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Research Article

Innovation Adoption and Its Effect on the Profitability of Dairy Farms in Sahiwal District, Punjab, Pakistan

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Innovation sustainability index, Net present value, benefit cost ratio, profitability of dairy farms, total information score

Abstract
Innovation is the development of a new idea or a new production method to improve the performance of ongoing operations. The purpose of this study was to determine the adoption of innovation and its impact on the profitability of dairy farms in district Sahiwal, Punjab, Pakistan, using a structured questionnaire distributed to 160 dairy farmers using a random sampling technique. The obtained data were analyzed in order to compute the dairy farm income, total revenue, profit margins, and net present value and benefit cost ratios. Multiple regression analysis used to determine the effect of innovation adoption on the profitability of dairy farmers. The mean value of quarterly profit across dairy farms was 30772.71 TL with NPV and BCR values of 222.44 and 1.68 respectively. The profitability of the dairy farmers negatively affected by the age of the farmer, and a positive association found between the farming experience, total number of milking animals and innovation adoption index. Land, machinery, and credit costs must be minimized by the government to improve the adoption practices among dairy farmers.

INTRODUCTION

The process of acclimating humanity to the planet's limits may be too slow to considering halting planetary decay. The world may be more like an unmanageable food shortage, with rising food prices, spreading food turmoil, and eventually political insecurity (Pardey et al., 2012). Between 720 and 811 million people in the world faced hunger in 2020 (FAO, 2022). According to statistics, 22.4 percent of the population in developing countries earns $1.25 per day (Chen and Ravallion, 2012). Agriculture is key sector to address the problem of hunger, poverty and employment across globe. Due to financial and policy constraints, there is a significant gap between agricultural productivity and research and development sector (Alston et al., 2010). Most farmers in developing countries rely on conventional production methods, limited inputs, and limited access to capital and resources with low economic returns, and small land holdings for their living (Muzari et al., 2012; Cinemre and Kılıç, 2015; Türkten et al., 2016). Famers' production potentials is critical to meeting anticipated rising inputs cost, and it is helpful to examine ongoing modern technologies and adoption of innovations impact on the gross margins in cases of current farming scenario to improve living standards. The success of the Asian green revolution based on the successful adoption of modern and advanced technologies, as well as the improvement of the economic well-being of the farming community through employment, poverty reduction, high returns, and improved land productivity (Ravallion and Chen, 2004). Innovation is new idea, thought or practices that is unknown in the beginning, is opted by the innovators, followed by group or community as a way forward to mitigate the problem of sector or organization (Rogers, 1995; Berger, 2005; Yildrim et al., 2021). Agriculture technologies are methods, applications, procedures, techniques and machines for cumulative output growth with minimalizing costs (Jain et al., 2009; Loevinsohn et al., 2013; Challa, 2013; Türkten et al., 2017). Innovations in agriculture include not only the use of modern technologies, but also the acquisition of knowledge, information, and techniques with the assistance of the extension system, as well as the development of appropriate marketing strategies to achieve the desired results (Demiryürek, 2014). Agriculture Information System in which the government, research institutes, farmers, and private partners collaborate to find a viable solution to a common problem, through innovations adoption under challenging and sticky circumstances (Pound and Essegney, 2008; Demiryürek, 2014). Technology adoption is without any doubt a key factor to address the expenses and vulnerability regarding production sector of economy. The economist claimed that financial perspective most important factor to consider for the adoption of modern agricultural technologies, because ambiguity regarding productivity and benefits must addressed for subsistence living standards (Giorgia et al., 2020). Adoption of technology is critical for increasing farm productivity and financial development. Individual firms must invest in modern innovations to maintain smooth efficiency level (Sauer et al., 2019). A number of studies around the world investigated the relationship of social, economic, institutional features, social networks, managerial role, ecological characteristics, climatic and environmental factors with the adoption of innovations. (Makokha et al., 2001; Ouma et al., 2002; Ransom et al., 2003; Wekesa et al., 2003; Rezvanfar, 2007; Matuschke and Qaim, 2008; Uaiene et al., 2009; Foster and Rosenzweig, 2010; Lavison, 2013; Akudugu et al., 2012; Margaret and Samuel, 2015; Thomas et al., 2017; Michele et al., 2019; Kolawole and Olufemi, 2019; Giorgia et al., 2020; Shahbaz et al., 2020; Amos et al., 2020; Shahbaz et al., 2022). All of these studies explain the significant positive and negative relationship between

the variables of social, economic, and institutional role on the adoption of agricultural innovations. Livestock production is a crucial sector particularly in developing countries and its development largely depends on innovation adoption. There are a number of studies focusing on different subsectors of animal husbandry. (Eryılmaz et al., 2020) investigated innovation adoption in Canik district of Samsun province while (Boz et al., 2011) sought the factors influencing the adoption of innovation among dairy farmers in the Eastern Mediterranean region of Turkey. (Budak et al., 2011) focused on innovation adoption among sheep farmers while (Boz, 2015) study searched the factors influenced innovation adoption among goat farmers in the same region. Since every sub sector of animal husbandry such as dairy farming, beef cattle farming, goat farming or sheep farming requires different practices and innovations results of these studies lead to different conclusions. (Kılıç and Eryılmaz, 2020) identified structural characteristics of dairy farms operating in Samsun province. Although there have been many studies regarding innovation adoption and its profitability in animal husbandry around the world, there is a lack of studies focused on this subject in Pakistan. Therefore, this study aims to fill this gap. The purpose of this research was to calculate the profitability of partial and full adopters and compare their socioeconomic characteristics to the sustainable innovation index in the Sahiwal district of Punjab, Pakistan.

MATERIALS and METHODS

Study area selection play an important role for to address the research problem. Socio-economic characteristics of Shaiwal farmers depend on dairy sector. Therefore, the Sahiwal district selected as research area where main income source is agriculture and dairy farming to address the problem. This lies in between the major cities of Lahore and Multan with area of 3261 km^2. Sahiwal tehsil was randomly selected form the Shaiwal division. In second part two union council were selected form tehsil Sahiwal. In third stage, one village from each union council selected for data collection. The lists of dairy farmers showing the number of dairy cattle and innovations obtained in advance with the help of livestock assistance and field staff. A well-structured questionnaire designed that having close and open-ended questions to collect information. Face-to-face farmers interview about their innovation adoption practices and options available for bringing uprising in their living standards involved in dairy farming. The sample were determined considered the number of innovation adopted owned by each individual dairy farmer. The sample size calculated by using formula of (Cochran, 1977):

$N = (S * Z \alpha/2 /e)$

N = Sample size for the study

S= Standard Deviation

$Z (\alpha/2) = 1.96$; standard normal variate value at 95% confidence level

e = Error

Total sample of 160 farmers calculated using this formula by using random sampling technique as used by (Ugwumba et al., 2010) in his study. Out of 160 respondents, 80 respondents from each village selected by the application of proportional allocation sampling technique. This primary data collected and entered in MS Excel. SPSS software packages used for data analysis. Data analysis process composed of two parts. The first section contains the socioeconomic characteristics of the selected farmers. The second section contains important information about dairy farm innovations presented in research and adopted by the farmer; and the third section contains the operational expense and revenue associated with daily dairy activities over a three-month period from April to June in 2021 in district Sahiwal. In second part, the profit of dairy farmers, gross margins, benefit cost ratio, and net present value of dairy farms were calculated. The total revenue and costs associated with dairy farm activity were

required for these calculations (Garcia et al., 2003; Khalid et al., 2017) which are as follow;

Total revenue = Price of milk * Quantity of milk produced (Pi*Yi)

Total expense = Price of all the inputs used * Quantity of inputs used (Qi * Ci)

Farm Profit = Pi *Yi - Qi * Ci (Revenue – Variable cost)

NPV = Discounted Benefit – Discounted Cost (Discount rate = 10%)

BCR = Discounted Benefit / Discounted Cost (Discount rate = 10%)

The innovation index of the dairy farmers also calculated in the first part. (Dasgupta, 1968) developed the Innovation Sustainability Index for calculating the innovation adoption score of the adopters. In this technique, he calculated not only the total number of innovations adopted by the individual, but also the year number in which these practices practiced by the adopter. He proposed that as the value of the index rises, farmers' sustainable adoption practices improve. In other words, higher the value of index leads to more innovative farmer and index value calculated as;

Innovation Sustainability Index = Total adoption years x Number of innovations adopted

Total number of innovations

Total number of innovation available in the study area were artificial insemination of dairy cattle, maize silage, automatic machines for animal milking, refrigeration of milk, credit facility, vaccination against dairy disease, Mineral mixtures and salt, concentrate feed and parasite treatments. These innovations were selected considering the earlier studies of (Boz et al., 2011; Budak et al., 2012; Boz, 2015) studies, as well as structural characteristics of dairy farming in the research area. Particularly maize silage was proven to have high feeding value (Karadeniz and Saruhan, 2019) and therefore it was included as an innovation in this study. This study also includes of socio-economic characteristics of dairy farmers involved in innovative practices (Demiryürek, 2008; Yildrim, et al., 2021). In the second part of the study, factors influenced the profitability of dairy farms was estimated using the innovation index as one of the explanatory variables. The multiple linear regression model used with the assumption of normal distribution where linear relationship exist among dependent and independent variable using scatter plot or Z value of all the variables used in the multiple regression model lies between the ranges of ± 1.96. Multicollinearity between independent variable and is determined through VIF value less than 5 indicated no multicollinearity suggested by (Pan and Jackson, 2008) are assumption for multiple linear regression and following is the equation used for analysis:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + e \quad \text{Eq. 1}$$

Y = Quarterly Profit of Dairy Farms (TL)

X_1 = Age of dairy farmer

X_2= Education years of farmer

X_3= Family size

X_4= Land holdings (Acres)

X_5= Area under fodder crops (Acres)

X_6= Innovation sustainability Index

X_7= Total Information Score

X_8= Total dairy animals (Number)

X_9= Total milking animals (Number)

e = error term

Multiple regression analysis used for the determination of profit impact on the socio-economic characteristics of farmers along with the total information score and innovation adoption index with confidence interval of 95 percent and F test is applied to check the overall significance of the model by using criteria $F_{cal} > F_{tab}$.

RESULTS and DISCUSSION

Table 1 showed that the average age of the dairy farmers was 45.74 years, and the average level of education in the study area was 9.13 years. The dairy farmers' average family size was 5.42, with a farming experience of 18.59 years in the dairy sector. The majority of farmers in the area have subsistence land holdings of 13.985 acres on average, with 3.76 acres

under fodder crops. Dairy farmers in Sahiwal district having average innovation index score of 25.22 and an average information score of 473.44. Average number of dairy animals in the study area found 19 with the average milking was 12 in number. This study investigated the impact of profitability on dairy farmers' adoption of new technologies

Table 1. Socioeconomic characteristics of dairy farmers

Variables	Mean	Std. Deviation
Age (years)	45.74	± 12.26
Education (Years)	9.13	± 3.68
Family size	5.42	± 2.10
Dairy farming Experience (Years)	18.59	± 9.19
Owned Area (Acres)	13.98	± 22.38
Innovation sustainability Index	25.22	± 19.83
Total Information Score	473.44	± 165.62
Area under fodder crops (Acres)	3.76	± 1.84
Total number of dairy animals	19.11	± 7.79
Total milking animals	12.41	±4.90

Table 2 demonstrated dairy farmers' innovation adoption practices. Among all the adoption, vaccination is the most adopted practice in the study area with highest percent of 93.75 followed by artificial insemination (83.75%), maize silage (81.87%), dairy cattle vaccination (93.75%), ecto parasite treatment (81.25%), salt & mineral mixtures (80%) and endo-parasite (73.12 %). On the other hand, credit was the least adopted practices with the percentage of 17.5 followed by milking machines (32.5%), and record keeping (50.62%), feed concentrate (63.12%) are the least adopted innovations practices in the study area.

Table 2. Innovation practices by the Dairy farmers

Innovations	Adopter	%	Non-adopter	%
Artificial Insemination	134	83.75	26	16.25
Silage	131	81.875	29	18.12
Record Keeping	81	50.625	79	49.37
Vaccinations	150	93.75	10	6.25
Concentrated feed	101	63.125	59	36.87
Milking Machine	52	32.5	108	67.5
Ecto parasite Treatment	130	81.25	30	18.75
Endo parasite Treatments	117	73.125	43	26.87
Mineral Mixtures & Salt	128	80	32	20
Credit Facility	28	17.5	132	82.5

Table 3 showed the mean value gross margins, profit margins, and economic ratios as well as the standard deviation for all variables used in the calculation. The most important component is the dairy farm's total revenue, with mean value of 26746 TL. Total cost item with a mean value of 9657.25 TL. The third most important factor, gross margin, having mean value of 30772.71 tl is later used for multiple regression analysis. The fact that the NPV has a positive mean value of 222.44 indicates that the benefit from dairy farms outweighs the costs. The BCR ratio has a mean value of positive1.68, indicating that dairy farmers are making a healthy return over their investments.

Table 3. Gross margins and economic measures of dairy farms (1TL = 18.02 Rs.)

Variables	Mean	Standard Deviation
Silage/ Fodder Cost (TL)	3447.72	± 2023.06
Vaccine Cost (TL)	17.58	±11.28
Veterinary Cost (TL)	47.47	± 18.20
Artificial insemination cost(TL)	75.18	± 97.28
Concentrate Cost (TL)	2291.27	± 1638.23
Hay Cost (TL)	2651.74	± 1455.28
Electricity and water cost (TL)	118.57	± .00
Labor Cost (TL)	1007.68	± 392.01
Total cost (TL)	9657.25	± 5258.48
Quarterly Revenue (TL)	26746.29	± 13451.32
Quarterly Profit (TL)	30772.71	± 41379.86
NPV	222.44	± 299.11
BCR	1.68	± 0.60

Table 4 indicated that the profitability of dairy farmers influenced by socioeconomic variables such as age, education, family size, farming experience, land holdings, land under forage crops, as well as the innovation index and type of adoption. Z value of all the variables used in the multiple regression model lies between the ranges of ± 1.96 showed that data is normally distributed.

Table 4. Multiple Regression Analysis for Innovation Adoption on Profitability of dairy farmers

Parameters	Coefficients	T value	Significance
(Constant)		-2.79	.001**
Age (years)	-.15	-1.68	.09
Education (Years)	.021	.36	.71
Family size	-.06	-1.12	.26
Dairy farming Experience (Years)	.311	3.63	.00**
Land Holdings (Acre)	.03	.39	.69
Fodder Crops (Acre)	.06	.58	.56
Innovation sustainability Index	.12	2.20	.03*
Total Information Score	.04	.79	.43
Total dairy animals	-.34	-1.79	.07
Total milking animals	1.02	5.81	.00**
R^2		78.3	
F Value		31.73**	

*p<0, 05 **p<0,001

VIF value of all the selected variables has value less than 2 rejecting the chance of multicollinearity. The R^2 shows the goodness of fit. The value of R^2 is 78.3 represented that 78 percent variation in profit function was due to the variable included in the model and significance of F value endorse the situation. Coefficient of age, family size and total dairy animals has negative sign with rest of the variables has positive sign of association with the profitability of the farmer. Profitability of dairy farmers significantly influenced by innovation adoption index. More experienced gained by the dairy farmers, it improve the management level, better preparation to face the challenges and timely management of inputs operation at farm improve the profitability of dairy farm (Nyekanyeka et al., 2011). Higher the number of milking animals at farm generate more income on regular not only finance the cost of farm but also generate healthy income for the farmers to improve their living standards. Innovation sustainability index has positive association with the

profitability of the farmer which indicated that the adoption of innovation practices influenced the manufacturing practices and increase profits by improving the operations and management sector's productivity, accuracy, knowledge, competency and lowering the operational and management cost of firm or enterprise (Leiponen, 2000; Cefis and Ciccarelli, 2005; Shockley and Colleagues, 2011).

CONCLUSION

Adoption of innovation is critical in consolidating farmers and activating them in farm activities. Farmers can boost agricultural output, milk yield, product quality, and the standard of living for rural residents. A well-informed and understanding farming community, as well as large profit margins can accelerate adoption of innovations in a rural society. The impact of farmer profitability on innovation adoption highlighted in this study. The vast majority of farmers in the study area were only marginal adopters. The findings revealed that farmer profitability is significantly positively associated with innovation adoption and information score regarding the consistency and usefulness of innovation. The more farmers engage in innovative practices through interaction with the informative mindset, the easier farm management practices will be and the higher the profitability level, which will help to reduce poverty and improve living standards. Similarly, the profitability of dairy farmers positively related to the amount of land owned and the amount of land planted in forage crops. Unfortunately, the cost of land, rent, and credit is very high, and farmers have limited resources, which reduces the availability of green fodder over time along with poor credit excess is key barrier for the adoption of innovations. To encourage dairy farmers to adopt innovations, the government should subsidize dairy-related machinery, lower the interest rate on credit, and create an efficient extension network. Pakistan is an agriculture-based country and experiencing issues such as low production, food insecurity, inefficient agricultural management, and a complex agricultural system, which slow down the pace of country's economy. Due to low production and poor quality, competition in international markets is low. Because most farmers in rural areas are illiterate and unskillful, the government should establish education program centers for farmers and train them in farming. There are no price policies for farmers to get reasonable prices in crops, so the government should maintain logical production prices to set farmers' living standards. As a result, the government implements strategies to improve the agricultural system, such as investing in farmers through cheap credit, improve extension system, increasing livestock trade, timely vaccination against diseases with the collaboration of diary and livestock department healthy inflation adjusted pricing of outputs, ensure quality feed and mineral mixtures products and efficient utilization of natural resources. Pakistan should improve both the public and private sectors cooperation and coordination in order to improve the dairy sector systems. Dairy sectors requires the use of subsidized modern technology, so the farmers can avail the opportunities of mechanization, well-organized production, transportation, processing and storage methods for dairy products, improve packing and quality through dairy cooperatives and dairy associations. Build more small dams because most areas are water-stressed and have poor food and fodder crops, causing dairy animals to stop producing during peak milking season. Agriculture zones with public-private partnerships for domestic and international trade with no barriers or restrictions, as well as the implementation of efficient production policies for the smooth operation of the country's dairy sector

REFERENCES

Akudugu, M., Guo, E., Dadzie, S. 2012. Adoption of modern agricultural production technologies by farm households in Ghana: What factors influence their decisions? Journal of Biology. Agriculture and Healthcare 2(3): 1-14.

Berger, J.I. 2005. Perceived consequences of adopting the internet into adult literacy and basic education classrooms. Adult Basic Education. 15(2): 103-121.

Boz, I., Akbay, C., Bas, S. Budak, D.B. 2011. Adoption of innovations and best management practices among dairy farmers in the Eastern Mediterranean Region of Turkey. Journal of Animal and Veterinary Advances. 10(2): 251-261

Boz, I. 2015. Adoption of innovations and best management practices by goat farmers in eastern Mediterranean Region of Turkey. Journal of Agricultural Extension and Rural Development. 7(7): 229-239.

Budak, D.B., Boz, I., Akbay, C., Bas, S. 2012. Factors influencing the adoption of selected innovations by sheep farmers in the East Mediterranean region of Turkey. Journal of Animal and Veterinary Advances. 11(10): 1713-1718.

Bucci, G.D., Bentivoglio, M., Belletti, Finco, A. 2020, Measuring a farm's profitability after adopting precision agriculture technologies: A case study from Italy. Journal of ACTA IMEKO. 9(3): 65-74

Cefis, E., Ciccarelli, M. 2005. Profit differentials and innovation', Economics of Innovation and New Technology. 14: 43-61.

Chen, S., Ravallion, M. 2012. More Relatively Poor People in a Less Absolutely Poor World. Policy Research Working Paper 6114. Washington D.C.: World Bank.

Cinemre, H.A., Kılıç, O. 2015. Tarım Ekonomisi. Ondokuz Mayıs Üniversitesi, Ziraat Fakültesi, Ders Kitabı No:11, (5. baskı), Samsun.

Demiryürek, K. 2014. Agricultural knowledge, innovation, and social communication network. Agricultural Extension and Consultancy. Publication of Gaziosmanpaşa University, No: 2.

Demiryurek, K., H. Erdem, V., Ceyhan, S., Atasever, Uysal, O. 2008. Agricultural information systems and communication networks: The case of dairy farmers in the Samsun province of Turkey. Information Research. 13(2): 4.

Eryilmaz, G.A., Kiliç, O., Boz, İ., Kaynakçi, C. 2020. Süt sığırcılığı yapan işletmelerin tarımsal yeniliklerin benimsenmesi ve bilgi kaynakları yönünden değerlendirilmesi: Samsun ili Bafra ve Canik ilçeleri örneği. Journal of the Institute of Science and Technology, 10(2): 1361-1369.

FAO (Food and Agriculture Organization). 2022. Hunger and food insecurity. https://www.fao.org/hunger/en/

Foster, D., Rosenzweig, M. 1995. Learning by Doing and Learning from Others: Human Capital andTechnical Change in Agriculture. Journal of Political Economy. 103(6): 1176-1209.

Garcia, O., K. Mahmood, Hemme, T. 2003. A Review of Milk Production in Pakistan with Particular Emphasis on Small Scale Producers. PPLPI working paper no.3. Food and Agricultural Organization of United Nations. Pp-33

Karadeniz, E., Saruhan, V. 2021. Mardin ekolojik koşullarında farklı ekim zamanlarında yetiştirilen ikinci ürün silajlık mısır (*Zea mays* L.) çeşitlerinin silaj özelliklerinin araştırılması. ISPEC Journal of Agricultural Sciences. 5(2): 275-289.

Kariyasa, K., Dewi, A. 2011.Analysis of Factors Affecting Adoption of Integrated Crop Management Farmer Field School (Icm-Ffs) in Swampy Areas. International Journal of Food and Agricultural Economics 1(2): 29-38.

Kiliç, O., Eryilmaz, G.A. 2020. Samsun ilinde süt sığırcılığı yapan işletmelerin yapısal özellikleri. Türk Tarım ve Doğa Bilimleri Dergisi. 7(3): 637-645.

Khalid, U.B., Shahbaz, P., Ul Haq, S., Javeed, S. 2017. Economic Analysis of Integrated Farming Systems on Farm Income. A case Study of Sahiwal District, Punjab, Pakistan. Int. J. Manag. Econ. 3: 1434–1444.

Lavison, R. 2013. Factors Influencing the Adoption of Organic Fertilizers in Vegetable Production in Accra, Msc Thesis, Accra Ghana.

Leiponen, A. 2000. Competencies, innovation and profitability of firms. Economics of Innovation and New Technology. 9:1-24.

Makokha, S., Kimani, S., Mwangi, W., Verkuijl, H., Musembi, F. 2001. Determinants of Fertilizer and Manure Use for Maize Production in Kiambu District, Kenya. CIMMYT (International Maize and Wheat Improvement Center) Mexico.

Matuschke, I., Qaim, M. 2008. Seed market privatization and farmers` access to crop technologies: The case of hybrid pearl millet adoption in India. Journal of Agricultural Economics. 59: 498-515.

Mensah, A., M. Asiamah, C.A. Wongnaa, F. Adams and Etuah, S. 2020. Adoption impact of maize seed technology on farm profitability: evidence from Ghana. Journal of Agribusiness in Developing and Emerging Economies. 11(5): 578-598

Mwangi, M., Kariuki, S. 2015. Factors Determining Adoption of New Agricultural Technology by Smallholder Farmers in Developing Countries. Journal of Economics and Sustainable Development. 6(5): 208-216.

Nyekanyeka, T. 2011. Analysis of profitability and efficiency of improved and local smallholder dairy production: A case of Lilongwe milk shed area (No. 634-2016-41506).

Ogundari, K., Bolarinwa, O.D. 2019. Does Adoption of Agricultural Innovations Impact Farm Production and Household Welfare in Sub-Saharan Africa? A Meta-Analysis. Journal of Agricultural and Resource Economics Review. 48(1): 142–169

Ugwumba, C.O.A., Okoh, R.N., Ike, P.C., Nnabuife, E.L.C., Orji, E.C. 2010. Integrated farming system and its effect on farm cash income in Awka south agricultural zone of Anambra State, Nigeria. American-Eurasian Journal of Agricultural and Environmental Science, 8(1): 1-6.

Ouma, J., F. Murithi, W., Mwangi, H., Verkuijl, M., Gethi, De Groote, H. 2002. Adoption of Maize Seed and Fertilizer Technologies in Embu District, Kenya. CIMMYT (International Maize and Wheat Improvement Center), Mexico, D.F.

Özsayin, D. 2019. Economic Analysis of Dairy Cattle Farms in Turkey: A Case of Karacabey District. Türk Tarım ve Doğa Bilimleri Dergisi. 6(4): 759–765.

Pan, Y., Jackson, R.T. 2008. Ethnic difference in the relationship between acute inflammation and serum ferritin in US adult males. Epidemiology & Infection, 136(3): 421-431.

Pardey, P.G., J.M. Alston., C.C. Kang. 2012. Agricultural Production, Productivity and R&D over the Past Half Century: An Emerging New World Order. Invited plenary paper presented at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August 2012

Ravallion, M., Chen, S. 2004. How have the world's poorest fared since the early 1980s? World Bank Research Observer. 19(2): 141-170.

Rezvanfar, A. 2007. Communication and socio-personal factors influencing adoption of dairy farming technologies among livestock farmers. Livestock Resource Rural Development. 19.

Rogers, E.M. 1995. Diffusion of Innovations (Fourth Edition). The Free Press, New York.

Sauer, J., Vrolijk, H. 2019. Innovation and performance–evidence at micro level. Applied Economics 51(43): 4673-4699.

Shahbaz, P., Boz, I. 2020. Adaptation options for small livestock farmers having large ruminants (cattle and buffalo) against climate change in Central Punjab Pakistan. Environmental Science and Pollution Research, 27(15): 17935-17948.

Shahbaz, P., Abbas, A., Aziz, B., Alotaibi, B.A., Traore, A. 2022. Nexus between Climate-Smart Livestock Production Practices and Farmers' Nutritional Security in Pakistan: Exploring Level, Linkages, and Determinants. International Journal of Environmental Research and Public Health, 19(9): 5340.

Shockley, J.M., C.R. Dillon., Stombaugh, T.S. 2011. A Whole-Farm Analysis of the Influence of Auto-Steer Navigation on Net Returns, Risk and Production Practices. Journal of Agriculture land Applied Economics. 43(1): 57-75.

Türkten, H., Yıldırım, Ç., Ceyhan, V., Gündüz, O. 2016. Samsun ilinde sığır besiciliği faaliyetlerinden ortaya çıkan atık ve yan ürünlerin değerlendirilmesi ve yönetimi, Anadolu Tarım Bilimleri Dergisi, 31: 353-359.

Türkten, H.C., Yıldırım, V., Ceyhan, H., Soytoprak. 2017. The effects of applying biological control measures in greenhouse cultivation on the production efficiency in Kaş district of Antalya province, Turkey. European Journal of Sustainable Development, 6(3): 1-10.

Uaiene, R., C. Arndt, Masters, W. 2009. Determinants of agricultural technology adoption in mozambique. Discussion papers No. 67E

Udimal, T.B., Z. Jincai1, O.S. Mensah, Caesar, A.E. 2017. Factors Influencing the Agricultural Technology Adoption: The Case of Improved Rice Varieties (Nerica) in the Northern Region, Ghana. Journal of Economics and Sustainable Development. 8(8): 137-148.

Vollaro, M., Raggi, M., Viaggi1, D. 2019. Innovation adoption and farm profitability: what role for research and information sources? Bio-based and Applied Economics. 8(2): 179-210.

Yildrim, Ç., Türkten, H., Boz, İ. 2021. "Farmers' Points of Views of Rural Issues and Their Recommendations for Solutions." Black Sea Journal of Engineering and Science 4(1): 8-13.

Yildrim, C., Turkten, H., Ulhaq, S., Ceyhan, V. 2021. Effects of different types of labor hiring on economic performance and efficiency of farms in Kaş District of Antalya Province, Turkey. Journal of Agricultural Science and Technology, 0-0.

Wekesa, E., W. Mwangi, H. Verkuijl, K. Danda, De Groote, H. 2003. Adoption of Maize Technologies in the Coastal Lowlands of Kenya. CIMMYT, Mexico, D.F