Research Article

Empirical Investigation of Impact of Land Fragmentation on Crop Productivity in Punjab, Pakistan

Rakhshanda Kousar[1], Muhammad Sohail Amjad Makhdum[2], Raza Ullah[1], Aqeela Saghir[3], Sohaib Usman[3*] and Tahira Sadaf[1]

[1]Institute of Agricultural and Resource Economics, University of Agriculture Faisalabad, Pakistan; [2]Department of Economics, Government College University Faisalabad, Pakistan; [3]Institute of Agricultural Extension and Rural Development, University of Agriculture Faisalabad, Pakistan.

Abstract | Agriculture plays a key role in the economy of Pakistan. However, its growth is decreasing in the recent past due to land fragmentation. It is a constraint for agricultural productivity. The study aims at analyzing the impact of land fragmentation on productivity and profitability of crops. The primary data were collected from 120 farmers of rural area of Faisalabad. This study calculated the extent of land fragmentation by using Simpson index. Production function was employed to estimate the impact of land fragmentation on the crop productivity. The results suggested that higher the land fragmentation of the farms, negative is the impact on the productivity. The findings of the study have important implication for formulating of efficient land use policy.

Received | March 22, 2019; **Accepted** | December 01, 2019; **Published** | February 01, 2020
***Correspondence** | Sohaib Usman, Institute of Agricultural Extension and Rural Development, University of Agriculture Faisalabad, Pakistan;
Email: sohaibusmancheema174@gmaial.com
Citation | Kousar, R., M.S.A. Makhdum, Razaullah, A. Saghir, S. Usman and T. Sadaf. 2020. Empirical investigation of impact of land fragmentation on crop productivity in Punjab, Pakistan. *Sarhad Journal of Agriculture,* 36(1): 217-223.
DOI | http://dx.doi.org/10.17582/journal.sja/2020/36.1.217.223
Keywords | Land fragmentation, Crop productivity, Simpson index, Pakistan

Introduction

In Pakistan, most of the poor live in rural areas and majority of it associated with agriculture sector. Agriculture sector's share is almost 18.5 percent in Gross Domestic Product (GDP) and employs almost 38.5 percent of total labour force. However, with the passage of time, share of agriculture is decreasing and most of the people are suffering with low level of employment in this sector (GoP, 2019).

Agriculture productivity is a significant determinant of Pakistan's economy. The foremost element for agricultural production is land which has a substantial value in rural areas due to its leading role as a sign of economic, social and political status. Land is a fixed and immovable natural resource that employed as a source of earning. Land also works as a safety against risks and shocks. Even though, land is the main strength in rural areas of developing country like Pakistan, but its distribution is highly asymmetric (Kousar and Abdulai, 2015) and ownership is shrinking quickly due to fragmentation.

Land fragmentation refers to the existence of separate number of plots of same landowner at different places and they can be framed as single units (Sun and Li, 2010). Agricultural fragmented land is a complicated phenomenon comprises on five aspects such as total fragmented plots, size of plot, topography and distance from the farm buildings of plots and plot scattering (Latruffe and Piet, 2014).

Agricultural land fragmentation is widespread

throughout the world resulted from social, political, institutional and historical factors such as land reforms, inheritance laws, consolidation, housing schemes, transaction costs and personal valuation of land ownership (Latruffe and Piet, 2014). It has both positive and negative effects on agricultural productivity and efficiency. If the production strategies, price level of different inputs and production level are in favour of land fragmentation, then it does not affect agricultural efficiency but if this condition does not prevail then this leads to low efficiency of agriculture (You, 2010). Land fragmentation has great influence on the economic growth development of an economy and leads to subsistence agriculture. Economic growth and development are linked with mechanization, but land fragmentation is a big constraint for it (Mcpherson, 1982).

Land fragmentation is also common in Pakistan which is a main reason for low agricultural productivity, such as due to continued process of land fragmentation almost, 68 percent of total farms or about 80 percent of the cultivated area has become small, subsistent and below subsistent level farms where modern advanced technology for increased crop production cannot be effectively applied. In Pakistan, per capita arable landholding is only 0.168 ha (GoP, 2017).

Past empirical studies on land fragmentation has analysed the determinants of land fragmentation (Dhakal and Khanal, 2018), impact of land fragmentation on land productivity (Kadigi et al., 2017), production diversification (Ciaian et al., 2018), technical efficiency (Jha et al., 2005), cost of production (Villanueva and Colombo, 2017), inefficient use of inputs and labor force availability (Nguyen et al., 1996; Shuhao et al., 2008). However, the findings of these studies are mixed as its effects are specific to each case. Keeping in view the importance of this subject area of research, the aim of this study to investigate the impact of land fragmentation on crop productivity and provide guidance for policy makers on land consolidation measures to promote agricultural sustainability.

Materials and Methods

Study area

In this study, primary data were collected from wheat and sugarcane growers of Faisalabad district in 2018. Sugarcane is a cash crop sown in Kharif season and wheat is an important staple food crop sown in Rabi season. In Pakistan, there are two cropping seasons, Kharif and Rabi. Kharif season starts from April-June and ends in October-December while Rabi begins in October-December and ends in April-May. Following Kousar and Abdulai (2015); Kousar et al. (2018) and Kousar et al. (2019), data were collected through multistage random sampling technique. Five administrative divisions of the district were selected. From each administrative division, two villages were selected randomly. A total of 120 farmers (small, medium and large) were selected following a multistage stratified random sampling procedure.

The following formula was used to determine the sample size for the present study.

$$n= (P (1-P)z^2)/e^2$$

Where;
n represents the total sample size selected for the study, P represents the estimated proportion of population being farmers. It was hypothesized that 60 percent of the rural population are engaged in agricultural sector. Z is the level of confidence according to the standard normal distribution. The present study considered 5 percent probability level (Z = 1.96) while e is the tolerated margin of error set at 9 percent for this study. Putting these values in the formula yields a sample size of 114 respondents for the present study which, for ease of calculations, is increased to 120 respondents.

Descriptive statistics

The socioeconomic characteristics of farmers such as age, education family size, farm size, livestock and input costs etc. are provided in Table 1.

Net return, gross return and total cost of all three categories of farmers

Gross returns, total cost and net returns were calculated for both wheat and sugarcane growers.

The average net return, gross return and total cost per acre of sugarcane farm consumed by all three categories of farmers are indicated in Table 2. The total amount of gross return per acre for small, medium and large farmers was rupees 45700.51, 47547.18 and 46084.5, respectively. Similarly, for average total cost per acre they consumed rupees 44560.26, rupees 46139.74 and rupees 45497.75, respectively. The price of average net return per acre for

small, medium and large farmer was rupees 1140.25, 1407.44 and rupees 290.75, respectively.

The average net return, gross return and total cost per acre of sugarcane farm consumed by all three categories of farmers are indicated in Table 3. The total amount of gross return per acre was rupees 80333.33 for small farmer, rupees 83775.64 for medium farmers and rupees 92900 for large farmers. While, these three group of respective farmers were consumed rupees 47808.97, rupees 66584.62 and rupees 81776.25 of average total cost respectively. The price for average net return per acre was rupees 32524.36, rupees 27191.03 and rupees 11123.75 respectively by small, medium and large farmer. The overall result showed that the large farmer had more average gross return per acre that gained least profit as compared to the others.

Model specification

The empirical analysis in which semi-logarithmic equation can be used to check the multiple linear regression model variables estimation results.

$$\ln Y = \beta oi + \beta 1iSI + \beta 2iEH + \beta 3iAH + \beta 4iFS + \beta 5iFS + \beta 6iSC + \beta 7iFS + \beta 8iLC + vi \quad ...(1)$$

Y= βo + β1 (Simspon Index) + β2 to βnare socio-economic variables + vi (Disturbance term) With; βoi,…,β8i are unknown coefficients,vi is adisturbance term with standard properties, and i=1,…,120.

A spatial problem is fragmentation of land which depending on many facts, factors and parameters. Six relevant factors were cited by King and Burton (1982): number of parcels that belongs to holding, holding size, shape of every parcel, size distribution of parcel and the spatial distribution of parcels. In Pakistan, there are large complexions are present in land fragmentation. In this way, few roads are present to access parcel and ownership rights have many problems. For example, undivided shares that are owned to parcel, i.e. it may belong to more than one landowner; or a parcel may have dual or multiple ownership, i.e. the land is owned by one person whilst the trees growing on the land are owned by someone else and a third party has ownership rights to the water. In addition, a land parcel may not have a title deed. The existence of all these different factors highlights the complexity of representing and measuring land fragmentation. For measuring and representing the land fragmentation are used Simpson index, Average plot distance and Farm Size. Simpson's land fragmentation index formula are as follows:

$$SI = 1 - \frac{\sum_i^n ai^2}{(\sum_i^n ai^2)^2} \quad ...(2)$$

Where;

n is denoted by number of plots and ai is denoted by area of each plot. Simpson index (SI) Value lies between the zero and one, 1 degree value of SI indicating the lower degree of land fragmentation and near to zero-degree value of SI indicating that higher degree of land fragmentation. Simpson Index value can be determined by the average plot size, the number of plots and the plots size distribution. Distance to the plots and farm size cannot be captured by the SI. Distance between each parcel and the effect of economies of scale are captured by using the average distance of plots to the homestead and farm size within a farm.

Production function approach

In order to estimate the impact of land fragmentation on crop productivity, production function approach was used here. The typical examples of production function in literature are Cobb-Douglas and Translog production functions. Despite the well-known limitation, the Cobb-Douglas production form is used in this study because it has the advantage of being easily interpreted in economic term and has achieved widespread empirical support from data of various industries, including agriculture and for various countries (See also Kousar and Abdulai, 2015).

Thus, a typical Cobb-Douglas production function is specified as:

$$\ln Y_i = \sum_j \alpha_j \ln X_{ij} + \sum_k \beta k + \varepsilon_i \quad ...(3)$$

Where Y_i represents the total value of agricultural output of farm household i. X_{ij} is the quantity of input j used by farmer i. α and β are input intensity parameters that represent the elasticities of output with respect to the individual inputs. ε_i is the error term summarizing the effects of omitted variables. The variables included in the vector X_{ij} are age, education of the household head, family size, farm land, livestock, credit, fertilizer cost, seed cost, and labor cost.

Results and Discussion

Results of Simpson's land fragmentation index is given in Table 4. The value of mean fragmentation index is 0.62. Results indicated that land fragmentation is

Table 1: *Summary statistics of the important variables.*

Variables	Definition of Variables	Mean	S. D
Output	Output value per acre in Rs.	562358.56	486347
Age	Age of the household head in years	49.03	14.53
Education	Number of schooling years of household head	6.70	5.23
Family Size	Total household members	8.01	3.45
Farm Land	Total farm land in acres	10.36	11.20
Livestock	1 if the HH real livestock, 0 otherwise	0.67	0.41
Credit	1 if HH take credit, 0 otherwise	0.47	0.23
Fertilizer cost	Expenditures on fertilizers in Rs.	6768.50	7288.90
Seed cost	Expenditures on seed in Rs.	9202.54	9892.42
Labor cost	Expenditures on hiring labor in Rs.	3908.34	4525.76

Table 2: *Net return, Gross Return and Total Cost per Acre of Wheat Growers.*

Wheat Farmer Category	Average Gross Return/Acre (Rupees)	Average Total Cost / Acre (Rupees)	Average Net Return / Acre (Rupees)
Small	45700.51	44560.26	1140.25
Medium	47547.18	46139.74	1407.44
Large	46084.50	45793.75	290.75
Overall	46444.06	45497.91	946.09

Table 3: *Net return, Gross Return and Total Cost per Acre of Sugarcane Growers.*

Sugarcane Farmer Category	Average Gross Return/Acre (Rupees)	Average Total Cost / Acre (Rupees)	Average Net Return / Acre (Rupees)
Small	80333.33	47808.97	32524.36
Medium	93775.64	66584.62	27191.03
Large	92900	81776.25	11123.75
Overall	89002.99	65389.94	23613.04

Table 4: Extent of Land Fragmentation in study area.

SI Index	No. of Respondents	Farm Size(acre)
0.01-0.20	35	0.5
0.21-0.40	40	2
0.41-0.60	27	3.5
0.61-0.80	12	6
0.81-1.00	6	10

more at the small size of farm and very low land fragmentation at the large farm. Thus, it can be revealed that high extent of land fragmentation is linked with the farming of small plots. These results are in line with the study of Sundqvist and Andersson, 2007; Okezie et al., 2012; Latruffe and Piet, 2014 who also quantified the degree of land fragmentation by using household level data.

The Cobb-Douglas production function approach was used to estimate the impact of land fragmentation and other different socio-economic variables on productivity of wheat and sugarcane growers. The independent variables included in model were farm size, education, age, family size, total seed cost, fertilizer cost, labor cost and Simpson index. The dependent variable in the model was productivity value of crop output per acre which is employed by previous empirical studies (Abdulai et al., 2011; Kousar and Abdulai, 2015). The value of each crop output is estimated by using village level median prices of the prices that farmers indicate their crops would currently fetch on the market. This avoids the problem of using the same set of prices for all farm.

The results of production function in Table 5 shows that the coefficient of Simpson index is negative and statistically significant, indicating that land fragmentation tends to decline crop productivity. High degree of land fragmentation results in uneconomic sub-division of land that leads to high cost of production and hindering

Links Researchers

of mechanization. The results suggested that with the higher land fragmentation of the farms indicating the negative impact of Simpson index on the adoption of new technology and management practices by improving the requirement of labor for the betterment of the production throughout the year. These results are in line with the study of Shuhao et al., 2008; Dhakal and Khanal, 2018 and are in contrast with the study of Kadigi et al. (2017).

Table 5: *Econometric Results of the Impact of Land on productivity of Farmers.*

Variables	Coefficients	T Statistics
Constant	3.24**	3.12
SI	-0.010**	2.60
Edu	0.073*	1.739
Age	0.095	0.930
Family Size	-0.168	1.614
Farm size	0.068*	2.22
Livestock	0.465*	1.84
Fertilizer Cost	-0.048	2.47
Seed Cost	-0.253	2.68
Labor Cost	-0.131	1.76
R^2	0.39	
Adjusted R^2	0.27	

Regarding socio-economic variables, education appeared to have positive and significant impact of crop productivity. Thus, these results highlighted the human capital theory as indicated by other studies (Kousar and Abdulai, 2015). Coefficient of family size is negative but statistically insignificant.

Physical assets of farmers like land and livestock appeared to have positive impact on land productivity. It indicates that physical assets of farmers like land and livestock appear to be important inputs in the production process. The linkage of farm size and productivity is expected to be positive because of the existence of economies of scale. These results offer evidence from the previous literature (Kousar and Abdulai, 2015; Kousar et al., 2018). However, the link may not be positive in some cases as some previous empirical literature is not consistent on the presence of such economies of scale in agricultural production like reported by the study of Gorton and Davidova, 2004.

The coefficient of expenditures on inputs like fertilizer, seed and labor have expected negative sign, indicating that higher input prices have negative effect on crop productivity. This is probably due to the fact that land fragmentation tends to enhance time and cost of inputs such as seed, labour, and fertilizers which in turn decline the crop productivity. These results are in line with the empirical literature on crop productivity and profitability (Manjunatha et al., 2013; Abdulai and Huffman, 2014).

Conclusions and Recommendations

Land is important source of minerals, agricultural consumables and other primary products and hence, its role is very crucial for agricultural production. Land fragmentation is an arising issue since last two decades. It refers to the existence of separate number of plots of same land owner at different places and they can be framed as single units. Agricultural land fragmentation is a complicated phenomenon comprised on five aspects such as number of fragmented plots, plot size, topography and distance from the farm buildings of plots and plot scattering. It is a constraint for agricultural mechanization hence technological advancement and the resulting economic growth. In developing countries like Pakistan, besides land fragmentation, uneven distribution of cultivable land is also problematic. Agricultural productivity and profitability may suffer due to uneven distribution and fragmentation of land.

The study in hand aims at analysing the impact of land fragmentation on productivity and profitability of crops. The primary data has been collected from 120 farmers of rural area of Faisalabad.

Respondent were selected using multistage random sampling technique. Multiple regression was used in order to meet the set objective by using the collected data on the software of Social Package for Social Scientists (SPSS). For measuring and representing the land fragmentation Simpson index, Average plot distance and Farm Size were used. Simpson index (SI) value lies between zero and the one, 1-degree value of SI indicates the lower degree of land fragmentation and near to zero-degree value of SI indicates the higher degree of land fragmentation. Simpson Index value can be determined by the average plot size, the number of plots and the plots size distribution. The results suggested that higher the land fragmentation of the farms, negative is the impact of Simpson index on the adoption of new technology and management

practices by improving the requirement of labor for the betterment of the production throughout the year. The higher value of the Simpson index regarding labor cost, increases but fertilizer costs reduced, oxen and seed costs. While the impact of land fragmentation on the modern technologies and management have a negative effect on the productivity. The findings have important implication for the design of land consolidation programs that will help to employ modern technology. The problems associated with land fragmentation can be overcome by applying the specific land management programs like; voluntary parcel exchange, land consolidation, land funds, land banking and cooperate farming.

Novelty Statement

This study provides analysis to analyzing the impact of land fragmentation on productivity and profitability of crops. Calculated the extent of land fragmentation by using Simpson index. Production function was employed to estimate the impact of land fragmentation on the crop productivity. It is critical for improving Pakistan's com-petitiveness in the world market through quality improvement and value addition.

Authors' Contribution

Rakhshanda Kousar conducted the research. M. Sohail Amjad Makhdum analysed the data and wrote the article. Aqeela Sagir did data collection and review of literature. Raza Ullah helped in performing the analysis and reviewing the manuscript. Sohaib Usman helped in editing of manuscript. Tahira Sadaf helped in data collection and methodological part.

References

Abdulai, A., V. Owusu and R. Goetz. 2011. Land tenure differences and investment in land improvement measures: theoretical and empirical analyses. J. Dev. Econ. 96(1): 66–78. https://doi.org/10.1016/j.jdeveco.2010.08.002

Abdulai, A. and W. Huffman. 2014. The adoption and impact of soil and water conservation technology: An endogenous switching regression application. Land. Econ. 90(1): 26-43. https://doi.org/10.3368/le.90.1.26

Ciaian, P., F. Guri., M. Rajcaniova., D. Drabik and S.G. Paloma. 2018. Land fragmentation and production diversification: a case study from rural Albania. Land. Use. Pol. 76(1): 589-599. https://doi.org/10.1016/j.landusepol.2018.02.039

Dhakal, B.N., and N.R. Khanal. 2018. Causes and consequences of fragmentation of agricultural land: A Case of Nawalparasi District, Nepal. Geo. J. Nepal. 11(1): 95-112. https://doi.org/10.3126/gjn.v11i0.19551

GoP. 2017. Economics survey of Pakistan, 2018-19. Economic advisory wing, finance division, Islamabad, Pakistan.

GoP. 2019. Economics survey of Pakistan, 2018-19. Economic advisory wing, finance division, Islamabad, Pakistan.

Gorton, M. and S. Davidova. 2004. Farm productivity and efficiency in the CEE applicant countries: a synthesis of results. AgriC. Econ. 30(1): 1-16. https://doi.org/10.1111/j.1574-0862.2004.tb00172.x

Jha, R., H.K. Nagarajan and S. Prasanna. 2005. Land fragmentation and its implications for productivity: Evidence from Southern India. Pp. 30-98.

Kadigi, R.M., J.J. Kashaigili., A. Sirima., F. Kamau., A. Sikira and W. Mbungu. 2017. Land fragmentation, agricultural productivity and implications for agricultural investments in the southern agricultural growth corridor of Tanzania (SAGCOT) region, Tanzania. J. Dev. Agri. Econ. 9(2): 26-36.

King, R. and S. Burton. 1982. Land fragmentation: notes on a fundamental rural spatial problem. Prog. Geo. 6(4): 475-494. https://doi.org/10.1177/030913258200600401

Kousar, R. and A. Abdulai. 2015. Off-farm work, land tenancy contracts and investment in soil conservation measure in rural Pakistan. Aust. J. Agric. Res. Eco. 59(3): 119.

Kousar, R., M.S.A. Makhdum and Q. Abbas. 2018. Secured land rights, household welfare and agricultural productivity: evidence from rural Pakistan. Pak. J. Agric. Sci. 55(1): 243-247. https://doi.org/10.21162/PAKJAS/18.5063

Kousar, R., M.S.A. Makhdum., A. Abbas and J. Nasir. 2019. Issues and Impacts of the Apricot Value Chain on the Upland Farmers in the Himalayan Range of Pakistan. Sustainability. 11(16): 4482. https://doi.org/10.3390/su11164482

Latruffe, L. and L. Piet. 2014. Does land fragmentation affect farm performance? A

case study from Brittany, France. Agric. Sys. 129(1): 68-80. https://doi.org/10.1016/j.agsy.2014.05.005

Manjunatha, A.V., A.R. Anik., S. Speelman and E.A. Nuppenau. 2013. Impact of land fragmentation, farm size, land ownership and crop diversity on profit and efficiency of irrigated farms in India. Land. Use. Pol. 31(1): 397-405. https://doi.org/10.1016/j.landusepol.2012.08.005

McPherson. M.F. 1982. Land fragmentation: a selected literature review. Harvard Univ. Harvard Inst. Int. Dev. 141(1): 4–8

Nguyen, T., E. Cheng and C. Findlay. 1996. Land fragmentation and farm productivity in China in the 1990s. Chin. Econ. Rev. 7 (2): 169-180. https://doi.org/10.1016/S1043-951X(96)90007-3

Niroula, G. and G.B. Thapa. 2007. Impacts of land fragmentation on input use, crop yield and production efficiency in the mountains of Nepal. Land. Deg. Dev. 18 (3): 237-248. https://doi.org/10.1002/ldr.771

Niroula, G.S. and G.B. Thapa. 2005. Impacts and causes of land fragmentation, and lessons learned from land consolidation in South Asia. Land. Use. Pol. 22 (4): 358-372. https://doi.org/10.1016/j.landusepol.2004.10.001

Okezie, C.A., A.C. Ulunma and S. Jamalludin. 2012. Exploring the link between land fragmentation and agricultural productivity. Int. J. Agric. For. 2(1): 30-34. https://doi.org/10.5923/j.ijaf.20120201.05

Shuhao. T.A.N., N. Heerink., G. Kruseman and Q.U. Futian. 2008. Do fragmented landholdings have higher production costs? Evidence from rice farmers in Northeastern Jiangxi province, PR China. China. Econ. Rev. 19(3): 347-358. https://doi.org/10.1016/j.chieco.2007.07.001

Sun, Y., and Y.Z. Liu. 2010. Evaluation of land use sustainability based on land fragmentation: A case on Fenyi County, Jiangxi Province. J. Nat. Res. 25(5):802-810.

Sundqvist, P. and L. Andersson. 2007. A study of the impacts of land fragmentation on agricultural productivity in Northern Vietnam. Bachelor thesis, Uppsala University, pp. 41.

Tan, S. 2005. Land fragmentation and rice production: a case study of small farms in Jiangxi Province, PR China. Ph.D. thesis. Wageningen University. Pp.160.

Villanueva, M.P. and S. Colombo. 2017. Cost analysis of parcel fragmentation in agriculture: The case of traditional olive cultivation. Bio. Eng. 164(1): 135-146. https://doi.org/10.1016/j.biosystemseng.2017.10.003

You, L. 2010. Analysis of land fragmentation in PR China: Case study in taizhou city of Zhejiang Province. Univ. Twente Fac. Geoinf. Earth Obs. (ITC). https://webapps.itc.utwente.nl/librarywww/papers_2010/msc/la/liyou.pdf