THE POTENTIAL BENEFITS OF AGROFORESTRY SYSTEMS IN ARID ENVIRONMENT OF DISTRICT BHAKKAR, PAKISTAN

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ABSTRACT

Agroforestry has a long and illustrious history that dates back to antiquity and is still widely practiced today. The agroforestry system demonstrates how several environment pairs can be used simultaneously by combining native and introduced species. In this study, we evaluate the potential of agroforestry in the district of Bhakkar to maximize a variety of socioeconomic benefits. According to the findings of the study farmers were generally supportive of intercropping and border cropping. Most farmers regarded agroforestry systems as most beneficial due to their ability to protect surrounding crops from dust storms. Age, education level, and distance from the farm to the market were significant factors in determining agroforestry adoption. In contrast, farmers who are older, less educated, and whose properties are located closer to markets were less likely to plant trees in between and on the border of the fields. Cultivators should be aware of the potential benefits that might be derived from agroforestry systems and should strive toward making the growth of these systems economically and environmentally. Further, in order to ensure sustainable economic development and prosperity for all, it is necessary to encourage active community-based management practices. The establishment of model agroforestry farms at the village level can be a productive extension technique; nevertheless, in order for extension programming to be effective, it is necessary for partners to share both an appreciation of the problem and a vision of viable solutions. The corrective actions be taken in order to streamline the existing systems and develop methods and approaches that are sustainable over the long run-in order to improve agroforestry in Pakistan.

Keywords: Agroforestry, Sustainable, Intercropping, socioeconomics, sustainable economics.

INTRODUCTION

The demand for food and the use of wood as a source of energy places a significant stress on natural forests (Bamwesigye *et al*., 2020). Because of the need to preserve them for future generations, these woods have been set aside as forest reserves, which means that access to them by the general public is severely restricted. Techniques of agroforestry were also advocated in order to increase agricultural productivity and provide domestic markets with wood and non-wood products (Soe & Yeo-Chang, 2019). However, activities focused on reforestation and conservation helped mitigate the negative consequences of deforestation. As part of agroforestry systems, supplementary sources of timber

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like fuelwood trees have been planted on agricultural areas (Elagib & Al-Saidi, 2020). In low-income nations, the agricultural sector is crucial for rural livelihoods and development (Nyoni *et al*., 2019). Despite the fact that land pressure and climate change harm agricultural systems in emerging nations, they both endanger the production of food (Aukema *et al*., 2017). Despite the relative effectiveness of intensive farming practices that are encouraged in many parts of the world, land degradation reduces productivity and results in a food shortfall (Kogo *et al*., 2021).

In view of the current scenario, developing countries' agriculture and forestry sectors must create an effective production system (Ikram *et al*., 2021). Multipurpose trees can be raised by utilizing agroforestry techniques, which involve combining perennial trees on farmlands with crops (Kumar *et al*., 2019). Producing more wood and food will result from this. Multipurpose Trees are believed to play protective and productive roles in order to preserve the essential characteristics of farmlands and the production of their products (Muimba-Kankolongo, 2018). Farmers can access a range of food goods and services from these organizations. Using a mix of Multipurpose Trees and agricultural crops grown from known genotypes appropriate for diverse agro-ecological zones, it is possible to significantly boost food, fuel, fodder, wood, and crop output (Iiyama *et al*., 2018). Natural resources must be maintained to enable sustainable development and to be able to meet the requirements of future generations. Both in-situ and ex-situ conservation techniques have benefits (Purnomo *et al*., 2020). In actuality, a thorough genetic conservation programme will need a mix of in-situ and ex-situ methods. To protect genetic resources, a national policy must be created with the participation of all relevant parties (Nambiar, 2019).

Agroforestry has recently seen increased interest from development communities and research as a cost-effective way to improve food safety while contributing to mitigation and adaptation of climate change. This is in light of ongoing food shortages that have been predicted by climate change, as well as rising prices for agricultural contributions that are dependent on fossil fuels (Shahzad *et al*., 2021). The concept of planting trees on agricultural fields is as old as agriculture itself. Farm forestry is based on the principle of linear or compact tree growth alongside crop fields on privately owned farmlands. This is routinely done in both locations that receive rainwater and irrigation (Barudanovi *et al*. 2002).Due to its geographic location in an arid and dry region of the world, Pakistan lacks significant forest resources of commercial value. Only 5% of Pakistan's area is thought to be covered with trees (Khan *et al*., 2017). Farming expansion presents a distinct set of difficulties for farmers in the arid region of Pakistan, where agriculture is primarily dependent on irrigation and rainfall (Khan *et al*., 2017). Due to soil fertility, low production, uncertain rainfall, and drought, agriculture is fraught with dangers. Most of Pakistan's desert region depends on

monsoon rains for agricultural production, but the results are inconsistent and meagre (Khan *et al*., 2017). Many Bhakkar farmers have recently been motivated to give agroforestry a try after seeing it thrive in the dune area. Farmlands are home to plant species like Frash, Kikar, and Eucalyptus, which are used to make plywood, sports equipment, furniture, and matches (Usman *et al*., 2022).

The only actual option and action that seems doable in light of these presumptions and conditions is planting trees on private acreage (Usman *et al*., 2022). To generate the necessary amount of wood to satisfy gracious demand, it is necessary to actively include the local population in this process. In the wake of accommodating and fruitful policies, a pragmatic approach to resolving present and future difficulties can be grasped and put into reality (Khan *et al*., 2017). This is done to stimulate interest in and knowledge of the advantages of growing trees alongside agricultural crops for both personal and business reasons among the local population (Fischer *et al*., 2017).Farmers' surveys can be helpful in this regard for setting a research agenda, testing hypotheses, creating extension strategies, and assessing the success of efforts. There hasn't been much agroforestry research done in Pakistan. In this study, we aimed to describe the indigenous agroforestry system in the Bhakkar region of Pakistan, which is arid, and to pinpoint factors affecting its acceptability. The study aims to highlight the potential of agroforestry by quantifying the wood consumption of fuel and construction timber. Farmer perceptions about farm forestry/agroforestry were also be assessed through a social survey.

MATERIALS AND METHODS

Study Area Description

This study focuses on the Bhakkar district of Pakistan's Punjab province (Figure 1). Between the Indus and Jhelum rivers, Bhakkar lies at the foothills of the Salt Range of the Potohar Plateau. The Thal region has an arid climate, rain-fed sand dunes, and marginal quality resources. However, a riverine tract along the Indus known as Kaccha makes up a portion of the district (Rahim and Hasnain, 2010). It receives less than 300mm of rain a year, resulting in water scarcity. The wind is a common climatic component that causes soil erosion. The Thal desert is a harsh environment that limits biodiversity (Khan *et al*., 2017).

Sampling Approach

The study was conducted in field area using 2 stage simple random sampling technique. In the first stage, ten villages were randomly selected from villages. In the second stage 10 respondents / farmers were randomly selected from each 10 villages. Thus the total number of respondents were 100. From each of the selected village ten (10) farmers who were actively practicing

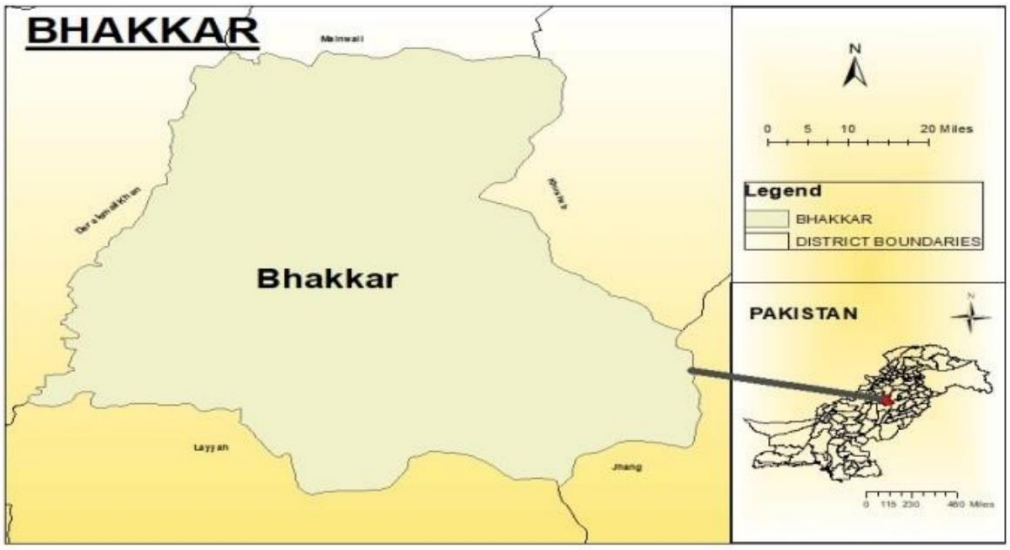

Fig.1: Map of Bhakkar District in Punjab Province of Pakistan

agroforestry were interviewed. Ten farmers were randomly chosen from among the ten communities that made up the sampling units. A well-structured questionnaire was created through the collaborative process in accordance with the study's goals. A timetable of interviews was set up specifically for this. The direct interview method was employed to gather the data. The interviewees were personally questioned at their farms and "bethaks." Each responder received an explanation of the study's goal, and his responses were recorded in accordance with the questions put forward. Although the questionnaire was written in English, the questions were carefully translated into the respondents' native language of Punjabi and asked in order to better understand and communicate with the respondents and to gather accurate and reliable information. Through a questionnaire, information from 50 respondents was gathered.

Data Analysis

We produced some basic descriptive statistics, such as mean values and standard deviations, for all of the data we collected using SPSS version 20. To ascertain whether or not there was a statistically significant difference in the means of sociodemographic characteristics between agroforestry adopters and non-adopters, T-tests on separate samples were used (Norman and Streiner 2008). Chi-square tests were used to examine the variations in views that farmers held about agroforestry. Unless otherwise stated, a 95% level of confidence was used to determine whether or not there was a significant difference in mean values. In order to identify the variables influencing the implementation of border farming or tree planting, logistic regression was used. When the dependent variable in question is dichotomous, logical regression

techniques which are similar to linear regression techniques should be used instead. Even though there are other models that are better suited for the current situation, the logistic model was chosen because it is straightforward and simple to comprehend. In logistic regression, the coefficient bi that corresponds to the independent variable xi is used to calculate the likelihood (P) of the dependent variable (y) as a function of the independent variables (xi). The dependent variable in the model was the adoption of border cropping or planting trees. The model included a number of socioeconomic variables as independent variables, such as land characteristics and resource variables, such as the total area under cultivation (ha) and the operational area Kanal. These factors included the person's age (in years), education level (in years), monthly non-farm income (in Pakistani rupees), the number of immediate family members (in numbers), and non-farm income. Because of their theoretical importance and how frequently they were found in earlier adoption studies, the independent factors were taken into account. To make the information more understandable, estimates of the beta and the value of Exp(b) are provided in the output under the heading "Findings".

The probability that the dependent variable will change to 1 when a specific predictor variable rises by one unit is denoted by the symbol Exp. This likelihood is represented by a percentage. According to the variance inflation factor of 10, which was 10, the variables did not demonstrate any major multi-co linearity difficulties. (Randolph and Myers 2013, citation needed) The Omnibus test of model coefficients was utilized for the purpose of determining whether or not all of the predictors in the model were capable of reliably forecasting the response (dependent) variable (Osborne 2014). A large finding lends credence to the conclusion that the data and model are well-fitted to one another. The conformity of the projections and the viability of the agroforestry systems as viable choices for alternative land uses in Bhakkar. The fact that the p value of this test is not significant indicates that there is a sufficient match between the values that were predicted and those that were actually found.

RESULTS

As a response to the rapid loss of tree cover and forest area, the practise of agroforestry and farm forestry has emerged as a distinct field of study in developing nations. In general, it directs people's attention toward obtaining and satisfying their wants for fuel wood, fodder, and timber, in addition to maintaining the integrity of the environment by planting appropriate trees on farms. Because of its topography, climate, and plenty of irrigated land, the Bhakkar district in the Pakistan state of Punjab is one of the regions that possesses a high potential and promising prospects for agricultural forestry and agroforestry. On their agricultural holdings, farmers were engaging in the practise of agroforestry. The fact that Frash and Kikar, in addition to other native woods, are supplied from this location to wood-based enterprises in other regions of the country is one way to

measure the richness of the area. Still, not enough research has been done on the topic because the people living in rural areas of the Bhakkar district get the majority of their needs met by the trees that are cultivated on farmlands. There has been no appropriate research done thus far to evaluate and handle important issues such as fuel wood, lumber, and feed. These problems have been going unaddressed for far too long. A favourable perception of the farmers in this context acts as a step forward, which will assist to ascertain coordination between the farmers, forestry extension services, and wood-based enterprises for the purpose of achieving the necessary development. The current investigation sought to estimate the amount of wood that is used for fuel and in the construction of buildings. A sociological survey will be used to examine and assess the perspectives of farmers on farm forestry and agroforestry. The findings of this evaluation will be addressed in the results.

Farmers of Adopters and Non-Adopters: Socioeconomic Data

Basic socio-economic characteristics of the farmers implementing tree planting compared to those who are not are shown in Table 1. All farmers were male.

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

Variables	Adopters	Non-Adopters	t-test	Sig
Respondent age	45.64	50.8	-2.66	**0.009**
Land holding ownership irrigated(acres)	9.26	9.88	-0.44	0.664
Land holding ownership Barani (acres)	2.90	4.42	-2.20	**0.03**
Land holding ownership uncultivated(acres)	2.28	2.34	-0.13	0.899
Land holding lease irrigated (acres)	11.92	11.92	0.00	1.00
Land holding tenant irrigated	4.64	4.64	0.00	1.00
Land holding tenant Barani	2.82	2.82	0.00	1.00
Annual wood consumption of timber (pkr)	77.1	72.6	1.36	0.176
Annual wood consumption of fodder in kg	9921	9921	0.00	1.00
Tress planted	2007.1	2007.1	0.00	1.00
Average annual production of timber (last 5 years) net income in pkr	8398	8212	0.48	0.633

p-values in the bold Show significant effects. Adopters (who adopted agroforestry and having technical knowledge about agroforestry, while non-adopters (those who practiced agroforestry but do not have technical knowledge about agroforestry.

In our results we observed significant variation ($p<0.05$) among the adopters and non- adopter's age wherein the adopter's of agroforestry systems

had a mean age of 45.64 years in contrast the mean age of non-adopters 50.8 respectively (Table 1 & Fig.2). On the other hand, we also observed significant variation ($p<0.05$) among the adopters and non- adopters in barani areas. Interestingly the adopters are having an average land 2.90 acres to that of non-adopters whose average was recorded as 4.42 acres respectively (Table 1& Fig.2). While we didn't observe any significant variation among the farmers of irrigated lands, landing holding tenant of irrigated and barani areas, in the consumption of timber, fodder, in terms of tree planted as well as annual production of timber for the last 5 years (Table 1, Figures 2 & 3).

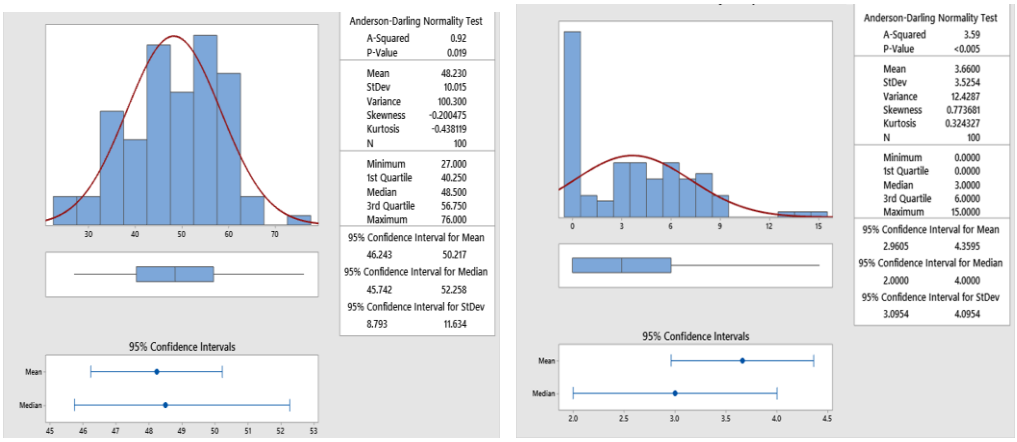

Figure.2. Summary report for Age of farmers and land holding size (acres) in Barani areas among adopters and non- adopters

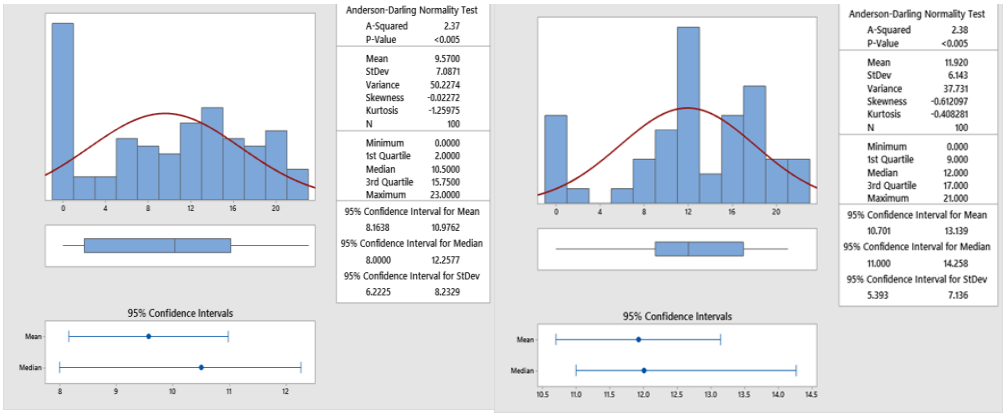

Fig. 3. Summary report for land holding irrigated land and irrigated land given on lease

Regression Equation

The regression equation is given below

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

= -87 - 0.0682 R_Age + 0.0027 LHA_OI - 0.1915 LHA_OB + 0.176 LHA_OU - 0.0108 LHA_LI + 0.0293 LHA_TI - 0.193 LHA_TB - 0.0113 AWC_Timber_Qt(CFT) + 0.000191 AWC_Timber_cost(PKR) - 0.000112 AWC_Fodder_Qt(Kg) - 0.00060 AWC_FW_Qt(Kg) - 0.153 TP_No. + 0.046 TP_Year + 0.0100 AAP(5y)_FW_DU(Qt_Kg) + 0.0242 AAP(5y)_FW_SM(Qt_Kg) - 1.36 AAP(5y)_Tim_DU(Qt_CFT) - 1.36 AAP(5y)_Tim_SM(Qt_CFT) + 0.0101 AAP(5y)_Tim_NI(PKR)

Table 4.2. Logistic regression analysis of tree planting adoption

Variables	Beta	SE	Wald	Sig	Exp
Constant	-87	291	13.33		0.771
Respondent age	-0.0682	0.0256	7.11	**0.009****	0.008
Land holding ownership irrigated(acres)	0.0027	0.0391	0.00	0.664	0.946
Land holding ownership barani (acres)	-0.1915	0.0873	4.81	**0.03***	0.028
Land holding ownership uncultivated(acres)	0.176	0.144	1.50	0.899	0.221
Land holding lease irrigated (acres)	-0.0108	0.0496	0.05	1.00	0.827
Land holding tenant irrigated	0.0293	0.0957	0.09	1.00	0.759
Land holding tenant barani	-0.193	0.196	0.97	1.00	0.324
Annual wood consumption of timber (pkr)	0.000191	0.000234	0.66	0.176	0.415
Annual wood consumption of fodder in kg	-0.000112	0.000214	0.27	1.00	0.600
Annual wood consumption of fuel wood in kg	-0.00060	0.00166	0.13	1.00	0.720
Tress planted	-0.153	0.130	1.38	1.00	0.240
Average annual production of timber (last 5 years) net income in pkr	0.0101	0.0333	0.09	0.633	0.761

* Significant at p<0.1; ** significant at p<0.05; SE standard error

Table 2 displays the findings of the logistic regression model for the adoption of tree planting. The results of the Omnibus test for model definition indicated that the model with all the predictors was significant (see model fit

statistics in Table 2). Regarding the personality qualities, the household head's age was shown to have a negative and significant impact (p value 0.01) on the adoption of tree planting by the ratio of 0.0256. According to this statistic, the likelihood of adopting agroforestry drops by 0.0256 for each year that the household head's age increases, assuming all other factors are maintained constant. The adoption of tree planting was positively and significantly impacted by land holding acre ownership barani with a ratio of 0.028 (p value 0.05). (Table 2).

DISCUSSION

Farmers who have received education are more likely to be aware of and comfortable with farming techniques that are creative, enhanced, and profitable. In addition, farmers who have received education are more likely to have frequent interactions with extension services, making them more receptive to the implementation of agroforestry systems. In addition, having a high education enables one to have a better knowledge of the newest technological advancements when reading through the many extended materials. Education was found to be a significant determining factor in the adoption of agroforestry-based land management approaches, according to Dhakal *et al*. (2015)'s findings. Gibreel (2013) came to a similar conclusion and found that farmers in western Sudan who had completed higher levels of schooling were more likely to implement the traditional gum Arabic agroforestry system. It was also shown that education was a crucial factor in determining the adoption of agroforestry systems in certain regions of Brazil (Do Pompeu *et al*., 2012). According to the findings of this study carried out in District Bhakkar, the level of education held by the head of the household was correlated with an increase in the chance of adopting tree planting. As a result, education was one of the primary factors that led to the implementation of agroforestry in the region. The amount of formally obtained education is a socio-economic aspect that is significant in the process of improving the lives of persons.

When it comes to adopting agroforestry practices, age is a significant factor. The older farmers are past the point in their careers where they are deemed to be extremely productive (Anim, 2011). The cultivation of trees is a labor-intensive endeavor, which is one of the reasons why this topic is so significant. Younger farmers may have more energy than their older counterparts, and they may be more interested in expanding their businesses beyond the realm of traditional agriculture in order to increase their overall income (Donkor and Owusu, 2014). The findings of this study, which were confirmed through group discussions, may also imply that the majority of young people in the area are unable to obtain formal employment, and that business activities are also limited. As a result, these farmers are more likely to supplement their household income through on-farm tree production, which was

confirmed through the findings of this study. It's also likely that this behaviour has something to do with the risk-taking nature of farmers, which is another plausible reason (Roe 2015). (According to the findings of this study, the average age of the household decision-maker was associated with a decreased likelihood of tree planting or adoption. This data indicates that elderly farmers were less likely to undertake tree planting or border cropping in the sand dunes. Instead, they favoured conventional farming methods such as ploughing, planting, and harvesting crops.

The findings of this study shed light on the factors that influence the adoption of agroforestry systems in the Bhakkar region of Pakistan. However, it is important to remember that research of this nature inevitably have certain restrictions that come with them. First, individual surveys cannot, in most cases, give solid evidence of cause and effect; as a consequence, the findings are primarily descriptive in character and do not provide definitive information regarding cause-and-effect linkages. Second, when conducting research of this nature, it is crucial to carefully draught the survey questions, as even minute differences in the phrasing of the questions can have a major impact on the responses people provide. It is for this reason that basic questions with a binary response format have been chosen, as this will enable the responders to assimilate the information more quickly and easily. Therefore, despite the possibility that this particular piece of detailed information was not gathered, the broad patterns of the perceptions held by farmers in the area were accurately reflected.

CONCLUSION

Agroforestry is a system or modern scientifically improved technique for cultivators to improve security of socioeconomic conditions and environment cleanliness by the fixed size of the land cultivated all components in the same field. This can be accomplished by cultivating all of the components in the same field. This objective can be reached by cultivating all of the components in the same field at the same time. It has been demonstrated beyond a reasonable doubt that both traditional and modern scientific agroforestry practices fundamentally have a number of beneficial assets for the purpose of gaining the profit of increased biodiversity, which aids in the reformation of the environment and increases the economic return of output for growers all over the world. The practice of cultivating agricultural crops, woody perennials (often referred to as tree crops or forest trees), and animals all on the same parcel of land at the same time under the same management is an example of agroforestry, which is one of the components and techniques of agroforestry. The current review study gave fundamental information regarding the various potentials and wood production of agroforestry systems in the District Bhakkar to generate sustainable production of income as well as environmental benefits.

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