Agricultura, Sociedad y Desarrollo

SOCIOECONOMIC FACTORS THAT INFLUENCE TECHNOLOGY ADOPTION FOR GENETIC IMPROVEMENT OF CATTLE IN PERU

Héctor V. **Vásquez**[1*], Christian Alfredo **Barrantes-Bravo**[2], Carmen N. **Vigo**[3], Jorge Luis **Maicelo-Quintana**[4]

[1]Dirección de Desarrollo Tecnológico Agrario, Instituto Nacional de Innovación Agraria-INIA, La Molina, Lima, Perú.
[2]Universidad Nacional Agraria La Molina, La Molina, Lima, Perú.
[3]Dirección de Desarrollo Tecnológico Agrario, Instituto Nacional de Innovación Agraria-INIA, La Molina, Lima, Perú.
[4]Instituto Nacional de Innovación Agraria-INIA, La Molina, Lima, Perú.
*Corresponding author: hvasquez@inia.gob.pe

Citation: Vásquez HV, Barrantes-Bravo CA, Vigo CN, Maicelo-Quintana JL. 2022. Socioeconomic factors that influence technology adoption for genetic improvement of cattle in Peru.
Agricultura, Sociedad y Desarrollo
https://doi.org/10.22231/asyd.v19i3.1358

ASyD 19(3): 312-330

Editor in Chief:
Dr. Benito Ramírez Valverde

Received: September 26, 2020.
Approved: February 23, 2021.

Estimated publication date:
December 07, 2022.

ABSTRACT

In the district of Florida (Peru), the process of technology adoption for the genetic improvement of cattle has been slow and the socioeconomic factors that influence this process are unknown. The objective of this study was to determine the socioeconomic factors that have influenced the adoption of technologies for the genetic improvement of cattle. A methodological model was used which integrates the quantitative and qualitative approach as a tool to obtain information through semi-structured surveys applies to a sample of 144 producers from the Florida district. A descriptive statistical analysis and correlation of variables were conducted and the logit model was used. Among the social factors that influenced the adoption of technologies for genetic improvement, there were: educational level, organization, technical assistance, land tenure, and knowledge in genetic improvement. The economic factors that influenced were: agricultural credit, main economic activity and milk production. In conclusion, socioeconomic factors influence the adoption of genetic improvement technologies for cattle, and increase the success rate in their implementation.

Keywords: market access, adopters, cattle herd, innovation, artificial insemination.

INTRODUCTION

According to the National Institute of Statistics and Information (2012) in Peru, cattle livestock production has great economic importance, with a population of 5 037 499 heads, of which 13% are milking cows (692,916 heads). In addition, between 1961 and 2012, there was a 62% growth of the population, with an increase of 1 921,441 heads of cattle. The Amazon region presents a total population of 157,166 heads of cattle, which develops in two large natural regions of sierra and rainforest, with differentiated productive systems that give adequate conditions for the development of sustainable development according to the Ministry of Agriculture and Irrigation (MINAGRI, 2014). The Gross Domestic Product of the agriculture, livestock production, hunting and silviculture sector of the Amazon region represents 3.5% of the national Gross Domestic Product of the sector with a value of 1 049 723 soles (Instituto Nacional de Estadística e Informática-INEI, 2019).

In genetic improvement in Peru, the following are considered as principal improvement practices: artificial insemination and use of breed sires (MINAGRI, 2017). Therefore, the characteristics of technological innovation for genetic improvement in the country are considered complex, because they require greater technical assistance for their adoption, and it is necessary for producers to have more agrarian information and higher use of technologies (Maicelo and Alegre, 2013).

Livestock production in Peru develops under three modalities: commercial livestock production, small and medium livestock production, and subsistence livestock production. In the study zone, the last two modalities predominate. They are characterized for being semi-intensive and extensive farms with Creole and improved Creole livestock, with producers who have an intermediate educational level, without access to formal credit and information, weakly organized, and with semi-developed connections with the market (MINAGRI, 2017). The predominant trading systems in the study zone are sale at street level and sale with local middlemen (Salazar, 2016).

The livestock-producing micro-basin of Pomacochas, district of Florida, presents a great potential for the production of dairy cattle, with a total of 7,742 heads of cattle and 15,000 ha of lands for this purpose (INEI, 2012). The soils are covered with natural and cultivated grasslands, presenting adequate soil characteristics for the installation of pastures, and the livestock activity constitutes the main factor generating employment and economic resources for the development of livestock producers, according to the Instituto de Investigaciones de la Amazonía Peruana (IIAP, 2010).

Innovation in genetic improvement of cattle in the district has been a slow process, having obtained some crosses with improved breeds; however, these animals have not produced milk and meat according to the productive average of Peru of 6 kg/cow/campaign for milk and 140 kg/heads for beef (MINAGRI, 2017), which is why the producer has been forced to have a larger number of animals and grazing areas for their breeding, as mentioned by the Regional Agriculture Direction of the Amazon (*Dirección Regional de Agricultura de Amazonas*, DRAA, 2011). Therefore, different public and private institutions have worked in the genetic improvement of cattle, through the application of different programs of technical assistance and introduction of technologies, such as artificial insemination and embryo transference, to achieve livestock production development. However, these institutions still have not managed to foster substantial changes in milk production, which postpones the implementation of technologies for producers (Delgadillo and Montaño, 2017). These institutions, until today, do not contemplate social and economic factors within their programs as the main axis for the development and adoption of new technologies.

Based on the aforementioned, the objective of the study was to identify which social and economic factors intervene in technology adoption for the genetic improvement of cattle in the region of Florida, Peru. The hypothesis that was considered is that socioeconomic factors influence the adoption of genetic improvement technologies.

MATERIALS AND METHODS

Description of the study zone

The study zone is located in the district of Florida between coordinates 5º 44’ 47.3” S, 77º 50’ 30.9” W and 5º 53’ 24.7” S, 78º 6’ 8.3” W, in the datum World Geodetic System (WGS) from 1984. The average altitude of the area is 2,200 masl. It presents a mean annual temperature of 14 °C generated by the Pomacochas Lake with a relative humidity of 87% (Estación Meteorológica Convencional-Pomacochas).

Population of interest

The district of Florida has a population made up by 8,257 agriculture and livestock producers: 4,393 men and 3,864 women, who are mostly adult population. The study unit was made up of a population of 791 agriculture and livestock units that handle cattle (INEI, 2012).

The sample was probabilistic and used stratified random sampling proportional to the sizes of each stratum, taking into consideration the size of the livestock herd, according to the number of animals that the producer handles (Table 1).

The sample size was obtained by using the formula proposed by Cochran (2000):

$$n_0 = \frac{\sum W_h P_h Q_h}{V}$$

where W_h: weighing in each stratum; P_h: producers that have the characteristics of interest, Q_h: producers that do not have the characteristic of interest; V: Variance expected given by: $V=(E/z)^2$; E: Maximum estimation error, and z: confidence value.

$$\text{If } \frac{n_0}{N} < 5\%, \text{ then } n = n_0$$

$$\text{If } \frac{n_0}{N} \geq 5\%, \text{ then } n = \frac{n_0}{1 + \frac{\sum W_h p_h q_h}{NV}}$$

Table 1. Sample size.

Strata	h (heads number) INEI 2012	Nh	Wh	Ph	Qh	WhPhQh	nh
Little	1 to 2	159	0.2011	0.50	0.50	0.05025	25
	3 to 4	131	0.1656	0.50	0.50	0.04143	21
	5 to 9	244	0.3085	0.50	0.50	0.07711	39
Medium	10 to 10	146	0.1846	0.50	0.50	0.04614	23
Long	20 to 49	105	0.1327	0.50	0.50	0.03318	17
	50 to 49	6	0.0075	0.50	0.50	0.00189	1
Total		791	1.0	…	…	0.25	126

Assignment of the sample: for proportional fixation to the size of the stratum (each stratum according to the number of animals per herd).

$n_h = N_h / N$ $h=1,2,\ldots,6$
If $p=0.50$ Probability of adoption in producers.
If $E=0.08$ and the coefficient of confidence of 95%; $z=1.96$.
$V=(E/z)^2$ $V=0.00167$

Correction for finite population was used:

$$n = \frac{n_0}{\left(1 + \frac{n_0}{N}\right)}$$

where n: Size of the final sample.

The initial size of the sample was 126, and after applying the correction factor an optimal of 144 producers was obtained.

Assessment variables and information gathering techniques

Two study variables with different dimensions were considered. The first corresponds to social factors such as: characteristics of the producer, migration, characteristics of the herd, production system, level of organization, access to information, and level of knowledge. The second to economic factors such as: economic characteristics of the producer, access to sources of financing, access to the market. Dependent variables were also considered, such as the degree of adoption, level of production, to support the study and the description of the results (Table 2).

The survey, which was structured with 55 questions (open and closed), constituted the fundamental basis for information gathering, both qualitative and quantitative, and its respective analysis.

Data analysis

The mixed approach which integrates qualitative and quantitative aspects was used, and the correlation between independent and dependent variables was determined. Then, the variables were segmented according to their measurement (ordinal, nominal and scalar), and finally a filtration of non-significant variables was conducted for the statistical analysis of data.

To test the hypotheses, bivariate correlations and the logistic regression model were used, which has a non-linear bond connection, monotonous, growing and limited between 0 and 1, which allowed analyzing the associations between the dichotomous categorical dependent variable (criterion variable) and quantitative and qualitative independent variables (regressive or predictive) (Pece *et al.*, 2012). To understand the part of the

Table 2. Study variables.

	Dimension	Study variables	Definition	Measurement Scale/Type	Coding
			Social factors		
Independent variable	Socioeconomic factors influencing technology adoption (Explanatory Variables)	Producer's characteristics	Sex of decision maker in herd	Nominal/ qualitative	1=Male 2=Female
			Age of person (years)	Nominal/ quantitative	1= Greater than 40 2= Lower than 40
			Number of family members	Discrete, continuous/ quantitative	0-15
			What level of education of the herd's head of household of the herd?	Nominal/ qualitative	1= Illiterate 2= Initial 3= Primary school complete 4= Incomplete primary 5= Secondary complete 6= Secondary incomplete 7= Technical high school 8= Higher education
			What is your place of birth?	Nominal/ qualitative	1= In the same community 2= Another community in the district 3= Another community in the province 4= Another community in the same region 5= Another region
			What is your main activity main activity that you carry out in the herd?	Nominal/ qualitative	1= Agriculture 2= Livestock 3= Forestry 4= Commerce 5= Homemaker 6= Transportation 7= Other
			The land you work is	Nominal/ qualitative	1= Owned 2= Leased 3= Shared 4= Granted/community 5= Landless

Table 2. Continuation.

	Dimension	Study variables	Definition	Measurement Scale/Type	Coding
Independent variable	Socioeconomic factors influencing technology adoption (Explanatory Variables)	Knowing the migration of the producer	Main places you travel within the country	Nominal/ qualitative	1=Cajamarca 2=Chiclayo 3=Piura 4= Trujillo 5=Lima 6=Other
			Main reason for you travel	Nominal/ qualitative	1=Commerce 2=Employment 3=Education 4=Family 5=Health 6= Tourism 7= Other
		Characteristics of the herd characteristics	Where do your cattle come from?	Nominal/ qualitative	1=From the same place 2=From the same region 3=From another region 4=Other sector
			Number of head of cattle in the cattle herd	Categorical/ quantitative	1= Less than 10 2= From 11 to 20 3= More than 20
			What breeds of cattle cattle you raise in your herd?	Multicriteria/ qualitative	1=Brown swiss 2= Simmental 3= Holstein 4= Cruces 5= Criollo
			You raise cattle cattle for	Categorical/ qualitative	1= Milk 2= Meat 3= Meat and milk
			Performs some processing of these products	Nominal/ qualitative	1=No 2=Yes
			What is the main source main source of feed for your livestock?	Categorical/ qualitative	1=Natural grass 2= Improved grass 3= Concentrates 4=Grass and concentrate
			What area of land is available for raising cattle?	Categorical/ quantitative	1= From 1 to 5 ha 2= From 6 to 10 3= From 10 to 20 4=More than 21 hectares
		Accessibility to the cattle herd	It has an access road to access to its herd livestock	Nominal/ qualitative	1= Horse trail 2= Carriageway 3=Road 4=None

Table 2. Continuation.

	Dimension	Study variables	Definition	Measurement Scale/Type	Coding
Independent variable	Socioeconomic factors influencing technology adoption (Explanatory Variables)	Management system	What management system do you use in your herd?	Nominal/ qualitative	1= Extensive "Loose". 2= Semi-extensive 3= Stabled "Stable" 4= Semi-stabled
			Mainly what problems you have in raising your breeding of your animals	Nominal/ qualitative	1=Food 2=Diseases 3=Management 4=Reproduction 5=Other
			What are the pasture availability problems?	Nominal/ qualitative	1=Rowed pasture area reduced 2=Low production 3=Strong droughts 4=Presence of frost 5=Overgrazing 6=Areas without rest
		Level of organization of producers	Are there cattle producer organizations in the area?	Nominal/ qualitative	1=No 2= Yes
			Are they associated with any producer association?	Nominal/ qualitative	1=Cooperative 2=Producers producers 3=Executing nucleus 4=Farming farmer community 5=Committee of the glass of milk 6=Other
			Are they associated with any producer association?	Nominal/ qualitative	1= Associate 2= Not associated
			The association of producers contribute to the development of the livestock activity	Nominal/ qualitative	1=Yes 2=No
		Information access	Mainly, through through whom or what media is informed about the genetic improvement breeding	Nominal/ qualitative	1=Neighbors/Relatives 2=Engineers or technicians 3=Institutions working in the community 4= Radio/Television 5=Other
			Has received training in the last year and how many	Nominal/ qualitative	1= No 2= Yes, How many

Table 2. Continuation.

	Dimension	Study variables	Definition	Measurement Scale/Type	Coding
Independent variable	Socioeconomic factors influencing technology adoption (Explanatory Variables)	Information access	Receives technical assistance on genetic improvement	Nominal/ qualitative	1= No 2= Yes
			Is there any genetic improvement program in the area	Nominal/ qualitative	1=No 2=Yes
			Institution providing information and technical assistance on genetic improvement	Categorical Continuous/ qualitative	1=DRA 2=Municipality 3=University 3= NGOs 4= Special projects 6= None
			Access to information on genetic improvement	Nominal/ qualitative	1= No 2= Yes
			What means of communication do you use to communicate with the inseminator?	Nominal/ qualitative	1= Cellular 2= Radio 3= Verbal 4= None
		Knowledge level	What is the genetic characteristic of your animals?	Nominal/ qualitative	1=Creole 2=Improved 3=Purebred
			What characteristic do you think needs to be improved in your cattle?	Nominal/ qualitative	1=Productivity 2= Size 3= Hardiness 4=Other, which
			Do you know about genetic improvement?	Nominal/ qualitative	1= No 2= Yes
			Do you know about technologies for genetic improvement?	Nominal/ qualitative	1= No 2= Yes
			On what topic have you received training in the last year?	Nominal/ qualitative	1= Genetic breeding. 2= Pasture management 3= Livestock management 4= Health 5= Other
			Can you recognize an improved animal?	Nominal/ qualitative	1=No 2=Yes
			What breeding practices do you know?	Nominal/ qualitative	1=Selection of the best animals 2=Crossbreeding with improved 3=Other
			What breeds of bulls do you use for breeding?	Nominal/ qualitative	1= Brown swiss 2=Holstein 3=Simmental 4= Otros
			Do you use ancestral customs for the improvement of your livestock?	Nominal/ qualitative	1=No 2=Yes, Which

Table 2. Continuation.

	Dimension	Study variables	Definition	Measurement Scale/Type	Coding
				Economic factors	
Independent variable	Socioeconomic factors influencing technology adoption (Explanatory Variables)	Economic characteristics of the producer	As head of household goes out to work outside his locality	Nominal/ qualitative	1= No 2= Yes
			What is the activity that provides the most income to support your family?	Nominal/ qualitative	1=Agriculture 2=Livestock 3=Other
			Do you pay for the artificial insemination or embryo transfer service?	Nominal/ qualitative	1=No 2= Yes
			What type of labor do you use to manage your livestock?	Nominal/ qualitative	1=Family 2=Hired laborers 3=Communal work (Minka) 4= Exchange with neighbors
			From which main activity does your income come from?	Nominal/ qualitative	1=Sale of agricultural products 2=Sale of livestock products 3=Salary income 4=Other
		Access to financing	Are there any companies in your area that provide credit to the agricultural sector?	Nominal/ qualitative	1=No 2=Yes
			Do you have access to any source of financing or credit?	Nominal/ qualitative	1= Yes 2= No
			Have you ever applied for credit?	Nominal/ qualitative	1= Yes 2= No
Dependent variable	Adoption of technologies for genetic improvement (Variable to be explained)	Adoption Grade	Adopts genetic improvement technology	Nominal/ qualitative	1=No 2=Yes
	Livestock production	Production level	Number of cattle dedicated to milk production	Nominal/ qualitative	1=No 2=Yes 1=From 1 to 5 2=6 to 10 3=11 a 15 4=16 to 20 5=More than 21 heads
			Liters of milk produced per campaign	Continuous/ quantitative	0 to more
			Amount of livestock sold annually	Continuous/ quantitative	0 to more
			Liters of milk sold monthly	Continuous/ quantitative	0 -500

dependent variable that is explained by the logit model, the Cox and Snell, and Nagelkerke R-squared tests were applied.

The πi logit model has probability of success in the binomial variable Y_i subjected to different scenarios $X_{i1},\ldots, X_{ip}$. The continuous or categorical variables can belong to X_{ij}, the model's factors $\beta_1,\ldots, \beta_p$ were evaluated by the maximum authenticity method.

The model used in the research study has a non-linear bonding function, which is monotonous, growing and limited between 0 and 1. The logistic regression analyzed data distributed binominally of the form: Hosmer and Lemeshow (2000).

$Y_i \sim B\ (p_i,\ n_i)$, para i=1,…, m.

The interpretation conducted of the estimates of parameter βj is equal to the additive effects in the logarithm of the odds ratio for a unit of change in the j-th explicative variable. For the case of the dichotomous explicative variable, and e^{β} is the estimation of the odds ratio (OR) for each risk factor X_i, with an equivalent formulation given by:

$$p_i = \frac{1}{1 + e^{-\left(\beta_0 + \beta_1 X_{1,i} + \ldots + \beta_k X_{k,i}\right)}}$$

The analysis of the variables was performed using the Statistical Package for the Social Sciences – SPSS software, version 20, to establish different correlations, and for the ordinal ones it was done through Spearman correlation coefficients (rs), Tau-b Kendal nominals, and Pearson scalar variables (Milla, 2013).

RESULTS AND DISCUSSION

The analysis of the degree of influence on the adoption of technologies allowed classifying the producers according to strata (Figure 1). It was found that the decision in the livestock herd is made in the largest percentage by men, in all the strata according to the analysis of the survey applied. These results corroborate the reports from INEI (2012) which indicate that in Florida 80.54% of the agriculture and livestock producers are men and 19.45% are women.

In herds that are larger than five heads, men are the ones who make the decisions, and women mostly participate in the activities of milking, transformation and commercialization of milk. In this regard, Sandoval *et al.* (2007) found in Mexico that in the small-scale livestock stratum, women's participation is higher; in medium-scale livestock producers, 60% of the decisions are assumed by the man. However, according to Rodríguez *et al.* (2015), the members that make up the family do not have an impact on the adoption of management technologies for milk production in Colombia.

The age of the producers, in all the strata, was over 40 years, representing 66.9%, which could mean a higher degree of adoption, as indicated by Roco *et al.* (2012), who mention that the age of the producer has a positive influence in the adoption of soil conservation practices.

Regarding the educational level, it is observed that in small-scale livestock producers there is an illiteracy rate of 9.3% which is lower than the illiteracy rate of the agriculture and livestock

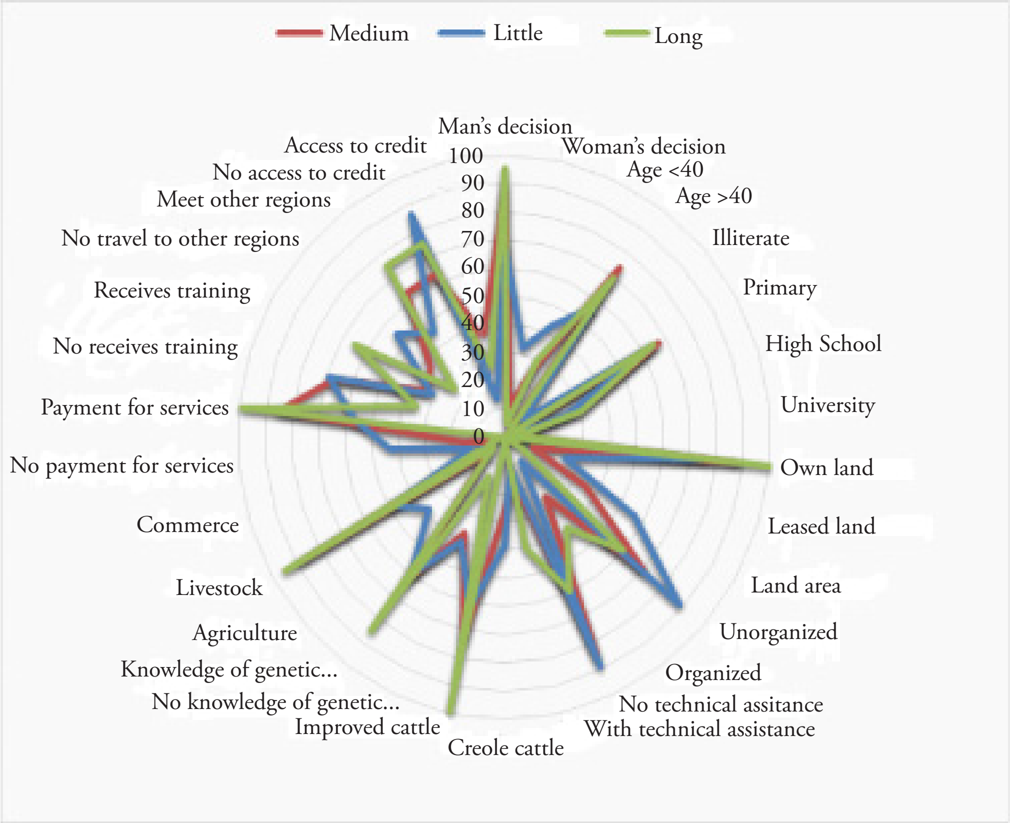

Figure 1. Percentage classification according to strata (small, medium and large) of producers that handle cattle in the district of Florida.

producer at the national level, which is 14.44% (INEI, 2012). When it comes to medium and large livestock producers, it was observed that 29.9% has secondary school level, while the large-scale livestock producers stand out with a higher degree, with 5%. Most of the interview respondents know how to read and write (93.7%), which indicates that the medium and large livestock producers have a higher degree of technology adoption for genetic improvement, since they receive training in issues related to genetic improvement through the participation of the extension technicians from government institutions such as the Regional Agricultural Direction (*Dirección Regional de Agricultura*, DRA), public universities, and some NGOs. In this regard, Mathios (2019) mentions that there is a relationship between the level of education and the levels of adoption of new technologies, since if most of the livestock producers have a low educational level, the adoption of new technologies of genetic improvement of cattle becomes more complicated.

Land tenure in the three strata indicates that the lands are property of the producer with 88.4%. In this regard, Molina and Álvarez (2009) state that the degree of belonging to the land is an important factor in technology adoption, since it allows the owner to invest in livestock exploitation without restrictions and to maintain a higher number of animals in the livestock herd.

Regarding the area of the land, small-scale producers have one to five hectares, which represent 56.3%; medium-scale livestock producers have 6 to 20 ha with 35.4%; and the large-scale livestock producers have 21 or more hectares with 8.3%. In this regard, Roco *et al.* (2012) found that the producers with larger plots have higher probability of technology adoption.

Concerning the organization, it is observed that in the strata there is high percentage of livestock producers who are not organized. From this group, small-scale livestock producers stand out with 88.7% of non-organized livestock producers. However, the large-scale livestock producers show an organization percentage of 40%. These results are different from those found by Sandoval *et al.* (2007), who mention that the livestock producers from two agroecological zones in Yaracuy (Venezuela), became organized with the objectives of purchasing inputs, wombs, product sale, and in most cases are related to small-scale producers of type C with 62.5%, and in the other strata, the organization is practically inexistent.

The producers in the different strata have improved cattle, and it is most notorious in the stratum of large-scale producers with 99%, who use natural mounting and artificial insemination with semen from improved bulls from genetic houses, with the aim of increasing the production of milk and meat. In this regard, Marizancén and Artunduaga (2017) manifest that the genetic improvement practices are being accepted by large-scale producers, primarily due to the commercial and productive demands, ensuring meat and milk livestock productivity which also influences the competitiveness of the sector.

According to the data gathered in the survey, the small-scale livestock producers have livestock production as main economic activity, with 48.5%, followed by agriculture with 38%, and commerce with 13.4%. These complementary activities generate additional economic income to maintain the herd. However, in the medium and large livestock producers, the situation is different, since 90% sustain their economy on livestock production and are worried over performing investments and improvements, with the aim of increasing the production and permanent income in the herd. In this regard, Sandoval *et al.* (2007) found that in Mexico, 87.5% of the small-scale livestock producers develop other activities that provide higher income than livestock production.

Regarding the movements that producers carry out, it is observed that small-scale livestock producers are the ones that least travel to other regions. On the other hand, medium and large livestock producers are the ones that show a greater displacement (62.9% and 75%), with trade being one of the main motives in places such as Chiclayo, which influences the capacity for innovation, since they have permanent access to new knowledge and technologies in genetic improvement, as corroborated by Orozco *et al.* (2009), who state that knowledge increases with the displacement of producers because it influences favorably the adoption from producers that have better possibilities of experiencing new technologies.

When it comes to access to training in livestock activity, most of the small and medium livestock producers do not have access to training (69.1% and 66.7%), which cause difficulties to understand new technologies and gain access to new knowledge. However, in large-scale livestock producers, 65% receives training, which increases their opportunities to have access to the technologies focused on genetic improvement, and management of grasses and diseases (Mesa and Machado, 2009).

Concerning the economic factor, willingness to pay for the genetic improvement service, it is seen that 43.3% of the small-scale producers and 14.8% of medium-scale livestock producers are not willing to pay for the services. This could be due to different circumstances such as limited economic resources or low level of knowledge of the techniques applied. Likewise, in the medium and large strata, there is greater predisposition to pay for these services (68.1%), which indicates that these producers use artificial insemination and embryo transfer more frequently. In this regard, Cuevas *et al.* (2013) found in Mexico that 41.9% of the production units carry out artificial insemination, presenting a higher level of economic resources to assume the cost of the dose and a higher knowledge of the benefits that it has to improve the herd.

Correlation of variables

The correlation of the data obtained in the survey determined that the educational level and the adoption of technologies for genetic improvement of cattle are positively correlated (r= 0.21**). That is, a producer with a higher educational level seeks information about a technology, and in addition to this, implements and adopts it through a transference channel that is sufficiently robust and dynamic (Camacho *et al.*, 2017). In this study, the small-scale livestock producers are the ones that present more limitations in technology adoption, due to the lower educational level, which makes access to knowledge and information more difficult. For their part, Velasco and Ortega (2008) mention that the producer's education is a factor that influenced the adoption of the technological practice of artificial insemination in double-purpose livestock farms of the Maracaibo Lake Basin.

Regarding the characteristics of the herd, it was estimated between the variables of area of land available for breeding and number of heads of livestock with technology adoption (r= 0.44**, r= 0.49**) and they evidence that as the area of land available and number of heads are higher, technology adoption for genetic improvement of cattle increases. In this regard, Vélez *et al.* (2013) evaluated in Mexico the factors that influence the probability of technology adoption in family dairy production units, and they found that when increasing by one hectare the areas devoted to livestock production, the adoption of technologies in management, reproduction and genetics, health, fodder, feed and the environment increased by 0.26%.

A positive correlation was found with the following variables: breeds of livestock (0.17**), origin of the livestock (0.253**), availability of grasses (0.215**), and feed (0.246**); that is, the producers who have these characteristics of herd management have better conditions for genetic improvement of their animals and purchasing power to innovate and adopt new technologies in benefit of the herd.

When it comes to level of organization, a positive correlation is found, since the existence of an organization of cattle producers in the study zone influences the adoption of genetic improvement technologies for cattle (r= 0.29**). In this regard, Valera (2013) in Cajamarca found that producers who belong to a producers' organization increase the intensity of adoption (r= 0.31**) and there is correlation between the fact that producers participate actively in an organization and in the adoption of the vine crop, because it eases access to information and knowledge.

Regarding technical assistance (r = 0.29**), it is indicated that with greater access to technical assistance in any of its modalities (individual or group) together with other factors, the probability of the participant adopting technology increases. In this regard, Forero *et al.* (2013) found in Colombia a highly significant correlation between technical training and assistance with technology adoption.

Likewise, a negative significant association was detected between the variable access to information in genetic improvement and technology adoption (r= -0.39*). That is, with lower access to knowledge in genetic improvement, the possibility of technology adoption for genetic improvement is lower, given that information and knowledge constitute essential components for adoption (Valera, 2013). Instead, if their level of knowledge improves, their personal training and ability to interrelate and participate in the development of their production units improve; and therefore, the technology adoption index increases (Mejía, 2016).

In the analysis about the level of knowledge, the variables tools for genetic improvement, permanent training, and having improved bulls (r= 0.49**), (r= 0.47**), (r= 0.38**), showed that producers who have greater knowledge have a higher probability of adoption for genetic improvement. In this regard, Maicelo and Alegre (2013) mention that an agricultural information and knowledge system connects people and institutions to promote mutual learning and to share and use technology, based on various sources, means and forms of communication of information.

In the variables of the economic factor, the main economic activity that the producer develops presented a positive correlation coefficient (r= 0.24**), which indicates that the producers who have livestock production as main economic activity, associated to a higher number of animals and hectares of land, have better possibilities of adoption. On the other hand, we can mention that the producers who carry out other economic activities such as agriculture or trade, among others, have less possibilities of adoption, since they diversify their activities to minimize risks and satisfy their basic needs, and do not have money to reinvest in the livestock activity (Oliva *et al*., 2018).

Regarding the willingness of producers to pay for the services of artificial insemination and embryo transfer, there was a positive correlation with technology adoption for genetic improvement (r=0.26**); it is shown that the producer had willingness to pay for the services of technology adoption for genetic improvement of cattle, associated to a higher income in the herd and better knowledge of the benefits that using these services entails.

Díaz *et al.* (2014), in Mexico, found that out of the total producers who have adopted technology, only 16.7% use artificial insemination and have willingness to pay for the service. However, they do not have good economic control of the livestock herd, which makes the adoption of technologies such as artificial insemination difficult.

In access to financing, the results indicate that the companies that provide credit to the agriculture and livestock sector and access to credit correlated positively with technology adoption (r=0.41**; r=0.31**); that is, the existence of credit companies and the ease in access to credit facilitate for medium and large producers to be able to adopt technologies (Roco *et al.*, 2012). The opposite happens with small-scale producers, for whom credit is expensive and difficult to obtain, because they are considered risky debtors and because the weakness of their land tenure rights offers few guarantees to back up their debts. According to Salas *et al.* (2013), access to credit is a factor that clearly explains the decision to accept or reject a new technology.

The variables milk production and livestock trade correlate with the high degree of significance with the adoption of technologies for genetic improvement of cattle (r= 0.44**; r= 0.46**). In this regard, Alvarado (2015) found that income and access to financing are considered important for economic growth and improvement of producers' quality of life.

The monthly income that results from livestock activity was positively associated with technology adoption (r=0.55**). This indicates that the producer who receives higher income from livestock activity has higher possibilities of adopting technology, to carry out improvements in the herd, since they consider it their main economic activity. In this regard, Salas *et al*. (2013) found in Mexico that livestock producers with the highest income are the ones who adopted technologies referring to the improvement and commercialization of livestock, to solve basic production problems.

Regression of variables

According to the logistic regression model, among the social factors that influence technology adoption, the ones that refer to the level of knowledge about tools for genetic improvement stand out (0.002**), with a positive coefficient of OR= 23.94. This indicates that there is association between this variable and technology adoption, where OR= 23.94 indicates that livestock producers who have greater knowledge about biotechnological tools for genetic improvement have 23.94 times more opportunities to adopt the technology.

Likewise, the variable genetic characteristic of the herd animals was significant (0.09*), since its OR was 5.30. This indicates that the livestock producers who have improved animals have 5.30 more opportunities to adopt the technology. For this case, the large-scale livestock producers who own 99% of improved animals are the ones that show higher interest to innovate and adopt technologies for genetic improvement of cattle.

The producer who belongs to an organization has an OR=4.64, which indicates that he has 4.64 times more possibilities of technology adoption for genetic improvement of cattle.

Regarding the economic factor, it was found that access to financing influences the adoption of technologies, because the variable linked to the companies that provide agriculture and livestock credit was significant (0.096*) with OR=3.29, indicating that as long as there is a higher number of credit companies, there are 3.29 times more opportunities to have access to credit to invest and adopt. In terms of the variable access to credit, it was significant (0.01*) and showed a high positive coefficient (B=3.07). This indicates that the degree of association between this variable and technology adoption, where OR=21.57 shows that livestock producers who gained access to credit to improve livestock production has 21.57 times more possibilities of technology adoption for genetic improvement (Table 3).

CONCLUSIONS

The profile of the adopter has a higher educational level (complete secondary), belongs to a producers' organization, receives technical training and assistance, and is owner of the land, which allows a higher degree of knowledge for the use of adequate tools and the incorporation of innovations in the improvement of the livestock herd. Likewise, they have areas of land with adequate pastures for animal feed, has a higher number of animals and of different breeds for a higher capacity of innovation.

The social variables such as education level, area of land available for breeding, number of heads of livestock, breeds of livestock, level of organization, technical assistance; and the

Table 3. Estimation of the logistic regression model (logit) of social and economic factors.

Factors	Study variables		B	E.T.	Wald	Sig.	Exp (B)/OR
Social	Producer's characteristics	Herd decision	-0.88	1.03	0.73	0.39^{ns}	0.42
		Educational level	0.47	0.34	1.98	0.16^{ns}	1.61
	Livestock's herd characteristics	Land tenure	-0.42	0.88	0.23	0.64^{ns}	0.66
		Heads number	0.63	0.46	1.87	0.17^{ns}	1.87
		Area of land available for Livestock	-0.18	0.45	0.16	0.69^{ns}	0.83
		Livestock breeds	0.14	0.19	0.51	0.48^{ns}	1.15
		Feeding	0.20	0.72	0.07	0.78^{ns}	1.22
	Organizational level	Organizational level	1.53	1.06	2.08	0.15^{ns}	4.64
	Information access	Technical assistance	-0.06	0.88	0.01	0.94^{ns}	0.94
		Technical assistance	-0.11	0.87	0.02	0.90^{ns}	0.89
	Knowledge level	Knowledge	-0.61	0.97	0.39	0.53^{ns}	0.54
		Genetic characteristics of animals	1.67	0.97	2.94	0.09^{*}	5.30
		Genetic improvement tools	3.18	1.00	10.06	0.002^{**}	23.94
		Recognizes animal enhanced	0.38	1.27	1.09	0.77^{ns}	1.46
Economic	Producer's economic characteristics	Principal economic activity	-0.46	0.48	0.90	0.34^{ns}	0.63
	Access to finance	Credit companies	1.19	0.72	2.77	0.09*	3.29
		Access to finance	3.07	1.24	6.11	0.01*	21.57
	Production level	Milk production	-0.02	0.03	0.54	0.46^{ns}	0.98
		Livestock marketing	0.15	0.12	1.52	0.22^{ns}	1.16

*p<0.1; **p<0.05, B: coefficient, S.E: standard error, Sig: significance, Exp (B)/OR: exponential coefficient B or Odd ratio.
The Nagelkerke R-squared value of 0.769 indicates that 76.9% of technology adoption for the genetic improvement of cattle is explained by the independent variables included in the logit model.

economic variables, such as main economic activity, access to financing, milk production and livestock trade are associated to technology adoption for genetic improvement of cattle, since they showed significant and highly significant coefficients of correlation.

The variables which contributed significantly and predicted the adoption of technologies for genetic improvement of cattle were: the genetic characteristic of the animals (Creole, improved and pure breed), the degree of knowledge of tools for genetic improvement. The economic factors that influence technology adoption are credit companies and access to financing.

The socioeconomic factors studied did influence the adoption of technologies for genetic improvement of cattle in the different segments of producers from the district of Florida.

The issue of technology adoption is broad and complex, which is why it would be very important to continue with the analysis incorporating professionals from other disciplines, such as Sociology and Economy, so that producers and their real needs can be understood with more rationality in order to facilitate the adoption.

The future that opens for each of the segments of producers studied, if the level of knowledge about the advantages of genetic improvement can be improved, is the adoption of technologies described that are considered an important mechanism for promotion of the productive and economic development of developing countries, especially from sectors such as the livestock and agriculture sectors and in zones of special management like the High Andean.

REFERENCES

Alvarado L. 2015. Análisis de la adopción de tecnológica de técnicas agrícolas orgánicas para productores de café. Natura@economía, 2(1). Recuperado de https://docplayer.es/amp/144642358-Analisis-de-la-adopcion-tecnologica-de-tecnicas-agricolas-organicas-para-productores-de-cafe.html

Camacho J, Cervantes F, Palacios MI, Rosales F, Vargas J. 2017. Factores determinantes del rendimiento en unidades de producción de lechería familiar. Revista Mexicana de Ciencias Pecuarias, 8(1), 23-29. doi: https://doi.org/10.22319/rmcp.v8i1.4313

Cochran W. 2000. Técnicas de Muestreo. México: Continental. pp: 17-19.

Cuevas V, Baca J, Cervantes F, Espinoza J, Aguilar J, Loaiza A. 2013. Factores que determinan el uso de innovaciones tecnológicas en la ganadería de doble propósito en Sinaloa, México. Revista Mexicana de Ciencias Pecuarias, 4(1). Recuperado de http://www.scielo.org.mx/pdf/rmcp/v4n1/v4n1a3.pdf

Delgadillo J, Montaño E. 2017. Innovación y competitividad del sistema lechero en Valles Centrales de Querétaro. Hacia un modelo de gobernanza territorial. Revista de Alimentación Contemporánea y Desarrollo Regional, 27(50), 1-38. doi: http://dx.doi.org/10.24836/es.v27i50.412

Díaz A, Sardiñas Y, Castillo E, Pardilla C, Jordán H, Martínez R, Ruiz T, Díaz M, Moo A, Gómez O, Tovar D, Arjona M, Ortega G. 2014. Caracterización de ranchos ganaderos de Campeche, México. Resultados de proyectos de transferencia de tecnologías. Avances en Investigación Agropecuaria, 18(2). Recuperado de https://www.redalyc.org/articulo.oa?id=83731110004

DRAA. 2011. Dirección Regional de Agricultura Amazonas. Plan estratégico regional agrario de la región Amazonas. Recuperado de http://www.regionamazonas.gob.pe/docs/portal/contenidos/2/060720171242302100049804.pdf

Forero C, Rojas G, Argüelles J. 2013. Capital social y capital financiero en la adopción de tecnologías ganaderas en zonas rurales altoandinas de Colombia. Corpoica Ciencia Tecnología Agropecuaria, 14 (2). Recuperado de http://www.scielo.org.co/pdf/ccta/v14n2/v14n2a04.pdf

Hosmer DW, Lemshow S. 2000. Applied Logistic Regression. Canadá: Jhon Wiley & Sons, Inc. Recuperado de: http://resource.heartonline.cn/20150528/1_3kOQSTg.pdf. 397 p.

IIAP. 2010. Instituto de Investigación de la Amazonía Peruana. Zonificación Ecológica y Económica del Departamento de Amazonas. Recuperado de http://iiap.org.pe/Archivos/publicaciones/PUBL520.pdf

INEI. 2019. Instituto Nacional de Estadística e Informática. PBI de las actividades económicas, por años. Recuperado de https://www1.inei.gob.pe/estadisticas/indice-tematico/pbi-de-las-actividades-economicas-por-anos-9096/

INEI. 2012. Instituto Nacional de Estadística e Informática. IV Censo Nacional Agropecuario. Recuperado de https://www.inei.gob.pe/estadisticas/censos/

Maicelo J, Alegre J. 2013. Análisis del sistema de información y conocimiento respecto a los ecosistemas de las palmeras *Ceroxylon peruvianum* en la cuenca media del río Utcubamba. Revista Indes, 1(1). Recuperado de http://revistas.untrm.edu.pe/index.php/INDES/article/view/7

Marizancén M, Artunduaga L. 2017. Mejoramiento genético en bovinos a través de la inseminación artificial y la inseminación artificial a tiempo fijo. Revista de Investigación Agraria y Ambiental, 8(2). Recuperado de https://dialnet.unirioja.es/servlet/articulo?codigo=6285365

Mathios MA. 2019. Sustentabilidad de hatos ganaderos en la cuenca baja del río Shanusi, Alto Amazonas-Loreto-Perú (Tesis de doctorado inédita). Universidad Nacional Agraria La Molina, Lima, Perú. Recuperado de: http://repositorio.lamolina.edu.pe/bitstream/handle/UNALM/4011/mathios-flores-marco-antonio.pdf?sequence=1&isAllowed=y

Mejía H. 2016. Impacto de la educación no formal en el desarrollo del sector ganadero del departamento de Olancho, Honduras 2013-2015. Revista Iberoamericana de Bioeconomía y Cambio Climático, 2(1), 133-145.doi: https://doi.org/10.5377/ribcc.v2i1.5689

Mesa A, Machado H. 2009. Capacitación de productores y directivos para la adopción de tecnologías de producción animal sostenible. Pastos y Forrajes, 32(1) Recuperado de http://scielo.sld.cu/pdf/pyf/v32n1/pyf08109.pdf

Milla M. 2013. Análisis estadístico de datos provenientes de experimentos con mediciones repetidas en espacio y/o tiempo. Revista Indes, 1(1). Recuperado de http://revistas.untrm.edu.pe/index.php/INDES/article/view/11/161

MINAGRI. 2017. Ministerio de Agricultura y Riego. Diagnóstico de Crianzas Priorizadas para el Plan Ganadero. Recuperado de https://repositorio.minagri.gob.pe/jspui/bitstream/MINAGRI/328/1/plan-ganadero-2017-2021.pdf

MINAGRI. 2014. Ministerio de Agricultura y Riego. Vacunos de leche situación actual. Recuperado de http://minagri.gob.pe/portal/40-sector-agrario/situacion-de-las-actividades-de-crianza-y-producci/303-vacunos-de-leche

Molina C, Alvarez J. 2009. Identificación de factores incidentes en las decisiones de adopción de tecnología en productores ganaderos criadores familiares. Agrociencia Uruguay, 13(2). Recuperado de http://www.scielo.edu.uy/pdf/agro/v13n2/v13n2a09.pdf

Oliva M, Leiva S, Collazos R, Vigo CN, Maicelo JL. 2018. Factores que influyen en la adopción de sistemas silvopastoriles con la especie nativa *Alnus acuminata* (aliso). Agrociencia Uruguay, 22(2), 1-9.doi: 10.31285/AGRO.22.2.9

Orozco S, Ramírez B, Ariza R, Jiménez L, Estrella N, Peña B, Ramos A, Morales M. 2009. Impacto del conocimiento tecnológico sobre la adopción de tecnología agrícola en campesinos indígenas de México. Interciencia, 34(8). Recuperado de http://ve.scielo.org/scielo.php?script=sci_arttext&pid=S0378-18442009000800007

Pece M, Acosta M, Bruno S. 2012. Aplicación de regresión logística en un estudio de emergencia de plántulas de algarrobo blanco (*Prosopis alba* Griseb.) en vivero, bajo diferentes concentraciones salinas. Quebracho Revista de Ciencias Forestales, 20(2). Recuperado de https://www.redalyc.org/articulo.oa?id=48126071008

Roco L, Engler A, Jara R. 2012. Factores que influyen en la adopción de tecnologías de conservación de suelos en el secano interior de Chile central. Revista de la Facultad de Ciencias Agrarias, 44(2). Recuperado de https://bdigital.uncu.edu.ar/app/navegador/?idobjeto=4746

Rodríguez H, Ramírez CJ, Restrepo F. 2015. Factores que influencian la adopción de tecnología de gestión en la producción lechera. Revista Temas Agrarios, 20(1). Recuperado de https://dialnet.unirioja.es/servlet/articulo?codigo=5456276

Salas J, Leos J, Sagarnaga L, Zavala M. 2013. Adopción de tecnologías por productores beneficiarios del programa de estímulos a la productividad ganadera (PROGAN) en México. Revista Mexicana de Ciencias Pecuarias, 4(2). Recuperado de http://www.scielo.org.mx/pdf/rmcp/v4n2/v4n2a10.pdf

Salazar JL. 2016. Caracterización del sistema de producción de ganado de la raza Brown Swiss distrito Florida Pomacochas, provincia de Bongará Amazonas, 2015 (Tesis de grado). Universidad Nacional de Cajamarca, Cajamarca, Perú. Recuperado de https://1library.co/document/z3d5vo7y-caracterizacion-produccion-distrito-florida-pomacochas-provincia-bongara-amazonas.html

Sandoval E, Morales G, Jiménez D, Pino L, Urdaneta J, Araque C. 2007. Caracterización de las diferentes modalidades de producción del sistema de ganadería bovina de doble propósito del Municipio José Antonio Páez del estado Yaracuy, Venezuela. Revista de la Facultad de Agronomía de la Universidad del Zulia, 24 (3). Recuperado de http://ve.scielo.org/scielo.php?script=sci_arttext&pid=S0378-78182007000300007

Valera J. 2013. Factores socioeconómicos que influyen en la adopción del cultivo de la vid en Magdalena, Cajamarca (Tesis de maestría). Universidad Nacional Agraria La Molina, Lima, Perú.

Velasco J, Ortega L. 2008. La Inseminación Artificial y su efecto sobre los Índices de Productividad Parcial en Fincas Ganaderas de Doble Propósito. Revista Científica (Maracaibo), 18 (3). Recuperado de http://ve.scielo.org/scielo.php?pid=S0798-22592008000300007&script=sci_arttext

Vélez I, Espinosa G, Omaña S, Gonzales O, Quiroz V. 2013. Adopción de tecnología en unidades de producción de lechería familiar en Guanajuato, México. Actas Iberoamericanas de Conservación Animal, 3 (3). Recuperado de http://www.uco.es/conbiand/aica/templatemo_110_lin_photo/articulos/2013/Trabajo014_AICA2013.pdf