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EFFECTIVENESS OF CROP MANAGEMENT PRACTICES FOR SUSTAINABLE AGRICULTURE IN NORTH-WEST, PAKISTAN

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Abstract

Effective crop management practices play a vital role in agricultural progress, with far-reaching socio-economic effects on farming communities. This research aims to evaluate the socio-economic outcomes of such practices in Khyber Pakhtunkhwa, Pakistan. Through comprehensive surveys and farmer interviews, the study uncovers potential benefits and challenges linked to adopting crop management techniques. Notably, 41% of farmers surveyed are young (up to 30 years old) with primary/middle education. Most respondents (50.7%) possess 11-20 years of farming experience, and 61.3% own less than 5 acres of land. In terms of income impact, 27.3% reported a substantial increase post-adoption, while 22.7% experienced reduced financial stress. The study identifies limited extension services as a significant barrier to wider adoption. By conducting multiple linear regression analysis, the research demonstrates that demographic factors such as age, education level and household income significantly influence the likelihood of farmers adopting crop management practices. It is concluded that implementing efficient crop management practices in Khyber Pakhtunkhwa has the potential to significantly enhance crop productivity, increase income generation and improve the financial well-being of farmers. To encourage wider adoption, interventions and extension services should be customized to align with the demographic characteristics of farmers, particularly targeting younger farmers with higher education levels and higher household incomes. Establishing platforms, such as farmer cooperatives, community-based organizations or online networks, allows farmers to share experiences, learn from each other and promote the adoption of effective crop management practices through collaboration and knowledge dissemination. The findings of this study are valuable for policymakers, agricultural stakeholders and farmers in understanding the significance of implementing efficient crop management practices for sustainable agricultural development.

Keywords: Crop management practices, socio-economic impact, Khyber Pakhtunkhwa, agricultural development, crop productivity, income generation, employment opportunities, food security and rural livelihoods.

Introduction

Agriculture plays a vital role in the economy of Pakistan. With a predominantly agricultural country, a significant portion of the population depends on farming for their livelihood. The fertile lands and diverse climate in the country allow for the cultivation of various crops, contributing to GDP, employment, and food security (GoP, 2022). Khyber Pakhtunkhwa, in northern Pakistan, heavily relies on agriculture, crucial for food security and rural livelihoods. However, traditional practices lead to low productivity and limited development (GoKP, 2022). Challenges like technology access, water scarcity and climate change hinder growth. Efforts to promote sustainable farming, research, and policies aim to improve productivity and farmer welfare (Shah *et al*., 2010). Historically, conventional farming in the region caused degradation, pollution, and low productivity (Waqas *et al*., 2017). Recognition of sustainable practices is growing, with various organizations emphasizing effective crop management for socio-economic development (Khan *et al*., 2017).

Importance of Crop Management Practices

Crop management practices are of great importance as they optimize crop production, ensure

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sustainability, enhance economic viability, promote resilience to climate change, and have positive social impacts. Emphasizing and implementing effective crop management practices are vital for the long-term success and sustainability of agriculture systems worldwide (Rahman, 2020).

Socio-economic Impact of Crop Management Practices

Implementing efficient agricultural techniques carries substantial socio-economic benefits. These methods not only elevate crop yield but also foster ecological viability, yield financial returns, trigger countryside progress, and enhance the caliber and safety of produce. It is imperative to motivate and aid farmers in the integration and execution of these methodologies, as this plays a pivotal role in establishing sustainable and all-encompassing agricultural systems (Diaz *et al*., 2022).

Role of Crop Management in Sustainable Agriculture

Crop management practices are essential for achieving sustainable agriculture. They contribute to the conservation of natural resources, minimize environmental impacts, mitigate climate change, enhance economic viability, ensure food security, and promote socio-economic development. By prioritizing sustainable crop management, farmers can create a resilient and environmentally friendly agricultural system for present and future generations (White *et al.*, 2012).

Research Objectives

The objectives of the study are to

1. Assess the changes in farmers' income and livelihoods resulting from the adoption of crop management practices.
2. Evaluate the productivity gains and cost-effectiveness associated with the adoption of crop management practices.

Methodology

The present study was conducted in the Khyber Pakhtunkhwa province of Pakistan to investigate the effectiveness of crop management practices for sustainable agriculture in the agro-ecological zones specifically focusing on the districts i.e. Dir Upper, Swat, Karak, and D. I. Khan. A total of 300 registered farmers were selected as respondents for the present study. These farmers were chosen from two distinct agro-ecological zones of Khyber Pakhtunkhwa. A well-developed interview schedule was designed to collect the primary data whereas, secondary data was taken from published and unpublished sources. Further, the collected data were analyzed through SPSS. V.20. the descriptive statistics of frequency distribution, percentages, means and standard deviations were used for general descriptions. Whereas regression analysis was also used to explore the relationship between demographic characteristics and the impact of socio-economic factors on crop management practices.

The multiple linear regression model represented as follows:

Impact of Socio-economic Factors = $\beta 0 + \beta 1 * \text{Age} + \beta 2 * \text{Education} + \beta 3 * \text{Landholding Size} + \varepsilon$

Where:

β_0 is the intercept (constant term).

β_1, β_2, and β_3 are the regression coefficients for Age, Farming Experience and Landholding Size respectively.

Age, Farming Experience and Landholding Size are the independent variables representing demographic characteristics.

ε is the error term, representing the random variability in the relationship not explained by the model.

Results and Discussions

Table 1 Demographic Characteristics of the Respondents

Factors	Frequency	Percentage
Age		
Up to 30 Years	123	41

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31-50 Years	79	26.3
51 Years and above	98	32.7
Education		
Illiterate	57	19
Primary/Middle	63	21.0
Matric	130	43.3
Intermediate and above	50	16.7
Farming Experience		
< 10 Years	40	13.3
11-20 Years	152	50.7
21 years and above	108	36.0
Land Holding Size		
<5 Acres	184	61.3
6-10 Acres	92	30.7
More than 10 Acres	24	8.0

The above table illustrates the demographic characteristics of the respondents, focusing on four essential factors: age, education, farming experience and land holding size. According to the data, 41% of the respondents were in the age category up to 30 years followed by 26.3% fall in the 31-50 years age range whereas, 32.7% of the respondents had 51 years and above age. Regarding education, the results revealed that 19% of the respondents were illiterate in the study area while 43.3% have completed matric followed by 21% who had education up to primary/middle. Moreover, 16.7% have pursued education beyond matriculation. Examining farming experience, 13.3% of the respondents had less than 10 years of experience in the farming followed by, 50.7% of the respondents who had 11-20 years and 36% had 21 years and above farming experience. Regarding land holding size, 61.3% possess less than 5 acres of land followed by, 30.7% who had 6-10 acres and 8% of the respondents own more than 10 acres of land.

The results in Figure 1 reveal a diverse range of opinions regarding the effectiveness of these practices in agriculture. Conservation agriculture, agroforestry and nutrient management garnered substantial support, with a considerable percentage of respondents agreeing or strongly agreeing with their benefits. In contrast, precision agriculture and water management received more mixed responses, with a significant number of respondents remaining neutral. Climate-smart agriculture and good agricultural practices also had a favorable outlook, although a notable proportion expressed disagreement. It is evident that perceptions vary across different agricultural practices, highlighting the need for targeted education and promotion of sustainable farming techniques to enhance their widespread adoption and positive impact on agriculture.

Figure 1 shows that respondents generally had positive views on practices like conservation agriculture, agroforestry, and nutrient management, with high percentages agreeing or strongly agreeing. On the other hand, precision agriculture and water management received more mixed opinions, with a significant number of neutral responses. Clearly, there is a clear variation in perceptions among different agricultural practices, highlighting the necessity for additional analysis and educational efforts to encourage the uptake of sustainable and efficient agricultural techniques.

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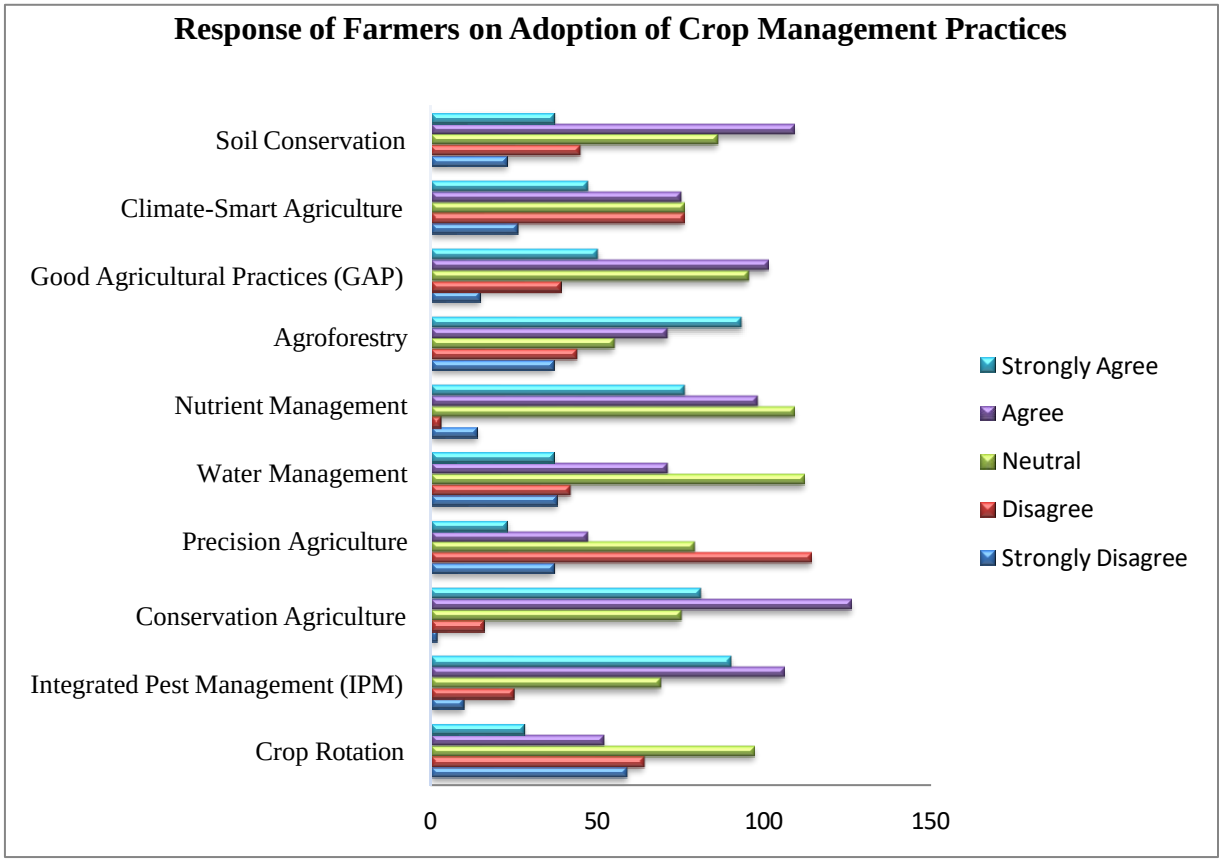

Figure 1. Adoption of Crop Management Practices

Figure 2 presents the impact of crop management practices on income, based on responses from farmers adopting crop management practices. Among the total respondents, 27.3% reported a substantial rise in their earnings, while 26.7% witnessed a moderate increase. The largest portion, accounting for 36%, indicated that their income remained relatively unchanged following the implementation of crop management strategies. Conversely, a small fraction of respondents (1.7%) experienced a moderate decline, and 8.3% reported a notable decrease in their income. The data highlights that a majority of respondents benefited positively in terms of income from the crop management practices they embraced, while a minority encountered a reduction. These insights hold significance for evaluating the efficacy of diverse crop management approaches within the agricultural domain.

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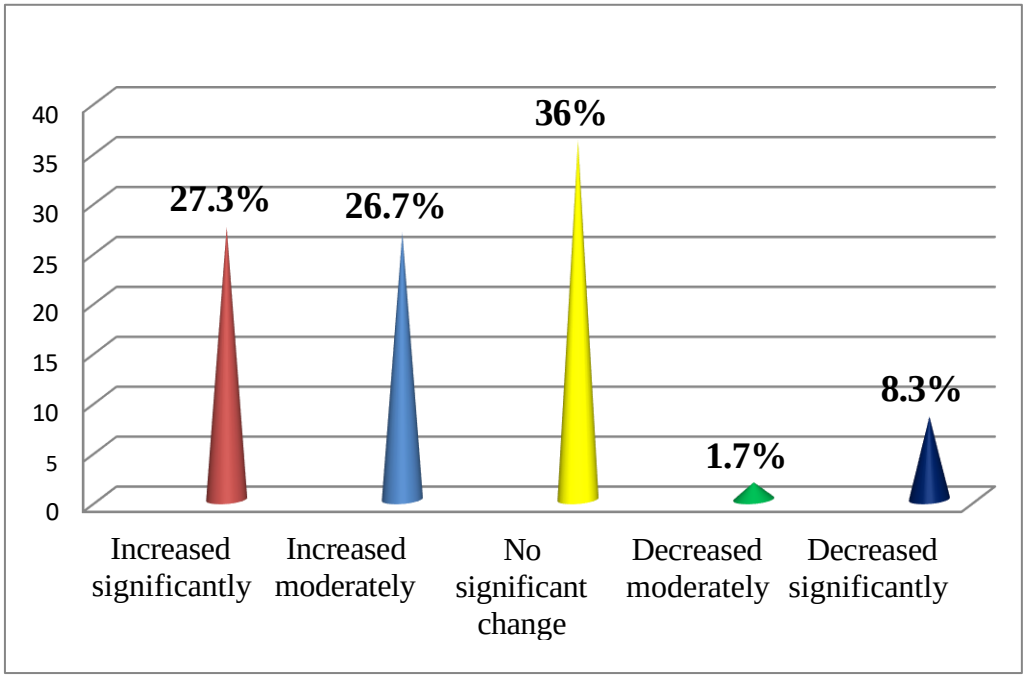

Figure 2. Impact of Crop Management Practices on Income

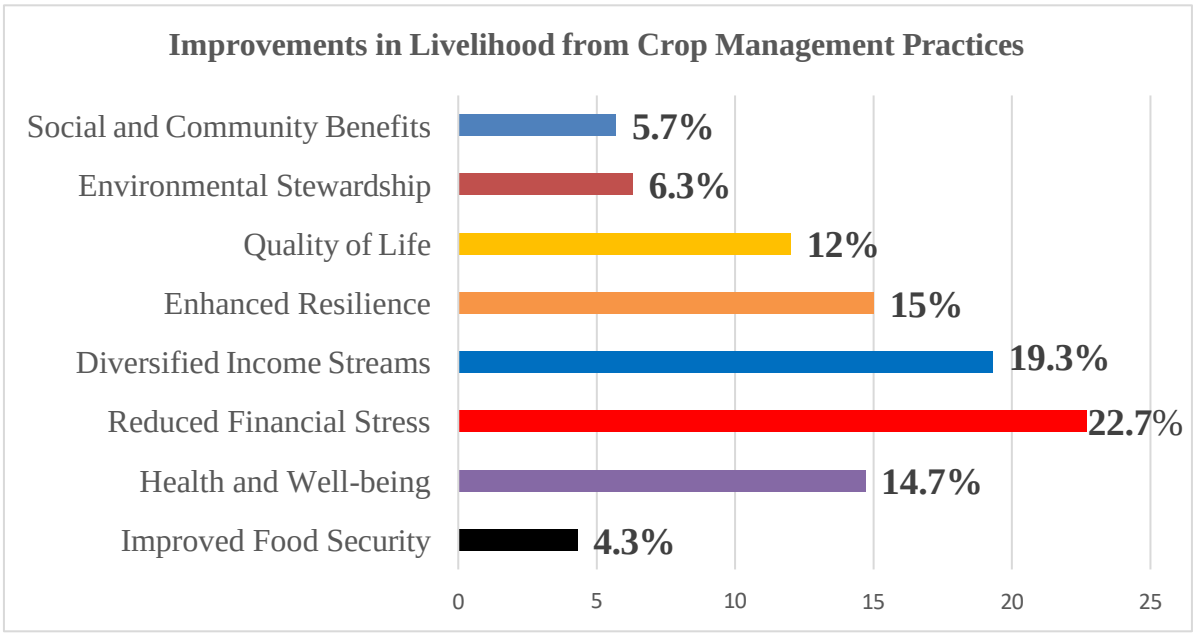

Figure 3. Livelihood Improvements

Figure 3 provides a comprehensive view of the positive changes in livelihood experienced by a farming community. Among these, 4.3% of individuals affirmed an advancement in food security, denoting an improved accessibility to nourishing sustenance. Noteworthy enhancements in health and well-being were identified by 14.7% of participants, indicating upgraded healthcare provisions and the adoption of healthier lifestyles. A considerable 22.7% acknowledged a reduction in financial strain, potentially attributed to amplified income opportunities and more effective financial management. The emergence of diversified income channels was observed by 19.3% of the

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populace, contributing to heightened economic stability through a range of income sources. 15% of respondents experienced enhanced resilience, indicating their ability to cope with challenges effectively. Quality of life improvements were reported by 12%, likely due to better access to education, healthcare, and improved living standards. Environmental stewardship efforts positively impacted 6.3%, while 5.7% experienced social and community benefits, reflecting stronger social cohesion and support systems. The data showcases the successful implementation of diverse initiatives that have contributed to the overall well-being and sustainable development of the population.

Table 3. Additional Sources of Income

Sources of Income	**Frequency**	**Percent**
Livestock and Dairy	64	21.3
Non-Farm Business	44	14.7
Off-Farm Employment	79	26.3
Remittances	9	3.0
Government Support Programs	52	17.3
Rent or Leasing	32	10.7
Investments or Savings	20	6.7
Total	300	100.0

Table 3 reveals a diverse array of income sources for a specific population. Livestock and dairy activities contribute 21.3% of the total income, while off-farm employment represents 26.3%, indicating a significant number of people engaged in non-agricultural work. Non-farm businesses account for 14.7% of the income, reflecting entrepreneurial endeavors in the community. Government support programs play a role in 17.3% of the income, providing crucial financial aid and subsidies. Rent or leasing activities yield 10.7% of the income and investments or savings contribute 6.7%. Remittances from family members working abroad constitute 3.0% of the income. The source of income of the respondents are diverse, reflecting a combination of traditional agriculture-based livelihoods and modern economic activities. Livestock and dairy, off-farm employment and government support programs are the major contributors to the income of the population, providing stability and growth opportunities. Additionally, non-farm businesses, rent/leasing, investments/savings and remittances contribute to the overall economic well-being of the community.

Table 4. Challenges/Barriers in Adopting and Implementing Crop Management Practices

Challenges/Barriers	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation	Z-Score	Rank Order
Climate Variability and Risks	27(9)	19(6.3)	13(4.3)	147(49)	94(31.4)	3.87	1.187	1161	I
Limited Extension Services	17(5.7)	65(21.7)	12(4)	94(31.3)	112(37.3)	3.73	1.313	1119	II
Limited Resources	28(9.3)	78(26)	18(6)	49(16.3)	127(42.3)	3.56	1.476	1068	III

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Access to Markets and Value Chain	30(10)	75(25)	26(8.7)	64(21.3)	105(35)	3.41	1.391	1023	IV
Policy and Institutional Factors	40(13.3)	123(41)	17(5.7)	61(20.3)	59(19.7)	3.16	1.392	948	V
Socio-economic Factors	35(11.7)	98(32.7)	7(2.3)	113(37.7)	47(15.7)	3.13	1.336	939	VI
Infrastructure and Technology Gaps	51(17)	101(33.7)	11(3.6)	49(16.3)	88(29.3)	3.06	1.532	918	VII
Pest and Disease Management	37(12.3)	92(30.7)	7(2.3)	157(52.3)	7(2.3)	3.02	1.192	906	VIII
Resistance to Change	35(11.7)	127(42.3)	22(7.3)	94(31.3)	7(2.3)	2.8	1.209	840	IX
Lack of Knowledge and Information	80(26.7)	103(34.3)	16 (5.3)	82 (27.3)	19(6.3)	2.52	1.310	756	X

The table presents the ranking of various challenges or barriers faced by respondents based on their mean scores on a five-point Likert scale. *Climate Variability and Risks* emerged as the most significant challenge (Mean = 3.87), with a majority of respondents agreeing on its impact, ranking first (I). *Limited Extension Services* (Mean = 3.73) and *Limited Resources* (Mean = 3.56) ranked second (II) and third (III), respectively, highlighting constraints in advisory support and resource availability. *Access to Markets and Value Chain* (Mean = 3.41) ranked fourth (IV), followed by *Policy and Institutional Factors* (Mean = 3.16, Rank V) and *Socio-economic Factors* (Mean = 3.13, Rank VI), indicating structural and economic barriers affecting respondents. *Infrastructure and Technology Gaps* (Mean = 3.06, Rank VII) and *Pest and Disease Management* (Mean = 3.02, Rank VIII) were perceived as relatively moderate concerns. *Resistance to Change* (Mean = 2.80, Rank IX) and *Lack of Knowledge and Information* (Mean = 2.52, Rank X) were the least significant barriers, suggesting that respondents do not consider these factors as major constraints. The standard deviations indicate some variation in responses, particularly for resource and infrastructure-related challenges.

Table 5 Regression analysis of the demographic characteristics and Socio-Economic Factors

Xi	Std. Error	Coefficient (β)	p-value	95% confidence interval	
				Lower	Upper
Age	0.215	0.078	0.006**	0.06	0.37
Education	0.398	0.062	0.000***	0.28	0.51
Landholding Size	0.529	0.089	0.000***	0.35	0.71

R^2 = 0.762 Dependent Variable (Xi) = Predictor Variable ***, ** and * *= Significant at 0.05*

The regression analysis results presented in Table 5 indicate that age, education, and landholding size have statistically significant positive effects on the dependent variable. Age shows a significant but relatively modest influence (β = 0.215, p = 0.006), suggesting that each additional year of age is associated with a 0.215-unit increase in the outcome, holding other factors constant. Education exhibits a stronger effect (β = 0.398, p < 0.001), implying that higher education levels contribute

substantially to the dependent variable. The most impactful factor is landholding size ($\beta = 0.529$, $p < 0.001$), indicating that larger landholdings are associated with greater increases in the outcome. The narrow 95% confidence intervals for all three variables suggest precise estimates, reinforcing the robustness of these findings.

Conclusions and Recommendations

The study concludes that implementing efficient crop management practices in Khyber Pakhtunkhwa can significantly enhance crop productivity, increase income, and improve farmers' financial well-being. Demographic factors such as age, education level, and household income play a crucial role in the adoption of these practices, with younger, more educated, and higher-income farmers being more likely to adopt them.

It is recommended to:

1. Strengthen extension services by expanding coverage and improving training for farmers.
2. Support vulnerable farmers through tailored programs and financial incentives.
3. Promote knowledge-sharing via cooperatives and digital platforms.
4. Enact supportive policies, including subsidies and infrastructure investments.

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