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AN INSIGHT TO INTEGRATED FARMING SYSTEM IMPACTS ON SOIL PHYSIOGRAPHY AND WEED CONTROL IN SOUTH WAZIRISTAN

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Abstract

South Waziristan, a tribal area of Pakistan is home to various horticultural crops serving local communities' livelihoods. In agricultural-based communities around the globe, farmers are actively involved in integrated and conventional farming practices that are likely contributing to the socio-economic paradigms of these farmers. The current research study focused on perceptions of farmers practicing integrated farming approaches and its role in controlling various problems regarding local farming. The snowballing technique was used to collect the data from two villages i.e. Kazha Panga and Raghzai, rural farmer's settlements were retrieved through a structured and semi-structured questionnaire from 300 individuals including the demographic and socio-economic status of respondents. The study investigated the impacts of integrated and conventional farming practices on various dependent and independent variables. A stratified sampling technique followed by face-to-face interviews and focused group discussions was conducted to collect the required data. To analyse the data a statistical software SPSS was used. The binary logistic regression model helped in understanding the behaviour of farmers toward various variables. The empirical evidence depicted that middle-aged farmers in the study site primarily perform the integrated farming system (IFS) (33%). The study infers that the majority of farmers adopting integrated farming systems (IFS) experienced weed decline, soil erosion control, and less salinity ($p<0.000$, $p<0.000$, $p<0.003$) on their farmlands. The study site was least explored regarding various agricultural practices. Therefore, there was a dire need of understanding and comparison of various villages adopting integrated farming systems. The study calls for detailed research work and implications to introduce and reform policies regarding revenue generation and awareness in farming communities. The study also suggests immediate awareness campaigns to advance the farmer's access to the national and international markets.

Key words: *Conventional farming, Integrated farming, Salinity, Soil erosion, Weed*

INTRODUCTION

Integrated farming is a mechanism helping in the maximization of crop products including agricultural crops, forest trees, and livestock from available land resources (1). These products are utilized by locals for various purposes ranging from domestic consumption to marketing (2). Integrated farming approaches provide highly diversified productions as compared to conventional single cropping systems. Thus, the focus on IFS is gaining popularity due to improved economic/financial reimbursements (3). Sustainable IFS aims to balance the social, economic, ecological, and cultural needs of current and future generations including the maintenance of multiple employment opportunities (4, 5). The majority of

researchers stated that IFS helps sustain biodiversity, least damage to crops, and productivity enhancement (6-8). The current major imbalance in supply and demand of food products is stressed due to overpopulation and overexploitation of agriculture resources (9, 10).

The population pressure changes consumption patterns and high usage of agricultural lands for housing societies (11). According to the global perspective climate change is a looming threat to various farming practices (12) however, the cumulative results are strangulating local farmers' interests (11, 13). Various researchers have conducted surveys in response to farmers' perceptions regarding problems in farming i.e. insect pest infestation, weed invasion, soil erosion, least yield, and irrigation. Most of the researchers depicted that IFS is helpful in the mitigation of weeds, diseases, insects, and pests (14, 15). Various problems must aim at reduction to minimize its effect on farmers' economic and ecological interests (14-16). Dey *et al.*, observed during their research that these problems faced by local farmers must be controlled through various scientific techniques, however, the poor farmers can control it through the indigenous knowledge of IFS (17, 18).

IFS management is helpful in rural communities' households on smaller scales. Most of the components include livestock, water, crops, land, and trees envisaging multiple agriculture-based economic outcomes on a piece of land and enhancing financial dividends (19). According to various researchers' perceptions, the system of agriculture is an evolutionary progression experienced by humans, and later-on the strategy changed into IFS defined as the integration of livestock along the trees and agriculture crops (19, 20). Moreover, it is believed that the IFS phenomenon is a new inclination in the developing world (21). Hooks et al. (22) asserted that innovative ideas and strategies of integrated farming not only ensure economic dividends but also contribute to social uplift and protection of ecological resources.

The increasing demand of agricultural products due to rise in population is causing a diversion from conventional agricultural practices to the IFS. Therefore, IFS will need to be ensured as a farm-based initiative for the socio-economic benefits of farmers and sustainable outcomes for their livelihood (23). It is also believed that the farmers receive various information in order maximize their yield and generate high revenue from an organized farming system (24). Food security and human health are interlinked and mainly dependent on agriculture and livestock production. The qualitative and quantitative supply of food for human consumption is significantly dependent on micro-nutrient concentrations. While, the concentration and composition of micronutrient in turn is determined by crop rotation, species mixtures, soils profile and influenced through integrated farming practices (25).

Pakistan based on agro-economy is in the list of world top 10 most populated countries having 220 million people. Agriculture is contributing 40% of the employment opportunities and 19.8% GDP however; demand of agricultural products is increasing gradually (26). Therefore, it is believed that agriculture is the backbone of the national economy and contributes to health, food security, poverty reduction, financial constraints and livelihood of the local communities but, some factors are challenging its vitality. These challenges include socioeconomic constraints and atmospheric anomalies associated with alarming increases in temperature and current Pandemic situations are strangulating the agriculture sector. The emerging scenario of cost escalation and climatic changes enhance the demand for IFS. The system of integration helps in maintaining sustainable management and improving yield and profitability (24). Besides this, it envisages protecting farmers from monetary/financial losses and productively contributing towards biological integrity.

Regular yield extraction from agricultural lands has limited soil resources ability; however, the chemical inputs are hazardous to the environment and human beings. The IFS is a cost-effective framework that ensures land/soil fertility without causing damage to the environment and human existence. Thus, it contributes to the socio-economic uplift of the farming communities. However, the potential is the less explored avenue in the case of Pakistan (23).

The current study was designed to assess the trends/tendencies of IFS in two villages i.e. Kazha Panga and Raghzai villages of District South Waziristan. The purpose of the study was to assess the recent orientations of the local farmers towards IFS and management strategies. The study also helped in finding

perceptions of farming communities for informed decision-making and the economic potential of the IFS. No such cross-sectional studies highlight integrated farming practices comparison in two different villages. The inputs are obligatory for ensuring the resilience of the farming sector in the wake of looming climate-related challenges i.e. soil erosion, salinity, land degradation, and weed invasion.

METHODOLOGY

DESCRIPTION OF THE STUDY AREA

District South Waziristan having complex and diversified climate landscape with mild summers and harsh winters situated on south west corner of Pakistan. The area is situated at E 69°42′ longitude N 32°24′ latitude and with an altitude of 1250–2134 m above the sea level (Fig. 1). The area is composed of irregular topography, erratic weather condition, and two main ranges of the country (Suleiman and Hindu Kush). The mean annual precipitation in hilly areas ranges up to 6 inches per annum however; the plain areas have hot summers in comparison. Ethnographically the area is composed of three major tribes inhabited i.e. Wazir, Mehsud, and Burki. The temperature falls below 0 °C in winter mostly at higher altitudes however; summers are comparatively hot in the plain areas (1, 2).

South Waziristan is suitable for growing variety of agricultural crops and fruity trees however; the increasing population is putting pressure on agricultural products and land degradation. Therefore, a viable solution is needed to mount the pressure on natural resources. The strategy of IFS is pragmatic, environmentally friendly, less time-consuming and high productive with minimal usage of the land. Moreover, it is pertinent to mention the recent anthropogenic disturbance and call for the assessment of problems, potential, and prospects of IFS. Some of the researchers opined that the IFS helps in enhancing land productivity, and weed control and boosts the local farmer's resilience in combating the looming environmental challenges (2).

The current study was done to understand the IFS impacts on the local communities and their lands. Therefore, the majority of respondents were selected from various land holdings to perform a holistic appraisal. The majority of the lands in village Raghzai are rain-fed areas however; the village Kazha Panga lands are mostly dependent upon the tube wells irrigation system.

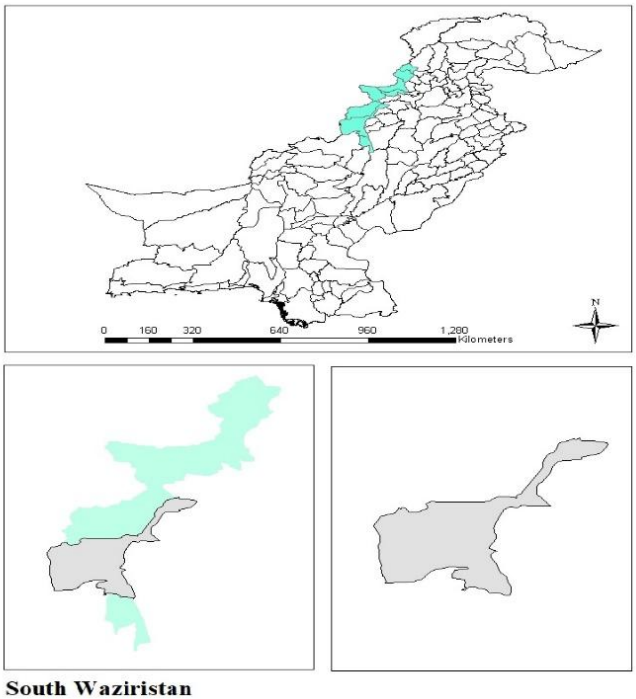

Fig. 1. Map of the study area: District South Waziristan

BACKGROUND INFORMATION AND RESPONDENTS' CHARACTERISTICS

The respondents from both the villages were male because the females were reluctant to give interviews according to the local norms and cultural ethics. The majority of the researchers observed that the

tendencies for integrated farming are mostly common among males as compared to females. However, the findings of the study are against the conclusion drawn by Wiebe et al. (3). They did not observe any disparity in this regard based on gender however; in South Asian countries most of the communities are reluctant to involve females in farming practices (4).

In the population of 150000 individuals it was pertinent to interview a group of 300 farmer involved in various agricultural practices. Some of the farmers were reluctant to the because of the fear of imposing government taxes and land disputes in the area. From both the villages (Kazha Panga & Raghzai) 150 each respondent was selected for the interviews to perform reliable analysis and significance outcomes. Almost all the respondents were male because the female are mostly skeptical to such type of surveys/interviews due to religious and cultural norms. According to the survey majority (100) of locals were in the age class 40-49 however, the least (7) respondents were in the age class 20-29 and above 70 age (8) (Fig. 2). The study concludes that majority of respondents involved in the integrated farming were male and of the middle aged. Similar observations were rendered by Ponnusamy and Devi (5). The people in this age group mostly preferred the IFS as a reliable resource of revenue generation. It productively contributes towards the family income and wellbeing. The observations tabled Pandey *et al.* (6) portray that the income generation and monetary factor stimulate for integrated farming more than any other factor in developing regions. The study also suggests to conduct such type of surveys in least developed tribal areas where the farmers have lack of knowledge regarding IFS in order to enhance their livelihood.

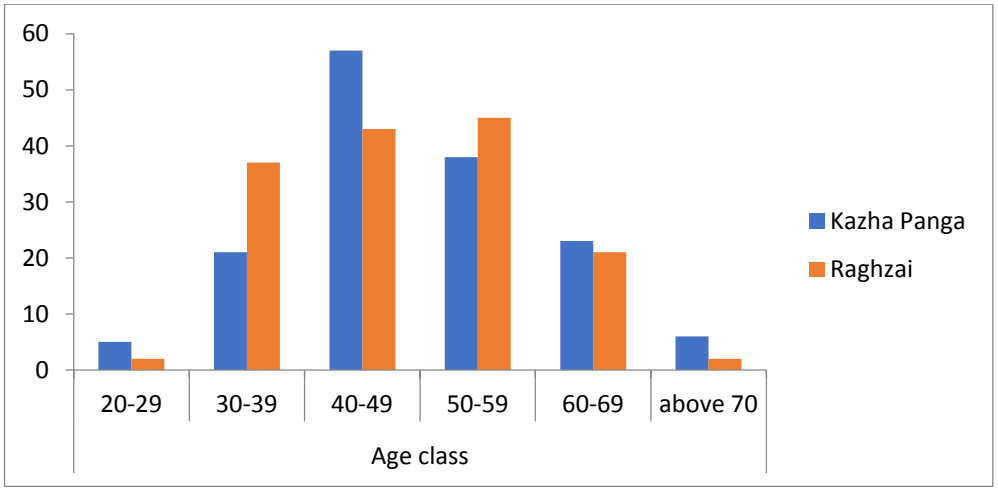

Fig. 2. Respondent's age-class distribution in study area (Kazha Panga and Raghzai)

DATA COLLECTION

A structured and semi-structured questionnaire was generated to collect the data from both villages (Raghzai, KazhaPanga). The questionnaire was compartmentalized in two sections, having socioeconomic and demographic aspects of the population. The second section focuses on various practices, potential, and prospective benefits of the IFS to the local communities. A total of 300 farmers were to record their perceptions regarding IFS. The survey was limited to only two villages due to the law and order situation. These areas are highly sensitive because these study areas are situated on border territories at the Durand line. The selected farmers were interviewed personally with the help of a well-structured questionnaire to collect the appropriate data (7).

STEPS DURING SURVEY DATA COLLECTION

Before data collection, the agriculture department was consulted with selecting the best comparison sites for the data collection. The personnel of the department escorted us to the main farmers of both villages and, later on, acted as guides in the remaining data collection. The snowballing technique was used to identify the farmers who adopted IFS approaches on their lands. This method is considered a bridge between the Government and local farmers. During the data collection, the local communities' socioeconomic and cultural dimensions were observed. Local language Pashtoo was used as communication language in all the interviews so that the locals feel at ease during the interview conduction. Individual

interviews and focus group discussions with local communities worked as a bridge in between the respondents (7, 8).

QUESTIONNAIRE ORGANIZATION AND DATA ANALYSIS

The recorded data was organized, managed, and analyzed according to the established parameters of descriptive and inferential statistics using Microsoft Excel and SPSS 21 software's. The co-relation test, Chi-square test, frequency, Graphs, tables, and pie charts were created during analysis (9). Moreover, the logistic regression model was used to determine the impacts of IFS on various demographic and socio-economic variables. The current research weighs the impacts of independent variables (age, family size, family type, and qualification) on the inclinations of farmers regarding IFS, challenges and outcomes. Descriptive analysis was done to assess the characteristics of farmers in both the villages (Kazha Panga and Raghzai). Besides this various outcomes and challenges were correlated with different variables to interpret the prevailing tendencies for postulating sustainable measures.

RESULTS AND DISCUSSION

The current research was based on an assessment of integrated farming management practices describing demographic information of two villages in South Waziristan. The first village with the high-class communities Kazha Panga and the second village with the middle-class communities Raghzai are dependent upon various agricultural farming practices. The demographic characteristics (Age, family structure, education, and farming experience, income, and farm assets) of both the villages' respondents were gathered to conclude the significant findings from the respondents. The study was designed to understand the perceptions of the farmers and the possible outcomes from the communities adopting IFS. It was observed that South Waziristan's soil can grow all types of agricultural and horticultural crops grown in the country, therefore IFS practice will be highly beneficial and will generate maximum revenue for the locals (10). The majority of South Asian countries focus on IFS agricultural practices to utilize the land for the whole year and generate maximum revenue from various farming practices adopted on their lands (11-13).

FARMERS HOLDING ASSETS

The local community's especially farmer's responses were recorded regarding their household assets (Table I). It was observed that the majority of farmers of the village Kazha Panga were well equipped with household assets including ploughing and harvesting machinery as well as tube wells for water harvesting however, there were the least amount of people with no assets. In comparison to the village KazhaPanga the farmers of village Raghzai were less equipped with farming machinery including a Tractor, Thresher, fodder chopper, and tube well. Moreover, a high number of farmers were with no assets because of getting less revenue and products from their conventional farming system. Similar tendencies were observed by Bahinipati (12) stating that the majority of the farmers nowadays have advance machinery and tools i.e. tractors, trolleys, and grass cutters to ease their work and extract maximum revenue.

Table I. Villagers Household and farm assets (Cross Tabulation)

Village Name	Farm Assets				
	Tractor/Trolley	Thresher	Fodder Chopper	Tube well	No Assets
KazhaPanga	54	19	33	31	13
Raghzai	17	13	74	12	34

IRRIGATION SYSTEM DEPLOYED BY FARMERS

The respondents were enquired about the irrigation system to understand the sources of water harvesting in both the villages. Majority of the farmers from the village KazhaPanga were deploying the irrigated farming system by extracting water through tube wells. The farmers of the village Raghzai were with lack of resources and financial problems, mostly deploying on the rain water harvesting (Table II).

Reddy *et al.*, 2020 demonstrated during his results that farmers mostly rely on tube wells and canals for irrigation in south Asian countries (6).

Table II. Villager's response on water harvesting techniques (Cross Tabulation)

Village Name	Farming type		
	Irrigated	Rain-fed	Both
KazhaPanga	137	1	12
Raghzai	54	87	9

SOCIOECONOMIC DIMENSIONS

Our results showed that most of the farmers were reluctant to show their revenue generation however, the snowballing technique helped to discover the main farmers for the survey conduction (Table III). The majority, (65%) of the farmers from the village Kazhapanga was generating 0.5-1 and 1-1.5 million of revenue from their farming practices. They were mostly deploying on IFS to generate high revenue. Moreover, the village Raghzai farmers were collecting less revenue as compared to the Kazha Panga. Most (82%) of the respondents depicted that they generate less than 0.5 million from their farming practices. It is believed that IFS helps sustain agricultural products, generate high revenue, clean the environment, and enhance food quality (14).

Table III. Villager's annual income from agricultural activities (Cross Tabulation)

Village Name	Annual income from agricultural activities (Million)		
	Less to 0.5	0.5 to 1	1 to 1.5
Kazha Panga	53	54	43
Raghzai	123	17	10

THREATS AND HAZARDS

Table IV describes the respondent's perceptions on the use of pesticides were highly alarming because, farmers of the village KazhaPanga (86%) and Raghzai (94%) were using pesticides for diseases, insects, and pest infestation. According to the surveyors most of the locals depicted that they have also used DDT for the control of various diseases and pests, however DDT is banned by IUCN (International Union for Conservation of Natural Resources) all over the globe due to imminent threats. The use of pesticides has major impacts on the local communities and wildlife health. Moris and Micheal, (14) shared their experience of high usage of pesticides by the local farmers due to lack of awareness and full confidence about biological pests control methods make them dependent on chemical pesticides (5).

Table IV. Village * Use of pesticides to the crops (Cross Tabulation)

Village Name	Do you apply pesticides to your crops?	
	Yes	No
KazhaPanga	129	21
Raghzai	142	8

LOGISTIC REGRESSION MODEL-BASED FINDINGS

The logistic regression model (Table V) was applied to determine the integrated farming pattern of various crops adopted by local communities and their role in weed control and revenue generation (Table I).

The binary logistic regression model is composed of eight variables; the majority variables showed a significant prediction of contribution in the model however, some of the variables showed non-significant contributions in the model. The independent variables included Education, Family members, Experience, Annual Income, Soil fertility, Soil erosion, and salinity. The annual income and annual expenditure showed non-significant predictive contributions against the IFS however, education, experience, soil fertility, soil erosion, and salinity showed significant contributions to the IFS. The model depicted concordant results, adequately distributed, and asymptomatically efficient therefore, the maximum likelihood method was used to evaluate the probability functions (4, 7, 15, 16). The annual income and number of family members showed non-significant contribution showing that locals with the high-income generation and having more

family members were not interested in the IFS. However, the previous studies depicted that the communities with the high income and more family members were mostly preferring the IFS practices on their lands to generate high revenue (17).

Among significant independent variables literacy rate showed negative correlation and statistically significant to the IFS (B = 0.411; Wald =9.010, p<0.032). Farmers perceived that IFS is more beneficial as compared to conventional farming system. Panday 2018 portrays that the farmers with high literacy rate were more concerned about the IFS however, the farmers with less education and experience were more convinced towards conventional farming system (18). It was also observed that the respondents from educated families are more inclined towards integrated farming resultantly generating high revenue.

The model depicted that well qualified farmers were mostly concerned about the IFS because they believed that the system is more beneficial and generate high revenue for the farmers (B = -3.597; Wald =24.352, p<0.027). Various researchers reported similar findings and stated that high qualified farmers were more involved in integrated farming practices in order to generate high revenue from a small piece of farm lands (19). Furthermore, they experienced that well educated personnel were mostly involved in the integrated farming practices.

Table V. Logit estimates of coefficients of effect on various variables

Variables	B	S.E.	Wald	df	Sig.	Exp. (B)
Education	-3.597	0.729	24.352	1	0.001	0.027
Family members	0.009	0.540	0.000	1	0.986	1.009
Experience	-0.807	0.346	5.428	1	0.020	0.446
Annual income	-0.168	0.190	0.780	1	0.377	0.845
Soil fertility	2.479	0.591	17.572	1	0.000	11.929
Weed invasion	-1.966	0.548	12.857	1	0.000	0.140
Soil erosion	-1.428	0.175	66.901	1	0.000	0.240
Salinity	-1.527	0.521	8.593	1	0.003	0.217
Constant	11.5838	3.56642	10.5497	1	0.00116	107348

*B = Beta, S.E = Standard Error, Wald = Wald Chi Square, Df = Degrees of Freedom, Sig = Significant p ≤ 0.005

Our results showed that the farmers experience was statistically significant to the IFS (B = -0.807; Wald =5.428, p<0.020). Majority of the farmers highly affiliated to the farming experience were more interested in the IFS. Majority experienced farmers adopting integrated farming practices were extracting high revenue from their farms (20). It is depicted that most of the educated and well experienced personals were getting high revenue and were mostly involved in the integrated farming. This sharing of experience enhances their revenue generation and enriches experience (21).

The logistic regression model suggested that the farmers deployed on IFS were experiencing high soil fertility and were more prominent to the system (B = 2.479; Wald =17.572, p<0.000). This impact of soil fertility helped farmers in promoting integrated farming however, the farmers with conventional farming systems were complaining about the soil fertility. Our model suggested that during the farming system, the soil becomes poor in fertility mostly prone to various weathers making it less fertile. The soil fertility was positively correlated and statistically significant to the IFS. The model showed that the people mostly prefer IFS perceived high soil fertility in their farms. The farming community in both villages is inclined and has a wide tendency towards local and chemical fertilizers (22) however, most of the farmers were fertilizers because of natural fertility in the soil due to IFS.

The model showed that the weed invasion was negatively correlated and statistically significant (B = -1.966; Wald =12.857, p<0.000). The model showed that the weed invasion was controlled in most of the farms where IFS was applied however the fields with conventional farming were mostly invaded by various weeds. Argade *et al.*, 2021 observed similar results during their research study stating that integrated farming is the best solution to curtail the weed invasion in the farming crops (23). Moreover, he stated that

crop integration helps to mitigate weeds, diseases, and pests. Similar results were depicted by Jesudas *et al.*, 2014 showing that integrated farming helps in controlling weed invasions in any specific area (24).

The impacts of IFS on soil erosion were negatively correlated and statistically significant showing that the farmers adopting IFS were facing fewer soil erosion problems (B = -1.428; Wald =66.901, p<0.000). Various researchers depicted that the IFS is more helpful in the reduction of soil erosion problems (23).

Furthermore, the farmers adopting conventional farming systems were more prone to soil erosion problems. The salinity was negatively correlated and statistically significant to IFS (B = -1.527; Wald =8.593, p<0.003). The model showed that the farmers adopting IFS were facing the least salinity problems however, the farmers with conventional farming systems depicted that they are more prone to the high salinity problems (25, 26).

CONCLUSION

Generally, farmers' perception towards the integrated farming in village Kazha Panga is mostly positive however, the communities of Raghzai have not been fully adopted the integrated system but were more inclined towards the conventional farming system. The integration of various farming approaches can help in socio-economic and environmental aspects to the small scale farmers. These approaches can also help in sustainability, livelihood enhancement, vulnerability reduction, employment opportunities, high energy, and more carbon sequestration. It is concluded that IFS is helpful in reduction of soil erosion, weed control, high revenue, less salinity, and gradual decrease in the rate of diseases, insects and pest infestation. Moreover, the results depicted that the IFS helps in appreciation of multifunctional role and sustainable income for the farmers. The study concluded that the farmers receive less profit because of the control of middle men in the market. Majority of the middlemen buy the products from farmers on low rates and sell it in the market on high prices to the merchants. The high demand of food, fodder and timber products in the market imposed the farmers to adopt the strategy of integrated farming.

Green revolution has declined the concept of integrated farming due to the total dependence of people on conversion of forest land into agriculture crops. Majority farmers preferred using chemical fertilizers to enhance the crop yield which introduced various diseases, insect and pest infestation. Later on, the increasing rates of chemical fertilizers and various diseases imposed the farmer communities to use organic fertilizers that helped them to get high yield for 4-5 years. The current research depicted that most of the farmers with lack of integrated farming were facing high problems of diseases, insects and pest infestation.

Policy implications:

Pakistan is an agricultural products rich country playing vital role in enhancing the livelihood of the local farmers. Lack of job opportunities in the hilly area forces local farmers to generate revenue for enhancing likelihood from the farming practices. Most of the farmers are exploited by the middle men in order to purchase their products on least payments. The agricultural crops are facing drought condition due to recent climatic changes, salinity, drought, weed invasion, and soil erosion. To tackle these problems local farmers were more inclined to IFS in order to extract sustainable outcomes.

The agricultural products and livelihood of the locals is important for the development however; a nexus could be developed between them to get win-win results by introducing awareness campaigns for the introduction of IFS. In order to generate nexus, the Government needs to make special policies to minimize the usage of pesticides and introduction of various integrated farming practices. The lack of proper marketing channel has decreased the revenue generation of farmers due to the middlemen. In order to alleviate the poverty, the Government should help local farmers to help them in providing suitable market chain and valuable process for their products.

Study implications:

Integrated farming practice and agro-forestry is a potential option for increasing the income of the local farmers.

Various constraints faced during IFS could be tackled through risk management, market intelligence, and value chain addition.

Productivity could be enhanced through innovative and quality enhanced inputs including good variety seeds, birds, livestock, and forest trees.

Farmers empowerment and full access to the highly developed machinery and tools would contribute to high revenue realization.

Conflict of interest:

Authors have no conflict of interest.

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