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Livelihood Improvement through Agroforestry Compared to Conventional Farming System: Evidence from Northern Irrigated Plain, Pakistan

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Abstract: The concept of sustainable livelihood garnered a prominent status in humanitarian and international development organizations that aim to calculate and build a livelihood for agroforestry farmers. However, it is difficult to measure and analyze as well as visualize the data of livelihood improvement from agroforestry (AF). This paper comparatively assessed 400 smallholder farmers' livelihood through AF and conventional farming (CF) systems in the Northern Irrigated Plain of Pakistan. The findings showed that AF has a mixed impact on farmers' livelihood capital, including human, physical, natural, financial and social capital. Specifically, AF significantly improved financial capital in terms of timber, non-timber and fuel wood income. Furthermore, the physical capital (buffalo plough, generators and sprinklers), natural capital (the extent of cultivated land and land ownership; the number of households (HHs) growing vegetables, fruit crops and medicinal crops) and social capital (the number of social groups that HHs involved and number of HHs sharing crop seeds) of AF farmer HHs were significantly improved compared to those of CF farmers. However, the results show that financial capital gain through crop income, HHs owning high-value vehicles (tractors) and farmers trust and collective activities were significantly higher in CF farmers than AF ones. Therefore, to enhance the contribution of AF to rural livelihood, advanced extension services and government involvement on research planning and implementing are needed.

Keywords: agroforestry; conventional farming; livelihood improvement; Northern Irrigated Plain; Pakistan

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1. Introduction

Agriculture is considered the backbone and the single largest sector of Pakistan's economy in terms of labor participation [1,2]. According to Pakistan Economic Survey, around 63.6% of Pakistani people in rural areas and 42% of the country's workforce are employed in the agriculture sector directly or indirectly. The agriculture sector contributes 19.3% of Pakistan's GDP [3]. However, in recent decades, this sector has been affected by numerous challenges such as the increasing population and increasing demand for agriculture products [4]. Likewise, the country's fertile land resources are finite, and it needs to adopt sustainable land use options/alternatives on agricultural lands to increase productivity. For this purpose, different types of agriculture policies and practices were introduce at the governmental and non-governmental levels [5]. This scenario requires the optimum use of agricultural lands by adopting various agricultural practices to improve rural livelihood [6]. Empirical evidence confirms that agroforestry adoption in a region provides support to the farming system by generating an assured income for the local people [7–9].

Agroforestry (AF) is similar to organic agricultural practice, in which woody perennials are deliberately integrated with crops or livestock on the same piece of land management in a spatial or temporal manner [10]. On the other hand, conventional farming (CF) is more similar to the inorganic farming of crops, which relies on pesticides, herbicides or fertilizers to combat pests, weeds and soil infertility with the objective to maximize yield [11]. Contrary to conventional systems, agroforestry systems could maintain greater agrobiodiversity, provide a more varied form of livelihood, increase income and land security, decrease dependency on rainfall and have more diverse water sources [12]. It has been proposed that agroforestry is a more sustainable agricultural system compared to conventional agriculture and forestry that maintains biodiversity and provides ecosystem services without compromising productivity, especially regarding provisioning services [13]. AF is usually practiced with the aim to implement a sustainable land management system that can be developed to increase farm productivity and rural people's welfare by alleviating poverty [14]. According to the Food and Agriculture Organization, about 1.2 billion people in rural areas around the world depend on agroforestry [15]. AF plays a significant role in increasing agricultural yield, raising farm income, improving soil fertility and reducing soil erosion as compared to CF systems [16,17]. Trees generate more employment, and AF is believed to be more profitable than conventional farming is [18]. There is increasing evidence that AF has, in many cases, been more successful in forest conservation and rural community welfare, whereas the impact of CF has not always had positive outcomes. To date, AF activities have resulted in both positive and negative impacts [19]. Several issues such as institutional corruption and exclusion have the possibility to create a negative impact from AF.

Compared to other developing countries in the region (e.g., Nepal and India), relatively fewer studies have been conducted on AF in Pakistan. Those studies mainly focused on the cash income derived from AF. Moreover, the research results were ambiguous. Some studies have reported that the economic benefits provided by AF helped to enhance the living standard of the rural population in Pakistan [20], whereas other research indicates that poorer farmers who are totally dependent on subsistence agriculture cannot afford the high initial cost of agroforestry establishment, nor can they wait for crop output for extended periods [21].

Recently, Farooq et al. [8] conducted research in Central Punjab, Pakistan, using several socioeconomic variables. Their study particularly focused on AF farmers and revealed that less poor farmers have more income from AF than poor farmers do due to extra investment. Additionally, they revealed that income generation helped poor farmers to maintain the minimal living standards. However, no studies have reported the impact of AF on overall livelihood. Therefore, the effectiveness of AF programs in improving livelihood cannot be guaranteed [22].

Globally, AF systems are distributed in tropical and subtropical as well as temperate regions [23,24]. While tropical and subtropical regions have attracted the attention of a large number of researchers, analysis of the impact of AF on developing nations such as Pakistan is comparatively limited [25]. According to the Punjab Agriculture Department office [26], about 82% of farms in the study area are classified as smallholders, with a landholding of less than 1 ha [27] and having a lower yield of wheat and rice due to inappropriate farming techniques. Therefore, they grows trees on the farmland to support their livelihood [8]. However, many farmers prefer to stick with modern CF systems. Even though they practice both AF and CF, these systems has been less intensively studied and no comparisons have been made among them. Thus, even after several decades of implementing the approach, it is still debated whether the AF approach improves rural livelihood in developing nations. Therefore, there is a need for more empirical studies to understand the impact of AF.

Moreover, within the country, only a few studies have shown the potential of applying a livelihood framework approach for both AF and CF systems. Therefore, this research provides insights on whether the AF system better improves farmers' livelihood compared to the CF system, or if CF is the more suitable practice to improve farmer well-being. This comparison will help to understand the pros and cons of both systems. For this purpose, this study was conducted in the Northern Irrigated Plain of Pakistan to examine the influence of AF and CF on farmers' livelihood in terms of five types of capital, namely financial, physical, natural, social and human. This study aimed to answer two key questions: (1) What is the socioeconomic condition of existing AF and CF farmers? (2) What is the role of agroforestry in livelihood capital compared to conventional agricultural systems?

2. Theoretical Background

Assessment of an approach such as AF will not only yield feedback on the productiveness or effectiveness of the approach, but will also help in finding out whether the approach is suitable for the target population and whether there are any ongoing concerns that need to be resolved as the approach continues. For instance, the sustainable livelihood framework helps to organize the factors that constrain or enhance livelihood opportunities and shows how they relate to one another [28]. It can be used both in planning new development activities and assessing the contribution to livelihood sustainability made by existing activities [29].

The sustainability of existing activities can be measured by comparing one approach with another. The semi-experimental, control–impact (CI) design is a well-known approach that collects data at the control and impact locations only and is a similarly common method used to examine the effects of existing programs such as AF [30]. Therefore, this study applied CI design to analyze the role of AF compared to the conventional agricultural systems (CF). The diagrammatic view of the study is shown in Figure 1. The impact of a farming system on livelihood can be evaluated using several indicators. Indicators are defined in many different ways. The Organisation for Economic Co-operation and Development stated that an indicator is a quantitative or qualitative factor or variable that provides a simple and reliable means with which to measure achievement, to reflect the changes connected to an intervention or to help assess the performance of a development actor [31]. Since the contribution of AF can be assessed from various viewpoints, one can assert provided indicators of impact assessment and present their own opinion. Social scientists assess the effect of AF using user satisfaction and impacts on livelihood outcomes [32]. Considering the livelihood outcomes, the livelihood capital or assets are the main indicators used in assessing outcomes. The amount and types of capital that influence the livelihood outcome that can be found in the society vary among studies. This study used five types of capital identified by Carney [33]. These capital types are natural, human, social, physical and financial. Natural capital comprises the natural resource stocks from which livelihoods are derived. Human capital represents the knowledge, skills and quality and quantity of labor available to pursue different livelihood strategies, whereas social capital includes, for instance, the social activities and networks upon which people depend to pursue their livelihood objectives. Physical capital refers to the basic infrastructure and producer goods needed to support livelihoods, and financial capital indicates the financial resources that people use to support their livelihood. Several studies conducted in Nepal by Regmi et al. [34], in Malawi by Beedy et al. [35], in Bangladesh by Rahman et al. [36], in Brazil by Tubenchlak et al. [14] and in Ethiopia by Beyene et al. [37] investigated the impact of AF on livelihood around the globe. Moreover, some researchers highlighted the impact of the sustainable livelihood framework, and they especially emphasized the five types of livelihood capital [38,39]. Hence, this study also evaluated the contribution of AF using the different capital types, namely natural, physical, human, social and financial. As shown in Figure 1, the rural people in the study area can be categorized as CF farmer HH or AF farmer HH. Their farming activity (AF or CF) influences their level of livelihood capital. The impact on livelihood capital can be positive or negative. It can be measured by evaluating the outcomes of the types of capital—for instance, whether livelihood capital improved as a result of a specific farming system or not. Finally, appropriate management strategies and policy implications were applied on the outcomes to achieve sustainable livelihood.

As reported by Thulstrup [40], sustainable livelihoods are a key component of rural development, and vice versa. The sustainable livelihoods approach emphasizes that livelihoods should be considered in terms of people's access to capital assets, the ways in which people combine these capital assets to create livelihoods and how people are able to enlarge their assets [33]. In addition, the internal and external conditions, such as actors and institutions, are also important to consider during AF activities [41]. To understand how people's livelihoods are affected by AF compared to CF, and to formulate relevant policies that might help farmers to cope with any risk associated with them, it is helpful to quantitatively evaluate the relationships between different farming systems (AF an CF) and livelihood capitals [38].

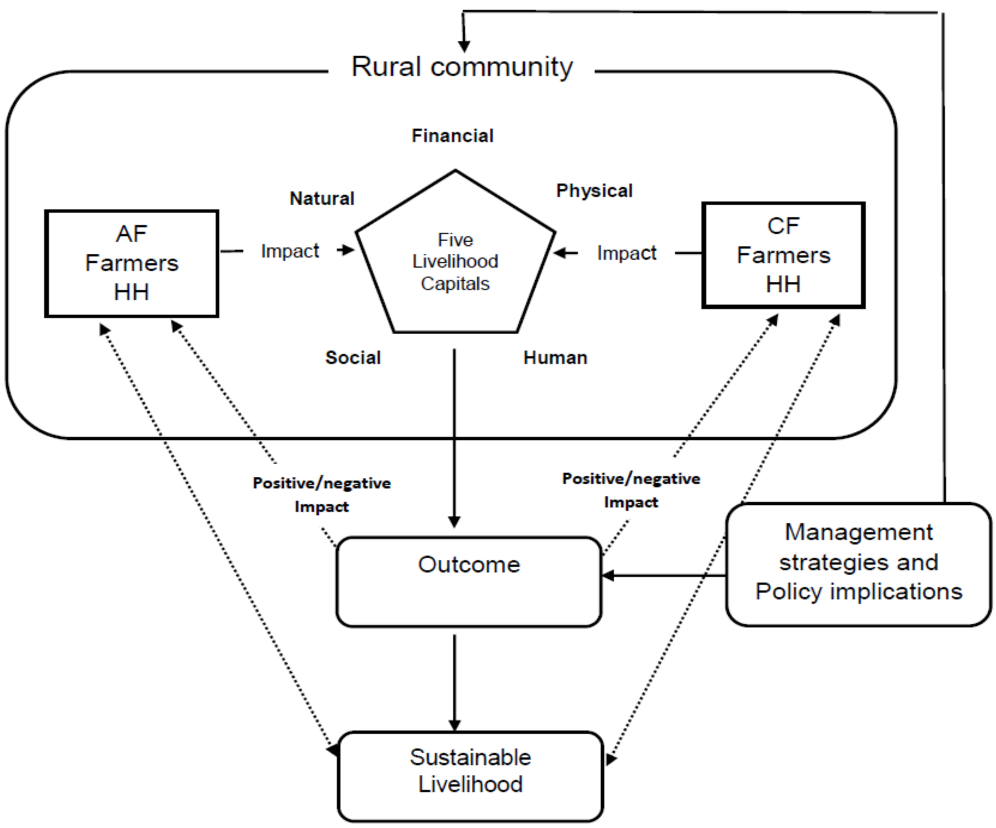

Figure 1. Conceptual framework of sustainable livelihood improvement through AF compared to CF.

3. Materials and Methods

3.1. Study Area

Pakistan is divided into ten agroecological zones according to physical geography, rivers, water availability, soil type, agricultural land utilization and climate [42]. Data were collected from one of the agroecological zones of Pakistan, namely the Northern Irrigated Plain (Zone IV-A). In this zone, two districts, named Gujranwala and Hafizabad, were purposefully selected (Figure 2). These two districts fall in the second biggest province of Pakistan, named Punjab, with an area of 205.344 km^2. The importance of selecting these districts is because they lie between the Sutlej and Jhelum Rivers, which contribute to the world's largest canal system and the majority of the agricultural land is canal-irrigated.

The climate in the Northern Irrigated Plain (Zone IV-A) can be split by two areas. The northeastern climate's average daily maximum temperature in summer reaches 39.5 °C, and the average maximum monthly temperature reaches 45 °C. The minimum average daily temperature is 6.2 °C in winter, and the minimum average monthly temperature drops to 2 °C. The average annual rainfall in the northern part is between 300 and 500 mm. The soil structure of land is sandy loam to clay loam. From an agricultural point of view, this region serves as the food supplier and fruit basket of the whole country [43], and most of its people directly or indirectly rely on agriculture as their main source of income [44]. Wheat and rice farming, mixed crops farming, shifting cultivations (lentil and millet), vegetables and sugarcane cultivation are the main agricultural activities in the study area [45]. Agroforestry plays a significant role in this area by supporting fuelwood demand and providing fodder for livestock farming. The main tree species grown in AF lands include eucalyptus (*Eucalyptus camaldulensis*), jujube (*Zizyphus* nummularia), athel (*Tamarix aphylla*), Jandi (*Prosopis cineraria*), gum arabic tree (*Acacia nilotica*) and Phulai (*Acacia modesta*) as well as shrubs such as banwali (*Acacia jacquemontii*), Sihar (*Rhazya stricta*) and shrubby seablite (*Sueda fruticose*). These are used for construction material, fuel and animal fodder in villages. Grass species such as Ravenna grass (*Saccharum*), lemongrass (*Panicum cymbopogan*), Sewan grass (*Lasiurus*) and Indian goosegrass (*Eleusine*) were dominant in most of the AF lands [7].

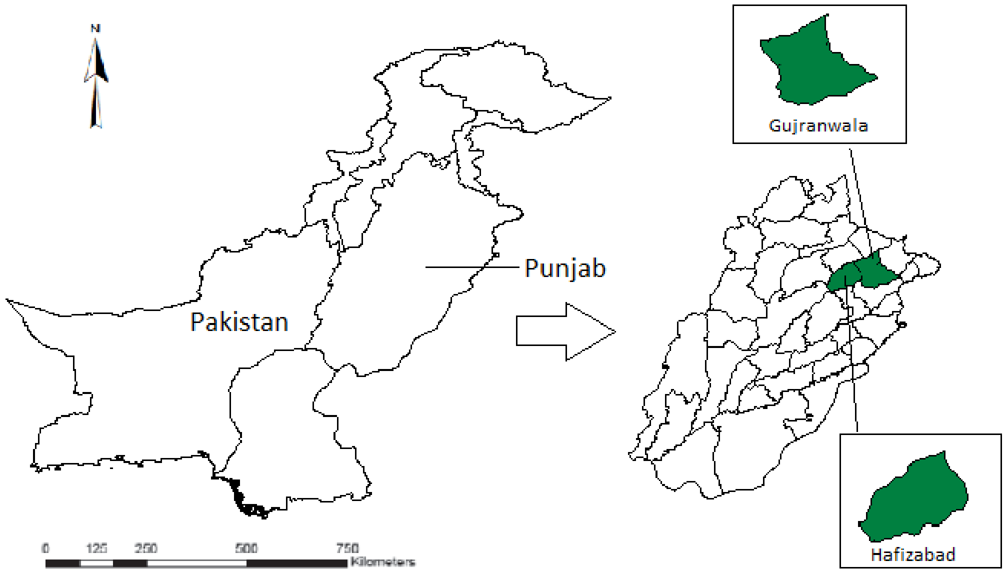

Figure 2. Location of selected study site of Gujranwala District and Hafizabad District in Pakistan.

3.2. Data Collection and Regression Variables

The Gujranwala and Hafizabad districts have 7 tehsils: Gujranwala city, Gujranwala Saddar, Wazirabad, Kamonki, Naushehra Virkan, Hafizabad city and Pindi Bhattian. Among the seven, four tehsils (Kamonki, Naushehra Virkan, Wazirabad and Pindi Bhattian) were selected randomly for the study. During data collection, 40 villages were further randomly selected out of the 4 tehsils across the two districts. Lists of the households in the 40 villages were collected from the tehsil office. Preliminary information on AF and CF farmers in the study area was collected from the village headmen (*lumberdar*) and the district Punjab Agriculture Department office. Then, the households who are involved in agroforestry as their main income generation activity and those who are involved in conventional agriculture as their main income source were separated from the list. Then, an equal number of households (5) was selected from each category (5 agroforestry farmers and 5 conventional agriculture farmers). In total, 400 households were selected to participate in the survey.

A semi-structured questionnaire was used to collect data related to the five types of capital, namely physical (transport, irrigation and infrastructure), natural (water, soil, agriculture and agroforestry and livestock), financial (livestock, financial capital base, agriculture and agroforestry), human (knowledge and skill, health and labor) and social (network and social groups).

According to Ostrom [46], the research issue should be the primary driver of variable selection. Since the research purpose was to assess the contribution of AF and CF to people's livelihood assets, we used a stakeholder-based problem definition in our variable collection. As a result, a system was created to analyze the contribution of AF and CF to socioeconomic units through the use of several indicators, i.e., the livelihood capitals (financial, physical, natural, human and social) of individuals. Natural capital comprises the natural resource stocks from which livelihoods are derived. Human capital represents the knowledge, skills and quality and quantity of labor available to pursue different livelihood strategies, while social capital indicates the social activities and networks upon which people depend to pursue their livelihood objectives. Physical capital refers to the basic infrastructure and producer goods needed to support livelihoods. Financial capital indicates the financial resources that people use to support their livelihood [33]. Following Hanif [47], Tiwari [48] and Quandt et al. [49], a system of indicators and variables was constructed to capture livelihood capital in five forms. Those variables are listed in Table 1.

The questionnaire was pre-tested before the final interviews. An interview was conducted with the head of the household. After the interview with the farmers, informal interviews with key informants and group discussions were also carried out. The group discussions were conducted in each of the sub-districts, with 8–10 farmers in each group. Some secondary information was obtained from the Punjab Agricultural Department website, statistical yearbooks and other sources [26].

3.3. Data Analysis and Research Hypothesis

Simple descriptive statistics were used to summarize the livelihood capitals. Five capital assets were compared between households with and without agroforestry. One-way ANOVA [50] was conducted to determine if the averages for certain livelihood assets were significantly different between the agroforestry and conventional farmers. Descriptions of the variables used in the livelihood capitals analysis are given in Table 1. A key hypothesis of study is that AF provides better conditions to support sustainable livelihoods for smallholder farmers compared to CF.

Table 1. Detailed description of the five capitals used in the livelihood analysis.

Livelihood Assets		Variables	Variable Description
Physical capital	Infrastructure	House size	Square meters
	Roads	Roads' condition	Earthen road, gravel road, carpet road
	Irrigation facilities	Number of HHs having easy access to irrigation water	Yes or no
	Household equipment	Ownership of farming equipment	Ownership of buffalo plough, generator, pipes/hoses, hand water pump, sprinklers (yes or no)
	Communication	Communication devices	Ownership of radio, TV, computer (yes or no)
	Transportation	Household vehicles	Ownership of bicycle, motor cycle, tractor, car (yes or no)
Financial capital	Savings	Access to a bank account	Yes or no
		Bank accounts held by household	Number
	Off farm	Off-farm income	Pakistan rupees (PKR)
	Livestock	Livestock income	Pakistan rupees (PKR)
	Farm	Conventional agriculture income	Pakistan rupees (PKR)
		Agroforestry income (timber, fuelwood, NTFP)	Pakistan rupees (PKR)
	Subsidies	Household subsidies received from government	Yes or no
Natural capital	Farmland	Extent of cultivated land (ha)	Hectares

Table 1. *Cont.*

Livelihood Assets		Variables	Variable Description
		Own farmland	Yes or no
	Types of livestock	Ownership (poultry, cattle, buffalo, goat)	Yes or no
	Diversity of farm crops	Number of different crops planted	Number
	Soil erosion	Severity of soil erosion on farmland	Low or high
Human capital	Household size or labor availability	Male and female members	Number
	Education	Level of education of household head	Illiterate, primary, secondary, advanced, university
	General health of family	Scale of poor to good	Poor or good
	Health problems' impact on ability to practice livelihoods	Scale of none to very much	None, medium and very much
Social capital	Group activities	Participation in groups	Number of groups
		Participation in agriculture or tree-planting group	Yes or no
		Strength of relationship with neighbors	Number of activities done with neighbors

4. Results

4.1. Financial Capital

The financial capital data show that 87.5% of AF farmer households possess a bank account (Table 2). On the other hand, 87% of conventional farmers hold a bank account. Moreover, 22% of AF farmers receive subsidies from the government directly or indirectly, whereas this amount for conventional farmers is lower, as only 15% of them receive subsidies from the government. However, the results show that the crop income generated by AF farmers is lower than that of conventional farmers. The average crop income annually obtained from the farmland of AF farmers is around 41.7% of the total income, whereas the conventional farmers' average crop income is around 60.6% of the total income. Contrarily, timber income, fuelwood income and non-timber fruit income are only generated by AF farmers; as the conventional farmers do not have trees on their agricultural land, their income from these different income sources is zero. The average annual income of AF farmers from timber, fuelwood and non-timber fruit contributes to 24.2%, 1.7% and 0.5% of the total income, respectively. The financial capital study shows that AF farmers' average livestock income is 21.6% of the total income, while conventional farmers earn 26.6% of their total income from livestock. In addition, off-farm income contributes to 10.3% of AF farmers' total income and to 12.7% of conventional farmers' total income. The above results show that there are statistically significant effects for four variables, namely, crop income, timber income, fuelwood income and non-timber income, in the two farming systems (AF and CF). Our results further indicate that timber income, fuelwood income and non-timber income were significantly higher ($p < 0.05$) in AF than CF. On the other hand, crop income was significantly higher ($p < 0.05$) for CF farmers than for AF ones. However, other financial variables related to savings and subsidies as well as off-farm and livestock income do not show a statistically significant difference between the two farming systems.

Table 2. Comparative analysis of the financial capital of AF and CF famers.

Variables	AF Farmers	Conventional Farmers	F Statistic	Prob > F
Number of HHs with a bank account	175 (87.5%)	174 (87%)	0.02	0.8812
Number of bank accounts (mean)	1.48	1.42	0.36	0.5479
Number of HHs receiving subsidies from government	44 (22%)	30 (15%)	3.26	0.0717
Crop income (PKR) *	455959.8	624545.7	43.98	0.0000
Timber income (PKR) *	264926.8	0	310.47	0.0000
Fuelwood income (PKR) *	19284.94	0	288.74	0.0000
Non timber forest product income (PKR) *	5536.56	0	95.60	0.0000
Livestock income (PKR)	236369.5	275581.5	3.84	0.0608
Off-farm income (PKR)	112092	130807.5	3.45	0.0642

* Significant difference ($p < 0.05$).

4.2. Physical Capital

The impact on physical capital of the two different categories of farmers was assessed by evaluating the farmers' house size, road conditions and household equipment, household vehicles and communication devices (Table 3). The result shows that the average house size of the AF farmers is 206.905 square meters (m^2), which is higher than the average house size of the conventional farmers of 203 m^2. The majority of the AF farmers' houses (52%) are linked with earthen roads, while the majority of the conventional farmers' houses (55%) are linked with carpet roads. Both categories of farmers have access to irrigation, but the AF farmers' lands have more availability of irrigation water than conventional farmers' lands do. In total, 81% of AF farmers' land has access to irrigation, while 49% of conventional land has access to irrigation water. In terms of the household equipment owned and used by both farmer types, they are almost similar, with both using pipes/hoses and hand water pumps, whereas generators and sprinklers are more utilized by AF farmers on their farmland. The results for household vehicles show that the same amount of bicycles and motorcycles is owned by both AF and CF farmers. The conventional farmers employ tractors for agricultural practice more than the AF farmers do due to fact that AF farmers face hurdles when it comes to operating tractors because of the trees on their farmland. The results for communication/electronic devices indicate that equal numbers of both household types have television (TV) and radio facilities.

The results of the one-way ANOVA indicated that access to irrigation water; having household equipment such as a buffalo plough, generator and sprinklers and having a tractor was significantly ($p < 0.05$) influenced by the farming system. However, almost all communication devices and road conditions did not show any significant influence based on the farming system (AF or CF). Regarding access to irrigation water, AF farmers have easier access to irrigation water than conventional farmers do. Moreover, a significantly higher number of AF households own a buffalo plough ($p = 0.000$), generator ($p = 0.0038$) and sprinklers ($p = 0.0000$). However, the number of households owning tractors was significantly ($p = 0.0034$) higher among conventional farmers than in AF ones.

Table 3. Comparative analysis of the physical capital of AF and CF famers.

Variables	AF Farmers	Conventional Farmers	F Statistic	Prob > F
Size of house	206.905	203.16	0.72	0.3964
Road condition				
HHs with earthen road	105 (52%)	89 (44%)	2.57	0.1100
HHs with carpet road	95 (47%)	111 (55%)	2.57	0.1100
Number of HHs having easy access to irrigation water *	163 (81%)	99 (49%)	50.85	0.0000
Household equipment				
Buffalo plough *	61 (30)	25(12)	20.06	0.0000
Generator *	90 (45%)	62 (31%)	8.45	0.0038
Pipes/hose	189 (94%)	191 (95%)	0.21	0.6473
Hand water pump	104 (52%)	108 (54%)	0.16	0.6895
Sprinkler*	40 (20%)	8 (4%)	25.68	0.0000
Household vehicles				
Bicycle	200 (100%)	197 (98%)	3.03	0.0825
Motorcycle	181(90%)	171 (85%)	2.37	0.1245
Tractor *	163 (81%)	183 (91%)	8.71	0.0034
Communication devices				
Radio	101 (50%)	98 (49%)	0.09	0.7649
TV	197 (98%)	197(98%)	0.00	1.0000

* Significant difference ($p < 0.05$).

4.3. Natural Capital

The impact on natural capital of the two different categories of farmers was analyzed by measuring the extent of cultivated land, ownership of the cultivated land, types of livestock, types of crops cultivated and number of HHs facing soil erosion (Table 4). The result shows that the average amount of cultivated land of the AF farmers sample is 1.8 ha, and the average amount of cultivated land of the CF farmers is 1.6 ha. In total, 100% of AF farmers had land ownership, whereas 88% of CF farmers had land ownership rights. Considering the types of livestock owned by AF and CF farmers, of the AF farmers, 25% own poultry, 10% own cattle, 42% own buffalo and 7% keep goats; from the CF farmers, 21% own poultry, 15% own cattle, 50% own buffalo and 9% keep goats. Comparatively, the results show that CF farmers are more likely to keep and rear livestock than the AF farmers are. In terms of types of crops cultivated, the study indicates that of the AF farmer HHs, 42% grow grain crops, 46% grow vegetables, 33% grow fruit crops and 24% grow medicinal crops; of the CF farmer HHs, 61% grow grain crops, 26% grow vegetables, 10% grow fruit crops and 9% grow medicinal crops. To summarize, the AF farmers in the study area strongly prefer to cultivate vegetables, fruit trees and medicinal crops, whereas the CF farmers choose to grow grain crops and pulses. In addition, 51% of the AF farmers claimed that they face high soil erosion due to agroforestry, while 69% of CF farmers said they face high soil erosion.

The results of the ANOVA show that AF farmers have a significantly ($p < 0.05$) higher extent of cultivated land than CF farmers do. Additionally, a significantly higher number of AF households grow vegetables ($p = 0.0000$), fruits ($p = 0.0000$) and medicinal crops ($p = 0.0001$) compared to CF farmers. On the other hand, a significantly ($p < 0.05$) higher number of CF farmers were growing grain crops (0.0001). However, the types of livestock among the two groups of farmers did not show any significant variation. Regarding the severity of soil erosion, a significantly higher ($p < 0.05$, $p = 0.0001$) number of CF farmers stated that they are facing high soil erosion compared to AF farmers.

Table 4. Comparative analysis of the natural capital of AF and CF famers.

Variables	AF Farmers	Conventional Farmers	F Statistic	Prob > F
Extent of cultivated land (ha) *	1.815	1.6095	9.41	0.0023
Ownership of the cultivated land *	200 (100%)	177 (88%)	25.86	0.0000
Types of livestock				
Number of HHs rearing poultry	50 (25%)	42 (21%)	0.90	0.3431
Number of HHs rearing cattle	21 (10%)	30 (15%)	1.82	0.1781
Number of HHs rearing buffalo	85 (42%)	101 (50%)	2.58	0.1093
Number of HHs rearing goats	14 (7%)	19 (9%)	0.82	0.3648
Types of crop cultivate				
Number of HHs growing grains *	84 (42%)	122 (61%)	14.92	0.0001
Number of HHs growing pulses	73 (36%)	60 (30%)	1.90	0.1685
Number of HHs growing vegetables *	92 (46%)	52 (26%)	18.06	0.0000
Number of HHs growing fruits *	67 (33%)	21 (10%)	33.23	0.0000
Number of HHs growing medicinal crops *	49 (24%)	19 (9%)	16.53	0.0001
Number of HHs with high soil erosion *	102 (51%)	139 (69%)	14.75	0.0001

* Significant difference ($p < 0.05$).

4.4. Social Capital

In this section, the impact on social capital of the two different categories of farmers was assessed by evaluating the following: number of social groups; whether they share advice about agriculture, share crop seeds and borrow farming equipment from each other; whether children play together; whether HHs look after each other's children, borrow money in times of need, herd livestock together and share food in times of need (Table 5). The results in this section provide empirical support for the idea that agroforestry can and does increase food security in social and political contexts. The result shows that AF farmers are involved in more social groups than the non-AF farmers are. An AF farmer's average number of groups is 2.07, which is greater than that of CF farmers. In total, 31% and 45% of AF HHs like to share seeds and food, respectively, while conventional farmers share less, at 18% and 43%. In total, 9% of AF farmers herd their livestock together, whereas only 4% of conventional farmers herd livestock together. In contrast, 92% of the conventional farmers like to share advice among each other, 58% borrow farming equipment, 60% borrow money in times of need and 48% have their children play together, while these figures for AF farmers are comparatively lower.

The differences in social capital among the two farming systems were examined using an ANOVA. Our results indicated that there were significant differences ($p < 0.05$) in the number of social groups, number of HHs sharing crop seeds, number of HHs borrowing farming equipment, number of HHs borrowing money in times of need and number of HHs where children play together. Furthermore, our results highlighted that a significantly higher number of AF HHs were involved in social groups ($p = 0.0010$) and sharing crop seeds ($p = 0.0026$) compared to CF farmers. On the other hand, a comparatively larger number of CF households borrowed farming equipment ($p = 0.0006$) and money ($p = 0.0067$) from each other in times of need. Moreover, children of CF farmers were more willing to play each other than the AF farmers' children were, and the value is statistically significant ($p = 0.000$).

Table 5. Comparative analysis of the social capital of AF and CF famers.

Variables	AF Farmers	Conventional Farmers	F Statistic	Prob > F
Number of social groups *	2.075	1.755	10.99	0.0010
Number of HHs sharing advice about agriculture	178 (89%)	184 (92%)	1.04	0.3074
Number of HHs sharing crop seeds *	63 (31%)	37 (18%)	9.18	0.0026
Number of HHs borrowing farming equipment from each other *	83 (41%)	117 (58%)	11.84	0.0006
Number of HHs where children play together *	47 (23%)	96 (48%)	27.82	0.0000
Number of HHs looking after each other's children	28 (14%)	21 (10%)	1.14	0.2869
Number of HHs borrowing money in times of need *	93 (46%)	120 (60%)	7.42	0.0067
Number of HHs herd livestock together	18 (9%)	9 (4%)	3.23	0.0732
Number of HHs that share food in times of need	91 (45%)	86 (43%)	0.25	0.6158

* Significant difference ($p < 0.05$).

4.5. Human Capital

The results for human capital show that the mean number of male and female members in each AF HH is 3.5 and 3.3, respectively, while the respective values for conventional farmer HHs are 3.4 and 3.2. It is important to understand the labor availability of households on the field. Another interesting finding was that the majority of the AF farmers and CF farmers had received secondary education as shown in (Table 6). Furthermore, this study's comparison revealed that AF and CF farmers' health conditions were almost the same. A total 84.5% of AF farmers and 81.5% of CF farmers had good health condition. In addition, both types of farmers suffered a mean of 1.6 and 1.4 occurrences of common sickness annually.

The ANOVA findings indicate that all variables used for assessing the human capital except the variable "Number of occurrences of common sickness" do not show any significant variation among agroforestry and conventional farmers. The illness variable alone showed a statistically significant difference ($p = 0.0075$) among the two farming systems, with AF farmers showing a significantly ($p < 0.05$) higher chance of developing common sickness compared to CF farmers.

Table 6. Comparative analysis of the human capital of AF and CF famers.

Variables	AF Farmers	Conventional Farmers	F Statistic	Prob > F
		Household size		
Male members (mean)	3.5	3.44	0.28	0.5983
Female members (mean)	3.325	3.275	0.18	0.6730
		Education of HH head		
Number of HHs with illiterate	7 (3.5%)	11 (5.5%)	0.93	0.3359
Number of HHs with primary education	33 (16.5%)	30 (15%)	0.15	0.6973
Number of HHs with secondary education	80 (40%)	77 (38.5%)	0.09	0.7594
Number of HHs with advanced education level	61 (30.5%)	64 (32%)	0.10	0.7470
Number of HH with university education	17 (8.5%)	17 (8.5%)	0.00	1.0000
Number of HH having "Good" health condition	169 (84.5%)	163 (81.5%)	0.64	0.4258
Number of occurrences of common sickness (mean) *	1.66	1.48	7.23	0.0075

* Significant difference ($p < 0.05$).

5. Discussion

5.1. Financial Capital

The impact of AF and CF on the financial capital of farmers was assessed by evaluating the number of households that have a bank account and the number of bank accounts, whether households receive subsidies from the government and their annual income from different income sources. The results indicated that being a farmer of AF does not significantly influence saving in banks or obtention of subsidies from the government. However, a study conducted in Kenya [51] found that farmers who manage sustainable agricultural practices, including agroforestry, are able to save more on average than other farmers. Farmers mainly plant trees on farmland for fruits, fuelwood, timber and fodder for livestock [52]. Agroforestry ensures the maximum production of trees on farmland and increases farmers' incomes [53]. Hence, AF farmers obtained a significantly higher income from timber, fuelwood and non-timber products than CF farmers did. Similar to our study, a study conducted by Rahman et al. [36] in Bangladesh and one by Yang et al. [39] in China indicated that agroforestry ensures tree cover for higher timber and fuelwood production, which generate the highest income for poor farmers who can thus earn their livelihood. However, when AF trees not selected to complement each other, they may compete with crops or livestock for resources. If farmers plant trees in narrow alleys, it is likely that when they grow bigger, their crowns will shade most of the land below. In this situation, farmers need to switch to shade-tolerant crops; otherwise, they will experience poor harvest and lower crop income. In line with this, the study results also indicated a lower crop income from AF than from CF.

5.2. Physical Capital

The comparison of the physical capital among the two farming systems, namely AF and CF, indicated promising results for AF farmers in terms of owning household equipment. More AF farmers owned a buffalo plough, generator and sprinklers compared to the CF farmers. The reason is that AF farmers hold a larger amount of land than CF farmers do (Table 5), and they are willing to buy and keep equipment that is needed for daily farming activities. Due to the larger amount of farmland, farmers do not have more time to perform work manually (watering with water buckets or using *Mammoty* for weeding). Hence, they prefer to use low-cost, advanced special equipment that is necessary for cultivation and maintenance. A study conducted in Indonesia found that farmers are more optimistic about using sprinklers and drip irrigation for the survival trees in the increasingly long dry seasons because the World Agroforestry Centre is improving their understanding of AF [54]. Similar to our study, the study conducted in Kenya applied the ownership of farm equipment as a variable to measure the role of agroforestry in building livelihood resilience to floods and drought in a semi-arid region. In their study, they revealed that AF both directly and indirectly improves physical capital and builds livelihood resilience to floods and droughts [49].

Major AF systems in tropical regions pay more attention to irrigation. Water management, especially during establishment, will be important in any attempt to establish trees in a dry environment. Micro-catchments, hand watering or irrigation should be anticipated [55]. Therefore, AF farmers prefer to possess farmland with easy access to irrigation water. These findings are identical with the current study.

Our results on household vehicles show that CF farmers own a significantly higher number of tractors than AF farmers do. Tractors are the most suitable transportation mode in rural Pakistan, where the majority of roads are earthen and under construction. Every season, CF farmers prefer to use a tractor to transport their harvest to the market (especially rice and wheat). Compared to CF, AF has a long-term production cycle. Therefore, AF farmers prefer to hire tractors during the harvesting time of timber or fuel wood. Similar to our study, a study conducted in Shangla District, Pakistan, reported that vegetable and rice transport via tractors would be cheaper because of the easy access on the dirt roads leading there [56].

Regarding the non-significant difference between the farming systems (AF and CF) and road type and vehicles, the most probable reason is that the income generated from either AF or CF is not sufficient to bring about a change in road type and vehicle. However, in contrast to our findings, a study conducted in Malawi indicated that AF supports infrastructure development in rural areas [35].

5.3. Natural Capital

People do not like to cultivate perennial crops when the land is illegal or rented, thus making it insecure. The security of their use rights is highly concerned when practicing AF. The study results also showed that almost all AF farmers hold private ownership of the cultivated land. A study entitled "Who Adopts Agroforestry in a Subsistence Economy", conducted in Terai of Nepal, also highlighted that households with a larger extent of land practice AF in a subsistence economy [57]. Our finding is supported by previous studies by [37] in Ethiopia and [58] in Nepal, which found that agroforestry farmers own more lands than conventional farmers do.

Furthermore, our study found that AF farmers planted more vegetables, fruits and medicinal crops, while CF farmers grew more grain crops. It was argued that the presence of trees on a plot would significantly decrease the food crop yield [59]. Therefore, grain-crop-growing farmers do not like to keep trees on their farmland as they affect the light availability for crop. In previous studies on the types of crops cultivated in CF and AF, we found both similar and contrasting results. A study conducted in India by [60] reported that more fruit trees were planted in AF sites to generate more income. Similarly, [61,62] reported that horticultural crops such as trees and vegetables and medicinal crops such as ginger and turmeric were grown in AF sites in southwest and north Bangladesh. However, in contrast to our findings, the study [52] highlighted that AF farmers in Gazipur, Bangladesh, have more grain and pulse crops and fewer numbers of fruit crops in their farmland along the boundary.

In 2020, the Pakistani livestock sector contributed about 60.6% to overall agriculture and 11.7% to the GDP [63]. The buffalo products from Pakistan have excellent demand even in international markets. Nowadays, buffalo rearing in Pakistan is being considered a most lucrative and profitable business [64]. Therefore, the majority of farm households in Pakistan prefer to keep livestock without considering the farming system, whether CF or AF. Similarly, our results also show that there were no significant differences in farm animal management among CF and AF farmers.

As with much other research around the globe, our study reported that CF causes more soil erosion than AF does. A study conducted in arable steep-lands in central Kenya reported that conventional farming causes 80% more soil erosion than AF does [65]. The reason for this is that AF systems improve soil stability and prevent erosion through several processes. Sepúlveda et al. [66] reported that tree mulch made by AF intercepts rainfall, decreases the velocity of runoff water, reduces evapotranspiration and limits soil crusting. Moreover, trees and hedges provide a permeable barrier that slows down and intercepts water runoff [65]. However, a multi-dimensional meta-analysis conducted on 52 articles that directly compared cocoa agroforestry systems and monocultures found that there were no significant differences in AF and monoculture in relation to the main soil parameters [67].

5.4. Social Capital

In general, the results for social capital were mixed. Our study found that AF farmers were more involved in social groups than CF farmers were. In line with our study, [68] also found that under a social forestry program conducted in Indonesia, AF farmers have been granted increased authority to act as group. A study conducted in northern Bangladesh highlighted that even though farmers agreed with the statement that the relationship with other communities has improved, they were also aware of ongoing conflict between neighboring farmers due to AF practices [47]. According to the findings, although AF helped to improve social interactions among farmers by involving the groups and their group meetings, the overall impact on improving trust among members appeared to be lower than that among CF farmers. For example, comparatively fewer AF farmers borrow money and equipment from each other. This may happen due to not only trust but also several other reasons. As mentioned in the section of physical capital (Table 5), the AF farmers own more farming equipment than the CF farmers do, so AF farmers do not need to borrow farming equipment from each other.

In addition, the majority of kids in AF farm-owning families do not play with kids of other families. The reason for this is that children who can be involved in farm activities such as collecting poultry eggs, feeding farm animals and weeding in farm fields do not have leisure time to go and play with other kids. They usually play with their own family members or are busy with their work. Similar to our study, [69] found that children in AF households are encourage to be involved in agroforestry due to the lower availability of labor supply.

5.5. Human Capital

The impact of farming system (AF/CF) on the human capital of the farmers was assessed by evaluating the household size, farmers' education and farmers' health condition. In general, our results indicated that the farming system (AF or CF) does not significantly relate to the formal education of the HH head and the family size. Several other studies conducted mostly in developing countries also indicated findings in line with the current study. For instance, a study conducted in the Indus River Basin, Pakistan [20], indicated that there was no significant difference in the number of family members in both AF and CF farmers' households.

Regarding education, the study conducted by [70] on factors affecting the adoption of silvopastoral AF systems in Colombia indicated that AF adoption was not influenced by the education level of the farmers. However, in contrast to our findings, [71] in Tanzania and [25] in the Swat region of Pakistan indicated that farmers who were willing to plant trees in their farmlands had higher education levels than those who practiced conventional farming. Furthermore, they indicated that the development of human capital in the form of farming system skills and knowledge is accumulated through education, and that the higher the education level of the household head is, the greater the chance is of positive decision-making about practicing AF rather than CF.

This study found that AF farmers were more vulnerable to having common sickness than CF farmers were. There is evidence that loss of biodiversity increases pathogen transmission. This shows that the species that spread most pathogenic products persist with decreases in biodiversity [72]. However, similar to our study, recent evidence from [73] shows that increasing biodiversity through forestation or practicing AF is associated with increased disease burden.

6. Conclusions

This study aimed to answer the call for more comprehensive research exploring the influence of AF on rural livelihood compared to CF. Results from two farming communities practicing AF and CF in the Northern Irrigated Plain in Pakistan indicate a mixed impact on five types of capital, namely human, physical, natural, financial and social.

According to the results of the one-way ANOVA, AF improved financial capital in terms of timber, non-timber and fuelwood income. Physical capital, such as having household equipment (buffalo plough, generator and sprinklers), also showed significant improvement with the implementation of AF rather than CF. Furthermore, the results also show that AF has a significant positive effect on some of the variables in natural capital (extent of cultivated land and land ownership, number of HHs growing vegetables, fruits and medicinal crops) and social capital (number of social groups that HHs involve and number of HHs sharing crop seeds).

On the other hand, the result shows that financial capital, such as crop income; physical capital, such as HHs owning tractors; natural capital, such as the number of HHs growing grains; and social capital, such as the number of HHs borrowing money and equipment as well as the number of HHs where children play together, were significantly higher in CF farmers than in AF ones. In terms of human capital, the study results show that except for the common sickness variable, all other variables, such as HH education level and family size, are not influenced by the farming system (AF or CF). However, AF farmers showed a higher occurrence of common sickness than CF farmers did.

According to the findings, AF has generally increased the livelihood capital in the Northern Irrigated Plain, Pakistan. Hence, as one could believe, the sustainable livelihoods of poor households have been improved due to AF. However, this impact has been limited, and the impacts on different income groups were not assessed in this study.

On the negative side, the majority of AF farmers stated that planting exotic woody crops as tree components in the AF land reduces the water availability for annual crops as well as leading to dryness in the soil. Moreover, they highlighted the allergic condition caused by the exotic trees, and their views were confirmed in the results of human capital, where the variable of common sickness occurrence showed increased illness among AF farmers than in CF farmers. The results of this study suggest that the AF system should be promoted in the Northern Irrigated Plain of Pakistan due to the socioeconomic advantages in order to enhance the sustainable livelihood of farmers. However, more multidisciplinary research on adapting AF trees and government involvement in research planning and implementing is needed to understand the characteristics of the different farming systems. In addition, a special focus should be placed upon developing community-based management strategies that combine trees, crops and livestock to produce products and services of high demand by farm communities and the market.

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