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Decisive Factors Associated to Land Tenure and Plot Size in Sugarcane Fields in Mexico

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ABSTRACT

Diversity in the sugarcane field is the result of the combination of social groups, historical processes and natural conditions, which vary in every region. Among the factors affecting agricultural production, land ownership represents the most valuable economic capital, along with other factors related to the social and cultural capital of the farmer; and women tend to have less access to this than men do. We attempted to diagnose the factors that affect land ownership in the sugarcane field in Tamaulipas, Mexico, taking a gender perspective. Data from a sample of 546 sugarcane suppliers from 6 municipalities in Tamaulipas were obtained, and the association between dichotomous variables was sought by applying statistical tests, such as Yule's φ (phi) coefficient, tetrachoric correlations and Fisher's test; a predictive model based on logistic regression was also constructed. The association between gender variables and land ownership, decision-making power, irrigation, sugarcane registration, other income, alternative crops, and area in hectares is evident. Women represent less than one-fifth of the total sugarcane suppliers in Tamaulipas, Mexico. They own agricultural land with available irrigation in a slightly higher proportion than men, but their plots are smaller, and they have less say in their cultivation. They lag behind in terms of being included in sugarcane registers and are less often involved in other productive activities to provide them with additional resources for subsistence; it is desirable that the government enforce gender equality and guarantee a legal framework so that women can have rent or possession and control of agricultural land, without size limitation.

Keywords: Economic Resources of Women; Agriculture in Tamaulipas; Micro Analysis of Farm Firms; Land Ownership; Regional Economic Activity

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1. Introduction

Agriculture is a basic activity that provides food for family consumption, and the trade of surplus produce generates the first link in several agro-industrial chains, which is why it is so important. In particular, the agricultural activity of sugar cane (S*acharum officinarum*) cultivation and sugar production is significant due to the volume and value of the product, as well as the impact on the generation of direct and indirect jobs associated with the crop, to which 44.4% of the ejido lands in Mexico are dedicated, while in other countries the magnitude varies [1, 2]. Tamaulipas, located in the northeast of Mexico, is the third province with the greatest productive potential for this crop, only behind Sinaloa and Michoacán, with 7.81% of the area [3].

The sugarcane agroindustry is strategically important in Mexico; however, it has ceased making a significant contribution to regional development due to stagnation in productivity, both in terms of its manufacture and in the field. This relates to the quality of agricultural land and the availability of irrigation, which determine sugarcane yields, in addition to other factors such as climate, seed variety, and cultural work [4]. Even so, it has been pointed out that this crop produces favorable changes in the lives of farmers [5].

Despite the diversity of participants at all levels of the sugar agro-industrial chain, not all social actors who carry out agricultural work do so under the same conditions, as women experience inequality in a number of respects, including the wage gap and access to education, as well as land ownership [6–8]. By social inequality, we can understand "the inequitable distribution of social wealth, as well as insufficient access to credit, quality education, productive assets, new technologies, culture and recreation…" [9].

Women's participation in the labor market is essential because of its evident contribution to accelerating regional economic growth [6]. Apparently, when men migrate from the countryside, women take charge of agricultural exploitation and their work becomes apparent; this increases the number of them who become heads of household in developing countries, but many women limit their labor participation in order to exercise family care [10, 11]. However, women face more difficulties when it comes to communal rural land, where men, who limit female opinion in assemblies and in making important decisions, actively participate [12]. A recent report by the Food and Agriculture Organization of the United Nations (FAO) [7] indicates that in 40 of 46 reported countries, more men hold land ownership rights than women, and only in 47 of 104 countries are women granted the same participation as men, concerning the right to agricultural irrigation.

The gender gap in access to resources in agriculture is evidence of the inequality that prevails in much of the world [13]. Therefore, this study seeks to analyze some factors associated with the cultivation of sugar cane that define the role of Tamaulipas producers: 1) the cane field, size and type of plot, 2) ownership and decisions about agricultural land, and 3) origin of the farmer's income. Due to its importance, it is convenient to define the sugarcane producer as a subject of analysis; for the purpose of this work, the term "sugarcane supplier" has been used as in Mexican legislation; the Law for the Sustainable Development of Sugarcane defines it as "Producers, individuals or legal entities, whose land is totally or partially dedicated to the cultivation of sugarcane for industrial use and who have entered into a Uniform Contract sanctioned by the Sugarcane Production and Quality Committee or a special conditions contract". Thus, characterization of the actors of an agricultural system represents an important task and is scarce in the sugarcane region in study.

2. Literature Review

2.1. The Sugarcane Field; Size and Type of Plots

The sugarcane field in Mexico is very diverse, resulting from the combination of social groups, historical processes, and natural conditions that vary in each region [1, 14]. These are territories where inequality and exclusion continue to exist [15]. The 7 sugarcane regions in the country (see **Figure 1**) manifest edaphic and topographical differences that have caused important contrasts: in almost all of them, smallholdings, sugarcane monoculture, difficulties in accessing irrigation, and concerning the introduction of technology to the field persist to a greater or lesser extent [16]. The sugarcane

field presents very diverse characteristics in other regions of America; for example, in Colombia it shares half of the territory of the Cauca Valley with maize and soybeans. This is the main sugarcane growing region and presents irrigation difficulties and a mixed property regime, where 14 private sugar mills compete—using their own land—with more than 1,200 small and medium producers to supply their raw material [17].

Figure 1. Map of 7 sugarcane regions in Mexico.

Source: Image taken and adapted from Conadesuca's Geoportal Map Library [18].

Inequality is also apparent in the sugarcane field in Argentina: the assignment of tasks in this country is related to the agricultural and family cycles [19, 20], highlighting the low participation of women as sugarcane producers (less than 9%) and a greater female contribution in the form of unpaid than in paid work. Women producers participate in agricultural tasks, only when the property is small and does not generate sufficient income to outsource the work [8]. In contrast, the sugarcane field in Peru is notable for generating acceptable yields, above the Latin American average. However, it also presents marked atomization of land ownership, where 19% of women participate as producers in this Andean country, 72% of producers are affiliated to a sugarcane organization, more than half of the producers (54%) claim to have more than 3 crops growing simultaneously, and the rest (46%) have at least one other crop apart from sugarcane. The presence of additional economic activities, such as animal husbandry on sugarcane plots, was reported for 100% of properties [21].

Regarding the size of plots, evidently in ancient times agricultural land was very fragmented; complex territorial processes involving the aristocracy and the feudal peasant determined the size and ownership of the land [22, 23]. Under these conditions, the owner could only carry out subsistence agriculture, so perhaps for this reason, Mexican peasants hold on to their plots with affection, even when they are unproductive, as they represent part of the family patrimony that will pass to subsequent generations [15]. By the 20th century, the situation changed in many Latin American countries; the large estates caused agrarian reforms that defined the current average surface of family agriculture at 6.83 ha in Mexico, 4.48 ha in Colombia, 1.29 ha in Peru, and 107.45 ha in Argentina, to cite some examples [24]. The size and typology of the sugarcane plot also determine categories among producers, each with their own characteristics and means of production. The last agricultural census in Mexico reported more than 200,000 production units that plant a little more than 1 mil-

lion hectares of land dedicated to sugarcane cultivation throughout the country, for self-consumption, commercialization and other uses, in which the average land size is only 5.03 hectares [25]; **Table 1** provides the above information segmented into the 7 sugarcane regions (with the northeast region and Tamaulipas highlighted in bold type), made up of 267 municipalities in 15 states, in which the crop is grown and whose production is destined for the country's 50 sugar mills.

Type of land. Like any crop, sugarcane requires an adequate agro-environment and saccharide content for yield to improve; meaning the topographic conditions and soil characteristics of the region can be limiting factors for crop productivity [2]. In most agricultural lands in the sugarcane zone of Tamaulipas, ideal physical conditions exist for planting this crop: Vertisols and Lithosols predominate, as well as Rendzinas, Feozem, Regosols and Cambisols, with neutral or moderately alkaline pH in most of the region, although these soils are poor in organic matter [3, 26].

Table 1. Sugarcane production units' size, by region, in Mexico.

Region	State/Province	Production Units	Land Area in Hectares	Hectares Per Production Unit
Northwest	Sinaloa	405	5,697	14.1
15 municipalities	Nayarit	7,020	34,657	4.9
		7,425	40,354	5.4
Pacific	Jalisco	23,144	116,051	5.0
64 municipalities	Colima	1,558	18,563	11.9
	Michoacán	5,837	16,034	2.7
		30,539	150,648	4.9
Northeast	Tamaulipas	7,346	82,355	11.2
25 municipalities	San Luis Potosí	17,095	107,094	6.3
	North Veracruz	4,962	61,315	12.4
		29,403	250,764	8.5
Southeast	Chiapas	7,856	27,828	3.5
22 municipalities	Tabasco	8,261	43,102	5.2
	Campeche	2,510	24,687	9.8
	Quintana Roo	14,381	151,346	10.5
		33,008	246,963	7.5
Cordoba-Gulf	Oaxaca	11,161	47,982	4.3
29 municipalities	West Veracruz	25,372	111,222	4.4
		36,533	159,204	4.4
Central	Puebla	11,360	19,569	1.7
56 municipalities	Morelos	14,105	31,113	2.2
	Mexico State	139	156	1.1
	Central Veracruz	3,030	5,433	1.8
		28,634	56,272	2.0
Papaloapan-Gulf	Veracruz	39,209	190,753	4.9
15 municipalities	Oaxaca	3,841	24,587	6.4
		43,050	215,339	5.0
Sugarcane crop regions		208,592	1,119,543	5.4
Country (as reported in census)		200,317	1,007,713	5.0

Source: Self-elaborated, based on INEGI data [25].

Irrigation in sugarcane fields. Sugarcane cultivation requires abundant irrigation, so a shortage of water represents a limiting factor for the crop, and the Huasteca sugarcane region where Tamaulipas is located suffers from significant water deficiency for more than 6 months a year, meaning that sugarcane yields are low or moderate. Land ownership and access to irrigation are two socio-economic factors related to the competitiveness of sugar production [4, 5]. Water is a resource that must be exploited sparingly, as in some places it is scarce or contaminated [27] and must be shared among many agricultural producers, who grow in smallholdings (and this contemplates water pressure for the entire field). In Mexico, fragmentation of agricultural lands increased by almost 8% over 2 decades, contrary to what happened in South America, where the number of agricultural farms decreased by between 10% and 20% [24].

2.2. Ownership and Decisions on Agricultural Land

Land tenure. As in other Latin American countries, sugarcane plots in Mexico are predominantly small rural properties, and individuals may own a small property of up to 300 hectares of land dedicated to cultivation, consisting of ejidal, private, or properties of mixed type [28]; in Mexico, an «ejido» is a form of land tenure regulated by the government as social property, through a legal entity formed by at least 20 Mexican citizens, which may own rural land dedicated to agriculture or livestock. Land tenure has involved a persistent struggle in the country that in 1992 made possible the certification of more than 92% of agrarian property. This was extraordinary because having documentation that guarantees land tenure for the farmer can represent a means to access financial credit, thus enabling him to increase family and community assets by working the land with greater prerogative and autonomy [22]. In many countries, rules concerning land tenure are cultural and determine who can own land, for how long, and under what conditions [29]. It is thus common for property to be inherited rather than sold; as if the right to property is restricted, women have to look for other jobs or emigrate.

Men and women are considered equal in Mexican agrarian legislation, with Article 12 establishing that both can inherit ejidal rights [28]; however, inequality has been found in terms of ownership of land plots in the country, with a ratio of 3 to 1 in favor of men; less than 27% of ejidal lands are owned by women [12]. A similar situation is apparent in other countries: a study on the gender gap regarding access to land for rural women in Costa Rica stated that "… they suffer from various difficulties in accessing land, and if they own it, plots are usually smaller and of lower quality" [30]. Land ownership favoring women may also reduce gender violence [7].

The power to make decisions. In some regions in the past, decision-making concerning some traditional economic activities such as agriculture depended on procedures that obeyed control bodies at different hierarchical levels, with higher classes predominating [23]. Appropriate planting decisions can provide economic stability to sugarcane producers [14] by varying crops, investing in technology or increasing cultural work, which are important economic decisions, but farmers persist in planting this crop, waiting for opportunities for a financial bonanza that takes time to arrive.

Support lists for sugarcane growers. Small and medium-sized rural producers can access government benefits such as direct support programs for coffee and sugarcane growers or those that grant guaranteed prices for crops of strategic importance. These require being included in a register [12]; however, lack of inclusion in land tenure can limit opportunities to access these rural support programs; in particular, sugarcane producers can register in the General Registry of Sugarcane Suppliers in the Ministry of Agriculture and Rural Development (SADER) in order to access individual support. In 2021, this was approximately USD $356.10 per supplier [2]; being included in a register also enables suppliers to access financing with an industrial partner, the mill that buys the sugarcane from them, or to access other sources of financing to modernize their agricultural infrastructure. Thus, access to credit and government support are important, as they can help women increase their productivity and become more self-sufficient [11, 29].

2.3. Farmers' Sources of Income

Alternative crops and other income. Previously, we commented that most sugarcane production is on smallholding properties due to the atomization of land ownership in some regions of Mexico. The insufficient yield of the crop, combined with periods of low sugarcane prices, causes suppliers to opt for combining the planting of sugarcane with other crops to survive [2, 27]; this diversification is a strategy that sugarcane producers can adopt to improve their agricultural productivity during times of economic hardship, along with livestock and forestry activities [14, 31]. They can also venture into other occupational activities, and it is usual for women to work outside the agricultural field, including in urban situations [32]; this multi-activity is considered an adaptive strategy and is more common in rural areas [33].

Research on land tenure has been common in the last decade in the economic and administrative sciences, in econometrics and finance studies, and Mexico was the most related geographic area in such studies [13]; this study aims to make a diagnosis of the land ownership sit-

uation in the sugarcane field in Tamaulipas, representing one of the states in Mexico with the most specialization in sugarcane production, a situation that gives it a competitive agroindustrial advantage. The differentiation of data by gender [30] benefits the analysis of economic information, and exposes the situation experienced in the Mexican countryside, especially among the most vulnerable population, such as women.

3. Materials and Methods

Geographical context. The northeastern sugarcane region, also known as the Huasteca, includes the states of San Luis Potosí and Tamaulipas, as well as the northern region of Veracruz. There are 7 sugar mills; one of them is in Tamaulipas, a state whose sugarcane zone comprises an area of 30,000 ha and is located between the parallels 23°17′00″ and 22°32′04″ N and the meridians 99°20′09″ and 98°36′00″ W (see **Figure 2**). The Tamaulipas sugarcane zone includes 8 municipalities in the southwestern area: Antiguo Morelos, El Mante, Gómez Farías, González, Llera, Nuevo Morelos, Ocampo and Xicoténcatl. The economic region named El Mante is made up of 6 of these municipalities (excluding González and Llera), where warm subhumid and hot climates predominate, conducive to developing sugarcane activity on fertile lands, owned by more than 65% of the community [9, 34].

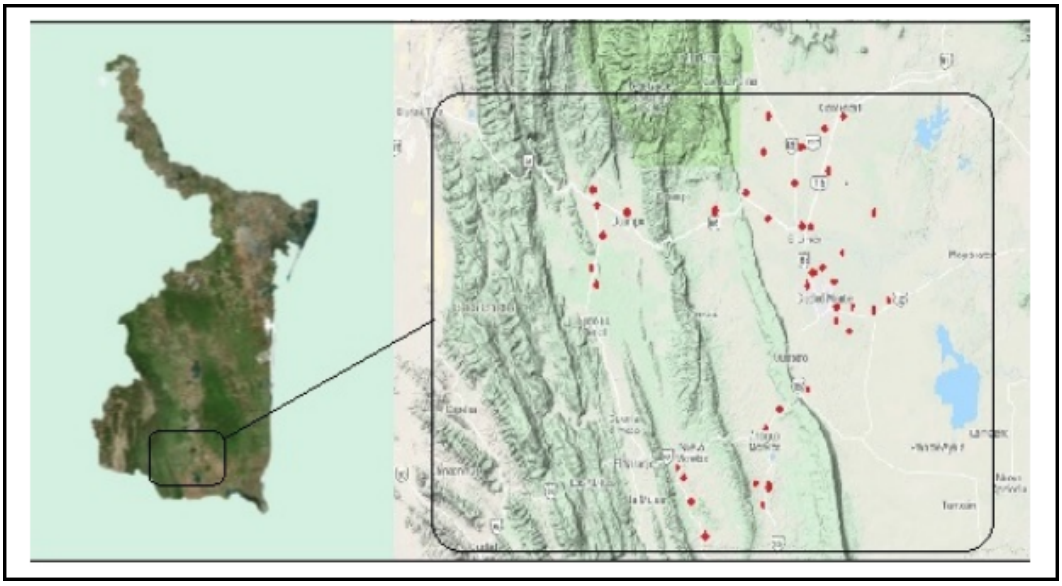

Figure 2. Location of the sugarcane supply area in Tamaulipas and data collection points.

Source: Self-elaborated.

Socioeconomic context. In 2020, the El Mante region had a population of just over 185,000 people and had practiced an economic vocation for more than a decade, where services predominate (39.4%) over agriculture (22%) and commerce (21.6%). This area has an illiteracy rate (2.2%), below the state and national average; poverty of (43.4%) and extreme poverty of (6.1%); also below the national average. Of the 6 municipalities that make up the region, only 2 have limited marginalization and the rest have a medium degree of marginalization; the level of schooling and degree of human development are also slightly below the state average [9, 35].

Objective. The objective of this exploratory and cross-sectional work is to verify the hypothesis that land ownership in the Tamaulipas sugarcane fields, the size of plots and other factors related to the agricultural producer's capital vary depending on whether the supplier is a woman or a man. Sugarcane producers are the subject of analysis. This hypothesis stems from the recognition that this region presents low indicators of inequality and social deprivation [9], as whereas 14% of the population in the municipalities where sugarcane is planted throughout the country live in extreme poverty [2], in the El Mante region this percentage is 6.1. However, discrim-

ination towards women in land ownership is a problem that affects all primary activities, including agricultural, as well as livestock or forestry. It is thus evident in several regions of the world that women have access to resources to produce food for their families, but their control over these is less than that of men [7, 36, 37].

Sample description. Given its availability and in order to promote data sharing and reuse of information, we accessed the database amassed by Paz-Pérez [38]. In the cited work, 5,792 producers were reported in the register of sugarcane suppliers during the 2018–2019 cycle, and a statistical sampling by strata and clusters was used to amass responses from 546 suppliers at 76 collection points in the 6 municipalities of the El Mante region (see **Figure 2**). Those producers were informed of the scope of the research and gave their consent for the interviews and data collection. To this sample, there were applied an instrument consisting of 42 variables. The objective, methodology and results differed from those presented here.

Instrument. 8 variables about the sugarcane supplier and the economic and social capital involved in agricultural activity were extracted from the database referred to above, to be used in the analysis of this work. Variables 1 to 7 are on a dichotomous scale, where 1 is the value of the present category and 0 is the value of the absent category; variable 8 was coded on a nominal scale and then transformed into binary, classifying as 0 the responses below the mean and as 1 responses above the mean. We built a matrix using the data collected and emptied this into the SPSS software version 28 for processing. **Table 2** presents the statistical values, dimensions and indicators of the variables used.

Table 2. Variables and their dimensions and indicators.

Variable	Dimension	Indicators	Coding	Mean	Std Dev
1. Gender	Gender of producer	Man Woman	1 0	0.82	0.384
2. Land ownership	Economic capital	Property owner Not property owner	1 0	0.9505	0.217
3. Decision	Social capital	Decides on crop Does not decide on crop	1 0	0.9652	0.183
4. Irrigation	Economic capital	Irrigates Does not irrigate	1 0	0.5879	0.492
5. Register	Social capital	Included in sugarcane register Not included in sugarcane register	1 0	0.4542	0.498
6. Other income	Economic capital	Has income other than sugarcane Has no other income	1 0	0.4432	0.497
7. Other crops	Economic capital	Grows other crops Does not grow other crops	1 0	0.141	0.348
8. Hectares	Economic capital	Plot exceeds > 7 ha Plot is less than < 7 ha	1 0	0.56	0.496

Source: Self-elaborated.

Procedure. 2 x 2 contingency tables were constructed with each pair of variables to examine the associations between them, where the rows represent the forms of capital of variables 2 to 8 and the columns represent the cases by gender corresponding to the first variable, as shown in Equation (1). The null hypothesis of independence between the two variables is tested using the statistical tests indicated.

$$(a\ b)/(c\ d) \quad (1)$$

To check whether gender (variable 1) is associated with variables 2 to 7 (referring to the economic and social capital of the sugarcane producer), we applied the Yule φ (phi) coefficient (commonly used to study social behavior with demographic factors), expressed in Equation (2), which measures the intensity of the relationship between two dichotomous or binary variables. Akoglu [39] states that correlation does not imply causation and proposes that the intensity of this indicator, due to its characteristics, can be considered moderate from a result >0.10, strong from >0.15 and very strong from >0.25.

$$\varphi = ((c * b) - (a * d)) / \sqrt{((a + b) * (c + d) * (a + c) * (b + d))} \quad (2)$$

To check the association between the real dichotomous variable gender (variable 1) and another binary variable that results from categorizing the continuous variable of hectares (variable 8), the tetrachoric correlation coefficient (TCC) was used. The formula for this can be expressed as (3); a coefficient which requires a normal distribution of data; that each of the cells equals at least 10% of the total value of N and that the scale underlying the binary conversion is continuous and not discrete [40, 41].

$$r\_tet = \cos((180 * \sqrt{((b * c)))}) / \sqrt{((a * d) / (b * c))}) \quad (3)$$

where cos = trigonometric function of the cosine.

Fisher's exact test was used as a contrast technique, another non-parametric statistic also applicable when the variables are binary, in which the association of all the variables was confirmed as significant. Additionally, to estimate the probability of the variable Land tenure as a function of the other dichotomous variables, odd ratio (OR) by logistic regression was used [42, 43]; this technique requires a dichotomous dependent variable *y* and one or more independent qualitative variables *x1, x2 ... xn* that can also be dichotomous and must be mutually exclusive [44]. The logistic regression model can be expressed as Equation (4).

$$\log(p/1-p) = b0 + b1x1 + b2x2 + b3x3 \ldots + bnxn \quad (4)$$

Where:

p = is the probability that *y* takes value 1 in the presence of covariates *x*

b0 = intercept or regression constant

b1, b2, b3, bn = coefficients of the covariates in the regression model

x1, x2, x3, xn = qualitative independent variables

Logistic regression processing in SPSS was performed using the forward stepwise method; slightly approximate Cox and Snell square and Nagelkerke R-square values were obtained; the Hosmer and Lemeshow test yielded a higher value than the significance, which is a good indicator of the goodness of fit of the model, reliable values for the regression analysis, according to Ortega [45].

4. Results

Gender. In the Tamaulipas sugarcane field, suppliers are at a proportional rate of 4 men to every woman (17.9%); this result concurs with data from the last national agricultural census of 2019 [12], which reports 17% of female agricultural producers; it also coincides with the 16% average of female heads of agricultural holdings in Latin America [24]. **Table 3** shows the results of the association between the variable Gender and the variables referring to the economic and social capital of sugarcane producers.

Table 3. Results from statistical tests.

Variable	Indicators	Frequencies Men	Frequencies Women	Proportion	Fisher (Sig) Bilateral	φ (Sig)	r_{tet}
2. Land ownership	Is land owner	422	97	0.951	0.030 $^{x\,1}$	−0.085 ^{x}	
	Is not land owner	26	1			(0.048)	
3. Decision	Decides what to cultivate	438	89	0.965	0.003 ^{x}	0.144 ^{y}	
	Does not decide what to cultivate	10	9			(0.001)	
4. Irrigation	Irrigates	251	70	0.588	0.006 ^{x}	0.124 ^{x}	
	Does not irrigate	197	28			(0.005)	
5. Register	Included in sugarcane register	218	33	0.460	0.005 ^{x}	−0.116 ^{x}	
	Not included in sugarcane register	230	65			(0.006)	
6. Other income	Has income other than sugarcane	210	32	0.443	0.013 ^{x}	−0.109 ^{x}	
	Has no other income	238	66			(0.010)	
7. Other crops	Grows other crops	73	4	0.141	0.001 ^{y}	−0.131 ^{x}	
	Does not grow other crops	375	94			(0.002)	
8. Hectares	Plot exceeds >7 ha	261	47	0.564	0.040 ^{x}		0.339
	Plot is less than <7 ha	187	51				

Note: ^{x} significant at 0.05 ^{1} ^{y} significant at 0.001 ^{1} unilateral.
Source: Self-elaborated with collected data.

Land tenure. In Tamaulipas, 95.1% of sugarcane suppliers own their farms and the rest are tenants. The test result (φ = –0.085) showed a weak association between land ownership and gender (**Table 3**), possibly affirming that female producers in Tamaulipas have slightly more access to land ownership than male producers, although the reasons why men take more risks than women were not investigated, as while 6.1% of men rent land, only 1% of women do so; this result may also indicate discrimination against women in land rent. This particular result for sugarcane cultivation is important because Tamaulipas is the third state showing the greatest access of women to land ownership, at 29%, only behind Sinaloa with 31% and Puebla with 30% [12].

Decision power. Regarding decision-making power for planting, 96.5% of the suppliers in this sugarcane area decide what to plant: 10 out of 448 men (2.2%) stated that the person who decides is another person, such as the owner of the plot or a third party, whereas 9 out of 98 women (9.1%) stated the same. The result from the test (φ = 0.144) indicated that gender is moderately associated with decision-making power for planting, with women having less decision-making power, although we did not question who commanded that power. Currently, agrarian law favors women, indicating that the establishment of farms or industrial agricultural units on the best communal lands [28] should be exploited by women over 16 years of age. However, in practice it is evident that this is rarely implemented, as female participation in agricultural work is negligible [27].

Irrigation. Most small-scale farms in Latin America lack adequate soil and irrigation [24]; even though greater access to irrigated land would permit improved harvests. Irrigation is essential in the sugarcane zone of Tamaulipas and has been reported by several authors to be sufficient in 56% of the lands in the region and supplementary in 9%, whereas the rest do not have this resource [3, 31, 46]. Contrastingly, sufficient irrigation is reported for only 20% of sugarcane plots throughout the country, and auxiliary irrigation is at an equal level, with the rest of the land being rain-fed [2]. In this work, it was found that 58.8% of the producers in the area have access to water (**Table 2**), a higher percentage than in other sugarcane zones, although the productivity of the field in this region is lower than the national average [47], perhaps because crops are not irrigated enough times. Apparently, the degree of association between gender and irrigation variables (φ = 0.124) moderately favors women: irrigated land exceeds 70% for women's properties, with only 54% for men's properties.

Sugarcane register. It is interesting that the respondents who stated that they were not included in the sugarcane register in 2019 were 292 people (54% of the sample), whereas the state registry for the 2023–2024 cycle reported 235 free producers (7.38% of the total), and the national average is 11.52%. The peasant continues to connect to his territory and seeks to adapt to the changing conditions of the environment, reproducing his uses and customs related to the countryside [15]. This may explain why producers do not place themselves in any register, if their parents did not do so either but still carried out their agricultural activity. Doing so would make it possible to obtain benefits in the form of access to credit and financing or direct support from the government, which would improve the economic situation of the producer and his family. This indicator is also moderately associated with gender (φ = –0.116); the result shows that, while half of the men claimed to be on a register, only a third of the women responded the same.

Other income. An advantage of having other sources of income is that the producer can use these resources to subsidize his other crops [33]; although it is not easy to carry out other activities that generate income in rural areas, if the farmer lives near urban areas or has better access to them, it becomes possible [24]. Perhaps the more than 13,000 km of paved roads in Tamaulipas stimulate inter-municipal communication and are the reason that 44.3% of sugarcane suppliers in the area obtain alternative income to that from agriculture. We discerned a moderate association between the indicator (φ = –0.109) and gender: 46.8% of men and 32.6% of women obtain other income. This information contrasts with that reported by other authors [34], as apparently 60% of producers in this area receive other income, including income from retirement or pension.

Other crops. The result for this variable is interesting, as 14.1% of sugarcane producers in the region si-

multaneously plant another crop, a situation repeated to varying extents throughout Mexican rural areas. Another advantage of having more than one crop is that sugarcane suppliers divide their plots to plant sugarcane and vegetables and are thus able to receive a double benefit from the same plot[14]. Mexican legislation permits this if each activity is carried out by a different person: a) a grant exclusively for sugarcane cultivation, or b) a grant for agricultural activity in general; this represents an additional source of income for the family unit. The result of test φ = –0.131 also indicates a moderate association between this indicator and the producer's gender; in this sugarcane area, only one woman out of 25 plants another crop apart from sugarcane, whereas one in 6 male producers diversifies their planting.

Size of plot. Plots in sugarcane areas of Tamaulipas have an average size of 10 hectares, but the most frequent value (mode) is 6 ha, while the national average in Mexico is 4 or 5 ha[2, 25]; this area exceeds that of other sugarcane regions (see **Table 1**), where agricultural lands reach 2 and 3 ha on average in some municipalities[14, 27]. The tetrachoric correlation statistic showed that the average size of the plots in the study area associates very strongly with the gender of the sugarcane producer (r tet = 0.339): whereas 48 % of women own plots that exceed 7 ha on average, this value is 58% in the case of men, marking ten percentage points of difference in favor of men. This negates the hypothesis of equality of plot size based on gender; women's landholdings do not exceed 46 ha, whereas some men hold plots of between 51 and 260 ha (**Figure 3**). Ethnic origin also relates to the size of agricultural holdings: indigenous people in several South American countries have farms that are on average smaller than those of non-indigenous people and they are more involved in subsistence farming than in corporate farming[24].

Binary logistic regression was also performed, in which the variables Gender (1) and Decision (3) were found to be determinants of the variable Land Tenure (2), since their values at the 95% Confidence Intervals [95% CI] are within the allowed range a while the rest of the variables were not significant (see **Figure 4**). In Tamaulipas, women are 5.97 times more likely to be the owners of their sugarcane plot than men, despite the fact that there are fewer female sugarcane growers (17.9% of the total). Also, men who stated that they make planting decisions are 8.2 times more likely to be the owners of the sugarcane plot than those women and men who argued that they do not make any decisions about sugarcane cultivation. The predictive model found explained 10.8% of the change in the dependent variable.

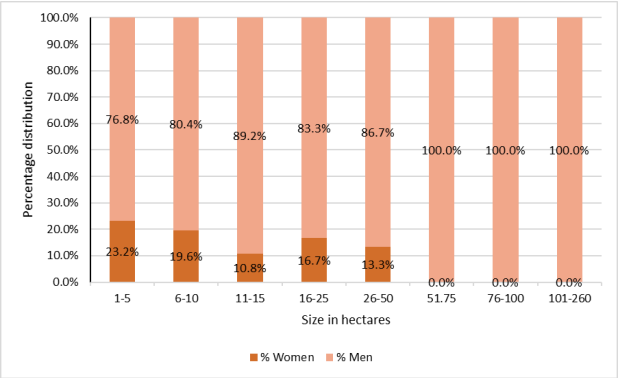

Figure 3. Size and distribution of sugarcane plots in Tamaulipas, by gender.

Source: Self-elaborated.

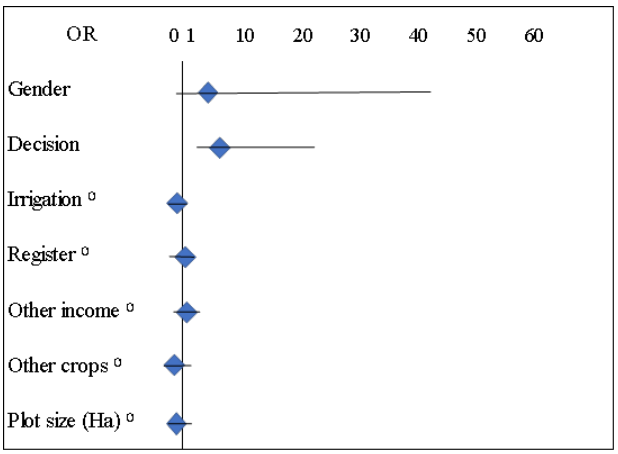

Figure 4. Associated factors with land ownership in Tamaulipas, Mexico.

Source: Self-elaborated.

Note: ⁰ Not significant. R2 0.035 (Cox & Snell), 0.108 (Nagelkerke), Model X2 = 19.630, dof = 1. Hosmer & Lemeshow test = 0.350.

From the results, the logistic regression equation was obtained, expressed as (5).

$$y = 2.959 + 2.418b(\text{gender}) - 2.722(\text{decision}) \quad (5)$$

Equation verification. In the land tenure test, it was considered the case of a male producer who makes the decisions of his crop; substituting the values, the result is:

$y = 2.959 + 2.418\ (1) - 2.722\ (1) = 2.655$

Therefore, the probability p that the producer involved owns the sugarcane plot will be:

$p = 1 / (1 + e\ ^\wedge\ - y) = 0.98$

If the producer is a woman who makes her planting decisions, the result will be:

$y = 2.959 + 2.418\ (0) - 2.722\ (1) = 0.237$

And the probability that she is the owner of the sugarcane plot will be: $p = 1 / (1 + e\ ^\wedge\ -y) = 0.44$

If the producer is male, but does not make planting decisions, the result will be:

$y = 2.959 + 2.418\ (1) - 2.722\ (0) = 5.377$

And the probability that he is the owner of the sugarcane plot will be: $p = 1 / (1 + e\ ^\wedge\ -y) = 0.48$

Finally, if the producer is a woman but does not make her planting decisions, the result will be:

$y = 2.959 + 2.418\ (0) - 2.722\ (1) = 2.959$

And the probability that she is the owner of the sugarcane plot will be: $p = 1 / (1 + e\ ^\wedge\ -y) = 0.95$

5. Discussion

This work contributes to the research on the size of agricultural plots carried out by other authors (see Campos Ortiz and Oviedo Pacheco [48]) and offers a new angle in relation to gender. The size and ownership of land are linked to another problem: the fragmentation of the agricultural field, which has a greater impact in lower-income countries; in some regions of the world, women have less access than men to land ownership and pay higher registration costs than men [37], but recently there have been favorable changes in some countries. In Latin America, the average agricultural plot has increased, following a number of legal reforms [24]. In contrast, in some African nations, fragmentation has increased and the trend towards decreasing plot size continues in several countries [49] such as Swaziland, where it has been recorded that the cultivation of sugar cane indicated less land control for women, who also face less access to cane producer associations [50]. Obstacles to women's progress in agriculture are also apparent in other regions of Southeast Asia, in the form of lack of land, irrigation, and access to finance [29, 51].

Women's agricultural involvement does not always concern paid activities; sometimes they work in the fields and also in activities outside the fields; this is more so when there are no agricultural tasks in their own crop and they usually share their income with the rest of the family [32, 51]. Women may be as capable as men in terms of managing any crop and tend to adopt new technologies more readily than they do [52] but are less likely to risk renting land [53]; however, to improve productivity in the sugarcane field, it is necessary to reduce discrimination against them. One way to do this would be by guaranteeing the right to agricultural property for women, young people and indigenous producers, which would allow them to access credit and enable them to make optimum decisions for their productive unit [10, 11]. In Mexico, the legal framework that guarantees the rights of property and control of land in favor of women is below that of several countries in the Latin American region and far below that of several European countries in this category. For the situation to improve, it is desirable that governments ensure a legal framework that protects the rights of all people to own and control land, to decide on land inheritance, to provide the resources to work it, and to access financing, in accordance with the Sustainable Development Goals (SDG) of the United Nations Organization [29, 37].

However, legal reforms require simultaneous education concerning land rights in rural communities to make it easier for men to accept the transfer of land ownership in favor of women [54]. In another example, we document two affirmative actions that guarantee access to land ownership in the state of Veracruz, Mexico [55]: 1) free legal advice provided by municipal authorities, and 2) free procedures in agrarian trials. For these authors, agrarian reforms have been insufficient to guarantee women's full access to land ownership in other regions of the country, and they affirm that the inclusion of gender in the wording of some laws has only allowed their access *de jure* (by right) but not *de facto* (in fact). The problem of land ownership and the size of sugarcane plots is more evident in rural communities in the southeast of Mexico, where they endure persistent high or very high marginalization, whereas this phenomenon is less evident in the northern region where Tamaulipas is located, perhaps due to lower rates of marginalization [1].

In addition, Tamaulipas is the state with the third highest average number of hectares per sugarcane production unit in the country: 11.2 hectares vs. 5.4 hectares for the country average (see **Table 1**).

6. Conclusions

This work contributes, at the regional level, to the recognition of the determinants of sugarcane cultivation in a sugarcane-growing region of Mexico. In this area, the average plot size is higher than the national average, although the literature points out that the causes of this difference are diverse. The distribution of agricultural land in developing countries is not gender-balanced, with male land ownership predominating. In the northeastern region of Mexico, women account for almost one-fifth of sugarcane suppliers, hold tenure of their plots and have access to irrigation on equal terms with men. However, their landholdings are smaller, revealing a strong correlation between the size of sugarcane plots and gender, with women at a disadvantage. As in other regions, men tend to have more decision-making power over aspects related to the crop, such as the choice of seed or agricultural practices. However, women who do not exercise this power are up to 4.5 times more numerous than men. The economic and social capital of farmers is closely linked to their experience and rootedness in the crop, which in this region exceeds 90 years. In addition, inclusion in agricultural registries and access to additional income or complementary crops to sugarcane show a moderate association with gender, also to the disadvantage of women. More studies like this one are needed, as the 7 sugarcane-growing regions of the country are different; then, these results lead to the conclusion that the size of sugarcane plots is a key factor in the fight against inequality, as there is a clear advantage of men over women in terms of ownership of larger plots of land, even in the absence of female ownership of plots of land larger than 50 hectares. Guaranteeing land tenure for women and children, as well as ensuring their equal access to water resources and financing, could enable women to develop their agricultural activities more efficiently, thus increasing the productivity of the countryside and giving them the opportunity to acquire larger tracts of arable land than they currently own.

7. Limitations and Strengths of the Study

Moderate association between results of variables, such as those found here, are common in social research; thus, we consider them valid. A strength of the research lies in the medium sample size, which exceeds 500 cases, which is adequate for social studies, making the statistical tests performed more robust and strengthening analysis [41]. A limitation of this research is the nature of the available data, as it was not possible to add variables or change the binary type of items; among its limitations is the exclusive use of dichotomous variables, which tend to offer biased estimates. This can be avoided by using appropriate statistical techniques, such as the tetrachoric correlation applied here, suggested by authors.

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Informed Consent Statement

All respondents were informed of the scope of the research and consent was obtained for interviews and data collection.

Data Availability Statement

All data supporting the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares no conflict of interest.

References

[1] Morett-Sánchez, J.C., Cosío-Ruiz, C., 2017. Overview of ejidos and agrarian communities in Mexico. Agricultura, Sociedad y Desarrollo. 14(1), 125–152. (in Spanish). Available from: https://acortar.link/ZUm7i8 (cited 4 October 2024).

[2] SADER, Secretaría de Agricultura y Desarrollo Rural, 2022. National Sugarcane Agroindustry Program PRONAC 2021-2024. (in Spanish). Available from: https://acortar.link/dRXuTG (cited 4 October 2024).

[3] Ruiz Corral, J.A., Medina García, G., Ramírez Ojeda, G., et al., 2014. Production potential. In: Mata Vázquez, H., Rodríguez del Bosque, L.A., Rodríguez-Morelos, et al. (eds.). Integrated Sugarcane Management. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP): Monterrey, Mexico. pp. 67–82. (in Spanish)

[4] Aguilar Rivera, N., 2017. Productive and competitive structure of the sugar agroindustry. In: Vázquez, M., Rivera, A., Delgado, G. (eds.). Factors Affecting Sugarcane Production in Tamaulipas. Fertigation and Soil and Climate Characterization. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP): Villa Cuauhtémoc, Mexico. pp. 2–32. (in Spanish)

[5] Afghan, S., Ehsan Khan, M., Raza Arshad, W., et al., 2023. Economic importance and yield potential of sugarcane in Pakistan. In: Kumar Ghimire, B. (ed.). Sugarcane—Its Products and Sustainability. IntechOpen. DOI: https://doi.org/10.5772/intechopen.105517

[6] Chávez Bermúdez, B.F., Flores Fernández, Z., 2017. Women's labor participation: Perspectives and challenges. In: Arroyo Cisneros, E.A., Montoya Zamora, R. (eds.). Labor and Human Rights. Some Contemporary Challenges. Instituto de Investigaciones Jurídicas, Universidad Juárez del Estado de Durango: Victoria de Durango, Mexico. pp. 109–130. (in Spanish)

[7] FAO, 2024. The situation of women in agrifood system. FAO: Rome, Italy. pp. 1-264. (in Spanish). DOI: https://doi.org/10.4060/cc5343es

[8] Figueroa-Rodríguez, K.A., 2024. Women in sugarcane industry. Revista de la Asociación de Técnicos Azucareros de México. 37(2), 18–21. (in Spanish). Available from: https://acortar.link/2U8GGA

[9] Ramos Salinas, R., 2020. Desarrollo social de Tamaulipas. Universidad Autónoma de Tamaulipas & Colofón, S.A. de C.V.: Ciudad Victoria, Mexico. pp. 1-133. (in Spanish)

[10] CEPAL: Comisión Económica para América Latina y el Caribe, FAO: Organización de las Naciones Unidas para la Agricultura y la Alimentación, IICA: Instituto Interamericano de Cooperación para la Agricultura, 2017. Outlook for Agriculture and Rural Development in the Americas: A Look at Latin America and the Caribbean 2017-2018. IICA: San José, C.R., Costa Rica. pp. 1-267. (in Spanish). Available from: https://acortar.link/Rfde3f (cited 8 Oct 2024).

[11] Kawarazuka, N., Doss, C.R., Farnworth, C.R., et al., 2022. Myths about the feminization of agriculture: Implications for global food security. Global Food Security. 33, 100611. DOI: https://doi.org/10.1016/j.gfs.2022.100611

[12] Jerez Velasco, M.E., 2023. Gender inequalities in access to ejido land in Mexico: An obstacle to equity and empowerment of rural women. Universita Ciencia. 11(31), 43–62. (in Spanish). DOI: https://doi.org/10.5281/zenodo.8148583

[13] Salmeron-Manzano, E., Manzano-Agugliaro, F., 2023. Worldwide research trends on land tenure. Land Use Policy. 131, 106727. DOI: https://doi.org/10.1016/j.landusepol.2023.106727

[14] Thiébaut, V., Hédouin, C., Legendre, A., 2013. Sugarcane and economic liberalization. Peasant strategies and territorial changes in Jalisco and Veracruz. Sociedades Rurales, Producción y Medio Ambiente. 13(25), 15–44. (in Spanish). Available from: https://sociedadesruralesojs.xoc.uam.mx/index.php/srpma/article/view/229

[15] Peraza Leal, N.P., Velázquez Torres, D., 2020. Shaping rural territory: Peasants and their persistence. A case of Mexico's southern border. Perspectiva Geográfica. 25(1), 56–76. (in Spanish). DOI: https://doi.org/10.19053/01233769.9259

[16] Thiébaut, V., 2014. Economic liberalization and sugarcane: Three case studies in México. Ulúa Revista de Historia, Sociedad y Cultura. 23, 95–124. (in Spanish). DOI: https://doi.org/10.25009/urhsc.v1i23.1093

[17] Pérez, M.A., Peña, M.R., Álvarez, P., 2011. Sugarcane agro-industry and water use: Critical analysis in the context of agrofuels policy in Colombia. Ambiente & Sociedade. 14(2), 153–178. (in Spanish). Available from: https://acortar.link/cfnWtJ

[18] CONADESUCA: Comité Nacional para el Desarrollo Sustentable de la Caña de Azúcar, 2024. Geoportal Map Library. (in Spanish). Avaliable from: https://acortar.link/B5ew41 (cited 8 Oct 2024).

[19] López Martínez, J., Molina Vargas, A., 2018. The labor situation of women in the agricultural sector in Mexico, 2008-2016. Análisis Económico. 33(83), 100–111. (in Spanish). DOI: https://doi.org/10.24275/uam/azc/dcsh/ae/2018v33n83/Lopez

[20] De Arce, A., 2015. Gender and sugarcane production. Family labor in northwestern Argentina (1930-1960). In: Ortega López, T.M. (ed.). Day Laborers, Peasant Women and Farmers: Agrarian History from a Gender Perspective. Prensas de la Universidad de Zaragoza: Zaragoza, Spain. pp. 111–141. (in Spanish). Available from: https://acortar.link/782aFb

[21] Andrade, C., 2020. Sugarcane fields in Humaya, province of Huaura, Peru. Peruvian Agricultural Re-

search. 2(1), 35–40. (in Spanish). DOI: https://doi.org/10.51431/par.v2i1.623

[22] Beraud-Macías, V., Sosa-Ramírez, J., Maya-Delgado, Y., et al., 2018. Agrarian reform and ejido land use changes in Aguascalientes, 1983-2013. Agricultura, Sociedad y Desarrollo. 15(3), 443–463. (in Spanish). DOI: https://doi.org/10.22231/asyd.v15i3.855

[23] Calatayud, S., Garrido, S., 2021. Social inequality and decision making in the commons: The governance of the largest irrigation canal in Spain (the Acequia Real del Júcar, Valencia) in the 19th century. Historia Agraria. 83, 97–128. (in Spanish). DOI: https://doi.org/10.26882/histagrar.083e03c

[24] Leporati, M., Salcedo, S., Jara, B., et al., 2014. Family farming in numbers. In: Salcedo, S., Guzmán, L. (eds.). Family Agriculture in Latin America and the Caribbean: Policy Recommendations. FAO: Santiago, Chile. pp. 35-56. (in Spanish)

[25] INEGI. Instituto Nacional de Estadística y Geografía, 2023. Agricultural Census 2022. (in Spanish). Available from: https://acortar.link/tYipnW (cited 22 September 2024).

[26] Mata Vázquez, H., Báez González, A.D., Ruiz Corral, J.A., et al., 2017. Climatic and edaphic characterization of the supply area of the Aarón Sáenz Garza sugar mill, Tamaulipas. In: Vázquez, M., Rivera, A., Delgado, G. (eds.). Factores que Afectan la Producción de Caña de Azúcar en Tamaulipas. Fertirrigación y Caracterización Edafoclimática. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP): Villa Cuauhtémoc, Mexico. pp. 33–63. (in Spanish)

[27] Sandoval Contreras, R., 2022. Social Construction of Reality: Sugarcane Growing Village. Carta Económica Regional. 34(129), 5–26. (in Spanish). DOI: https://doi.org/10.32870/cer.v0i129.7832

[28] Procuraduría Agraria, 2014. Agrarian Law and Glossary of Agrarian Law Terms 2014. Mujica Impresor, S.A. de C.V.: México, D.F., Mexico. pp. 1-268. (in Spanish). Available from: https://acortar.link/WYzeiO

[29] FAO-AUC: Food and Agriculture Organization of the United Nations, African Union Commission, 2020. Leaving no one behind – a regional outlook on gender and agrifood systems. FAO-AUC: Addis Ababa, Ethiopia. pp. 1-200. DOI: https://doi.org/10.4060/cb1086en

[30] Acuña Alvarado, M., 2020. The gender gap in access to land: a look from the agricultural policy aimed at rural women in Costa Rica. Anuario del Centro de Investigación y Estudios Políticos. 11, 162–194. (in Spanish). DOI: https://doi.org/10.15517/aciep.v0i11.43257

[31] Aguilar-Rivera, N., Algara Siller, M., Olvera Vargas, L.A., 2015. Water management as a limiting factor for sugarcane productivity in Mexico. Revista de Geografía Norte Grande. 60, 135–152. (in Spanish). DOI: https://doi.org/10.4067/S0718-34022015000100008

[32] Tigabie, A., Teferra, B., Abe, A., 2022. Access and control of resources by rural women in North Shewa Zone, Amhara region, Ethiopia. Research on World Agricultural Economy. 3(4), 751. DOI: http://dx.doi.org/10.36956/rwae.v3i4.751

[33] Martínez Borrego, E., Vallejo Román, J., 2019. Pluriactivity, consumption and persistence of corn in two municipalities in the northwest of the State of Mexico. Revista Euroamericana de Antropología. 7(15). 41–53. (in Spanish). DOI: https://doi.org/10.14201/rea201974153

[34] Sánchez Muñoz, N.E., García Fernández, F., Sánchez Aldape, A., 2015. The sugarcane agro-industrial chain. In: García Fernández, F. (ed.). Regional development strategies for El Mante, Tamaulipas. Building a region of knowledge. Pearson Educación de México, S.A. de C.V.: México, D.F., Mexico. pp. 77–92. (in Spanish). Available from: https://acortar.link/4T0bMt

[35] García Fernández, F., Flores Flores, A.J., De la Garza Cárdenas, M., 2015. Diagnosis and specialization of El Mante region. In: García Fernández, F. (ed.). Regional development strategies for El Mante, Tamaulipas. Building a region of knowledge. Pearson Educación de México, S.A. de C.V.: México, D.F., Mexico. pp. 5–36. (in Spanish)

[36] FAO: Food and Agriculture Organization of the United Nations, 2013. Governing land for women and men. FAO: Rome, Italy. pp. 1-110. Available from: https://www.fao.org/4/i3114e/i3114e.pdf

[37] FAO: Food and Agriculture Organization of the United Nations, 2022. Tracking progress on food and agriculture-related SDG indicators 2022. FAO: Rome, Italy. pp. 1-170. DOI: https://doi.org/10.4060/cc1403en

[38] Paz-Pérez, D.E., 2019. Socio-demographic factors affecting sugarcane production in Tamaulipas. Revista Tecnociencia Superior. 1(2). 1–6. (in Spanish). Available from: https://rioverde.tecnm.mx/documentos/tecno_ciencia/Revista_TecnoCiencia2.pdf

[39] Akoglu, H., 2018. User's guide to correlation coefficients. Turkish Journal of Emergency Medicine. 18, 91–93. DOI: https://doi.org/10.1016/j.tjem.2018.08.001

[40] Martínez-Abad, F., Rodríguez-Conde, M.J., 2017. Behavior of product-momentum and tetrachoric-polychoric correlations on ordinal scales: A simulation study. RELIEVE: Revista Electrónica de In-

vestigación y Evaluación Educativa. 23(2), 1–21. (in Spanish). DOI: https://doi.org/10.7203/relieve.23.2.9476

[41] Freiberg Hoffmann, A., Beatriz Stover, J., De la Iglesia, G., et al., 2013. Polychoric and tetrachoric correlations in exploratory and confirmatory factorial studies. Ciencias Psicológicas. 7(2), 151–164. (in Spanish). DOI: https://doi.org/10.22235/cp.v7i1.1057

[42] Ochoa-Sangrador, C., 2019. Diseño y análisis en investigación. International Marketing y Comunication, S.A.: International Marketing & Comunication, S.A.: Spain. pp. 1-152. (in Spanish)

[43] Kappes, M., Riquelme, V., 2021. The p-value and measures of effect: Their interpretation in quantitative nursing research. Revista Ene de Enfermería. 15(2), 1-13. (in Spanish). Available from: http://ene-enfermeria.org/ojs/index.php/ENE/article/view/1247

[44] Berea-Baltierra, R., Rivas-Ruiz, R., Pérez-Rodríguez, M., et al., 2014. From clinical judgment to multiple logistic regression. Revista médica del Instituto Mexicano del Seguro Social. 52(2), 192–197. (in Spanish). Available from: https://www.medigraphic.com/pdfs/imss/im-2014/im142r.pdf

[45] Ortega-Páez, E., Ochoa-Sangrador, C., Molina-Arias, M., 2022. Simple binary logistic regression. Evidencias en Pediatría. 18(11), 1–9 (in Spanish). Available from: https://acortar.link/Nz9SHx

[46] Santillán-Fernández, A., Santoyo-Cortés, V.H., García-Chávez, L.R., et al., 2016. Influence of drought and irrigation on sugarcane yields in different agroecoregions in Mexico. Agricultural Systems. 143, 126–135. DOI: https://doi.org/10.1016/j.agsy.2015.12.013

[47] CONADESUCA: Comité Nacional para el Desarrollo Sustentable de la Caña de Azúcar, 2019. Diagnóstico de la Agroindustria de la caña de azúcar. Región Noreste. Conadesuca: Ciudad de México, México. pp. 1–65. (in Spanish). Available from: https://acortar.link/EDH8ca

[48] Campos Ortiz, F., Oviedo Pacheco, M., 2015. Agricultural land extension and productivity. The case of sugarcane fields in Mexico. El Trimestre Económico. 82(325), 147–181. (in Spanish). DOI: https://doi.org/10.20430/ete.v82i325.143

[49] Mayele, J.M., Kolleh, J.B., Saburi, J.E., 2024. The impacts and causes of land fragmentation on farm productivity: Case review of East African countries. Open Journal of Ecology. 14, 455–482. DOI: https://doi.org/10.4236/oje.2024.145027

[50] FAO: Food and Agriculture Organization of the United Nations, 2008. From subsistence farming to sugar-cane monoculture: impacts on agrobiodiversity, local knowledge and food security. A case study of two irrigation and agricultural development projects in Swaziland. FAO: Rome, Italy. pp. 1-32. Available from: https://www.fao.org/4/aj042e/aj042e.pdf

[51] Sourn, T., Pok, S., Chou, P., et al., 2023. Assessing Land use and land cover (LULC) change and factors affecting agricultural land: Case study in Battambang Province, Cambodia. Research on World Agricultural Economy. 4(4), 925. DOI: http://dx.doi.org/10.36956/rwae.v4i4.925

[52] Kuldilok, K., 2021. The determination of organic practice and adoption in sugarcane farming in Thailand. Kasetsart Journal of Social Sciences. 42, 694–701. DOI: https://doi.org/10.34044/j.kjss.2021.42.3.35

[53] Sumbele, S.A., Ngane, B.K., Fonkeng, E.E., et al., 2018. Demographics of smallholder sugarcane farmers in five regions of Cameroon. Journal of Agriculture and Ecology Research International. 14(3), 1–12. DOI: https://doi.org/10.9734/JAERI/2018/39521

[54] Kaunza-Nu-Dem, M.K., Tijani, B., Millar, D., et al., 2016. The complexities of women land ownership in Northern Ghana. Open Access Library Journal. 3, e2789. Available from: https://acortar.link/OhtyjD

[55] Torres Sandoval, I., Daza Ponce, D.A., 2018. Actions from the municipality of Chicontepec (State of Veracruz, Mexico) to achieve gender equality in ejido land tenure. Revista Latinoamericana de Estudios Rurales. 3(5), 139–164. (in Spanish). Available from: https://ojs.ceil-conicet.gov.ar/index.php/revistaalasru/article/view/365