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Does Land Tenure Systems Affect Sustainable Agricultural Development?

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Abstract: The current study aims to investigate the agricultural investment differences among three kinds of land lease agreements and their effect on farmers' decisions regarding sustainable growth in terms of soil conservation and wheat productivity, using cross-sectional data from rural households in Punjab, Pakistan. The "multivariate Tobit model" was used for the empirical analysis because it considers the possible substitution of investment choices and the tenancy status' endogeneity. Compared to agricultural lands on lease contracts, landowners involved in agribusiness are more likely to invest in measures to improve soil and increase productivity. Moreover, the present study has also identified that the yield per hectare is much higher for landowners than sharecroppers, and thus, the Marshall's assumption of low efficiency of tenants under sharecroppers is supported.

Keywords: land tenure; soil conservation; Investment decision; farm productivity; land use sustainability; agricultural development

1. Introduction

The reformation of agricultural land has garnered broad support in many countries. Such reformation depends to a certain extent on the assumption that agrarian land under secured land tenancy status is preferable to other types of land right arrangements [1,2]. Secured land rights ensure permanent retention of farmland, which incentivizes and encourages farmers to invest in sustainable development for long-term benefits. To the contrary, many farmers with unsecured land rights, are very much interested in gaining short-term benefits from their investment. Hence, they tend to spend on supplements which help increase productivity but gradually diminish the sustainability of soil fertility. Empirical studies that were conducted in the sub-Saharan Africa and Asian countries demonstrated that unsecured land-use rights do not instigate any investment for the sustainability of soil fertility, which is not beneficial for the farmers [3–9]. Landlord's failure to renew contracts for unsecured land leases deter tenants from investing in technologies for sustainable soil conservation because the expectation of a future return on investment is uncertain [10]. Therefore, the lower investment in fertilizer, organic and green manure for soil conservation will subsequently lead to a considerable decrease in farm output.

On the other hand, Marshall's theory of inefficiency implements adequate risk management strategies and risk aversion practices [11,12]. Farmland reformation protects agricultural land (safety rights) and at the same time actively increases productivity although tenants face a limited impact on crop sharing. In many countries nowadays, farmers are especially aware of the risks and uncertainty, which has encouraged many stakeholders to help in land reform activities [13].

Based on previous literature, the effects of formal land ownership arrangements are mixed. Feder and Onchan [14] studied the effects of land ownership security in Thailand agricultural

investment and found that the investment of land improving measures was significantly affected by the security of ownership. Similarly, a study by Shively [15] indicated that the security of land tenure has a positive impact on soil conservation adoption in the Philippines. Moreover, Banerjee and Ghatak [16] revealed that the tenancy law on farmland tenancy in India allows improvement of sharecropping and progressive land tenure reform, which will eventually lead to a positive impact on farm investment and productivity.

Conversely, there is also research showing that sharecropping does not make a significant difference in farm productivity. This view was established by empirical research conducted in Tunisia [17]. Kassie and Holden [18] and demonstrated that sharecropper's land is less productive than owner-cultivators due to the potential threat of expulsion by the landowners. In Pakistan, Jacoby and Mansuri [19] established that non-monitored cultivators are less effective than monitored cultivators, indirectly suggesting that effective monitoring results in substantial productivity differences between sharecroppers and owners. Moreover, Ali, Abdulai [8] highlighted that land tenancy arrangements influence the decisions of farmers to invest for long-term benefit in order to increase their output. Finally, Kumari and Nakano [9] also established in their research that tenants under insecure land lease ultimately end up with significantly lower crop yields.

This research aims to contribute to the existing literature relating to decisions of the farmer for sustainable development in a new prospect of soil fertility for long-term benefit, where land right agreements are considered endogenous. In order to investigate how sustainable development is affected by tenancy status, proxy variables, namely, soil improving investment and farm productivity were measured. This study comprises of 305 wheat farmers from the Punjab province. The study begins with the examination of the demand for different soil and yields improving inputs affected by various land tenure arrangements. Share contract arrangements without incentives and apprehensive tenure arrangement often lead to lower yields, affecting the overall national productivity which becomes a crucial issue for relevant authorities. Sharecrop agreements are specifically a source of discouragement for inhabitants. However, Haider and Kuhnen [20] suggested that the change of share agreement into a fixed lease agreement will motivate tenant farmers to opt for sustainable development. To the contrary, fixed-lease agreements in Punjab is deemed unreliable because it is informal, with landowners usually neglecting to extend or renew the contracts in the future.

This paper utilizes a multivariate methodology representing other farm and family unit attributes between land tenure arrangements and attitude towards investing for sustainable soil fertility in order to enhance yield and evaluate a broader economic significance of tenure arrangements. The main objectives of the present study are to investigate whether tenancy contracts positively impact investment in soil sustainability and whether such contracts result in productivity-enhancing measures. This research proposed two hypotheses pertaining to the relationship between land use rights contracts, levels of investment, and farm productivity. Firstly, securing land rights can positively impact soil investment. Secondly, unsecured land rights will reduce farm efficiency, in line with the Marshallian theory of inefficiency. The Marshallian theory of inefficiency can be assessed by comparing the yield under shared cropping tenants with owner cultivated and fixed rental arrangements [11]. The current study focused on wheat production in Punjab, Pakistan, as it is one of the country's' leading cash crops, which accounts for 9.1% of value-added agriculture and nearly 1.7% of GDP. Pakistani Flour Mills Industries are heavily dependent on the national production of wheat, where Punjab generates 80% of the country's wheat production [21]. In Pakistan and Northern India, wheat is the staple food for nearly 500 million people living in these areas [22]. Most of the rural population rely on the production of wheat for their livelihood.

2. Materials and Methods

2.1. Data and Variables

This study employed cross-sectional data representing rural households in Punjab, Pakistan. The data in this study were gathered from farmers living in six different districts across the province of Punjab, Pakistan, using a survey method. A stratified random sample of 305 farmers producing wheat was selected for the survey. Prior to implementing the questionnaire in the survey, it was tested and validated through structured interviews conducted by trained domestic enumerators. Upon validation, the data collection was conducted from August to December 2017. The 305 farmers were from six districts that constituted Jhang, Sahiwal, Faisalabad, Sheikhupura, Khanewal, and Toba Take Singh (Figure 1). The survey respondents included 151 owner-cultivators, 119 fixed-rent tenants and 35 shared-crop tenants. However, the survey did not include mixed land arrangements, in order to draw a clear line towards the effects of different land regimes. Of the three variables outlined in this research, planting legumes (green manure) and the application of organic manure (animal waste like dung) is considered to be measured to enhance productivity and improve soil fertility, while the use of fertilizer is merely considered as a yield-improving measure. It is assumed that increased investment in soil conservation and improved farm productivity lead to sustainable agricultural growth.
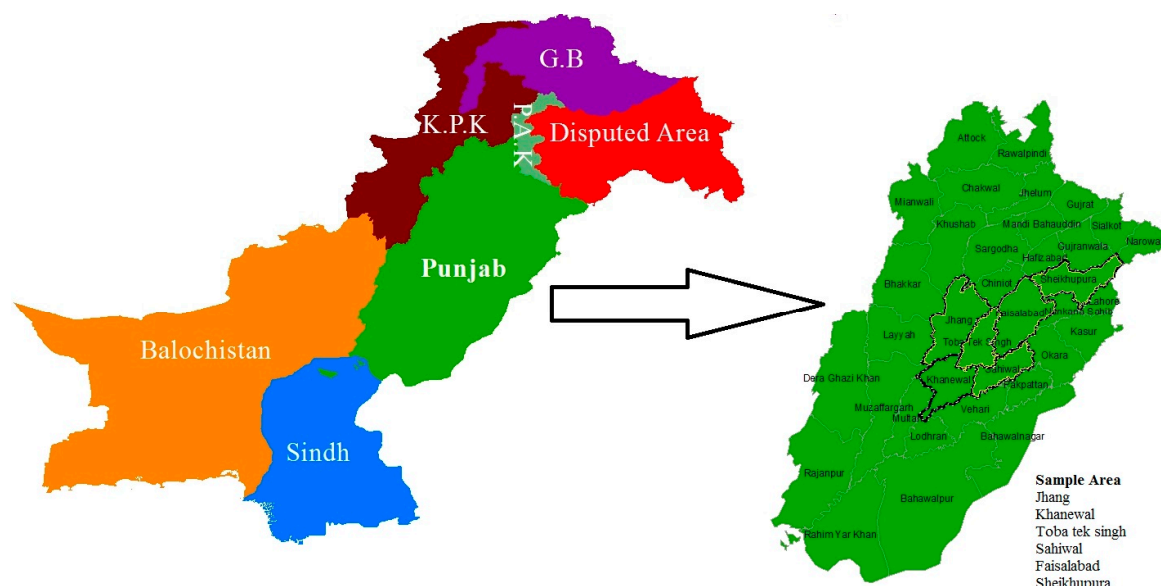

Figure 1. Sample Area.

Through the present survey, data on the characteristics of both the farm and the household was collected (Table A1). The variables at the household level include the farmer's level of education, age, gender, family size, along with their ownership of livestock, thresher, tractor, and other farm implements. Formal education can improve potential management capabilities of the former leading to exceptional cognitive ability because Advanced natural resource management practices like top dressing, preparation and application of manure, are knowledge-intensive activities that require a significant management contribution [23,24]. Other household characteristics include the extent of a farmer's participation in non-farm activities, their affiliation with any farmers' organization, and the extent of his access to credit services.

On the other hand, farm-level variables include the distance between the landowner and their farmland, using dummy variables to indicate whether the land is located within or outside the village. Other farm level variables include land slope, quality of soil fertility, and the size of the cultivated land. The soil quality was measured using a dummy variable: fertile and permeable land takes the value of 1, while unfertile and impermeable land takes the value of 0. In addition, data includes the

quantity and price of pesticides, seeds, agricultural labor (both employed and familial), and farm output. Besides, the investment specifications of the dependent variable were censored, while some observations were zero.

2.2. Model Specifications

As mentioned previously, this research focuses on two items, the impact of tenancy agreements on farm inputs and the number of investments needed for soil improvement, productivity enhancement, and farm efficiency to yield sustainable growth. In order to test the proposed hypotheses, the functions of agricultural production on the farm were defined as:

$$Y = f(X, T, N; Z) \tag{1}$$

where Y, X, T and N represent yield, labour, land, and inputs (such as manure investment, leguminous crops and fertiliser), respectively, while, Z is a vector of household and farm level characteristics. It is also well documented that, although the yield can be increased with the increase of chemical fertilizer, if the soil is not to replenished with organic fertilizers or any other soil improving organic material, the output will decline over time. Output declination can be caused by soil degradation, which undermines the original investment purpose. Since the consistent use of chemical fertilizers can lead to soil degradation, farmers tend to invest in organic fertilizers that can help improve soil structure and replace soil nutrients in a natural and economical way. This method fortifies the soil and maximizes their profit. Unlike chemical fertilizers, the nutrients in organic fertilizers remain active for much longer [24,25]. For the purpose of this study, it was speculated that various agents (extension contacts) are involved in maximizing profit. Maximum farm profit π is determined using the following equation:

$$\pi = max \ X, T, N \ [PY(X, T, N; Z) - WX - R(\theta, \delta) - CN] \tag{2}$$

where P, W and R (.) denote the output, labour cost per unit, and land cost, respectively. This formula equates to the three types of tenancy arrangements; landowners, fixed renters, and shared crop tenants. The cost of land is calculated as follows:

$$R \ (\theta, \delta) = (1 - \theta)\overline{R} + \theta\delta PY \tag{3}$$

where δ is the parameter of shared-output rate, for fixed rent and shared crop tenants "θ" is equal to 0 and 1 accordingly. Thus, δPY denotes sharecroppers' and $\overline{R}$ fixed renters' land cost. C represents the vector of the cost related to non-conventional inputs and Z is as previously described. As per Equation (2), maximum profits π can be expressed as price, parameters of household characteristics, and tenancy arrangements, shown as θ and δ as follows:

$$\pi = \pi(P, W, C, Z, \theta, \delta) \tag{4}$$

Hotelling's lemma is applied directly to any clearly defined profit function. For instance, in Equation (2), labour, investment, productivity-enhancing measures (manure, leguminous crops, and fertilizer), and the supply and demand of input and output are simple specifications of declined yield.

$$X = X(P, W, C, Z, \theta, \delta) \tag{5}$$

$$T = T \ (P, W, C, Z, \theta, \delta) \tag{6}$$

$$N = N(P, W, C, Z, \theta, \delta) \tag{7}$$

$$Y = Y \ (P, W, C, Z, \theta, \delta) \tag{8}$$

Equations (4)–(8) indicate prices of input and output, household characteristics, farm characteristics and types of land-use right influencing overall profits, the input and output demand and supply. However, if there is no moral hazard (Moral hazard arises due to the incentive structures which make it compulsory for tenant farmers to share their output with their landlords.), the optimal use of input and output will not depend on the contract's terms and conditions (θ and δ).

2.3. Empirical Strategy

The empirical investigation uses the specifications of declined yield as indicated in Equations (5)–(8) in order to analyse agricultural productivity along with the demand and supply of input and output. Firstly, this study assessed the farmer's behaviour towards sustainable development under different land arrangements. Through this assessment the per hectare productivity, profitability and investment demand between lands held by landlords and tenants under fixed term and sharecropping contracts were compared. It then compared these factors on lands held by landlords and tenant under fixed rent cultivation arrangements. The study also focused on the effects of land-use rights on investments for sustainable soil fertility (manure, M; green manure, L : fertilizers, F). Furthermore, a multivariate approach was also used to demonstrate how investment decisions are influenced by land tenure systems, represented by the farm and household characteristics, Equation (7). The investment sustainability potential was estimated using this approach. Subsequently, a variable instrumental method was used to test the effects of leasing arrangements using Equation (8) on yield per hectare, alongside farm and household characteristics. The Tobit model condition was used to create the investment measure scale for soil improvement by censoring the nature of investment-related variables. This equation is presented as follows:

$$J^*_{im} = \beta_{im}Q_{im} \ + \ \gamma_{im}Z_{im} + \mu_{im}; \ J_{im} = \left\{ \begin{array}{ll} J^*_{im} & if \quad J^*_{im} > 0 \\ 0 & otherwise \end{array} \right. , \ m = M, L, F \tag{9}$$

J represents the predicted household profit, i the three investment variables of improved soils, and m measures the increase in production. In the case of investing in soil and production improvement measures, J_{im} indicates variable, 0 and J^*_{im} indicate the unexpected dynamic variables. μ_{im} errors are distributed individually and identically, while β_{im} and γ_{im} are assumed as parameters of estimates. Q_{im} represents a tenant's arrangement and includes a constant variable of θ and δ, where, the tenant is either a land-owner or, shared cropper or fixed renter. The number of influences in the household and farm level characteristics was indicated by Z_{im}. Multivariate Tobit estimation used in this study as there may be a non-zero correlation between each Tobit specification.

Although previous literature revealed that the type of land ownership is exogenous, This studies have indicated that land rights and investment decisions can bear equal and mutual focus, confirming the presence of endogeneity in the land-related variables as represented by Equation (9) [26]. In order to demonstrate the endogeneity of lease arrangement variables, these variables specified as a function of its determinant in under given equation.

$$Q_{im} = \ J_{im}\psi_{im} + \ Z_{im}\gamma_{im} + \ \xi_{im}, \tag{10}$$

where ψ_{im} and γ_{im} are the parameters to be estimated, while the error term is ξ_{im}. Since the dependent variable in Equation (9) is constant, the method proposed by Blundell and Smith [27] was used to solve the endogeneity problem. Endogenous testing and effective estimation methods in the context of censoring and simultaneity has been developed by a number of academicians. The endogenous test was established by writing μ_{im} in Equation (9) from the ξ_{im} condition of Equation (10) as $\mu_{im} = \xi_{im}\varphi_{im} + v_{im}$, taking the place of μ_{im} into Equation (9) to generate a conditional model as below:

$$J^*_{im} = Q_{im}\tau_{im} + Z_{im}a_{im} + \varepsilon_{im}\varphi_{im} + v_{im} \tag{11}$$

　　　Null hypothesis test $\varphi_{im} = 0$ constitutes the test of exogenous Q_{im}. If $\varphi_{im} = 0$, it is not assumed to be rejected, thence it is accepted that the land lease arrangements are assumed to be exogenous factors in soil investment and productivity improvement measures.

　　　This test was performed during the first phase of the estimations in this analysis using Equation (10), after which regression residuals were used as the estimate of ξ_{im} in Equation (11). The specification was measured using standard censored regression, Equation (11). Here, the exogeneity was not rejected if residual coefficient items are statistically insignificant. Since the outcome variables in Equation (10) are distinct, a "linear probability model" was used to calculate an estimate of the standard error through the next phase of regression measurement. The use of the aforementioned method is also used to identify vectors of omitted instrumental variables.

　　　There are two types of variables that were excluded in the second phase of estimation in this study. The first is the dummy variable of investment decisions relating to land that is cultivated by the landowners (whether or not they are located in the same village), where there is a considerable distance between them. The second is the dummy variable used as a fixed tenant instrument indicating whether the location of landowner' residence and cultivated land is within the same village and whether there is a considerable distance between the land and the landlord's residence. As highlighted by Arcand, Ai [17] and Besley, Leight [28], the decision to lease agricultural land may be influenced by the fringe effects of heterogeneity of the landlord's efforts, and therefore, could depend on the characteristics of the landlord. However, the tenant's investment decisions do not necessarily depend on the characteristics of the landlord.

3. Results

3.1. Comparison of Land Regimes

　　　This study used the most common method to test the Marshal's Inefficiency hypothesis on land shared crop which does so by comparing the per hectare productivity of different land held by landlords and tenants under fixed rent and sharecropping cultivations. Moreover, a comparison was also drawn to examine the differences in the inputs and outputs. Table 1 lists the differences in the input, output, alongside farm and household-level characteristics between land operated by owners and sharecropper cultivators. *, **, *** designates significance level of 10%, 5%, and 1%, respectively.

　　　The *t*-values represent the significance of the mean differences. The value demonstrates that there are significant differences between the farm and household level characteristics of each tenure regime. Specifically, yield under owner cultivation (4342 kg/ha) is 19% higher than that of the sharecropper (3535 kg/ha). With only 1% significance, the difference was highly noticeable and significant. Additionally, almost all input applications were found to be significant between owner and shared crop cultivated lands. For instance, the average amount of fertilizer used was approximately 296 kg/ha and 248 kg/ha by the owner and shared crop land respectively, with a significant difference of 1%. The difference in the application of organic manure between owner cultivated (4016 kg/ha) and sharecropping tenants (2015 kg/ha) was also highly significant. Moreover, compared to the land under sharecropping contract, the owner cultivated land utilizes more seeds, pesticides, and their use of green manure is approximately 10% higher than that of sharecropping land. Therefore, the overall degree of inputs applied for the improvement of soil and productivity is higher for owner cultivated lands compared to the shared lands. Although the need for multivariate analyses of the other agricultural and household features (like infertile soil land under contract) remains, Marshallian Inefficiency theory is supported by the evidence of these key characteristic differences. When two types of land ownership were examined in terms of their total land holds, the difference was also found to be significant in the use of labor and animal ownership. In particular, the owner-cultivated lands are averagely larger than the land under shared contract, while the livestock ownership was estimated at 26% higher than that of sharecroppers. The household labor rate of self-owned land (9 days/ha) is higher than that of sharecropper land (6 days/ha), although the proportion of active labor is slightly higher on

sharecropper land (19 days/ha) compared to owner cultivated land (16 days/ha). The results also indicated that approximately 60% of owner-cultivators to have credit access, this is 40% only in the case of sharecroppers. With regards to credit access, almost all peasant farmers who were surveyed in the present research study used their land as collateral for loans. *, **, *** designates significance level at 10%, 5%, and 1%, respectively.

Table 1 also summarizes the results of fixed and sharecroppers lease contract holders. The average amount of cultivated land per hectare is much lower for sharecroppers than fixed renters, but this difference was not statistically significant. The Marshallian Inefficiency hypothesis was once again supported by the comparatively lower yield from the shared cropland. Fixed lease land utilized more fertilizers, pesticides, and organic fertilizers than shared land, while shared cropland used 6% more green manure than the fixed lease land. These results were consistent with previous literature where farmers on fixed lease arrangements than sharecroppers are more likely to reap the short-term benefits of mineral fertilizers than the long-term gains from leguminous crops. On the other hand, despite the use of green manure by sharecroppers, their per hectare yield remains lower than that of the fixed renters, which is once again evidenced by Marshallian Inefficiency. This variation is present because shareholders invest less in production inputs as they merely earn a fraction of the production limit predetermined by their land-use agreement.

The critical differences between owners and fixed lease tenants are also presented in Table 1. Based on the results, the per hectare yield (4342 kg/ha) of owner-cultivators was 9% higher than those under fixed rent contracts (3947 kg/ha), with a significant difference at 1%. Landowners invest more per hectare than the fixed term tenants, except for employed/hired labor. *, **, *** designates significance level at 10%, 5%, and 1%, respectively.

The land cultivated by the owner is also more fertile than the land under a fixed lease contract because owner-cultivators spend more on mineral fertilizers, organic manure, pesticides, and seeds. Hence, landowners also achieve a higher yield per hectare.

Table 1. Differences in key characteristics among owner, fixed renter and sharecropper.

Variables				Owner and Sharecropper		Fixed Renter & Sharecropper		Owner & Fixed Renter	
	Owner	Fixed Renter	Share Croppers	Differences	*t*-Value	Differences	*t*-Value	Differences	*t*-Value
Total yield (kg/ha)	4342.51	3947.47	3535.73	806.78	4.2 ***	411.74	2.42	395.04	3.36 ***
Output value (in PKR/ha)	116,028.91	11,2264.62	105,242.89	10,786.03	2.06 **	7021.73	1.07	3764.29	1.19
Net returns of output (in PKR/ha)	73,378.69	65,874.56	57,632.74	15,745.95	2.76 ***	8241.82	1.18	7504.13	2.26
Land area (ha)	4.280	3.903	3.134	1.15	0.94	0.769	1.6	0.38	0.55
Land years	14.83	14.69	6.66	8.17	4.70 ***	8.03	3.69 ***	0.14	0.09
Fertilizer used (kg/ha)	296.30	262.27	248.72	47.58	2.44 ***	13.55	0.51	34.03	1.81
Organic manure used (kg/ha)	4016.76	3508.82	2015.34	2001.42	3.10 ***	1493.48	2.20 **	507.94	0.95
Green manure used (ha).	0.70	0.59	0.63	0.07	0.44	−0.04	−0.269	0.11	1.08
Pesticides used (gram/ha)	1047.963	952.624	853.266	194.70	4.20 ***	99.358	2.4 *	95.34	3.37 ***
Seeds used? (kg/ha)	116.35	109.65	104.06	12.29	2.72 ***	5.59	1.16	6.70	2.78 **
Hired labour (days/ha)	16.60	21.15	19.97	−3.38	1.38	1.18	0.37	−4.56	−2.5
Family labour (days/ha)	9.26	8.34	6.91	2.34	0.96	1.43	0.69	0.91	0.57
Livestock (%)	0.96	0.61	0.71	0.25	3.11 ***	−0.1	−1.13	0.35	7.95 ***
Age (Year)	44.91	46.34	46.66	−1.75	0.68	−0.32	−0.12	−1.44	−0.86
Education (primary 0, high 1)	0.72	0.56	0.77	−0.05	0.37	−0.21	2.44 *	0.16	1.97 *
Credit access (%)	0.65	0.44	0.26	0.39	4.64 ***	0.18	2.05 **	0.21	3.55 ***
Tube-well (%)	0.74	0.57	0.34	0.39	4.64 ***	0.23	2.45 **	0.16	2.82 ***
Soil quality (%)	0.86	0.34	0.49	0.38	4.16 ***	−0.15	−1.52	0.52	9.92 ***

*, **, *** designates significance level of 10%, 5%, and 1%, respectively.

3.2. Econometrical Model Estimation

This section assessed the multivariate analysis to identify the impacts of leasing agreements on applied inputs and outputs using farm and household related variables. The study captured the effects of tenancy arrangements on farm productivity by using instrumental variables to control the potential endogeneity of tenure regimes. Table 2 tabulates the results from the first phase of regression. The first phase includes the impact of land lease agreements on farm and household level variables (Equation (10)), also identify the instrumental variables of second phase regression. Here, the linear probability was used to estimate the specifications of farm and household level characteristics in order to identify their relationship with the variables of land lease arrangements, where sharecropping was designated as an omitted variable. Furthermore, based on the F test, the joint meaning of the significance of distance and location under the term of the tenancy regime. The variable treated as an instrumental variable in the plot cultivated by the owner is a dummy variable suggesting that the farmer and plot are located in the same village; for fixed renters, instrumental variables treated as dummy variable suggesting that the location of landlord' land is in the same village or not and the distance between the both of them. It was hypothesized that both would be rejected if they are equal to zero at 1% significance. Based on Table 2, land which is located far from the landlord's home is less likely to be cultivated by owners, and more often will be on a fixed lease. However, if the land is located in the same village as the landowner, it will most likely to be cultivated by the owner or under a sharecropping contract. As for shared crop farming, a landlord prefers a plot to be located close to their home so that they can easily monitor their agent's activities.

Table 2. Factors influencing land tenancy using Linear probability model.

Variables	Fixed-Renter		Owner-Cultivar	
	Coeff.	t-Statistics	Coeff.	t-Statistics
Land hold	−0.091	−0.11	0.044	0.12
Soil Quality	−0.388	−7.23 ***	0.426	7.74 ***
Sloped	0.021	0.69	0.041	−2.18
Tube well	−0.017	−0.33	0.159	2.96 ***
Household	0.012	2.87 ***	−0.005	−0.62
Age	−0.006	1.67 *	−0.095	−1.17
Education	−0.656	−0.07	0.041	1.08 *
Livestock	−0.339	−1.76 *	0.292	4.42 ***
Farmer org	−0.041	−5.28 ***	0.027	0.52
Tractor	−0.087	−0.82	0.033	0.57
Thresher	0.159	−1.52	−0.171	−2.40 ***
Cultivated years	0.067	2.85 ***	0.015	0.63
Distance	0.066	1.33 **	−0.011	−0.21 **
Location	−0.139	2.58 ***	0.094	1.69 *
District	0.001	2.44 ***	−0.015	−1.07
F-Statistics (*p* values)	12.09		11.89	
	[0.000]		[0.000]	

*, **, *** designates significance level at 10%, 5%, and 1%, respectively.

On the other hand, Table 3 lists the statistical results of the second stage of investment regression, Equation (11). To further investigate the Marshall Inefficiency assumption, the sharecropping variable was designated as an omitted category in order to assess the effects of land lease system on an investment decision and to control the effects of other variables of household and farm. The results reflected that the "likelihood ratio test" and the "joint significance and correlation coefficient" (ϱ) rejected the null hypothesis that the investment variables do not correlate. The results also indicated that the Multivariate Tobit was more effective than a Simple Tobit model.

Table 3. Factors of land improving investment measures using Multivariate Tobit Model.

Variables	Organic Manure	z-Value	Fertilizer	z-Value	Green Manure	z-Value
Owner	0.174	0.53 **	0.337	2.52 ***	0.069	0.18 *
Fixed Renter	−0.879	2.44 ***	0.154	1.04 *	0.328	0.77
Landhold	−0.472	−3.41 ***	0.069	−1.27 *	−0.029	0.17
Soil quality	−0.296	1.28	0.062	0.67	−0.303	−1.04
Sloped	0.063	0.66	0.021	0.53	0.114	1.02
Tubewell	0.009	0.04	−0.148	−1.73 *	−0.216	−0.83
Farmer Org	0.403	2.07 **	0.039	0.50	0.753	3.06 ***
Household	−0.013	−0.42	0.016	1.38	−0.038	−0.99
Age	0.302	1.00	0.067	0.56	0.509	1.37
Education	0.159	1.16	0.065	0.11	0.151	0.84
Livestock	0.973	0.73	0.344	0.23	0.764	0.21
Tractor	0.298	1.35 *	0.191	0.11 *	0.215	0.80 *
Cultiyears	0.792	8.46 ***	0.026	0.67 *	0.125	1.07 *
Residual owner	0.043	1.01	0.039	1.20	0.251	0.60
Residual fix renter	0.260	0.84	0.161	0.90	0.146	1.05
Number of observations	305		305		305	
Joint significance of residuals	0.981	0.33	0.67	0.49	0.85	0.55
Cross equation correlation						
pOM,F	0.183					
	(2.20) **					
pOM,GM	0.264					
	(3.09) ***					
pF,OM	0.292					
	(3.72) ***					
LR test	25.3					
p value	(0.000)					

Location and distance represented as identifying instruments. *** at 1%, ** at 5%, * at 10%. Region fixed effect incorporated in the analysis, but not described here.

In addition, the variable results indicated that the residuals (owner and fix renter) obtained from the first phase regression was not statistically significant at any level, indicating that there is no simultaneity bias and estimated the coefficients consistently [29]. Furthermore, the table also summarized the joint Wald test for these residual vectors. The values were indicative that for every investment equation, the null hypothesis that the residual vectors are collectively equal to zero cannot be rejected, and the results were again confirmed by individual *t*-statistics.

Usually, land rights can be obtained by purchase, inheritance, or as a gift. In comparison with other states round the globe, individuals cannot easily participate in such activities to obtain land ownership in Punjab. The main interest factor in Table 3 is the coefficient for owners and fix-renter tenants. The owner's cultivating coefficient remained positive even after controlling household and farm characteristics based on the organic manure, chemical fertilizer and green manure utilization with significant differences of 10% (Table 3). This significant difference indicated that owner-cultivators were investing more in these soil improvement measures compared to tenant farmer. (In this study, we avoid calculating the marginal effect. Ref. [6] pointed out, the coefficients' marginal effects which is based on Tobit estimates depend to a large extent on the distribution assumptions). However, the fixed-rent tenants yielded different results, with positive coefficients for chemical fertilizer and legumes, and negative for manure. These results demonstrated that land ownership can significantly impact all kinds of soil improving investment measures. However, fixed renter also positively related to chemical fertilizer and green manure but significantly negative in the case of organic fertilizer. The variable that represents the land hold size is significantly positive for mineral fertilizers but yielded negative for green and organic manure. Moreover, livestock ownership positively affected organic fertilizers, chemical fertilizers, and legumes, but was not statistically significant. In a fertile land, investment in chemical fertilizers positively affected soil improvement compared to other variables but was still not significant. Meanwhile, being a member of the farmer's organization yielded significantly positive coefficient for all but not significant for fertilizer.

The age coefficients for all three types of investments were positive but was not significant. The tractor was significantly positive at 10% for all investment variables. Besides, results also

revealed that higher education level increases the tendency to invest in soil improvement and output enhancement measures. Moreover, farmland cultivated for a long-term received a higher quantity of manure and fertilizers in the land area used for legumes. The regional dummy was also statistically significant. A null hypothesis of the regional effect using the likelihood ratio test produced a sample chi-squared value of 25.3 at 1% significance. The values indicated significant clustering effects that may unveil climate change effects of different areas on agriculture and accessibility of infrastructure.

Table 4 summarises the impacts of lease arrangements on agricultural productivity. Estimates comprised the first-step Probit regression of the variables of lease arrangements on the farm and household characteristics and instrumental variables. The variable treated as an instrumental variable in the plot cultivated by the owner is a dummy variable suggesting that the farmer and plot is located in the same village, for fixed renters, instrumental variables treated as dummy variable suggesting that the location of landlord' land is in the same village or not and the distance between the both of them. The projected value of the lease arrangement variable from the first-step regression was then used in the productivity estimation to control the endogeneity. The results of the output elements as depicted in Table 4 indicated a statistical significance and positive impact on the yield per hectare of the owned and fixed rent tenants' lands. The findings also demonstrated a significant positive impact of organic manure, education and tractor. Moreover, the coefficients of other household and farm characteristics (fertilizer, hired and family labor, farm size, soil quality, household size, number of years of land use for cultivation and village position) were all in favor of farm productivity.

Table 4. Results of elements of all plots' output.

Variables	Coeff.	*t*-Value
Owner	0.208	2.5 ***
Fixed renter	0.101	1.75 *
Fertilizer	0.052	1.49
Organic Manure	0.045	3.28 ***
Family Labour	0.015	0.99
Hired Labour	0.028	1.11
Land hold	0.071	0.32
Soil quality	0.304	8.54
Education	0.112	0.36 *
Household	0.006	1.33
Age	−0.014	−0.30
Culti. years	0.043	2.50
Tubewell	0.055	1.62
Tractor	0.131	3.92 ***
Livestock	0.009	−0.42
Credit access	−0.037	−1.16
Village position	0.043	1.04
Region	−0.019	−2.23 **
Constant	7.365	23.14 ***
R Square	0.614	
Adjusted R	0.551	
F-value	9.73	
Prob > F	0.00	

*, **, *** designates significance level at 10%, 5%, and 1%, respectively.

4. Discussion

In many cases, land ownership status (owner, fixed renter and sharecropper) significantly influences the sustainable growth of agriculture. It was observed that land ownership had a positive impact on topsoil quality, improving investment and farm productivity. The relationship of land ownership status, soil investment and productivity was consistent with "moral hazard" and "hold

up effects". As mentioned previously, "hold up effect" occurs when leaseholders are not guaranteed a return on investment in generating a medium- or long-term yield outputs, which diminishes their investment in such activities. Likewise, a "moral hazard" arises due to the incentive structures which make it compulsory for tenant farmers to share their output with their landlords, leading to fewer production and investment actions. This observation was similar to the findings of Lawry, Samii [13] which strongly suggested that land improvement investments are highly biased towards ownership guarantees. After adjusting the other factors, the plots of owner-cultivators and fixed renters were compared, where the plot under sharecropping arrangements yielded lower. This finding was in line with that of Shaban [12] and Goldstein and Udry [7]. Therefore, based on these findings one can conclude that many potential farming benefits could be lost due to the use of unsecured land. Moreover, these findings go beyond the Marshall's Inefficiency hypothesis assuming that sharecropping farmers are less efficient than the other types of tenants since they only receive a fraction of the yield after investing a certain level of effort. Nevertheless, these findings are in stark contrast to the results reported by Place and Hazell [1] and Arcand, Ai [17]. These studies reported no significant relationship between land leasing and output. Jacoby and Mansuri [19] stated that the maintenance of shared tenants' productivity requires considerable supervision on the part of the landlord, in order to avoid the possible negligence of the leaseholders. Hence, we could conclude based on the current findings that there may be a lack of supervision of leaseholders in the present sampled area of Punjab.

The general phenomena in the study area, the fixed cost of land is borne by the landlord. On the other side, Variable cost divided into two parts; inputs cost (irrigation, fertilizer, and pesticide) and operational cost (land preparation and harvesting). Input cost is equally distributed between landlord and tenants. However operational cost is only borne by the tenants, which could be compromised and lead to lower productivity. To overcome this problem, there is a need to have a formal contract where responsibilities, duties, procedures of land preparation, cultivation and harvesting should be clearly defined. Moreover, fixed and operational cost should be divided equally between landlord and tenants to get long-term benefit of their investment and higher productivity.

On the other hand, the application of organic manure specifically indicated a positive impact, which was consistent with the findings of Gavian and Fafchamps [3] in Niger, Deininger and Ali [6] in Uganda, Jacoby and Mansuri [25] in rural Pakistan and Kumari and Nakano [9] in Fiji. Gavian and Fafchamps [3] also reported that there were incidences where farmers do not know how to use manure on their land and the selling of manure at a nearby marketplace for organic fertilizers was best practice rather than applying it to their rented lands. On the other hand, the land owner-cultivators still possessed a significantly positive impact on manure application even after controlling the ownership of livestock and further farm characteristics. This behaviour indicated that owner-cultivators apply more manure to reap the sustainable benefits of their soil investment. However, the results from the present study were also indicative of owners and sharecroppers with more livestock than fix-renters were still buying organic fertilizer from the market to apply to their land if they are determined to benefit from these investments. To the contrary, Jacoby and Mansuri [25] demonstrated that the inadequate commitment of landowners in rural Pakistan has led to the instability of land tenure, where it seems to have driven tenants to lower their investment in organic fertilizers.

In Ethiopia, Deininger and Feder [30] reported that as the size of the farm increases, farmers were less likely to meet the demand for manure at their cultivated plots. Conversely, Shively [15] and Abdulai and Goetz [31] documented the possibility of using soil fortification measures on large parcels is less likely to happen than that of small parcels. Therefore, farmers who invested in chemical fertilizer reaped a much higher return on these investments compared to others. The reason is that chemical fertilizers have higher concentration of nutrients that help plants to grow. But for long-term benefits, excessive use of fertilizer may be harmful for soil quality. However, being a member of the peasant farmer organization increases the investment possibilities in organic and green manure which correlates to farm productivity. The acceptance of chemical fertilizers over organic and green manure supports the thought that social-networks promote the information flow between agents, and thus strengthens

investment in agro-technology [32]. The old aged farmers who are illiterate tend to invest more in sustainable soil improving measures and increased yields over short-term benefits. These findings are consistent with the study by Nyanga, Kessler [33], where older farmers were found to be less likely involved in off-farm work activities and used their lands from a longer period of time for cultivation. Hence, they invested to enhance soil fertility to reap long-term benefits in terms of higher productivity. As for tractor ownership, the effect of wealth on the variable outcome was also demonstrated. Ref. [13] reported that the accessibility of credit from sanctioned institutional sources may directly depend on the requirements for collateral, or indirectly on the guaranteed rights of the borrower's property. Specifically, the application of mineral fertilizers and the cultivation of legumes require substantial cash investment. Kousar and Abdulai [34] supported these findings in line with the human capital theory that higher education level among farmers increases the tendency of soil improving and output enhancing investments for sustainable growth of agriculture.

5. Conclusions

The argument in favor of land right security for the sustainable social and economic growth of developing countries is a debate that continues to attract the focus of agricultural planners and scholars. Where land reforms have resulted in guaranteed tenure arrangements, these farmlands are known to be more productive, and thus encouraging agrarian land reform programs in many developing economies. This study used 305 wheat farmers as a target population from Punjab, Pakistan in order to study the effects of land regimes upon sustainable agricultural development in term of soil and yield improvement measures, and the farmers' investment decisions influencing farm productivity. Based on the results, this study observed some variations in the land right status of targeted farmers, and their investments for improved soil and increased productivity. The results indicated that input demand and output supply, such as fertilizers, pesticides and hired labor per hectare, was greater for both owner-cultivated and leased land than that of sharecropping, thus assuming the Marshallian hypothesis of inefficiency. This study also identified compelling evidence that the security of tenure is an important factor influencing the farmer's decisions on soil investments, and likewise, in applying organic fertilizer and farming legumes. In particular, owners with cultivation rights are more probable to spend in order to improve soil and increase output as compared to farmers under lease contracts. Moreover, the landlord's failure to commit to a secure tenure is a fundamental reason for low investments among fixed rent tenants.

This study also documented empirical evidence supporting the hypothesis that owner-cultivators are more likely to invest in sustainable development than tenant farmers who are under lease agreements. The higher output of owner cultivated land compared to tenant-farmed lands reflected in the tenant farmers' inclination towards spending in sustainable soil-improving technology as they only achieve a fraction of the productivity at a particular input level. Besides, the increasing supervision cost of landlords that prevents them from monitoring their tenants, and this lack of supervisory motivation also impedes productivity. It can be argued that in order to avoid Marshall Inefficiency under Pakistan's tenant contracts, share-cropped farmers should convert their agreements into fixed lease arrangements to facilitate investment in improved technologies, allowing them to achieve a better output.

The bottom line of these findings advocated the formalization of landlord commitments to tenants, in order to diminish the risk factors related to the lease agreements, which ultimately leads to a significant increase in efficiency. Conclusively, tenure security allows farmers to enhance investment and increase their agricultural productivity for sustainable agricultural growth.

Appendix A

Table A1. Descriptive Statistics.

Variable Description	Mean	Std. Deviation
Age of household head.	45.67	13.482
Gender of household' head. (Male 1, Female 0)	1.00	0.199
Acquired education level of household head. (High/secondary 1, Primary/no education 0)	0.67	0.638
Number of household members.	7.47	3.353
Farmer owns tractor. (Yes 1, No 0)	0.52	0.500
Farmer owns thresher. (Yes 1, No 0)	0.21	0.406
Farmer owns tube-well. (Yes 1, No 0)	0.63	0.485
Farmer owns other farm implements. (Yes 1, No 0)	0.63	0.484
Farmer owns livestock. (Yes 1, No 0)	0.80	0.403
Farmer engaged in non-farm work. (Yes 1, No 0)	0.45	0.498
Farmer is a member of Farmer's association. (Yes 1, No 0)	0.36	0.480
The farmer can avail credit facility. (Yes 1, No 0)	0.52	0.500
A farmer enjoys any power in the area. (Yes 1, No 0)	0.21	0.410
Village has road access. (Yes 1, No 0)	0.79	0.410
The inter-se distance between the plot and landowner's home. (KM)	1.18	0.479
Plot outside landowner's village. (Yes 1, No 0)	0.71	0.454
Soil quality is good. (Yes 1, No 0)	0.62	0.487
The land is a little sloped. (Yes 1, No 0)	0.34	0.766
Number of years land being used for cultivation.	13.84	12.581
The total land under wheat cultivation? (Hectare)	4.002	5.3259
Total wheat production per year? (Kg/Ha)	4095.80	996.356
Per acre cost of wheat production. (PKR)	44,678.62	17,401.167
Per acre value of wheat output. (PKR)	113,322.48	27,284.307
Net returns per hectare in PKR from the wheat output	68,643.94	29,064.269
Hired labor for a number of days per hectare.	18.76	14.907
Family labor for a number of days per hectare.	8.63	12.459
Total pesticides used? (Gram/hectare)	988.423	240.4516
Farmer is the owner of cultivated land. (Yes 1, No 0)	0.50	0.501
Farmer is fix-renter of cultivated land. (Yes 1, No 0)	0.39	0.489
Farmer is share-cropper of cultivated land. (Yes 1, No 0)	0.11	0.319

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