POTENTIAL OF AGROFORESTRY AND CONSTRAINTS FACED BY THE FARMERS IN ITS ADAPTATION IN DISTRICT PESHAWAR, PAKISTAN

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ABSTRACT

Agroforestry provides the exceptional potential to boost biodiversity, stop land degradation, and reduce poverty, especially in developing nations, but the reasons why farmers don't use it are not well understood. A variety of biotic and abiotic variables are contributing to the global decline in the size and health of forest ecosystems. Pakistan needs efficient food systems that enhance outputs, strengthen the economy, improve the environment, and retain societal acceptance. Thus, there is an urgent need to develop agroforestry across the province. This will increase agricultural revenue, reduce land degradation, raise agro-biodiversity, and increase carbon stocks in farming systems. The Peshawar area of Khyber Pakhtunkhwa in Pakistan underwent a survey of farm households to study the factors that affect the potential of agroforestry and the challenges that farmers confront in implementing it. The opportunity to achieve these objectives exists because ofPakistan's traditional agroforestry land management method. The ownership of any timber resource can be established by planting trees on privately owned farms, and well-managed systems have a tremendous deal of potential to both improve agriculture and ease the wood crisis. However, agroforestry practices are being adopted slowly in the province for several reasons. The main causes for Khyber Pakhtunkhwa's slowdown adoption of agroforestry practices are farmers' attitudes and perceptions, tiny landholdings, the land tenure structure, restricted marketing options, and a lack of planting materials. The present review study shows the potential of an agroforestry system to maximize various socioeconomic benefits, including food, fuelwood, fodder, fiber, timber, non-timber forest products, supplementary income, etc. Agroforestry systems' potential to provide farms with environmental services protecting soil erosion, bioenergy,the effects of trees in agricultural landscapes on carbon sequestration, sustainable land management techniques, pest control by natural enemies, and the global habitat for biological variety are all important. According to the study, cultivators in the country should be knowledgeable about the potential benefits of agroforestry systems. They should work to make the system's development economically and environmentally beneficial for farmers worldwide. The agroforestry system has the potential to give a faster rate of tree farm increment in accordance with forest policies for the sustainable livelihood of the farmers, thereby increasing the global tree cover areas relative to total geographic regions.

Keywords: Potential of Agroforestry, Climate change, Plantation, Farmers, Adaptation.

INTRODUCTION

Agroforestry has been widely acknowledged as a triple-win strategy for smallholder farmers due to its ability to reduce environmental damage, increase

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income, and increase climate resilience simultaneously, according to the International Centre for Research on Agroforestry (2017). It has been observed that agroforestry and related disciplines have become more relevant to policymakers in recent years (Buttoud, Place, & Gauthier, 2013). However, there has been little effort to carefully evaluate the long-term effects of integrated agroforestry systems and agroforestry extension programs, despite thissignificant interest and spending (Brown, Miller, Ordonez, & Baylis, 2018). Agroforestry incorporates forms of knowledge with national research studies and small-minded attitudes in order to increase the likelihood that agricultural investments will yield positive economic returns (Dhyani, 2014). In order for an agroforestry system to be sustainable and distinctive, management techniques play a crucial role. Mixed species agriculture has specific agronomic, physiological, and phonological requirements in contrast to mono-crop agriculture (Manna *et al*. 2018).

Traditionally, people have used a wide variety of multipurpose trees on their farms. These trees are maintained according to local and climate conditions by maintaining their density, frequency, and a wide variety. Agroforestry techniques such as these are known as traditional agroforestry (Bijalwan *et al*. 2014). It has been reported that woodlots produce the majority of fuelwood or firewood outside of forests, such as agroforestry farms and traditional irregular regenerations of tree covers along field boundaries (Horst and Hovorka, 2019). Approximately 64% of Pakistan's 208 million inhabitants live in rural areas, and 50% are employed in agriculture (Pakistan Economic Survey 2018). It is estimated that 80–90% of rural residents rely on wood as their main home energy source, most of which is obtained from forest lands or agroforestry systems owned by the public or the government [add reference]. Agroforestry on such lands can provide fuel, feed, and other 2 products to communities and farmers if the lands are not exploited. There is a need for Pakistan to develop and put into practiceefficient land-use strategies for farmers' fields to produce food and fibre commercially, improve the environment, and be socio-economically viable (FAO 2015b; Burgess and Rosati 2018).

Extensive agroforestry is practiced in the province's central plains (Peshawar valley), where irrigation water is abundant, fertile soil, and land holdings are often large. There are mainly two species of trees found in these regions: poplars (*Populus euramericana* and *Populus deltoides*) and shishams (*Dalbergia sissoo*), which are mostly planted along the edges of agricultural fields and near waterways (Khurshid, 2005). Farmers and their interactions with agroforestry should be analyzed from a socioeconomic perspective. As a result, agroforestry in our country would have a better opportunity to grow. It is possible to develop an effective farm forestry planning system by analyzing home and farm characteristics (Irshad *et al*., 2011). The study focused on describing the agroforestry system in the Peshawar valley and determining factors that affect its adoption. The objectives of the current study: i) to determine the perception of local farmers in Peshawar regarding the importance of agroforestry from an economic and environmental perspective. ii) determining constraints to agroforestry adoption by farmers and suggestions for improvement. iii) the current status of agroforestry in the region and the constraints that farmers encounter in implementing it.

Study Area

A district in Khyber Pakhtunkhwa, Peshawar, was selected for the study. This large ancient city serves as the capital of Khyber Pakhtunkhwa province in northern Pakistan's expansive Peshawar Valley. In the province's central plains (Peshawar valley), where irrigation water is plentiful, the soil is good, and landholding is comparatively considerable, agroforestry is done economically (Khurshid, 2005). Poplar (*Populus euramericana* and *Populus deltoides*) and shisham (*Dalbergia sissoo*) are the dominant species in these regions, and they are primarily planted on the edges of agricultural fields and near waterways (Khurshid, 2005). Farmlands with irrigation have a higher tree density than farmlands without irrigation. On irrigated and non-irrigated fields, the average number of trees per ha was seventy-two and twenty-seven. (Amjad, 1991). The most common species in irrigated areas are Poplar (*Eucalyptus camaldulensis*), Shisham *(Dalbergia sissoo*), Bakain (*Melia azedarach*)a nd Mulberry(*Morus alba*), whereas Ber (*Ziziphus mauritiana*), *Ailanthus altissima* are the main species grown on non-irrigated farms (Khurshid, 2005)

METHODOLOGY

The study was conducted in a field area using 2 stages simple random sampling technique. There are a total number of 224 villages in the district of Peshawar FLUP (2017). In the first stage, ten towns, namely Budhni, Budhai, Lala, Nasirpur, Garhi Sardar, Mian Gujar, Damane Hindki, Kukar, Khazana and Haryana Payan, were randomly selected out of the total villages. In the second stage, 10 respondents/ farmers were randomly selected from every 10 villages. Thus the total number of respondents was 100. Ten (10) farmers actively practicing agroforestry from each selected villagewere interviewed.

From all sampling units, 10 villages and 10 farmers were selected randomly. According to the study's objectives, a well-structured questionnaire was developed through the consultative process. An interview schedule was organized for this purpose. The direct interview method was used for data collection. The respondents were interviewed personally at their hujras & farms. Each respondent explained the purpose of the study, and his responses were recorded as per posed questions. The questionnaire was structured in English, yet the questions were precisely translated and asked in the local language

(Pashto) for better understanding and communication with the respondents to obtain reliable and required information with maximum accuracy. Data were collected from 100 respondents through the questionnaire.

Data Analysis

All collected data were computed using SPSS version 20 to produce basic descriptive statistics (mean values and standard deviations). Independent sample t-tests were used to determine the significance of differences in socio demographic characteristics between agroforestry adopters and non-adopters (Norman and Streiner, 2008). Agroforestry perception discrepancies among farmers were compared using chi-square tests. Except where otherwise noted, mean differences were deemed significant at a 95% confidence level. Logistic regression was utilized to identify the variables affecting the adoption of tree planting or border farming. Similar to linear regression methods, logistic regression is more appropriate when the dependent variable is dichotomous (Pampel, 2000). The logistic model was chosen because it is straightforward and simple to read, even if other models are appropriate for this situation. The likelihood (P) of the dependent variable (y) in logistic regression is calculated as a function of the independent variables(xi)as follows;

$$P_i = \frac{e^{b_0 + b_i x_i}}{1 + e^{b_0 + b_i x_i}}$$

where bi is the independent variable xi's corresponding coefficient (Pampel 2000). A variety of socioeconomic factors, such as land features, resource variables, such the total area under cultivation (ha) and the operational area Kanal, were included in the model as independent variables. The dependent variable was the adoption of tree planting or border cropping. These factors were age (years), education (years), monthly off-farm revenue (Pakistani rupees), the number of direct family members (no.), and off-farm income. The independent factors were included because they have theoretical significance and were frequently found in previous adoption studies. For ease of comprehension, estimates for the beta and the value of Exp(b) are provided in the output in the findings section. The probability that the dependent variable will change to 1 when a certain predictor variable grows by one unit is represented by the number Exp(b). The 18 variables did not exhibit serious multicollinearity issues, as indicated by the variance inflation factor of 10, which was 10. (Randolph and Myers, 2013). The Omnibus test of model coefficients was used to assess the model's ability to anticipate the response (dependent) variable with accuracy across all predictors (Osborne 2014). A significant finding supports the finding that the data and model are sufficiently fitted. This test's p-value is non-significant, suggesting that the predicted and actual values are adequately matched.

RESULTS

Overall, farmers were practicing agroforestry in the district of Peshawar. The main species in these regions are poplar (*Populus euramericana and Populus deltoides*) and shisham (*Dalbergia sissoo*), which are primarily planted on the edges of agricultural fields and near canals. It is crucial to do a socioeconomic analysis of farmers and how they interact with agroforestry. This would make it easier to determine the possibilities for the growth of an agroforestry system in the region. Farmers claim that there are a number of reasons why agroforestry practices are not being adopted quickly in the province. The main causes of the slowdown adoption of agroforestry practices in Peshawar include farmers' attitudes and perceptions, limited landholdings, the system of land tenure, restricted marketing prospects, and a lack of planting material Agroforestry will boost carbon stocks in farming systems, preventing land degradation, enhance agro-biodiversity, and diversify farmincome, all of which are essential needs for the province. Several farmers in the area practiced agrosilviculture. In this method, fast-growing exotic tree species like *Populus euramericana, Populus deltoides*, *Ailanthus altisima*, and *Eucalyptus camaldulensis* are grown on the edges of agricultural fields and alongside watercourses in single rows, occasionally double and multiple rows, with spacing ranging from 2x2 m to 5x5 m. The trees are grown in 8–10 year cycles, and the wood and fuel are provided directly to wood industries or businesses or sold to middlemen. In anagrosilvicultural system, various vegetables, wheat, maize, and sugarcane are grown as agricultural crops. Farmers in some regions also use the agrosilvopastoral system, another agroforestry type. It is a complicated aggregation of animals, agricultural crops, multipurpose shrubs, grasses, and trees on farmland. While agricultural crops, such as grains and vegetables, provide food for the farm's household, trees are cultivated for fuelwood, fodder, timber,or soil conservation and are a source of economic income. Animals serve as a source of food for the family, fertilizer for crops, and economic money. This type of agroforestry is extremely intricate, interdependent, and interconnected. In this kind of agroforestry system, trees *like Acacia modesta, Zyzyphus nummularia, Morus nigra*, and *Dalbergia sissoo* were grown.

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Basic socioeconomic background of farmer implementing tree planting

Basic socioeconomic characteristics of the farmers implementing tree planting compared to those who are not are shown in Table 1. Our study found that there was a significant difference in age between adopters and non-adopters of agroforestry systems, wherein adopters had a mean age of 42 compared to non-adopters mean age of 48, respectively (Table 1 & Figure 1). Meanwhile, we also observed significant differences ($p < 0.05$) between adopters and non-adopters in the number of family members in a household. The average number of households for adopters is about 6, whereas the average number of non-adopters household numbers was 9, respectively. In addition, we also observed significant variation among land under cultivation; the average land under cultivation with adopters was 12.24, while 15.08 was with non-adopters. We also observed substantial variation in market distance from the farm. While the rest of the parameters were observed as non-significant (Table 1 & Figure)

Table 1. Mean values of the variables included in the analysis of tree planting andvalues of the independent samples t-test.

Variables	Adopters	Non Adopters	t-test	Sig
Age of the farmers	42	48	-3.749	0.000
No of family members in a household	6.600	9.660	-6.905	0.000
Monthly income	37340	37340	.000	1.000
Land under cultivation	12.24	15.08	.000	0.000
Farm to Market distance	17.70	21.140	3.755	0.000
Trees planted	523.0	523.0	.000	1.000
Economic return	260800	260800	.000	1.000
Fuelwood consumption in winter(mn)	41.80	41.80	.000	1.000
Fuelwood consumption insummer(mn)	28.10	28.10	.000	1.000
Total fuelwood consumption(mn)	69.90	69.90	.000	1.000
Market price of fuelwood per kg	620.0	620.0	.000	1.000

Note: Bold p-values indicate significant effects. Practitioners of agroforestry who have technical knowledge about agroforestry, and non-adopters (those who do not have technical knowledge about agroforestry)

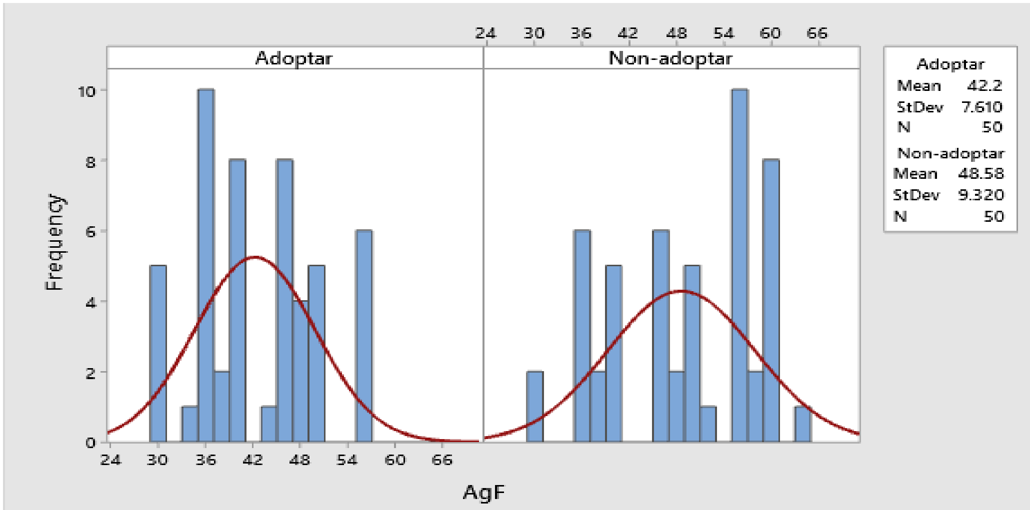

Fig. 1. Summary report for thrAge of farmers among adopters and non-adopters

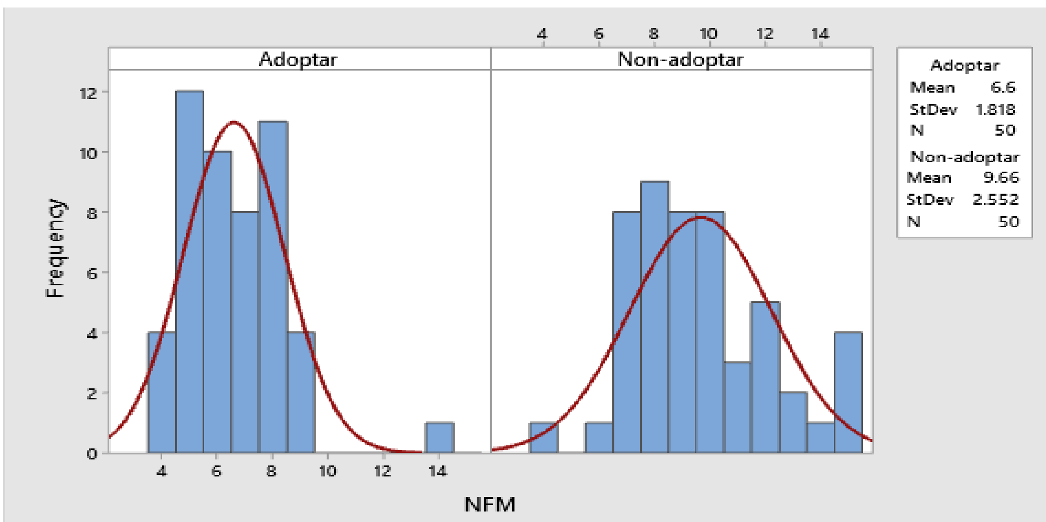

Fig. 2. Summary report of the number of family members in a household among adopters and non-adopters

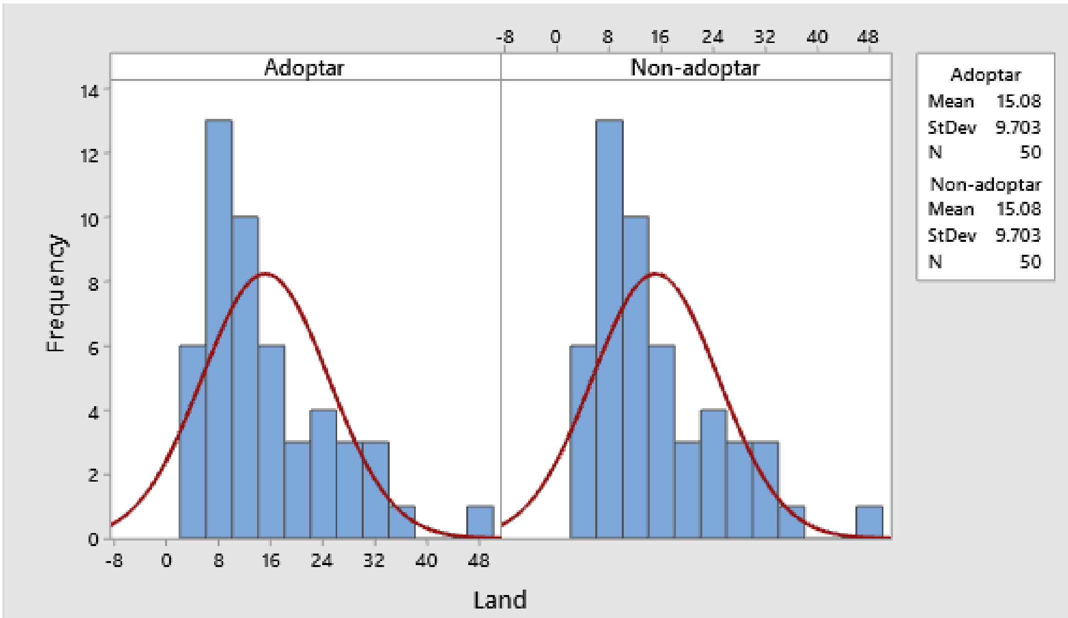

Fig. 3. Summary report for the Land of farmers among adopters and non adopters

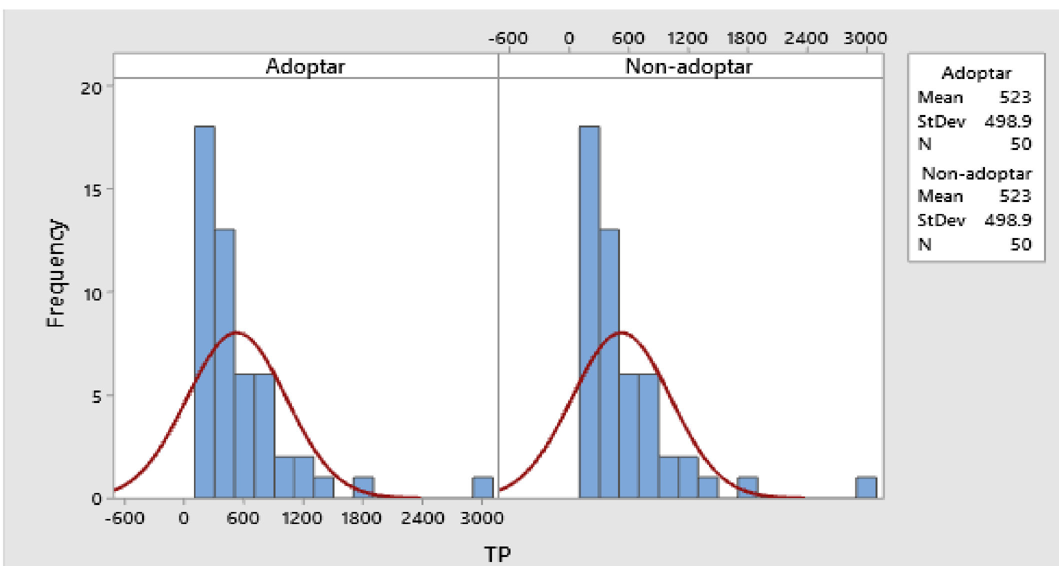

Fig. 4. Summary report for Trees Planted by farmers among adopters and non adopters

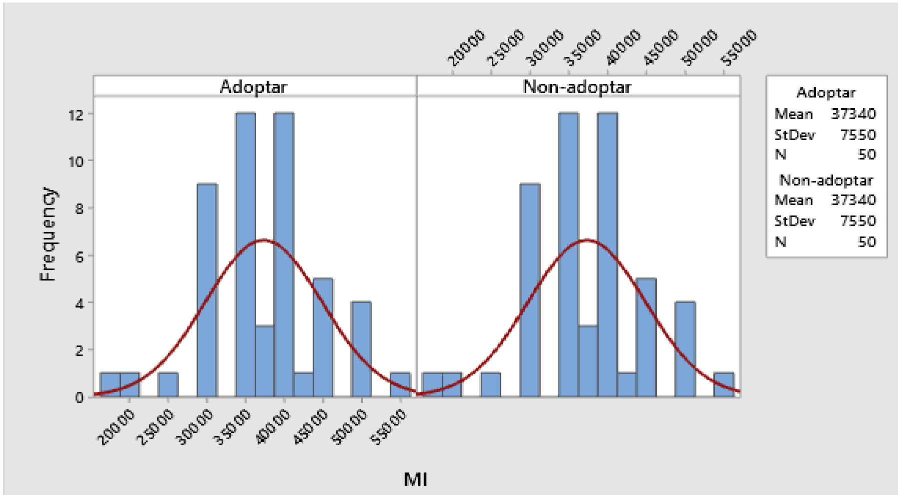

Fig. 5. Summary report for Monthly Income of farmers among adopters and non adopters

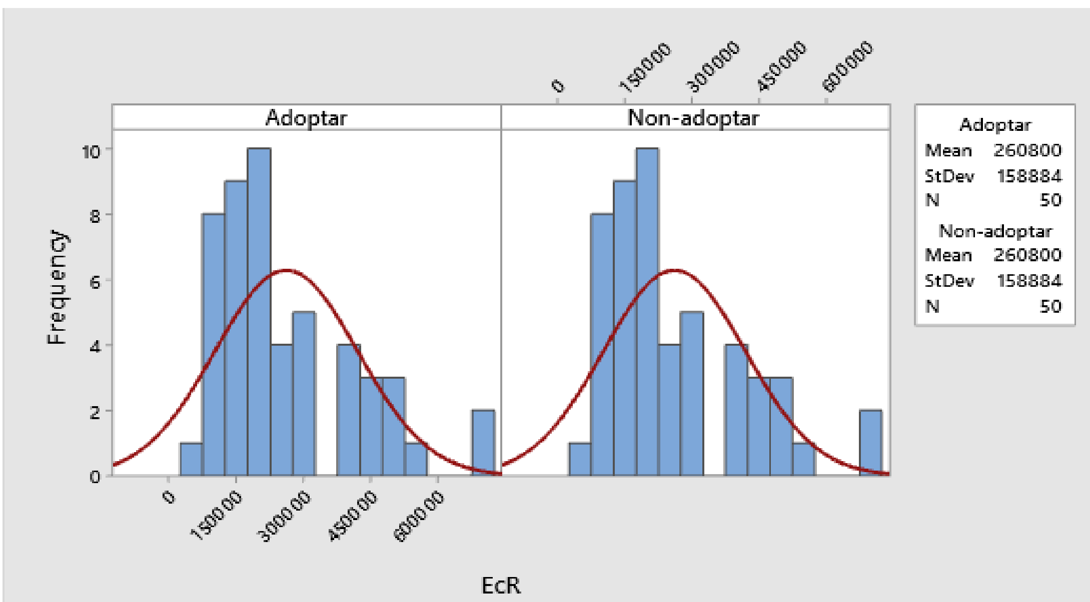

Fig. 6. Summary report for Economic Return(EcR) from Agroforestry among adopters and non adopters

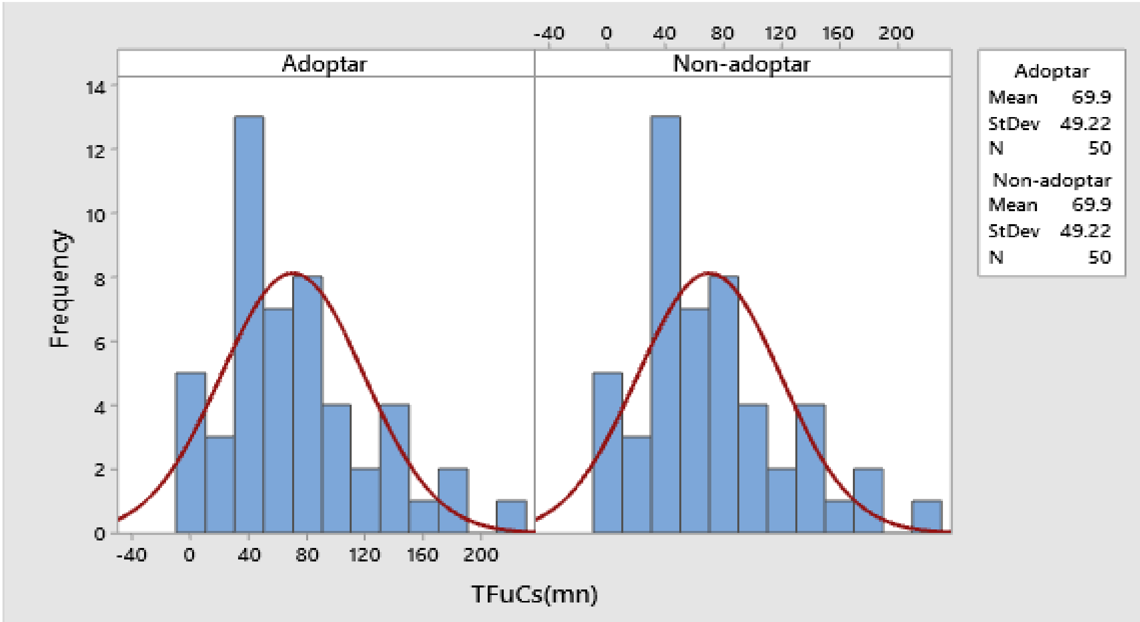

Fig. 7. Summary report for Total fuelwood consumption (TFuCs(mn)) by Agroforestry among adopters and non adopters

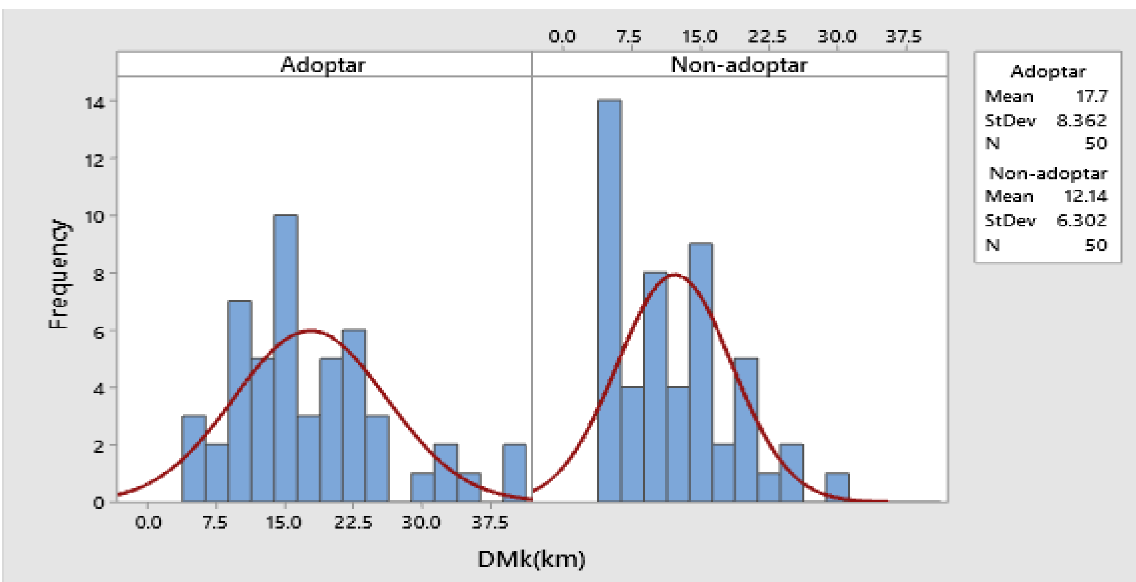

Fig. 8. Summary report for Farm to market distance(DMk (km)) by Agroforestry among adopters and non adopters

Adoption of tree planting by farmers

Regression Equation

$$P(Yes) = \exp(Y')/(1 + \exp(Y'))$$

$$Y' = 3.62 - 0.0858\ AgF - 0.750\ NFM + 0.000104\ MI + 0.0030\ Land + 0.00024\ TP + 0.1273\ DMk(km) + 0.000001\ EcR - 0.067\ FuCsW(mn) - 0.029\ FuCsS(mn) + 0.049\ TFuCs(mn) + 0.00007\ MkPri(kg)$$

AgF=Age of farmers, NFM=No of family members in a household, MI=Monthly income, TP=Trees planted, DMk(km)=Distance from farm to market, FuCsW(mn)=Fuelwood consumption in winter, FuCsS(mn)=Fuelwood consumption in summer, TFuCs(mn)=Total fuelwood consumption, MkPri(kg) = Market price per kilogram.

The results of the logistic regression model for the adoption of tree planting are shown in Table 2. The Omnibus test for model specification showed that the model containing all the predictors was significant (see model fit statistics in Table 2). Regarding personal characteristics, the age of the household head had a negative and significant impact ($p < 0.01$) on the adoption of tree planting with an odds ratio of 0.0400. This value signifies that holding other factors constant, an increase in the age of the household head by 1 year reduces the likelihood of adopting agroforestry by 0.0400.

Table 2. Logistic regression analysis of tree planting adoption

Variables	Beta	SE	Wald	Sig	Exp
Constant	3.62	2.87	23.44	0.015	2.87
Age of the farmers	-0.0858	0.0400	4.60	0.032	0.0400
No. familymembers in a household	-0.750	0.188	15.88	0.000	0.188
Monthly income	0.000104	0.000047	4.79	0.029	0.000047
Land under cultivation	0.0030	0.0545	0.00	0.956	0.0545
Farm to market distance	0.1273	0.0481	7.01	0.008	0.0481
Trees planted	0.00024	0.00138	0.03	0.863	0.00139
Economic return	0.000001	0.000004	7.01	0.719	0.000004
Fuelwood consumption inwinter	-0.067	0.142	0.22	0.639	0.142
Fuelwood consumption in summer	-0.029	0.139	0.04	0.834	0.139
Total fuelwood consumption	0.049	0.139	0.13	0.722	0.139
Market price of fuelwood per kg	0.00007	0.00263	0.00	0.978	0.00263

Significant at $p<0.1$; significant at $p<0.05$; significant at $p<0.01$; SE standard error

Monthly income had a positive and significant impact ($p < 0.05$) on the adoption of tree planting with a ratio of 0.000047. Also, the farm-to-market distance had positive and significant effects ($p < 0.01$) on the adoption of tree planting with a ratio of 0.0481. This value implies that an increase in farm-to-market distance by one km increases the likelihood of adopting agroforestry by 0.0481(Table 2).

DISCUSSION

Most farmers who participated in this study stated that they planned to increase their tree planting in the future and generally had positive opinions of both techniques. Given that adoption rates usually depend more on farmers' perceptions of risks and uncertainty than on real risks and uncertainties, this behaviour could significantly influence the future of agroforestry in the region (Meijer *et al*. 2015). The study's focus groups also revealed that, in addition to considering their financial situation, farmers often consider personal factors when deciding how to use their land (i.e., product pricing and input costs) (Pannel *et al*. 2006). As a result, farmers' perceptions are essential for influencing adoption behavior and explaining decision-making (Greiner *et al*. 2009. Since farmers' perspectives may influence behaviour, a key obstacle to creating effective strategies, particularly for smallholder farmers, has been the lack of high-quality data on farmers' attitudes (Damalas and Hashemi 2010; Hashemi *et al*. 2012). The results, which the study's discussions have supported, may also indicate that most of the region's youth cannot find formal employment, and business opportunities are scarce. As a result, these farmers are more likely to use on-farm tree production to supplement householdincome.

With increasing household head age, the likelihood of adoption of border crops or tree planting decreased. This result indicates that the elder farmers favoured traditional farming over tree planting or border cropping. The literature offers a number of theories for this tendency. The elder farmers are not of a generation that is thought to be very productive in agriculture (Anim 2011). This issue is significant since cultivating trees requires a lot of labor. A younger farmer may be as eager and motivated to pursue opportunities outside of traditional agriculture as a farmer of advanced age (Donkor and Owusu, 2014). The results, which were supported by the study's group discussions, may also indicate that most of the region's youth cannot find formal employment, and business opportunities are scarce. As a result, these farmers are morelikely to use on-farm tree production to supplement household income.

Another explanation for this behavior could be farmers' tendency to take risks (Roe 2015). Risk aversion is a significant barrier to farmers' ability to maximize output, especially in developing nations (De Brauw and Eozenou, 2014). Even though new agricultural technologies and contemporary inputs typically lead to increases in production, small-scale farmers in underdeveloped nations generally adopt new technology slowly (Brick and Visser 2015). Given that the majority of farmers in the poor world work in extremely dangerous conditions and confront several production hazards, such as climatic variability, this is not surprising (Hazell *et al*., 2010). Although numerous characteristics that can be regarded as predisposing factors are part of risk-taking, it is generally acknowledged that risk aversion rises with age (Morin and Suarez 1983). As a result, young people frequently adore taking risks and will do so while investing to generate significant profits.

However, older people tend to be risk averse, which means they worry about the negative effects of wrong decisions or actions without realizing that delaying decisions or taking no action has negative effects. The findings from sub-Saharan Africa demonstrated that while farmers who are food secure may operate as entrepreneurially inclined "opportunity seekers" and engage in agroforestry, those who are "food imperative" and who act as "risk evaders" find it more difficult for agroforestry to take hold (Jerneck and Olsson, 2014). Evidence from the conversations substantially supported this claim. Though the model's effect on the difference in mean age is large, it should be highlighted that, unless life expectancy is short, this discrepancy should be handled with caution from a practical standpoint.

With the household head's education, it is more likely that tree planting or border crops will be adopted. Therefore, the adoption of agroforestry in the area was greatly influenced by education. A major socioeconomic aspect in changing people's life is the amount of formal education. Farmers who receive education are more educated about and at ease using cutting-edge, enhanced, and profitable farming techniques. Additionally, educated farmers interact with extension services more frequently, which makes them more receptive to using novel techniques. A high level of knowledge also contributes to a better comprehension of the new technology while examining the various extension materials. The adoption of tree plantation was positively and significantly impacted by the distance from farm to market. Thus, the possibility of agroforestry technology adoption will increase withthe distance between the farm and the market. Although the conclusion initially appears counterintuitive, comparable findings have been documented in the literature. For instance, Zerihun *et al*. (2014) observed that the distance from the nearest market favorsthe adoption of agroforestry technology in South Africa. This finding in the current study indicates that marginal, distant areas are more likely than locations near markets and towns to pursue agroforestry.

In Pakistan's Khyber Pakhtunkhwa Province, the agroforestry systems being adopted as alternate land-use options are the subject of this study. However, these studies have intrinsic limitations that should be taken into consideration. Because individual surveys often cannot give conclusive proof of cause and effect, the results are mostly descriptive and do not provide specific knowledge regarding cause-and-effect linkages. Second, in research of this kind, it's critical to carefully craft the survey questions because even little wording modifications can significantly impact how respondents react. Short questions with a binary response structure were used to enable simple and quick processing by the respondents. So, even though detailed data may not have been gathered, the overall patterns of farmers' perspectives in the region were accurately portrayed.

CONCLUSION

The agroforestry system in the Peshawar region of Khyber Pakhtunkhwa province, Pakistan, is described in this paper along with the factors influencing its acceptance. The adoption of agroforestry in the Peshawar region was demonstrated to be influenced by age and the distance from the farm to the market. Generally, low-income farmers who are completely dependent on basic agriculture and who cannot afford the significant startup costs of building an agroforestry system or who cannot wait a longer period for crop outputs are less likely to adopt agroforestry than farmers who can wait three to four years for the crop to be harvested. Case studies on the adoption of agroforestry in developing nations offer helpful information for figuring out what encourages and inhibits adoption. Such studies provide an opportunity to supplement more conventional methods of evaluating treatments by illuminating why some interventions are unsuccessful or appear beneficial in some situations but not in others. The current study indicates possible areas for intervention to control farmer behaviour and establishes a baseline for comparisons of agroforestry adoption rates in the area or other regions with comparable farmers' profiles in light of the paucity of research on this topic in Pakistan. By identifying adoption hurdles, this research has offered a preliminary assessment of the uptake of agroforestry systems in the Peshawar region. It has also highlighted the need for agroforestry adoption to be sensitive to the socioeconomic conditions and the technology's characteristics, which are frequently neglected. Future studies could concentrate on various agroforestry systems to examine their profitability to determine the best crop and tree combinations for the study location and the impact of risk and uncertainty on adoption rates. The effectiveness of agroforestry projects in the area will be greatly influenced by the physical and intellectual participation of the local inhabitants at all levels of the community. Local farmers must take the initiative in determining the demands that can coexist peacefully with their socioeconomic circumstances, ownership of land, and sustainable lifestyle, resulting in prosperity over the long term.

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