production, offering a climate-smart solution that integrates disease resistance, high yield, and premium grain quality. This variety has strong potential to enhance farmer income, stabilize Basmati rice production, and contribute to food security under climate change scenarios.

Keywords: Basmati rice; Bacterial leaf blight; *Xa21* gene; Marker-assisted selection; Climate-resilient agriculture; Sustainable rice production



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Empowering Rural Women as Agripreneurs: Advancing Food Security and Value Chain Development

Abid Ali^{1,*}, Naveed Farah², Sumaira Bani³

¹MNS-University of Agriculture, Multan (corresponding author),

²University of Agriculture, Faisalabad,

³Sumaira Bano, Ghazi University, D G Khan

Correspondence to abidalvi.official@gmail.com

Abstract

Women in Pakistan have been the center of the agriculture sector where they play a major role in sowing, harvesting, livestock farming, food processing and post-harvest. However, their contribution to value-added agriculture and agribusiness is very low because of the social-cultural limitations, movement, lack of access to financial prospects and insufficient training opportunities. Such discriminations do not allow women to transcend household chores into lucrative agricultural value chains. The research paper draws on the experience of development interventions in Okara and Vehari districts to show how an organized process of empowerment based on climate-smart agriculture, business education, and community-based financial systems can help change women into agents of the agriculture sector as agripreneurs. The change will lead to improved household nutrition, robust food security, and establishment of sustainable local value chains, which align to national SDGs. The aim of the study is to (1) discuss the role and problems faced by women in agriculture and value addition; (2) determine how the entrepreneurship support has influenced the agripreneurial potential of women; and (3) explore gender-sensitive agri-based models as contribution towards food security and sustainable value chain. The qualitative-descriptive, methodology was utilized, and secondary data were collected in the form of program reports, evaluation reports, case studies, and thematic literature on women empowerment, Farmers Field Business Schools (FFBS), Village Saving and Loan Associations (VSLAs) and climate-smart agriculture. Thematic content analysis was used to generalize understandings on the effectiveness of training, outcomes of value-addition, financial inclusion, and change of behavior in communities that participated. Inter-case study of women farmers in Okara and Vehari specifically those practicing maize and potato value addition, were used in determining patterns of women empowerment, income gains, and market access. The use of NGOs and government data, FAO, and field-level analysis triangulation improved reliability and gave a full picture of intervention results. Results indicate that women that attended FFBS embraced better agricultural production, diversification, and increased yields in maize, vegetables, and crops in horticultures. Value addition training allowed women to make potato chips, maize flour, and dehydrated vegetables among other commercially viable items, which earned them more income and minimized losses after harvesting. VSLAs improved financial inclusion which enabled women to start micro-enterprises, invest in farm inputs and assume decision making roles in their homes. The examples of successful agripreneurs in kitchen gardening enterprise, CSA methods i.e. laser land leveling services and value chain process i.e. value-added potato products demonstrates a considerable increase in revenue, food and social status. collectively, the interventions increased food security, resilience and female leadership within rural community. The women in Pakistan have a high



agripreneurial potential that can be transformed with the help of specific capacity building, gender-sensitive financing, climate-friendly agriculture training, and value chain integration. The FFBS and VSLA models have empowered women with technical competencies, preparation to the market and control in production and income generation. Notwithstanding the continuous challenges associated with low mobility, access to markets, gender-based land tenure, and lack of institutional facilitation, empowered women help to enhance food security, increase dietary diversity, income to the household, and rural economies. Expansion of these models on the national scale has the potential to promote SDG 1, SDG 2, SDG 5, and SDG 8 quite a bit, as women are at the center of a resilient and inclusive agricultural value chain.

Keywords: Women Agripreneurship; Climate-Smart Agriculture; Value Chain Development; Food Security; Financial Inclusion



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Assessing Health Literacy Among University Students: Key Influences and Strategies for Improvement

Laraib Rehman Quraishi^{1*}, Sami Ullah¹

¹MNS University of Agriculture, Multan

*Correspondence to laraibqureshi399@gmail.com

Abstract

Health literacy plays a vital role in enabling individuals to make informed health decisions, particularly among university students who are at a critical stage of developing lifelong health behaviors. In the digital age, where access to health information is vast but not always reliable, students must possess the skills to seek, understand, evaluate, and apply relevant health knowledge effectively. The purpose of the research was to assess students' capabilities in accessing and utilizing health information and to investigate how factors like age, gender, academic discipline, year of study, and digital tools affect these abilities. A cross-sectional survey design was employed using a structured questionnaire distributed among 350 students from various academic disciplines. The sample comprised 58.9% female and 41.1% male students, primarily aged between 20-29 years (71.2%). Data was analyzed using descriptive statistics and frequency distributions to interpret health literacy levels and related variables. Results showed that 66.5% of students agreed or strongly agreed they could easily find health information, while 71.8% felt confident in understanding information from healthcare professionals. However, 17.2% of students struggled to assess the reliability of health content, and 19.2% lacked confidence in filling out medical forms. Additionally, only 54.8% of students believed they could critically evaluate health information, indicating a gap in analytical skills. Digital platforms were the most frequently used health information sources. About 67.2% of students often or always used reputable health websites. While 58.9% regularly relied on social media platforms. Family and friends were consulted by 60.3% of students, while institutional sources like university health centers were used by only 27.4%. The results highlight the need for educational interventions focusing on digital health literacy, critical thinking, and practical application of health knowledge.

Keywords: Health literacy; University students; social media; information; Multan



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Morpho-physiological response and expression analysis of alcohol dehydrogenase (ADH) genes for waterlogging tolerance in upland cotton

Muhammad Hamza Wakeel¹, Shoaib ur Rehman¹, Zulqurnain Khan¹, Akash Fatima², Shahid Iqbal¹, Mirza Abid Mehmood², Muhammad Asaf Khan¹ and Furqan Ahmad^{1*}

¹Institute of Plant Breeding and Biotechnology, MNS-University of Agriculture, Multan, Pakistan

²Department of Plant Pathology, MNS-University of Agriculture, Multan, Pakistan

*Correspondence to furqan.ahmad@mnsuam.edu.pk

Abstract

Cotton is a major cash crop sown mainly as a fiber crop throughout the world. Its contribution is about 35% of the world's fiber production. Severe biotic and abiotic stresses, along with climatic change, have impacted cotton production. Cotton faces significant challenges due to waterlogging, which impairs root oxygen supply and leads to yield losses. Cotton is poorly adapted to waterlogged conditions. Fifteen cotton genotypes issued from the germplasm of the MNS- University of Agriculture were evaluated for waterlogging tolerance. The genotypes were grown in polythene bags with sand and water-soluble fertilizer (NPK), following a completely randomized design with three replications. Waterlogging treatments were initiated at the seedling stage of plant development. The control group was maintained under normal irrigation conditions, while waterlogging stress was imposed for durations of 3, 7, and 10 days after seedling, respectively. Morphological parameters such as root and shoot length, fresh and dry weights, and physiological parameters including chlorophyll content, photosynthetic rate, transpiration rate, stomatal conductance were measured. Analysis of variance showed significant differences among genotypes, treatments and their interaction for all studied traits. Correlation analysis gave significant and positive association of all important traits. Biplot was utilized to screen the best- performing genotypes (Hataf-1, Hataf-2 and FH-444) and susceptible genotypes (FH-333, CYTO- 535 and FH-1133) in stressful conditions. Identification and physiochemical properties, phylogeny tree, identification of relevant domains and motif analysis, exon intron structural display, collinearity and gene duplication analysis, position of genes and sub cellular location of ADH genes were analyzed. GhADH11, GhADH12, and GhADH16 in expression analysis were identified as the most promising candidates associated with abiotic stress tolerance and further validation in water logging stress.

Keywords: Upland cotton, Waterlogging stress, Morpho-physiological traits, Genome wide analysis, expression divergence



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Non-Target Effects of Pydiflumetofen + Difenoconazole: A Synergistic Fungicidal Combination on Life Table and Population Parameters of *Musca domestica* (Diptera: Muscidae)

Naeem Iqbal^{1*}, Qammar-u-Din¹, Nauman Sadiq¹

¹Department of Entomology, Muhammad Nawaz Shareef University of Agriculture, Multan (60000), Pakistan

*Corresponding Author: naeem.iqbal@mnsuam.edu.pk

Abstract

This study shows that Pydiflumetofen + Difenoconazole has negative effects on life table and population parameters of house fly. Exposure to field recommended dose (400 ppm) and sublethal dose (200 ppm) greatly decreased the survival of pre-adults and the lifespan of adults, especially in males' disruptions in the body was observed. Lifespan and Survival rate were decreased, fertility increases respective to dose, which suggests a hormetic impact. Fecundity was 3-fold greater in population exposed field, and the mean generation time (T) was also reduced. Life table parameters, such as the gross reproductive rate (GRR) and the finite rate of rise (λ), showed that the population may turn over more quickly. However, the intrinsic growth rate (r) and the net reproduction rate (Ro) stayed statistically constant. On the basis of these findings it can be concluded that there is a complicated trade-off between survival and reproduction of house fly after exposure to said fungicide. Sublethal stress speeds up generational cycling and reproductive drive, which could change the way pest populations behave over time. The impacts on integrated pest management are very important. This combination of fungicides can effectively suppress fungal pests, but its unexpected effects on fertility could make long-term control efforts less effective. This study shows that pest control programs need to use the right doses and undertake more testing of the desired results of pesticides.

Keywords: fungicide, house fly, reproduction, survival, hermetic effect



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 – 12, 2026
MNS University of Agriculture Multan

Risk-laden Pesticide Practices among Mango Growers in Southern Punjab

Muhammad Asif Farooq^{1*}, Naeem Iqbal¹, Muhammad Bilal Ahsan², Farrukh Baig¹, Fawad Zafar Khan³

¹ Department of Entomology, MNS-University of Agriculture, Multan, Pakistan

² Department of Agribusiness and Entrepreneurship Development, MNS-University of Agriculture, Multan, Pakistan

³ Department of Outreach and Continuing Education, MNS University of Agriculture Multan

*Correspondence to asif.farooq@mnsuam.edu.pk

Abstract

Mango production is one of the rural livelihoods in Pakistan based on pesticide-intensive production and has high chances of contaminating the environment and poisoning human beings in case of misuse and poor safety measures. The survey was undertaken to evaluate the patterns, knowledge and protective behavior of mango growers in the major producing districts of southern Punjab on the use of pesticides using structured Urdu language questionnaire. There are several pesticide applications on Mango orchard in Multan, Muzaffargarh, Rahim Yar Khan and Khanewal, which are mostly prompted by insect and disease and fruit-fly pressures. Limited farmer awareness about toxicity, improper container disposal, and lack of personal protective equipment (PPE) contribute to acute and chronic pesticide poisoning in agricultural communities. A cross-sectional survey of 93 mango growers was implemented using an interviewer-administered questionnaire originally developed in Urdu to match local literacy and language. The tool captured demographics, orchard characteristics, spray frequency, income sources, pest management, use of traps, pesticide knowledge, PPE use, storage, container disposal, sprayer calibration, and awareness and management of pesticide poisoning. Respondents were mainly middle-aged male farmers (age range roughly 20–78 years) managing orchards from 1–200 acres with Chounsa and mixed varieties predominating. Many orchards received 2–8 sprays per season, with intensive use in high-value, large orchards reporting up to 7–8 applications. Chemical insecticides were widely used, while biopesticides and traps (pheromone, sticky, light and fruit-fly traps) were adopted by only a subset of growers. Advice was dominated by salesmen and farmer community, with relatively few farmers reporting guidance from agriculture officers, indicating a weak formal extension interface. Use of mask, gloves and shoes was inconsistent, and many farmers reported using nothing as PPE during spraying. Unsafe practices were frequent, including throwing empty containers in fields or canals, lack of sprayer calibration information, and disposal of left-over spray in water channels or by re-spraying fields, despite generally high stated “knowledge” of spray hazards and variable consultation with doctors or agriculture officers after poisoning.

Keywords: Mango; pesticides; farmer knowledge; pesticide poisoning; PPE southern Punjab; container disposal



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Yeast volatiles show promise as a semiochemical lure for *Carpophilus truncatus*, an emerging pest of almond orchards around the world

Farrukh Baig^{1, 2, 3, *}, Kevin Farnier^{1, 2}, John Paul Cunningham^{2, 4}

¹Queensland University of Technology, Gardens Point, Brisbane, QLD 4001, Australia

²Agriculture Victoria Research, AgriBio Centre, 5 Ring Road, Bundoora, VIC 3083, Australia

³Institute of Plant Protection, Muhammad Nawaz Shareef University of Agriculture, Multan 60000, Pakistan

⁴School of Applied Systems Biology, La Trobe University, Bundoora, VIC 3083, Australia

*Correspondence to farrukh.baig@mnsuam.edu.pk

Abstract

Carpophilus truncatus (Murray), a nitidulid beetle, has become a major threat to almond industries globally. While there are existing mass trapping strategies for other *Carpophilus* species, an effective lure for this nut-attacking pest is urgently required. This study leverages our knowledge of the chemical ecology of *Carpophilus*, particularly its relationship with gut-associated yeasts, to develop a new semiochemical attractant for *C. truncatus*. *Wickerhamomyces rabaulensis* was identified as the predominant gut-associated yeast in field-collected *C. truncatus*. Field bioassays demonstrated that traps baited with live cultures of *W. rabaulensis* captured more beetles compared to those baited with *Hanseniaspora guilliermondii*, a yeast from stone fruit-attacking *Carpophilus* species. GC-MS analysis revealed both qualitative and quantitative differences in the odour profiles of the two yeasts. Seven volatile compounds were identified and confirmed to be detected by *C. truncatus* antennae using GC-EAD. Choice-test bioassays showed adult *C. truncatus* preferred a synthetic blend based on *W. rabaulensis* volatiles over a commercial lure designed for stone fruit *Carpophilus* species. Field trials with various formulations of *W. rabaulensis* volatiles indicated that a modified commercial lure containing isoamyl acetate and isobutyl acetate was more attractive to *C. truncatus* and caught fewer non-target species such as *C. hemipterus*. This study demonstrates the potential of insect-yeast chemical ecology in developing effective semiochemical-based lures for monitoring and mass trapping *C. truncatus* in almond orchards.

Keywords: Attractant, Coleoptera, Mass trapping, Smart plant protection



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Trends in Pesticide Poisoning and Health-Seeking Behavior among South Punjab Agricultural Community in South Punjab, Pakistan

Muhammad Asif Farooq^{1, *}, Shafqat Saeed¹, Francesca Mancini², Naeem Iqbal¹, Shweta Dabholkar²

¹Department of Entomology, University of Agriculture, Multan, Pakistan

²Centre for Pesticide Suicide Prevention, University of Edinburgh, UK

Correspondence to asif.farooq@mnsuam.edu.pk

Abstract

The intensive agriculture that requires the use of pesticides in crop protection participates significantly in the acute as well as chronic human poisoning, especially in the rural agricultural communities of South Punjab, Pakistan. This research project had the purpose of describing trends in pesticide poisoning, active ingredients most frequently implicated, and understanding the health-seeking behavior among the affected population using a survey based on the field. A structured questionnaire was then given to 90 cases of pesticide poisoning identified by hospital records and community reports in the last 12 months and 5 years with key variables coded as the setting of exposure, intent, gender, survival, and the pesticide involved. The data were then tabulated in Excel and analyzed descriptively, and frequency distribution and percentage graphs were made on location of treatment, help-seeking, nature of poisoning, duration and pesticide groups responsible. Most of the respondents were male (83.3%), as male dominance in farm agriculture and pesticides. The case fatality burden was a high survival rate of 65.6 percent and one third of the cases were non survivors. Formal healthcare access and documentation had gaps as there were very even distributions of places of treatment, with hospital (35.6%), home (30%), and unknown settings (34.4%). In 77.8 percent of reports, assistance was solicited but 22.2 percent had no formal assistance. Concerning exposure conditions, 34.4% of the cases were deliberate (suicide), 28.9% occupational, and 36.7% of unknown nature, highlighting both the self-poisoning and unsafe work conditions as the key routes. The most common pesticide implicated was lambda-cyhalothrin (29.2% of the total cases identified), then emamectin benzoate (10.8%), and then abamectin (7.7%), and a broad array of other insecticides, herbicides and fungicides, with smaller proportions. In general, 70 percent of reported cases were in the past year and 30 percent in the past five years indicating an increasing or better captured recent burden. These results highlight the importance of more stringent control of pesticides, better safe-use education, and enhanced toxicovigilance and emergency response of rural agricultural communities.

Keyword: Pesticide poisoning, Agricultural communities, Lambda-cyhalothrin, Emamectin benzoate, Intentional and occupational exposure, Health-seeking behavior



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February 11 - 12, 2026
MNS University of Agriculture Multan

Gut Microbiome Modulation in Obesity and Polycystic Ovarian Syndrome: Therapeutic Potential of Functional Foods and Nutraceuticals

Muhammad Asif^{1, 2}, Sadaf Shakoor^{1, *}, Ayesha Usman², Iraj Fatima², Anas Shakoor¹, Nadia Hameed¹

¹Department of Food Science and Technology, UAF-Constituent College, Burewala.

²National Institute of Food Science and Technology, University of Agriculture, Faisalabad.

*Correspondence to sadaf.shakoor@uaf.edu.pk

Abstract

The rising prevalence of obesity and polycystic ovarian syndrome (PCOS) has intensified research into the mechanisms linking metabolic and reproductive dysfunction. The gut microbiome has emerged as a key regulator of energy balance, insulin sensitivity, inflammation, and hormonal homeostasis through complex interactions between the gut, brain, and endocrine system. Dysbiosis, characterized by reduced microbial diversity and altered abundance of beneficial bacteria, is strongly associated with obesity and PCOS, contributing to chronic low-grade inflammation, insulin resistance, hyperandrogenism, and impaired ovarian function. Altered microbial metabolites, including short-chain fatty acids, bile acids, and lipopolysaccharides, further exacerbate metabolic and endocrine disturbances in these conditions. Functional foods and nutraceuticals such as dietary fibers, prebiotics, probiotics, synbiotics, polyphenols, and omega-3 fatty acids have shown potential in restoring microbial balance, improving glucose metabolism, reducing systemic inflammation, and regulating reproductive hormones. These interventions act mechanistically by enhancing gut barrier integrity, modulating immune signaling, and influencing microbial metabolite production, thereby supporting metabolic and reproductive health. Gut microbiome modulation thus represents a promising, non-invasive therapeutic approach for managing obesity and PCOS. Integrating functional foods and nutraceuticals into personalized nutrition strategies may provide sustainable health benefits. However, interindividual variability, optimal dosage, and long-term efficacy remain key challenges. Well-designed clinical trials are essential to establish standardized guidelines and confirm the clinical applicability of microbiome-targeted interventions. This review highlights the therapeutic potential of gut microbiome modulation and emphasizes the role of functional foods and nutraceuticals as adjunct strategies for improving metabolic and reproductive outcomes in obesity and PCOS.

Keywords: Gut microbiome, Obesity, Dysbiosis, Functional foods, Nutraceuticals



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Morpho-physiological characterization of cotton genotypes for Cotton Leaf Curl Virus (CLCuV) tolerance

Muhammad Haroon¹, Umar Akram¹, Muhammad Ishtiaq², Babar Farid¹, Mahmood Alam Khan¹, Muhammad Ali Sher¹, Sher Zaman¹, Junaid Imam¹, Khahish Iqbal¹, Umar Ijaz Ahmed² and Furqan Ahmad^{1, *},

¹Institute of Plant Breeding and Biotechnology, MNS-University of Agriculture, Multan, Pakistan

²Department of Agricultural and Resource Economics

*Correspondence to furqan.ahmad@mnsuam.edu.pk

Abstract

Cotton is an important cash and fiber crop. It has a significant economic impact. However, there are several obstacles to cotton production, Cotton Leaf Curl Virus (CLCuV) is one of these factors, which lower fiber quality and yield. The development of tolerant varieties has become necessary due to the significant economic impact caused by the CLCuV, spread by whiteflies (*Bemisia tabaci*). The purpose of this work is to find out genotypes of cotton, tolerant to CLCuV with improved agronomic traits. Thirty genotypes were obtained from MNS-University of Agriculture, Multan and evaluated for CLCuV tolerance using a randomized complete block design. Morpho-physiological characteristics like plant height (cm), boll weight (g), boll count, leaf area (m²), leaf thickness (mm), whitefly population, hairiness, gossypol contents, fiber quality parameters like fiber length (cm), fiber strength (g tex⁻¹), fiber Uniformity (GOT %) and Micronaire value (µg/inch) were measured, along with Photosynthetic rate (A), Stomatal conductance (gs), Transpiration rate (E), Chlorophyll (Chl), activities of Protein, DPPH, Anthocyanin, POD, catalase (CAT), PPO and carotenoids were measured in order to examine the physiological and biochemical changes in cotton plants infected with CLCuV. Analysis of variance (ANOVA) was used to find significance difference among the genotypes. Biplot analysis was used to identify CLCuV tolerant genotypes among the genotypes. Most of the genotypes performing well such as FH-142, FH-992, DNH-67 and MNH-1050 were distinguished by their significant CLCuV tolerance. The results of the study help cotton sustainably by assisting in the identification of CLCuV tolerant cotton to add up in breeding programs.

Keywords: Upland cotton, Cotton Leaf Curl Virus, Morpho-physiological traits, Whitefly vector



Valorization of Banana Peel for the Development of High-Fiber Functional Snack: A Sustainable Approach to Food Security and Waste Reduction

Nida Firdous^{1,*}

¹Department of Food Science and Technology, FF&HS, MNS-University of Agriculture, Multan

*Correspondence to nida.firdous@mnsuam.edu.pk

Abstract

Food waste valorization has emerged as a promising strategy to enhance sustainability, strengthen food value chains, and improve food security. Banana peel, a major by-product of banana processing, constitutes nearly 30–40% of the fruit weight and is often discarded despite being rich in dietary fiber, phenolic compounds, antioxidants, and essential minerals. This study investigates the potential utilization of banana peel powder as a functional ingredient in the development of a nutritious, value-added snack product. Banana peels were processed through washing, blanching, drying, and milling to obtain fine powder, which was incorporated at varying levels into snack formulations. The developed products were evaluated for physicochemical characteristics, proximate composition, total dietary fiber, antioxidant activity, sensory acceptability, and shelf stability. Results indicated that incorporation of banana peel powder significantly enhanced fiber content, antioxidant potential, and mineral composition of the snack without adversely affecting sensory quality at optimized inclusion levels. The developed snack demonstrated improved nutritional value and functional properties, making it suitable as a health-promoting, high-fiber food product. Additionally, the study assessed the sustainability impact of banana peel utilization, highlighting its role in reducing agro-industrial waste, promoting circular bioeconomy, and creating opportunities for low-cost functional food production. The findings underscore the potential of fruit by-product valorization as an innovative pathway for sustainable food systems, contributing to waste reduction, value addition, and improved nutritional security. This approach supports resilient food value chains by transforming low-value waste into marketable, health-oriented products, aligning with global goals for sustainable development and resource efficiency.

Keywords: Valorization, Waste reduction, Food security, Value added products



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Deep Learning Based Climate and Environmental Monitoring for Sustainable Agriculture

Ramsha Ahmad^{1,*}, Manal Ahmad¹, Muhammad Ahsan Jamil¹

¹Institute of Computing, MNS- University of Agriculture Multan, Pakistan

*Correspondence to ramsha.ahmad@mnsuam.edu.pk

Abstract

Advanced monitoring of climate and environmental changes is increasingly critical for achieving sustainable agricultural practices and ensuring food security. This study investigates the application of deep learning techniques for climate and environmental analysis in agricultural contexts. The proposed framework integrates heterogeneous data from satellite imagery, remote sensing platforms, and in-field environmental sensors to assess land-use dynamics, soil conditions, and climate-induced stress patterns on crops. Deep neural networks, including convolutional and recurrent architectures, are employed to capture both spatial and temporal variations in environmental factors, enabling the detection of subtle changes that may impact agricultural productivity. The models provide early warning signals for environmental degradation, extreme weather events, and climate-driven crop stress, supporting timely interventions and risk mitigation strategies. By combining large-scale environmental datasets with deep learning analytics, the framework enhances the accuracy, resolution, and responsiveness of monitoring systems. The approach also facilitates evidence-based decision-making for climate-smart agriculture, promoting resilient farming practices and sustainable land management. Experimental results demonstrate significant improvements in environmental monitoring, predictive accuracy, and actionable insights compared to traditional methods. Overall, this study highlights the transformative potential of deep learning for climate and environmental monitoring in agriculture, enabling stakeholders to develop adaptive, sustainable, and resilient strategies in response to ongoing climate variability and environmental challenges.

Keywords: Deep Learning, Climate Monitoring, Environmental Analysis, Sustainable Agriculture, Remote Sensing, Climate-Smart Farming



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

An AI-Enabled Digital Framework for Smart and Sustainable Agriculture

Muhammad Nasir Siddiqui^{1, *}, Muhammad Ahsan Jamil¹, Israr Hussain¹

¹Institute of Computing, MNS- University of Agriculture Multan, Pakistan

*Correspondence to nasir.siddiqui@mnsuam.edu.pk

Abstract

The rapid advancement of digital technologies is fundamentally transforming conventional agricultural systems, enabling the shift toward intelligent, data-driven farming practices. This study proposes an AI-enabled and IT-integrated framework designed to accelerate innovation in digital agriculture and support sustainable food production systems. The framework leverages digital platforms to collect and integrate heterogeneous data from Internet of Things (IoT) sensors, farm machinery, remote sensing technologies, and agricultural management systems. Artificial intelligence-based decision engines analyze this data to enable precision farming, automated crop and soil monitoring, and adaptive resource management. Advanced machine learning and data analytics techniques provide real-time insights and actionable recommendations for crop health assessment, irrigation scheduling, fertilizer optimization, and operational planning. The proposed approach enhances farm productivity while minimizing resource wastage, production costs, and environmental impact. Furthermore, intelligent and scalable system design improves resilience against climate variability and uncertain agricultural conditions. Experimental results and performance evaluations demonstrate significant improvements in operational efficiency, sustainability indicators, and decision accuracy compared to traditional farming practices. This study highlights the transformative role of AI-driven digital agriculture in developing future-ready, efficient, and environmentally responsible food systems.

Keywords: Artificial Intelligence, Digital Agriculture, Precision Farming, Smart Farming Systems, IoT in Agriculture, Sustainable Agriculture



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Intelligent Optimization of Agricultural Value Chains Using Machine Learning Techniques

Muhammad Ahsan Jamil^{1, *}, Manal Ahmad¹, Ramsha Ahmad¹

¹Institute of Computing, MNS- University of Agriculture Multan, Pakistan

*Correspondence to ahsan.jamil@mnsuam.edu.pk

Abstract

The increasing complexity of agricultural value chains and the volatility of agri-food markets require intelligent, data-driven decision-support systems for modern agribusiness. This study presents a machine learning-based framework integrated within IT-enabled agribusiness platforms to optimize agricultural value chains and enhance market sustainability. The framework utilizes historical and real-time transactional data to forecast demand, analyze price fluctuations, and identify inefficiencies across key supply chain stages, including production, storage, logistics, and market distribution. Advanced machine learning models support accurate demand prediction, dynamic inventory planning, and reduction of post-harvest and operational losses. Through predictive and prescriptive analytics, the system improves supply-demand alignment and strengthens coordination among value chain stakeholders such as farmers, aggregators, and market operators. Improved price transparency and access to timely market intelligence further enhance market integration and decision-making. Experimental results demonstrate that machine learning models outperform conventional statistical methods in forecasting accuracy and responsiveness to market changes. The proposed framework leads to measurable improvements in operational efficiency, cost optimization, and resilience to market uncertainty. Additionally, data-driven decision-making contributes to sustainable agribusiness practices by minimizing resource waste and supporting stable market performance. This research highlights the transformative role of machine learning in digital agribusiness and provides a scalable solution for strengthening agricultural value chains in developing and emerging economies.

Keywords: Machine Learning, Agricultural Value Chains, Agribusiness Systems, Demand Forecasting, Supply Chain Optimization, Sustainable Agriculture



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 – 12, 2026
MNS University of Agriculture Multan

Dietary azolla and spirulina modulate physicochemical quality, oxidative stability and lipid composition of broiler meat

Said Dahmouni¹, Zineb Bengharbi¹, Djilali Benabdemoumene¹, Nouredine Benguennouna¹, Muhammad Waqar^{2, *}

¹Applied Animal Physiology Lab, Abdelhamid Ibn Badis University, Mostaganem, Algeria

²Food Technology and Innovation Research Center of Excellence, School of Agricultural Technology and Food Industry, Walailak University, Tha sala, Nakhon Si Thammarat 80161, Thailand

Correspondence to mwaqarvet@gmail.com

Abstract

The replacement of synthetic growth promoters with natural feed additives has become a priority in sustainable poultry production. Microalgae and aquatic plants have attracted considerable interest due to their high protein content and bioactive compounds capable of improving meat quality and oxidative stability. Azolla is an aquatic fern rich in protein, minerals, and phenolic antioxidants, and has been reported to improve nutrient utilization and meat traits in broilers. Spirulina (*Arthrospira platensis*), a microalga rich in phycocyanin, carotenoids, and polyunsaturated fatty acids, has demonstrated positive effects on meat color, lipid oxidation, and nutritional quality (Holman & Malau-Aduli, 2013; Mirzaie et al., 2020). However, comparative and combined effects of Azolla and Spirulina on broiler meat quality remain insufficiently explored. This study aimed to evaluate the effects of graded dietary inclusion of Azolla and Spirulina, administered individually or in combination, on physicochemical properties, oxidative stability, and nutritional quality of broiler chicken meat. A feeding trial was conducted using Arbor Acres broiler chickens randomly allocated into nine experimental groups and reared under identical management conditions. The control group received a standard basal diet. Three groups were supplemented with Azolla meal at 2%, 4%, and 6%, while three groups received Spirulina powder at 0.5%, 1.0%, and 1.5%. Two additional groups received combined supplementation (2% Azolla + 0.5% Spirulina and 4% Azolla + 1.0% Spirulina). At market age, breast and thigh meat samples were collected for pH, water-holding capacity (WHC), color (L*, a*, b*), lipid oxidation (TBARS), proximate composition, and fatty acid profile analysis. Data was analyzed using one-way ANOVA ($p < 0.05$). Compared with the control group, dietary supplementation significantly improved several meat quality parameters. Breast meat pH values were more stable in supplemented groups (5.82–5.88) than in controls (5.75). WHC increased by 6–12% in Azolla- and Spirulina-fed broilers, with the highest values observed in combined treatments. Spirulina supplementation significantly increased redness (a*) values (3.8–4.2) compared with the control (3.1). Lipid oxidation was reduced by 25–40% in supplemented groups, with the lowest TBARS values recorded in the combined Azolla–Spirulina diets. Protein content increased from 22.4% in the control to 23.5–24.1% in supplemented groups, while intramuscular fat decreased slightly. Spirulina inclusion increased total polyunsaturated fatty acids by up to 15% compared with the control. Dietary supplementation with Azolla and Spirulina significantly enhanced broiler meat physicochemical quality, oxidative stability, and nutritional value. Combined supplementation exhibited synergistic effects, particularly in reducing lipid



oxidation and improving fatty acid composition. These findings support the use of Azolla and Spirulina as sustainable functional feed additives in broiler production. Further studies should focus on optimization of inclusion levels and evaluation under commercial farming conditions.

Keywords: Azolla; Spirulina; broiler meat quality; oxidative stability; lipid composition



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Alternative animal pepsins differentially modulate coagulation efficiency and cheese quality of cow and camel milk

Said Dahmouni¹, Zineb Bengharbi¹, Djilali Benabdemoumene¹, Nouredine Benguennouna¹,
Muhammad Waqar^{2,*}

¹Applied Animal Physiology Lab, Abdelhamid Ibn Badis University, Mostaganem, Algeria

²Food Technology and Innovation Research Center of Excellence, School of Agricultural Technology and Food Industry, Walailak University, Tha sala, Nakhon Si Thammarat 80161, Thailand

Correspondence to mwaqarvet@gmail.com

Abstract

Milk coagulation is a critical step in cheese manufacture and is strongly influenced by milk composition and enzyme specificity. Camel milk presents particular technological challenges due to its low κ -casein content, large casein micelles, and altered mineral balance, which reduce its responsiveness to conventional bovine coagulants. In parallel, the valorization of animal by-products as alternative milk-clotting enzymes aligns with circular economy principles and sustainable dairy processing. Crude pepsins extracted from poultry, rabbit, and fish digestive tissues represent promising non-bovine coagulants; however, their comparative efficiency on cow and camel milk remains insufficiently characterized. This study aimed to compare the milk-clotting performance, cheese yield, physicochemical properties, and sensory quality of fresh cheeses produced from cow and camel milk using crude pepsins extracted from chicken, rabbit, and fish. Pasteurized cow (*Bos taurus*) and camel (*Camelus dromedarius*) milk were coagulated using crude pepsin extracts obtained from chicken proventriculus, rabbit stomach, and fish viscera. Milk-clotting activity, proteolytic activity, coagulation kinetics, and clotting strength were determined under standardized conditions. Cheesemaking trials were performed using equivalent enzyme activity units. The resulting cheeses were evaluated for yield, physicochemical composition, rheological firmness, and sensory attributes. Data were statistically analyzed using one-way ANOVA with significance set at $p < 0.05$. The effectiveness of the pepsin extracts differed markedly according to both enzyme origin and milk type. Chicken pepsin showed superior coagulation efficiency in cow milk, producing firm curds and cheeses with high structural integrity, but exhibited limited or no coagulating capacity in camel milk. In contrast, rabbit and fish pepsins successfully coagulated both cow and camel milk, although camel milk required longer coagulation and flocculation times and specific thermal conditions. Fish pepsin resulted in the highest cheese recovery in both milk types, whereas rabbit pepsin produced cheeses with more balanced physicochemical properties and improved textural characteristics. Sensory evaluation indicated higher overall acceptability for cow milk cheeses, particularly those produced with rabbit pepsin, while camel milk cheeses were generally less preferred due to softer texture and milder flavor. The performance of alternative animal pepsins is strongly influenced by milk type and enzyme origin. While chicken pepsin is well suited for bovine milk coagulation, rabbit and fish pepsins exhibit broader applicability, including camel milk. Rabbit pepsin offers the most favorable balance between technological performance and sensory quality.



These findings highlight the importance of targeted enzyme selection and process optimization to improve camel milk cheesemaking and promote sustainable use of animal by-products.

Keywords: camel milk; milk coagulation; alternative pepsins; cheese quality; enzyme specificity



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February 11 - 12, 2026
MNS University of Agriculture Multan

Determinants of Islamic Finance Adoption among SMEs: Evidence from South Punjab, Pakistan

Muhammad Faizan Malik¹, Muhammad Haseeb Raza^{1, *}, Muhbammad Khalid¹, Muhammad Nasir Siddiqui²

¹Department of Agribusiness and Entrepreneurship Development, MNS University of Agriculture, Multan

²Institute of Computing, MNS University of Agriculture, Multan

*Correspondence: haseeb.raza@mnsuam.edu.pk

Abstract

Small and Medium Enterprises (SMEs) are the backbone of Pakistan's economy, as they contributed to sustainability of overall exports, and generate 78% of employment, which helps to reduce poverty and expand the national economy. However, SMEs face considerable constraints in accessing financing from conventional banks due to high interest rates, strict collateral requirements, and rigid lending procedures. Due to these constraints, SMEs seek to have alternative financing mechanisms, especially the Islamic financing products which are aligned with both Sharia laws and Profit and Loss Sharing (PLS) agreements, such as Mudarbah and Musharkah. Regardless to expansion of Islamic banking in Pakistan, its adoption by SMEs is below the expectation, highlighting a specific research and policy gap. This study aims to identify the psycho-sociological factors of managers affecting the adoption of Islamic Finance by SMEs in South Punjab, Pakistan. To understand these factors; theory of Diffusion of Innovation and the theory of Reasoned Action are considered. For this purpose, primary data will be collected through face-to-face and online google form-based interviews of SME managers using a well-structured and pre-tested questionnaire. This study contributes to shifting the focus from institutional constraints to behavioral drivers of SME managers to improve SMEs' financial inclusion in Pakistan.

Keywords: SMEs, Islamic Finance, Physio-sociological characteristics



3rd International Conference Food Security and Value Chain Systems: Innovative Pathways for Sustainability and Resilience (ICFSVC-2026)

February 11 - 12, 2026
MNS University of Agriculture Multan

Plasma-Activated Water–Based Modification of Egg White Protein for Value-Added Food Systems

Muhammad Waqar¹, Manat Chaijan¹, Rotimi E. Aluko², Worawan Panpipat¹, Lovedeep Kaur⁴,

¹Food Technology and Innovation Research Center of Excellence, Department of Agro-Industry, School of Agricultural Technology, Walailak University, Tha sala, Nakhon Si Thammarat 80161, Thailand

²Department of Food and Human Nutritional Sciences, University of Manitoba, Winnipeg, MB, R3T 2N2, Canada

⁴Riddet Institute, Massey University, PB 11 222, Palmerston North 4442, New Zealand

Correspondence to mwaqarvet@gmail.com

Abstract

Sustainable and non-thermal processing technologies are increasingly explored to enhance protein functionality while minimizing energy input and quality deterioration in food systems. Egg white protein (EWP) is widely used as a functional ingredient; however, conventional modification methods may compromise its structural integrity. Plasma-activated water (PAW) has emerged as an innovative processing medium capable of inducing controlled protein modifications through reactive species generation. Understanding how PAW alters EWP structure–function relationships is essential for developing value-added food systems that support processing efficiency, product performance, and resilience across food value chains. This study aimed to evaluate plasma-activated water as a non-thermal strategy to modulate the structural and functional properties of egg white protein, with emphasis on charge behavior, molecular conformation, oxidative indicators, and interfacial functionality relevant to value-added food system applications. Egg white protein was treated with plasma-activated water or distilled water at a fixed protein-to-liquid ratio under controlled stirring and temperature conditions, with untreated protein serving as a control. Structural modifications were assessed using ζ -potential, surface hydrophobicity, intrinsic fluorescence spectroscopy, Fourier-transform infrared (FTIR) spectroscopy, dityrosine formation, and free sulfhydryl content. Functional performance was evaluated through solubility, turbidity, oil-holding capacity, emulsifying properties, and foaming characteristics, following established analytical protocols. PAW treatment induced pronounced charge-related changes in EWP, reflected by a reduction in ζ -potential and associated conformational rearrangements. Protein surface properties were altered, with increases in surface hydrophobicity indicating molecular unfolding. Spectroscopic analyses (intrinsic fluorescence and FTIR) revealed modifications in tertiary and secondary structures, suggesting controlled structural reorganization rather than extensive denaturation. Oxidative markers showed increased dityrosine formation alongside a reduction in free sulfhydryl groups, supporting the role of PAW-derived reactive species in protein restructuring. Functionally, treated samples exhibited decreased solubility and increased turbidity, while interfacial properties including oil-holding capacity, emulsifying behavior, and foaming ability were enhanced. Foam stability remained high, indicating functional resilience despite structural modification. Plasma-activated water demonstrates strong potential as a sustainable, non-thermal processing tool to tailor egg white protein functionality for value-added food systems. By enabling controlled structural modification and improved interfacial performance, PAW aligns with innovation-



driven strategies for strengthening food ingredient value chains. Further research is recommended to evaluate scalability, process optimization, and integration into industrial protein processing workflows to support sustainable food system development and resource-efficient manufacturing.

Keywords: Plasma-activated water; egg white protein; non-thermal processing; functional properties; sustainable food systems



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February 11 - 12, 2026
MNS University of Agriculture Multan

Postharvest Application of Fumaric Acid Improves Biochemical and Antioxidative Quality of 'Chandler' Strawberry Fruit

Shafa Nayab^{1, *}, Sami Ullah¹, Ishtiaq A. Rajwana¹, Kashif Razaq¹

¹Department of Horticulture, MNS-University of Agriculture, Multan

Correspondence to shafa.nayab@mnsuam.edu.pk

Abstract

Strawberry is non-climacteric and highly perishable fruit with a limited shelf life, making postharvest management critical for preserving its quality and marketability. Natural organic acids are recognized as safe and effective for fruit preservation, maintaining fruit quality and shelf life. The experiment was conducted to check the impacts of organic acid application on fruit quality and oxidative stress management of strawberry at postharvest level. Treatments included for fumaric acid were T₀ (Control), T₁ @ 0.5mM, T₂ @ 1mM, T₃ @ 2 mM). The treated strawberry fruits were examined for soluble solids content, titratable acidity, juice pH, ascorbic acid, total phenolic, and antioxidant content analysis throughout the shelf period (4 days) at 23°C and 50–60% relative humidity. The results indicated that the application of FA enhanced the antioxidant activity and total phenolic contents and defense response in strawberries as compared to control. Furthermore, it also promoted the activities of superoxide dismutase (SOD), catalase (CAT) and peroxidase (POD) and consequently, a decrease in hydrogen peroxide (H₂O₂) and Malondialdehyde (MDA) accumulation was also observed. The activation of ROS metabolism led to higher antioxidant capacity compared with control. Conclusively, the findings revealed that 1mM of Fumaric acid proved to be the most effective in maintaining the quality characteristics, delaying the decay incidence and extending the shelf life of postharvest strawberries.

Keywords: Strawberry, Postharvest, Antioxidative qualities,