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Artículo

Effect of irrigation water availability on the value of agricultural land in Guanacaste, Costa Rica: A hedonic pricing approach

Efecto de la disponibilidad de agua de riego en el valor de las tierras agrícolas en Guanacaste, Costa Rica: Un enfoque de precios hedónicos

Paulo Méndez Campos[1]
Johanna Solórzano Thompson[2]
Javier Paniagua Molina[3]

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[1] Universidad de Costa Rica. Costa Rica. Bachiller en Economía Agrícola y Agronegocios. Correo electrónico: paulo.m.6@hotmail.com
[2] Universidad de Costa Rica. Costa Rica. Docente en la Escuela de Economía Agrícola y Agronegocios. Correo electrónico: johanna.solorzano@ucr.ac.cr
[2] Universidad de Costa Rica. Costa Rica. Docente en la Escuela de Economía Agrícola y Agronegocios. Correo electrónico: javier.paniagua@ucr.ac.cr.

Resumen

La necesidad de agua y sus impactos en la agricultura y en la seguridad alimentaria son preocupaciones crecientes en todo el mundo y Costa Rica no es la excepción. En este contexto, la valoración de las tierras ante la disponibilidad de agua de riego y otras variables externas, ha sido utilizado por diferentes autores en todo el mundo. El objetivo de esta investigación fue el de estimar el cambio en el valor de la tierra asociado a la mejora en la calidad hidrológica en las fincas beneficiadas con los programas de riego en la región de Guanacaste. Para estimar este cambio, ese utilizó el método de precios hedónicos (HPM) aplicado a una muestra final de 90 referencias para la compraventa de inmuebles disponibles en el DRAT y su entorno, en el período 2018-2019. Los resultados del modelo ajustado indican que la disponibilidad de agua para producción y consumo en la zona de estudio pueden aumentar el valor de la tierra hasta en un 10%. Otras variables cumplen positivamente con las caracteristicas buscadas por empresas inmobiliarias y propietarios tales como, cercanía a centro poblacional, caminos accesibles, uso del suelo. Finalmente, el tamaño de la finca, tiene un comportamiento inverso al relacionar el precio por metro cuadrado. El modelo utilizado resultó ser una herramienta viable para la identificación de las variables que determinan el valor de la tierra en áreas destinadas principalmente a la producción agrícola y pecuaria en la zona de estudio.

Palabras clave: precios hedónicos, valoración de tierras, transformación Cochrane-Orcutt, econometría

Abstract

The need for water and its impacts on agriculture and food security are growing concerns around the world and Costa Rica is no exception. In this context, the valuation of lands in light of the availability of irrigation water and other external variables has been used by different authors around the world. The objective of this research was to estimate the change in the value of the land associated with the improvement in the hydrological quality in the farms benefited from the irrigation programs in the Guanacaste region. To estimate this change, he used the hedonic pricing method (HPM) applied to a final sample of 90 references for the sale of properties available in the DRAT and its surroundings, in the period 2018-2019. The results of the adjusted model indicate that the availability of water for production and consumption in the study area can increase the value of the land by up to 10%. Other variables comply positively with the characteristics sought by real estate companies and owners such as, proximity to the population center, accessible roads, land use. Finally, the size of the farm has an inverse behavior when relating the price per square meter. The model used turned out to be a viable tool for identifying the variables that determine the value of land in areas destined mainly for agricultural and livestock production in the study area.

Key words: hedonic prices, land valuation, Cochrane-Orcutt transformation, econometrics

Introducción

The agricultural sector has an important contribution to the Costa Rican economy, not only because it represents about 4% of the Gross Domestic Product (GDP), but also because many families are directly related to agricultural work, representing 11.9% of the employed population, either in primary activities or in the agricultural chains derived from agribusiness, distribution and marketing (Mora, 2019).

Guanacaste province is part of the Chorotega Region of Costa Rica, which concentrates a population of 365,778 people (Senara, 2018) and according to the National Household Survey (ENAHO), ranks second as the region with the lowest poverty rate in the country, only below the Central Region, with an average family income of 1 497.99 USD[1] and a per capita income of 536.80 USD (INEC, 2017).

Due to the effects of climate change on the Costa Rican agricultural sector, by 2015 agriculture recorded a 3.9% decline in sales, the most severe in the last ten years, mainly due to climate factors associated with the El Niño events (Estado de la Nación, 2016). This climatic event is even more notable in the Chorotega region, which is part of the Central American dry corridor and experiences significant droughts for long periods, causing reductions in agricultural sector yields below potential. In this regard, small-scale producers and rural communities are the most vulnerable to drought due to crop loss, impoverishment and population migration to overcrowded urban centers (FAO, 2016).

By 2015, Guanacaste province concentrated 11.7% of the country's farms, ranked fourth of Costa Rica's seven provinces in terms of number of farms and had the largest amount of area dedicated to agriculture (about 24.6%) (INEC, 2015). Because of its contribution to production indices in the agricultural sector and its particular climate, Guanacaste encompasses the main challenges for rural development such as adaptation to climate change, productive diversification and efficient use of water resources (Estado de la Nación, 2016).

The National Service of Groundwater, Irrigation and Drainage (SENARA) is an institution oriented towards the management of water resources in Costa Rica, in terms of irrigation, drainage and flood protection. Its work implies a direct relationship with the agricultural sector and an impact on the economic, social and environmental development of rural communities (Ley N° 6877, 1983). his institution manages the Distrito de Riego Arenal Tempisque (DRAT), which supplies water throughout the year to farms located in Guanacaste, mainly from agro-industrial companies dedicated to fruit, sugar cane and livestock (Blanco, 2016).

By generating a range of benefits in the communities associated with the DRAT, it is expected to result in an increase in the perception of value in the favored lands. Therefore, these bene-

[1] American dollars. The reference exchange rate as of December 2019 in Costa Rica was 576.5 Colones per US dollar.

fits can be classified as external factors that generate changes in that value, specifically of a political nature, since it is a project developed by a Costa Rican state institution.

The availability of irrigation water is a variable that impacts the differential price of land, being analyzed as the service for the communities affected by the drought; that is to say, it involves not only the water per se, but all the costs of availability of the water resource for the irrigation of the farms. This is known as the value of water in the destination (Berbel & Mesa, 2007). On the other hand, the external costs and benefits of an irrigation project are those that society as a whole will have to pay or enjoy as a result of the effects caused by the project on the environment (Jaime-Paredes & Tinoco-López, 2006).

The hedonic pricing method (HPM) has been commonly used to estimate the value of a good or service. In the Mashhad region, Iran, it was used to estimate the value of irrigation water with a semi-logarithmic model, which resulted in a value 8 times higher on irrigated farms than on farms with no water available for irrigation (Daneshvar et al., 2010).

With the application of the contingent valuation and HPM methods in the estimation of the economic value of irrigation water in Chalkidiki, Greece, a semi-logarithmic model was developed using Ordinary Least Squares (OLS) (Latinopoulos, 2005). This made it possible to determine that the value of the resource assigned by the people was low due to the low quotas paid by the public water service for agricultural irrigation, with the understanding that the farmers might not know and underestimate its real value, since they extracted groundwater according to their capacities to irrigate the crops (Latinopoulos, 2005).

In Honduras, Davila (2002) used the contingent valuation method to determine the economic value of water measured through the willingness to pay for the change in the well-being of the community, when water is available.

In Australia, HPM was applied to isolate the value of irrigation water by applying linear models, where the sale price of the agricultural component depended on changes in location from where land was sold at lower prices, the value of buildings, the water title associated with the transaction, and the area of property; the results showed a high relationship between water, land, and irrigation infrastructure (Bjornlund & O´Callaghan, 2015). HPM has also been applied in fixed-effect panel data models (FIPM), with the exception of addressing possible heterogeneity bias due to the nature of the data, to establish a causal relationship between changes in water availability and major changes in producer welfare, in the California region (Buck et al., 2014).

In England and Wales, the marginal value of agricultural land with certain characteristics was identified, among which soil, climate and location were prioritized; although population density could be a factor affecting the value of the land considering the establishment of nearby markets (Maddison, 2000). On the other hand, in Leon, Spain, the fact of having irrigation translates into an increase in the price per hectare on the land (Arias, 2001). However, the influence of the value of irrigation water on the sale price of the land is not simply one of the most determining factors, but this influence is closely related to the dependence of the agricultural activity on irrigation (Shultz & Schmitz, 2010).

Taking into account that the availability of water resources for irrigation could affect the price of land in communities affected by drought, the objective of this research was to estimate the change in the value of land associated with the improvement in the hydrological quality in the farms benefiting from irrigation programs in Guanacaste province.

Theoretical reference

In the valuation of a rural real estate, the basis is its raw lot, defined by its productive capacity, the location, the regularity of the land shape, its extension, the capacity of land use, presence of water sources, distance to the nearest development center and access roads (Borrero, 2017).

There are two types of valuation of the externalities of a good or service: (1) direct valuation, based on the assumption of hypothetical markets where the individuals interviewed express their willingness to pay for the goods and services that the market lacks and are the object of study (Del Saz et al., 2009); (2) the indirect valuation, where the HPM stands out as representing a utility generated based on the causal relationships of the attributes that the good has, and analyzes the perception of utility according to variations of the attributes. This is achieved through a multiple regression hedonic price function, based on the values of the goods and their attributes to estimate the marginal willingness to pay of the population for the analyzed good or attributes (Jaime-Paredes & Tinoco-López, 2006).

The usefulness of HPM in estimating the causal relationships of attributes is evident from its description, since it allows the decomposition of the price of a heterogeneous good into the implicit prices of its characteristics (Arias, 2001; Rosen, 1974). In this way, a valuation of irrigation water can be obtained using relatively simple techniques based on data on prices and land characteristics, published regularly in the press.

This marginal payment arrangement is known as the quantitative importance of the attribute, which is equivalent to its implicit price and is what would answer the research question posed (Azqueta, 1994). From another point of view, the HPM tries to analyze the differences between the purchase and sale prices of a good (land of different qualities) and to explain the origin of those differences, in such a way that it is possible to quantify them (Berbel & Mesa, 2007).

To analyze and quantify these differences, a linear or non-linear econometric function must be specified. The first functional form would indicate a constant variation in the price of the private good (dependent variable) at different values of the attributes (independent variables) affecting the price. But the model will most likely take a non-linear form where the implied price of an attribute will vary according to the quantity or availability of the attribute (Azqueta, 1994).

To exemplify this situation, the price of a property with agricultural potential is assumed and one of its attributes is the availability of water for irrigation or agricultural hydrological quality. If the specification of the price variable is non-linear with respect to the attribute, and assuming that its effect on the price of the land is positive, it can be inferred that, the greater the water availability (there are more water sources), the greater the value of the land. However, when there are many sources of water, one more source will not have a relative value equal to that of a farm with a water deficit. Therefore, the partial derivation of the land price with respect to the hydrological quality would behave in such a way that, as there are few sources of water, the marginal willingness to pay of a person for an additional source of water would be more than proportional to the increase in the hydrological quality.

The econometric models used in the HPM could present estimates biased by heteroskedasticity and spatial autocorrelation. Heteroskedasticity occurs when the variance of each error term is not constant and spatial autocorrelation occurs when there is correlation between data collected in one geographic unit with respect to nearby geographic units (Acevedo & Velásquez, 2008; Gujarati & Porter, 2010). On the other hand, to compare the econometric models, the information criteria of Akaike (CIA), Schwarz (CIS) and the log-likelihood are used, for which the model with the lowest information criteria will have greater forecasting efficiency (Gujarati & Porter, 2010).

Methodology

To estimate the change in land value associated with the improvement in hydrological quality on agricultural farms, the hedonic pricing method (HPM) was used. Initially, the different attributes that could estimate the price of land in the real estate market of Guanacaste province were identified.

References were collected for the purchase and sale of 137 properties available in the DRAT and its surroundings, in the period 2018-2019. A field visit was then made to verify and compare the information provided. Of the total number of properties, 45 were discarded because the information could not be verified with certainty or they presented outliers. The remaining 92 references were used in the first statistical model; however, it was necessary to eliminate two outliers whose regression errors were statistically significant and could interfere in the analysis causing heteroskedasticity.

The remaining 90 references were considered adequate for econometric modelling, without presenting heteroskedasticity, but with spatial autocorrelation, since the data were organized and processed by similar areas. To correct for this drawback, the Cochrane-Orcutt[2] procedure was used for regression on differences, considering the correlation coefficient for the first-order autoregressive pattern.

[2] Cochrane-Orcutt is a procedure that fits a linear econometric model for serial correlation.

The definition of the variables of the econometric model is shown in Table 1, where it should be highlighted that water availability is measured in two alternative and mutually exclusive ways. On the one hand, it is measured through a binary dummy variable called IRRIGATION (I), where "1" indicates if the available water allows for commercial irrigation and "0" if it does not; while the WATER variable (W) provides more information on the type of water availability for irrigation through five categories (Table 1).

Variable	Code	Unit	Details
PRICE	P	USD/m²	Unit price of land per square meter
SIZE	S	m²	Land size in square meters
DISTANCE	D	km	Distance far from main urban center in the region
WATER	W	1	No water sources
		2	Normal water sources, not for irrigation
		3	Good water sources medium useful for irrigation
		4	Very strong water sources for irrigation
		5	Extremely strong water sources for irrigation
USE	U	1	Livestock
		2	Crops
		3	Mixed use
		4	Urban use in the border of rural zone
ROAD	R	1	Bad roads, not asphalted
		2	Normal rural roads, usually ballasted
		3	Good roads, asphalted or not
		4	The best roads, asphalted
IRRIGATION	I	0	No water resources available for irrigation
		1	Water resources available for irrigation

To estimate hedonic prices, an e $Yh = fh(Sh, Nh, Xh)$ was established according to Azqueta (1994):

(1)

Where the term h is the price of a private good and is a function determined by the quality of the attributes (Sh,Nh,Xh).¬

The partial derivation of Equation 1 with respect to each one of the attributes corresponds to the respective marginal disposition to pay or to the implicit price, which responds to the price change that the good suffers when that characteristic increases by one unit while maintaining the rest of the characteristics constant (Arias, 2001). As mentioned above, the function h is most likely to take a non-linear form.

The Gretl software was used to develop the econometric models with the MCO method, and they were defined as follows:

Econometric models with variable IRRIGATION[3]

$$P = \beta_0 + \beta_1 S + \beta_2 D + \beta_3 U + \beta_4 R + \beta_5 I \quad (2)$$

$$lnP = \beta_0 + \beta_1 lnS + \beta_2 D + \beta_3 U + \beta_4 R + \beta_5 I \quad (3)$$

Model 1 (Equation 2) has linear form for all variables and for the 92 reference data set. The Model 2 (Equation 3) is the semi-registration form that works with the 90 reference data set and uses the Cochrane-Orcutt autocorrelation correction. On the other hand, in Model 4-A (Equation 4) a sample without extreme values was used, while in Model 4-B (Equation 5) the Cochrane-Orcutt autocorrelation correction was applied.

Econometric models with variable WATER[4]

$$P = \alpha_0 + \alpha_1 S + \alpha_2 D + \alpha_3 U + \alpha_4 R + \alpha_5 W \quad (4)$$

$$lnP = \alpha_0 + \alpha_1 lnS + \alpha_2 D + \alpha_3 U + \alpha_4 R + \alpha_5 W \quad (5)$$

Results

The basic descriptive statistics are presented in Table 2, for the data set with 92 references previously selected from the initial database. The econometric results of Models 1 and 2 are shown in Table 3, where it is observed that the second one presents a better performance according to the criteria CIA and CIS, a more adjusted R^2, the normality of the residues and the absence of heteroskedasticity and autocorrelation.

[3] Presence or not of water for irrigation.
[4] Presence of water under different analyzed characteristics (Table 1).

Table 2. Summary descriptive statistics for data set (n=92).

Variable	Mean	Median	Mínimum	Máximum
PRICE	3,8715	1,7017	0,1769	26,8060
SIZE	6,80E+05	1,17E+05	1 000,0000	9.40E+06
DISTANCE	12,1630	12,0000	0,5000	35,0000
USE	2,2826	2,0000	1,0000	4,0000
WATER	2,5000	2,0000	1,0000	5,0000
ROAD	2,5000	2,0000	1,0000	4,0000
IRRIGATION	0,4783	0,0000	0,0000	1,0000
Variable	**Stnd. Dev.**	**Coef. Variat.**	**Skewness**	**Ex. Kurtosis**
PRICE	5,1588	1,3325	2,5367	6,9323
SIZE	1.46E+06	2,1514	4,7374	25,1550
DISTANCE	7,3034	0,6005	0,8258	0,7910
USE	0,8028	0,3517	0,9865	0,4522
WATER	1,0217	0,4087	0,2486	-0,6172
ROAD	0,9778	0,3911	0,4255	-0,9853
IRRIGATION	0,5023	1,0502	0,0870	-1,9924
Variable	**5% Perc.**	**95% Perc.**	**IQ range**	**Missing obs.**
PRICE	0,3046	15,8760	2,7358	0,0000
SIZE	3 950,0000	2.34E+06	8.30E+05	0,0000
DISTANCE	1,8250	24,8000	10,6670	0,0000
USE	1,0000	4,0000	0,0000	0,0000
WATER	1,0000	4,0000	1,0000	0,0000
ROAD	1,0000	4,0000	1,0000	0,0000
IRRIGATION	0,0000	1,0000	1,0000	0,0000

Model 2 indicates that the elasticity of the unit price of land with respect to the SIZE variable is -0.2714, which means that with a 1% increase in size, the price decreases by 0.2714%. This is a basic variable in real estate valuation and is represented as the total area in m^2 that the property owns. The logical reasoning behind this attribute is that the larger the area, the higher the total value of the property. However, the price of the land is estimated on a unit basis (USD/m^2) and an inverse relationship is inferred between the variable in question and the price of the land, so that the larger the area, the lower the unit price per m^2.

The distance variable shows a coefficient of -2.13% for every kilometer that the properties move away from the nearest urban development center. This indicates that the price of land decreases the longer it is from the centers of supply, particularly because people wish to have easy access to resources without investing a lot of time in moving.

Land use and road availability are also statistically significant, with the understanding that people are willing to pay more as long as there is the possibility of different land uses and quality land access to the farms.

The binary irrigation variable, the objective of this research, was not statistically significant at 5% or 10%. In spite of this, p-Value is very close to 10% and can even be evaluated at 15% of statistical significance and, therefore, this variable would be statistically significant.

The regression coefficient for the binary irrigation variable (0.1545), indicates a rate of increase in the value of land of 15.45% due to the presence of irrigation water resources that increase the farm's own capacity to supply the hydrological needs of production and consumption, which basically consist of the availability of quality and quantity of water for irrigation, animal hydration and human consumption.

The results of the regressions and respective corrections of Models 3, 4-A and 4-B are shown in Table 4. It can be seen that the linear functional form of Model 3 is not suitable, contrary to the semi-logarithmic functional form (Models 4-A and 4-B) as it fits better with the data.

The Cochrane-Orcutt transformation was applied to Model 4-B to correct for the presence of spatial autocorrelation, it did not present heteroskedasticity and there was normality in the regression residues, so this model is adequate for prediction. In addition, it presents the highest R2 of the developed models, with which it can be deduced that 83% of the changes in the dependent variable are caused by the changes suffered by the independent variables analyzed; while the CIA, CIS and Log-likelihood criteria have progressively decreased in each model.

The elasticity of the unit land price for the SIZE variable is similar to Model 2 and shows how the price of land decreases by 0.2713% for every 1% increase in property size. The WATER variable, which captures the effect of irrigation with details by category, showed a 10% rate of increase in the price of land as the category of available irrigation water quality improves.

Finally, the forecast of the alternative 4-B model is quite accurate with respect to the data collected, and Figure 1 compares the behavior of the data estimated by the 4-B Model with 90 observations.

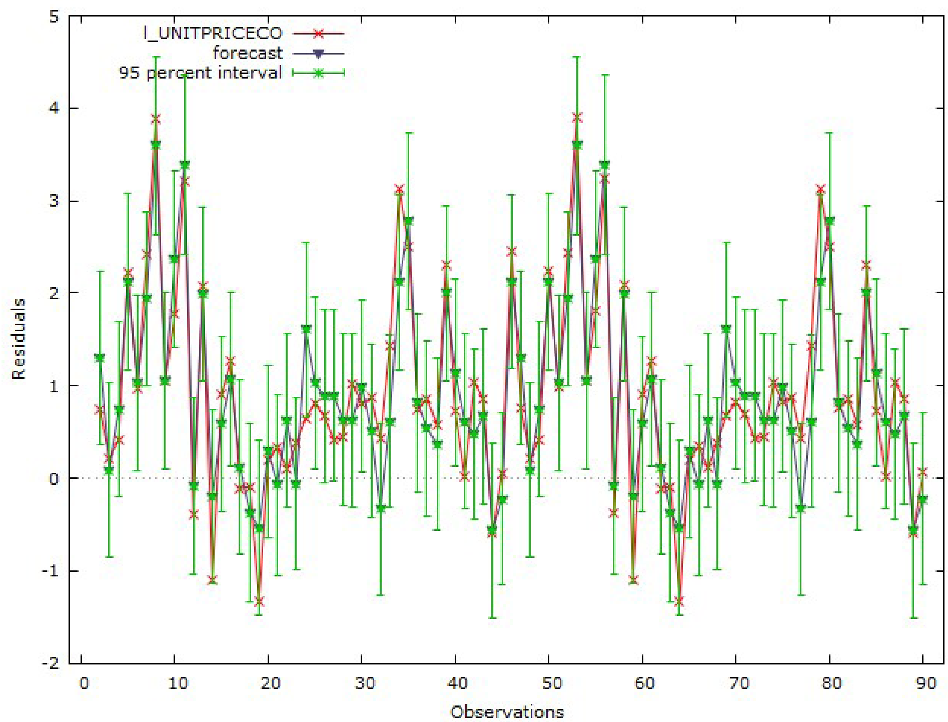

Figure 1. Forecast and adjusted data from Model 4-B for data set (n=90).

Table 3. Regression results for the modeling with IRRIGATION variable.

VARIABLE	Model 1 (Dependent variable: P)				Model 2 (Dependent variable: ln P)			
	Coefficient	Stnd. Error	p-Value[1]		Coefficient	Stnd. Error	p-Value[1]	
SIZE	-3,59E-07	2,66E-07	0,1797		-0,2714	0,0276	<0,0001	***
DISTANCE	-0,0629	0,0556	0,2610		-0,0213	0,0074	0,0053	***
USE	3,7543	0,5018	<0,0001	***	0,4751	0,0773	<0,0001	***
ROAD	1,2735	0,4522	0,0060	***	0,1972	0,0646	0,0030	***
IRRIGATION	-0,2372	0,8261	0,7747		0,1545	0,1014	0,1314	
const	-6,7587	1,7276	0,0002	***	3,2162	0,5718	<0,0001	***
R-squared	0,5430				0,8280			
Adjusted R-squared	0,5157				0,8177			
rho	0,0813				-0,0027			
Breusch-Pagan test for heteroskedasticity	81,2639		4,60E-06	***	0,8284		0,9752	
LM test for autocorrelation AR(1)	0,6258		0,4311		0,0007		0,9797	
Chi-square test for normality	16,4392		0,0003	***	0,0367		0,9818	
Akaike criterion	502,0570				121,1380			
Schwarz criterion	517,1880				136,0700			
Log-likelihood	-245,0286				-54,5691			
n	92				90			

1/ *** statistical significance at 1%, ** at 5% and * at 10%.

Table 4. Regression results for the modeling with WATER variable.

VARIABLE	Model 3 (Dependen variable: P)				Model 4-A (without extreme ouliers) (Dependent variable: ln P)[1]				Model 4-B (autocorrelation corrected) (Dependent variable: ln P)[1]			
	Coefficient	Stnd. Error	p-Value[2]		Coefficient	Stnd. Error	p-Value[2]		Coefficient	Stnd. Error	p-Value[2]	
SIZE	-3,8E-07	2,7E-07	0,1577		-0,2805	0,0310	<0,0001	***	-0,2713	0,5673	<0,0001	***
DISTANCE	-0,0700	0,0555	0,2105		-0,0221	0,0074	0,0038	***	-0,0157	0,0274	<0,0001	***
USE	3,8131	0,4981	<0,0001	***	0,4886	0,0839	<0,0001	***	0,4627	0,0057	0,0072	***
WATER	0,1852	0,4088	0,6516		0,0978	0,0538	0,0726	*	0,1007	0,0754	<0,0001	***
ROAD	1,1352	0,4586	0,0153	**	0,1679	0,0630	0,0092	***	0,1917	0,0485	0,0410	**
const	-7,0249	1,8185	0,0002	***	2,5292	0,5158	<0,0001	***	2,9486	0,0636	0,0034	***
R-squared	0,5430				0,7717				0,8300			
Adjusted R-squared	0,5164				0,7584				0,8197			
rho	0,0497				-0,2633				0,0282			
Breusch-Pagan test heteroskedasticity	83,8107		1,3E-16	***	1,4076		0,9235		0,6534		0,9854	
LM test autocorrelation 1	0,2484		0,6195		6,5299		0,0124	**	0,0718		0,7895	
Chi-square test for normality	17,3535		0,0002	***	5,5440		0,0625	*	0,2473		0,8338	
Akaike criterion	149,4990				126,2120				119,9700			
Schwarz criterion	164,6300				141,2110				134,9019			
Log-likelihood	-68,7490				-57,1069				-53,9850			
n	92				90				90			

1/ SIZE variable is in logarithmic form.

2/ *** statistical significance at 1%, ** at 5% and * at 10%.

Discussion

This analysis shows that external variables positively or negatively affect the price of land, depending on the availability and characteristics of the land. In this sense, there may be a high sensitivity of land prices when water use is mainly agricultural, because consumption increases to improve productivity and increase return on investment, as described Daneshvar et al. (2010).

Given the lack of rainfall and the presence of prolonged periods of drought in Guanacaste, water resources are the only input that can guarantee the success of the productivity of agricultural properties. However, if land use changes, the model could give different results in view of the need to supply domestic consumption, which is mostly provided by Costa Rican government institutions and could be underestimated.

Regarding the functional forms of the models, with Model 3 it was shown that the linear form was not the appropriate one, contrary to the semi-logarithmic one due to a better fit with the data used; this can be seen in comparison with the results of models 4-A and A-B. Research by Daneshvar et al. (2010), Latinopoulos (2005) y Schaerer et al. (2008) provides similar conclusions. Furthermore, Xiao (2017) discusses that the HPM method suffers from a number of possible econometric problems such as heteroskedasticity and autocorrelation, which could lead to biased estimation. Although these problems were corrected generating the results expected by the research team.

The results of Models 4-A and 4-B can be compared with Bjornlund & O´Callaghan (2015), who concluded that it is preferable to separate the values of land and water and not to capitalize on the value of irrigation infrastructure in an assumed variable for irrigated land, with the premise of demonstrating the productive value of water. In other words, this variable would indicate the value of the total water and the irrigation capacity of the farm, while the value of the land remains as total, being the value of the land with the possibility of being irrigated.

On the other hand, the result provided by the variable that assumes the distance between the agricultural property and the nearest urban development center, presented the expected behavior, since the greater the distance, the lower the perception of value of the land, as concluded Paniagua-Molina (2017) in an analysis carried out in Limón province, Costa Rica.

This research shows that land use is the variable that presented the highest rate in relation to the population's willingness to pay, considering that the area of study has historically presented a high agricultural and livestock production, although recently the population and urban growth has been close to 10% in Guanacaste (INEC, 2019) so that land use has evolved to a mixture between housing and production. Schaerer et al. (2008) carried out an analysis of real estate rental prices in the cities of Geneva and Zurich, with similar variables to those of this study, and showed that land use significantly affected rental prices, in addition to other variables such as proximity, size, view and water services.

In the same way, Davila (2002) determined that there is a positive relationship between the willingness to pay and the value of the lands where there is a greater total availability of water in summer.

Conclusions

Once the extreme values and the possible presence of statistical bias were corrected, the 4-B model turned out to be a viable tool for identifying the variables that determine the value of land in areas destined for agricultural and livestock production.

The study area is included within the driest region of the country, where the needs for water availability are, to a great extent, an indispensable part of economic and social development. In this case, farms or land intended for agricultural production will increase in value as the availability of water resources for irrigation increases and as available water becomes accessible to owners.

Other variables analyzed meet the characteristics sought by real estate companies and land owners, such as the presence of land accesses in good condition and the use of the land, which cause positive changes in the value of properties. Whereas, the extension of the property and the distance to developed population centers, have a negative effect on the unit value of the land.

Therefore, it is concluded that a property located in the DRAT with access to water resources for irrigation, for urban use, with asphalt roads and located as close as possible to a developed population center, will have a unit land value greater than one property with conditions to the contrary.

This research work has various implications since it allows the owners of the DRAT lands to know the real value of their properties, it can increase in the medium term, the economic level of the study area when realizing the capital gain through possible sales It also allows private and public entities to update the valuation mechanisms including new and modern analysis variables.

The availability of water for irrigation and the maintenance of these water sources is considered an environmental and social service that brings not only efficiency in crops, but also increases the potential for future economic well-being of the surrounding populations, as well as a better allocation. of resources of mortgage credit for development on a more exact value of the lands.

The application of this model in other rural areas of the country will allow to expand the coverage of real estate data updates and is a fundamental input for project feasibility studies, social development studies, valuations for commercial, tax and banking purposes, among others. In this sense, the results may vary according to the variables analyzed, specific conditions of the region and the culture of its population.

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