Research Article

Patrícia José de Almeida*, Carlos T. Salinas, Lucas Ramos, Celso Albano de Carvalho

Forms of land access in the sugarcane agroindustry: A comparison of Brazilian and Peruvian cases

https://doi.org/10.1515/opag-2022-0136
received April 14, 2022; accepted August 30, 2022

Abstract: Currently, many sugarcane mills face the challenge of obtaining sufficient raw material. This work analyzes and compares the land access forms to cane production in Brazil (big producer) and Peru (small producer). Data from Agricultural Censuses of the two countries are used. In the analyzed period, there was an increase in sugarcane production in both countries. It is observed that in Brazil, the tendency is for sugar mills to use land leasing or sharecropping contracts. In Peru, new sugarcane mills mainly use their own land. The access to land through agrarian contracts can be a factor of sustainability of the sugarcane agribusiness.

Keywords: land access, leasing, sharecropping, sugarcane agroindustry

1 Introduction

Sugarcane is one of the most important crops in the world and the three countries with the largest production volume in 2017 were Brazil (41% of world production), India (16%), and China (6%). In addition, the top 3 countries with published and cited sugarcane research are Brazil, the United States, and India [1]. Studies show that in Brazil (major cane producer) and in Peru (currently a small cane producer compared to Brazil, which is looking to return to being a large cane producer), there are a high potential for sugarcane cultivation and utilization of biomass sugarcane waste as renewable energy source [2–4]. In other studies, it was observed that in Brazil and Peru, the production of sugarcane is viable in pastures with low potential for agricultural productivity and it is indicated that this fact weakens the argument that the production of sugarcane sugar for ethanol production would be an obstacle to grain production. In a study based on data from the Office of Rural Development (EDR) of Mogi Mirim (municipality of the State of São Paulo), ref. [5] showed that sugarcane production did not influence the growth rate of areas of food cultivation from 1997 to 2007. In the same trend, refs [6,7] argued that a significant part of sugarcane production is taking place on low-efficiency pasturelands, which would not affect grain production.

On the other hand, ref. [8] analyzed the resizing of Mato Grosso do Sul due to the territorialization of sugarcane, and it is noting that many regions where pasture and soybean existed were replaced by sugarcane production. This caused an excess of unskilled labor being displaced from the fields to the municipalities in the region. In similar trend, ref. [9] stated that in regions where family farming constitutes the main means of subsistence, "changes in the agricultural structure can indeed create risks to food security" and, also, pointed out that in this sense, it is necessary to observe how the change in the use of land affects the production capacity of local communities, considering its influence on the price of land and other productive inputs. Another factor that is indicated in ref. [9] as relevant to sugarcane expansion and, directly related to the issue of employment, was the land problem. In this regard, this author highlighted that the practice of leasing contracts in several sugarcane-producing regions can lead to land concentration. Despite the lack of more structured studies on the determining factors for the use of more integrated structures

* **Corresponding author: Patrícia José de Almeida,** Facultad de Ingenieria - Universidad de Piura/UDEP (Peru), Ramón Mugica 131, Av., Urb. San Eduardo, Piura, Peru, e-mail: almeida_03@yahoo.com.br
Carlos T. Salinas: Facultad de Ingenieria - Universidad de Piura/UDEP (Peru), Ramón Mugica 131, Av., Urb. San Eduardo, Piura, Peru; Mechanical Engineering Graduate program - Santa Cecilia University, Rua Cesário Mota 08, Sala F-34, Santos, Brazil
Lucas Ramos: Facultad de Ingenieria - Universidad de Piura/UDEP (Peru), Ramón Mugica 131, Av., Urb. San Eduardo, Piura, Peru
Celso Albano de Carvalho: Program of Continuing Education in Economics and Business Management (PECEGE), Rua Alexandre Herculano 120, Vila Monteiro, Piracicaba (SP) CEP 13.418-445, Brazil

by mills (such as leasing or even vertical integration – the so-called own cane), professionals linked to the sector mention that the greater competition for cane in a same region would encourage mills to internalize the production of raw materials. Thus, given that their bargaining power would be reduced or they would be at risk of shortages, mills would opt for long-term contracts and other forms of supply chain integration. By this logic, the high concentration of mills in the same region, which intensifies the competition for sugarcane, tends to aggravate the tendency to land concentration, due to the greater integration of the supply chain by the mills. This process of concentration of plants in some regions is remarkable in the last cycle of expansion of sugarcane in the state of São Paulo, notably in the region of Ribeirão Preto.

There is strong evidence that the increase in raw material production can increase the efficiency of the sugarcane agroindustry, either by reducing the idle capacity of industrial plant or by increasing the cogeneration of energy [10]. In addition, to improve the industrial process of sugarcane, it is necessary to take advantage of solid biomass residues, among other ways, by biofuels' production, by burning bagasse and straw to increase the supply of electrical energy and increase overall energy efficiency [11].

Currently, in many sugarcane-producing countries in the world, sugarcane mills have difficulties in obtaining their raw material in sufficient quantity. In addition, the use of biomass sources to generate clean and renewable energy, the increase in sugar consumption due to the entry of new consumers in the market, and the development of new types of bioproducts such as fuels and plastic products by the sugar-energy sector increased demand for raw sugarcane [10,12]. Due to the expansion of the consumption of biofuels, it is reported the generation of conflicts in the regions close to the plants that are related to environmental and social issues. In view of this, it was recommended to include local voices to avoid conflicts between plants and the social environment [13]. Based on empirical work in Vietnam, it was argued that the practice of third-party contracts between farmers and mills should be encouraged to mitigate the adverse effects of information and income asymmetry in the sugarcane sector [14]. In a case study in Ghana, two specific types of land contracts were analyzed and it was found that, in these cases, there was an improvement in the income and well-being of smallholder farmers [15]. In a study in Nepal, it was found that a friendly relationship between sugarcane producers and buyers (sugar mills) can be favorable to fix a viable sugarcane price for both parties [16].

In Brazil and Peru, access to sufficient land has been a major obstacle for sugarcane mills and producers. In Brazil, due to the competitive economic environment in the sugarcane sector, many landowners often have to evaluate the convenience of practicing agrarian lease or sharecropping contracts for the production of sugarcane, which can be more profitable for them than if they worked the land themselves [12,17,18]. According to these studies, it is observed that sugarcane supply contracts or land leases and sharecropping between mills and sugarcane producers or farmers generally provide greater security in the supply and payment of the product. Although they may contain some restrictive clauses for owners, such as not being able to review the price of cane or not specifying the month of the cane harvest, as this is done according to the mill's need for raw cane. For the mills, the practice of agrarian contracts led to an increase in the area of land with sugarcane plantations, which resulted in an increase in the production of raw materials. This also led to more raw cane being used to generate energy from sugarcane bagasse [19]. Studies show that new forms of access to land have brought beneficial effects to the bioeconomy in Brazil [20].

In Peru, the opening of international food markets and the concentration of land ownership, especially since the 1990s, have allowed agribusiness to incorporate traditional agricultural spaces into its production chains [21–23]. In recent years, new irrigation projects in Peru have also incorporated new land areas for sugarcane cultivation and new mills have been installed and started operations using their own land. Due to the lack of resources (mainly financial) to meet the demands of the production process, small farmers have started to lease out their land. At the same time, agrarian contracts have started to create a source of income for these farmers [24].

In the case of the Peruvian sugarcane agribusiness, agrarian contracts, in addition to reducing the investment of financial resources in the purchase of land, have also enabled the production of raw materials necessary for the mills installed in traditional agricultural spaces. Observed that ref. [3] analyzed the producing energy feasibility in respect of sugarcane derivatives and showed the great potential for generating electricity from sugarcane residues in Peru.

The main objective of this work is to analyze the forms of access to land (for example, leasing and/or sharecropping) in the sugarcane agroindustry in two Latin American countries. One of them is Brazil, a large sugarcane producer and an important producer of biofuels with a cane productivity in the range of 70–80 t cane/ha. The other is Peru, currently a small sugarcane

producer with a cane productivity in the range of 120–140 t cane/ha, that restarted efforts to increase its participation in the sugarcane sector. Secondary data collected from the agrarian censuses of both countries to analyze the variation in agricultural production and the condition of farmers in relation to land ownership are used. First, information is collected and processed from the entire agricultural sector and then, it focuses on the sugarcane sector in the last two decades. The purpose is that a better understanding of the dynamics of the possible forms of access to land by the sugarcane agribusiness, both in Brazil and Peru, contributes to efficiently increasing the use of available land near the mills and, likewise, contributes to encourage and facilitate the increase in the use of clean and renewable energy sources in both countries.

2 Relations of sugarcane production and agrarian contracts in Brazil and Peru: background and hypothesis

2.1 Theoretical-conceptual framework

There is a consensus in the literature that the lease market is usually more active than the land purchase and sale market, as it establishes a relationship between risk sharing and incentives. A pioneer work in formulating the sharecropping model as an agreement between risk sharing and incentives is found in ref. [25]. There, the first principal-agent model is presented to study the problem of moral hazard in relation to unobservable work effort. The choice of the sharecropping system is due to its effects when direct supervision of the work effort is expensive or ineffective for the landowner. While leasing has more of an incentive effect, it also forces the lessee to share risk. Leasing and sharecropping also have welfare effects. In the short term, there are welfare effects because it allows the use of assets that can only be valued through access to land (e.g. family work, administrative and supervisory skills, indivisible assets) and facilitates access to resources for which the market is imperfect (mainly rural credit market). In the long term, access to land via lease and sharecropping can help producers to capitalize, accumulate wealth, and promote social ascension ("agricultural ladder") through land ownership [26]. The idea that the development of leasing and sharecropping can function as a guiding mechanism for agrarian conflicts, economic inefficiency, and social inequalities in rural areas has been widespread [27,28].

Data from the Agricultural Censuses in Brazil show that the practice of agrarian contracts (land leasing and/or sharecropping), despite the geographic concentration in some regions, is distributed throughout the national territory. It is argued that Brazilian legislation makes it difficult to establish these contracts, especially those involving poorer producers. It appears that the regulation of lease and sharecropping contracts is born in a context of specific and contradictory interests. Contract clauses do not always assist the economically weaker party. It is considered that the more intense use of agrarian contracts in the country depends on changes in legislation, so that it meets the socioeconomic conditions of tenants and sharecroppers, especially small producers [29].

Previous studies have verified regional heterogeneities and a clear dualism in agrarian contracts in Brazil [30,31]. On the one hand, there is the small tenants and/or sharecroppers, notably in the Northeast, who, for various reasons (i.e., restricted access to different markets, level of wealth and qualification, experience), are almost always unable to obtain a satisfactory performance to obtain surpluses tradable or make the payment of ground rent and remains in the activity with serious difficulties. On the other hand, there are more capitalized and experienced tenants and/or sharecroppers, particularly in the Southeast and Central-West regions, who have productive and financial conditions to be included in more complex and structured agroindustrial chains (i.e., soybeans, corn, sugarcane, cattle ranching) without the need to immobilize capital in the purchase of land [32].

The results of empirical research, in certain regions of Brazil, have verified that, from the point of view of landowners, the practice of agrarian contracts (leasing and or sharecropping), for the production of sugarcane, can be more profitable than production for supply to the mills [33]. For tenants and/or sharecroppers, sugarcane producers, the contracts established with the mills, despite having more restrictive clauses, provide greater security regarding the supply of the product and the forms of payment. From the mill's point of view, these contracts can provide access to the raw material needed for energy cogeneration from the burning of sugarcane bagasse and straw [19].

In the other hand in Peru, from 1990, after the process of commercial opening and agrarian restructuring, Peruvian agriculture gained new impetus. It is estimated that the share of the agricultural sector in the gross domestic product increased from 0.6% per year between 1970 and 1990 to 4.9% between 1990 and 2012. This

generated in the last period, among other phenomena, an expansion of the border agriculture, a recomposition of the crop portfolio, changes in the demographic profile (greater female presence), and raising the educational level of producers. Agroindustrial groups in Peru, to accompany the country's agricultural growth in recent years, have seen agrarian contracts as an efficient mechanism for accessing land. For the Peruvian sugarcane agroindustry, in particular, these contracts also enable the production of raw material necessary for the cogeneration of energy from the burning of sugarcane bagasse and straw, as well as reducing the investment of financial resources in the purchase of land.

2.2 Brazilian case

The production of sugarcane began in Brazil at the time when the country was still a Portuguese colony and, for almost two centuries, it was the main economic activity in the country. Due to climatic conditions and fertile soil, sugarcane cultivation spread throughout the Northeast region, emerging as a major sugar-producing center in the country. Sugarcane alcohol production took place due to the oil crisis in the 1970s. Thus, after more than four centuries, the cultivation of sugarcane, whose main purpose was the production of sugar, also started to serve as a raw material for the production of alcohol, as an alternative fuel. This production scenario for sugarcane in Brazil was consolidated through territorial extension, favorable climate, and public policies aimed at increasing sugarcane production.

Among the public policies instituted, the main one was the creation of Proálcool (National Alcohol Program), in 1975, considered one of the largest renewable energy programs in the world. This had the purpose of stimulating the growth of the production of sugarcane for the manufacture of alcohol, aiming to meet the needs of the internal and external markets. Therefore, this activity was encouraged by expanding the supply of raw materials, with an emphasis on increasing agricultural production, modernizing existing plants, and installing new production units. At the same time, the automobile industries made technical adaptations so that cars could run on alcohol. A decade after the institution of Proálcool, about 90% of the light automobiles produced were powered by alcohol. It is in this context that the areas occupied with sugarcane expanded across several regions of the Brazilian territory. The Brazilian Southeast was the region that presented the greatest growth, constituting since the 1975, as the largest producer. In the first stage of the program (1975–1979), the state of São Paulo received most of the resources, around 35%. As a result, it effectively consolidated itself in sugar-alcohol production, becoming the largest producer of sugarcane, and since the 1980s, it has supplied half of the national production. In addition, the state of São Paulo concentrates approximately 45% of the country's plants [34].

According to ref. [35], in the State of São Paulo, Brazil, mills and small and medium landowners prefer the sharecropping system in relation to the autonomous production system. Self-production was only more advantageous in locations very close to the industrial unit that purchased their crop. On the one hand, land located close to industrial units offers enormous benefits for the mills and distilleries, because the closer the production of the industry's raw material, the lower the transportation costs, an important component of the total cost of the sugarcane per ton. Due to current legislation, in the case where the producers or owners are individuals, the tax advantage of a sharecropping contract is clear in relation to the lease. Due to their relatively large infrastructure and scale of technology, mills generally achieve higher productivity than individual producers achieve and can propose a partnership regime such that the remuneration of the land is attractive to the owner. In addition, if it is convenient for the plant, if they choose to buy land, they can set a price per hectare higher than the market. According to ref. [19], the consolidation of agribusiness and the high growth of Brazilian agriculture brought prosperity, but, at the same time, the dispute and the price of land increased, as well as the displacement of other crops and pastures to the Center-West and North regions of the country. Particularly in the case of sugarcane, the hypothesis is raised that the expansion of this crop could compromise food security, since land previously used for cattle raising and/or grain production would be being used to produce the sugarcane necessary for the obtaining ethanol. Ref. [36] pointed out that the possibility of certifying the sustainability of biomass energy sources represents a viable solution to the land dispute problem, since food security and bioenergy production could be negotiated. Concerning aspects of social sustainability, ref. [37] warned about the efficiency of certification processes, particularly in terms of access to land, distribution, and concentration of production, and land price in agricultural areas subject to disputes. In addition, ref. [38] added the discussion of social sustainability, the issue of using sugarcane bagasse to generate energy. The mills use bagasse to produce energy for their own consumption and sell the surplus as a second source of

income. However, the supplier of this raw material is not remunerated for this, although initiatives in this direction are already registered.

In Brazil, land leasing and sharecropping exist practically throughout the national territory; however, there is great heterogeneity in the drafting of contracts, in the results of production and in the increase of efficiency. Previous studies have indicated a dual nature of contracts in Brazil [30,39]. On the one hand, small producers consider leasing and/or sharecropping as a means of subsistence for the family, either due to the precarious conditions of wage labor in the rural environment or due to rural unemployment resulting from the modernization of agriculture. Incentives are still few, which makes it impossible to make large investments in an activity that gives them low returns. On the other hand, the major producers participate in consolidated supply chains, with greater experience and entrepreneurial skills. Leasing and sharecropping are efficient mechanisms to eliminate the need to invest capital in the purchase of land and provide a quick return on investments. For owners, the use of leasing and sharecropping is, above all, a way of eliminating the concerns inherent to the productive activity and a viable alternative for income. In addition, landowners prefer agrarian contracts with wealthier and more qualified tenants or sharecroppers than the risk of default or loss of their land due to litigation.

According to a study on the dynamics of land occupation for use in the sugarcane sector in the state of São Paulo, it was found that most of the land occupied by new sugarcane plantations at the beginning of the present century was not based on the purchase of land but in lease or sharecropping [40]. The expansion of areas in sharecropping contracts for the cultivation of sugarcane, mainly by the mills, changed the use of land in large regions of the state. This fact configured the appearance of a new economic geography to meet the interests of the sugar and alcohol sectors.

In addition, ref. [40] argued that the explanation for the expansion of leased or sharecropping areas is not restricted to the interests of the sugar and alcohol sectors, as a lease is a contractual relationship between two parties. On the side of the landowners (the lessors), leasing is an instrument that can eliminate the economic risk inherent in agricultural activity involving economic damage to other crops, the need for investment to make improvements to the property and increase production, and the lack of working capital and funding. On the other hand, large-scale leasing for sugarcane cultivation can cause a great deal of market volatility and increase uncertainties regarding the return on investment made by the mills and payment to the owners, because the payment of the lease varies according to the price of sugar and ethanol on the international market. There are other reports in the literature about the practice of agrarian contracts[1] (leasing and/or sharecropping) by sugarcane agroindustries in Brazil as a way to expand sugarcane production [41,42].

According to ref. [19] some factors that can act as an incentive for tenants and sugarcane producers are, among others: (i) credibility in the performance of the plants, receiving a fair price for the cane and the viability of the business; (ii) prior knowledge of agricultural activity and the mode of insertion in the production chain; (iii) transparency in transactions, preparation of balanced contracts and advice organized locally to reduce mutual risks. On the other hand, the existence of power asymmetry in contractual relations obliges farmers to accept the rules imposed by sugarcane agroindustry and to continue to integrate due to the lack of better alternatives for economic insertion [29].

2.3 Peruvian case

In Peruvian case, from the historical point of view of land tenure in northern Peru, where sugarcane agribusiness has been important since colonial times, in the early 1870s, there were about 25 large landowners in the Chicama Valley, in the Department of La Libertad [43]. At the beginning of the twentieth century, there was a strong concentration of land destined for the sugarcane agribusiness, owned by national companies. At that time, there was a strong growth in the sugarcane industry, mainly in the north of Peru [46]. The agrarian reform carried out in the period 1968–1975, radically changed the land tenure structure. Private property was canceled and land ownership is transferred mainly through the formation of cooperatives, farm workers on sugar mill. This reform did not produce the expected positive economic and social results. In this period, there was a technological and productive delay in the planting of sugarcane and in the plants that were operated in the cooperative system by the former workers of the privatized plants. Poverty has taken over this economic sector [44,45]. During the agricultural reforms of the 1990s, the possibility of private property in the countryside was restored. Once again, agricultural companies started to appear, several of them with national and

1 For more details on the practice of agrarian contracts in Brazil, consult [29].

foreign private capital. Again, there is a concentration of land by large economic groups to ensure the expansion of industrial activities.

Regarding the forms of access to land in Peru, ref. [45] argued that, despite the difficult in the new legislation implantation, the buy–sell market occupied a prominent place as a form of access to land. In this initial period, the buy–sell market only was below the form of land access by inheritance. In turn, the lease market allowed the landless farmers (mainly younger) could temporarily have access to land and gain experience to in the future manage their own farming unit as well as accumulate funds to buy land. Along with the land market (i.e., buy–sell and leasing), Government played an important role in the award of new agricultural land (administrative adjudication), based on criteria for qualifying beneficiaries. The land access by inheritance, an intrafamily, and intergenerational form of access to land represents the central cause of the extreme fragmentation of land ownership in most of the Peruvian countryside. There are also community forms of access to land. They are large areas of land belonging to certain communities, which members are the so-called commoners [45].

Analyzing the practice of agrarian contracts in the Department of La Libertad [43] described that in the early 2000s, the growth in demand for processed artichokes began to require more and better areas of cultivation. In Santa Elena (hamlet in La Libertad region), this growth generated an economic flow between farmers and agroindustries, that is, the first became land suppliers for the second through lease agreements. In 2004, favorable soil conditions for artichoke production in Santa Elena had already consolidated a high demand for land leasing. It was necessary to convince small and medium farmers of the attractive opportunity of contracts. The main strategy for agribusinesses was to raise the lease price that went from 750 PEN/hectare per year to 3,500 PEN and, later, 4,000 PEN (note: 1 USD equal to 3.35 PEN). In view of this payment, small farmers began to lease their land due to the lack of incentives to grow their own crops (notably, insufficient financial capital). It is estimated that, in 2006, agroindustries were able to lease 420 ha in Santa Elena (i.e., more than 20% of the agricultural area of the hamlet) and insert more than 80 farmers into these contracts. In an empirical study in sugarcane regions of the north coast of Peru [46], it was found that approximately 30–40% of the cane milled by the mills comes from production on third-party land via direct purchase, leasing, or sharecropping.

In this study, because the mills are the main industrial agents in the sugarcane sector, they are frequently taken as a reference to discuss the access to land and the usefulness of the agrarian contract. Therefore, a specific type of ownership of the mills is not distinguished in this study, that is, the mills can be from the private sector, the government sector, the cooperative sector, or another. Based on this discussion, it is considered that access to land in Brazil and Peru by producer agents (mills, tenants sharecroppers), notably via agrarian contracts (i.e., leasing and/or sharecropping) can contribute to increasing the production of raw materials for sugarcane agroindustries. Likewise, it can contribute to improving the efficiency in the use of productive resources in agriculture and favor the renewable and clean energy sources, as well as reducing future social tensions in rural areas.

3 Data and methods

To obtain information on the forms of land access by sugarcane agroindustries in Brazil and Peru, data from the Agricultural Censuses of both countries are used. These Censuses are a rich source of secondary data with regard to Brazilian and Peruvian agribusinesses.

The last two Censuses from each country were selected to compare the data. In the Brazilian case, data from the Agricultural Censuses of 2006 and 2017 were chosen. Data from the 2006 and 2017 Agricultural Censuses in Brazil are available in print, on CD and in the computational collections of the Brazilian Institute of Geography and Statistics (IBGE) [47]. The data are collected and processed to analyze the temporal variation in forms of land access in the country, including leasing and sharecropping. The 2006 Agricultural Census had the year 2006 as a reference period (i.e., January 1 to December 31) and December 31, 2006, as the reference date. The 2017 Agricultural Census had the reference period October 1 from 2016 to September 30, 2017, and September 30, 2017, as a reference date. Complementary secondary data are collected from statistical reports of Conab (National Supply Company – Brazil) [48].

In the Peruvian case, data from the Agricultural Censuses of 1994 and 2012 were used. We are aware that the differences in the period of data collection in each country can generate a certain loss of relevant information but the Censuses of Agriculture of Brazil and Peru are among the most reliable sources of secondary data with which to analyze the sector. The National Institute of Statistics and Informatics of Perú (INEI), with the participation of the Ministry of Agriculture of Peru, raised the III Agricultural Census of 1994 (III CENAGRO) and the IV Agricultural Census of 2012 (IV CENAGRO). The data from

the 1994 and 2012 Agricultural Censuses in Peru are available online from the INEI. The III Agricultural Census of Peru took place from October 15 to November 30, 1994, nationwide, while the IV Agricultural Census of Peru took place from October 15 to November 15, 2012. Also, reports data from cane production to 2010–2020 from the Ministry of Agricultural Development and Irrigation of Peru (MIDAGRI) [49,50] are used.

Agricultural censuses are large databases. Based on previous studies [32], a careful data collection and processing are carried out regarding the practice of leasing and partnership contracts as a mechanism of land access. The processed data are used to outline a panorama in terms of leasing and sharecropping in Brazil and Peru, according to the location, the main economic activities and the explored area. In addition, the bibliographic review will be used to help identify and explain the main contractual conditions and the main characteristics of the contractors.

To give a previous overview about the dimension of sugarcane sector in both countries, the variation in sugarcane production in Brazil and Peru are presented in Tables 1 and 2, respectively. We can see that the Brazilian sugarcane production is approximately 65 times higher than the Peruvian sugarcane production. Although many other factors are present in the difference in cane production between the two countries, we must point out that the Brazilian territory is approximately eight times larger than the Peruvian territory. Based on territorial proportionality, it can be considered that the sugarcane sector in Brazil is approximately eight times larger than the Peruvian sugarcane sector. This fact will be considered in the comparison of the differences and similarities in the sugarcane sector in both countries.

The annual cane production in Brazil had a strong increase in the period 2005–2010 from 422.956 to 717.463 million t/cane, in the period 2010–2016, it increased slightly to 768.678 million t/cane, and in 2020, the production of cane was 654,527 million t/cane. Part of this decline is due to decreased productivity in t/ha in the field, in addition to other global economic factors. Peruvian cane production remained almost stable during the period 2012–2020 in the annual order of 10 million t/cane.

4 Results

4.1 Brazilian data and results

At first, results on the number of agricultural establishments and area, according to the condition of the producer, grouped by stratum of total area are presented. Figure 1 shows the total area of agricultural establishments in 2017 and 2006 and the total area occupied by tenants and sharecroppers in Brazil and regions. The vertical axis in Figure 1 is in logarithmic scale. The total area of establishments in Brazil conducted by tenant represents 4.87 and 4.52% of the total area in 2017 and 2006, respectively. The total area of sharecroppers represents 1.44 and 0.96% of total area in 2017 and 2006, respectively. The Midwest region with total area above 112 million ha is the first producer. The North, Southeast, and Northeast regions have a total area of agricultural establishments in the range of 60–70 million ha. The total area of establishments for Brazil is 351.29 million ha and the total area of establishments harvested with sugarcane in Brazil is 8.95 million ha in 2017 that represents the 2.55%.

In addition, Figure 1 shows the total area harvested with cane in 2017 conducted by owners, tenants, and sharecroppers that represents 57.76, 21.17, and 20.05%, respectively, for Brazil. This indicates that 41.23% of area harvested with cane is from land accessed by agrarian contracts. In addition, Figure 1 shows the total area harvested with cane for all regions. The Southeast region with 5.629 million ha is the major producer followed by Midwest region with 1.856 million ha. In Southeast region,

Table 1: Production (in thousand t) of sugarcane in Brazil and regions (2005–2020)

Region	2005	2010	2015	2016	2019	2020
North	1085.21	2071.62	4371.43	4581.32	3722.61	3488.84
Northeast	60874.75	68789.72	61546.27	55698.72	49121.30	48448.3
Midwest	37430.571	97430.026	136107.803	142219.652	140446.3	139804.7
Southeast	291991.211	498884.508	499677.593	517577.172	415043.9	428592.7
South	31227.899	50287.913	48587.170	48601.517	34383.3	34193.2
Brazil	422956.646	717463.793	750290.277	768678.382	642717.8	654527.8

Source: IBGE [47]; Conab [48].

Table 2: Production (in thousand t) of sugarcane in Peru regions (2012–2020)

Region/subregion	2012	2013	2014	2015	2016	2017	2018	2019	2020
Lambayeque	2767.0	3046.5	2894.5	2022.8	2241.9	2489.3	2648.0	2566.5	2184.2
La Libertad	5234.4	5398.6	5811.7	5529.7	5047.6	4473.1	4795.5	5514.3	5344.4
Ancash	722.0	871.8	857.5	988.2	1001.4	904.7	870.7	957.4	975.4
Lima	1582.9	1578.1	1728.2	1614.0	1459.3	1480.1	1528.3	1525.1	1378.4
Arequipa	62.3	97.0	97.6	56.9	41.3	52.2	55.8	64.6	64.8
Peru	10368.8	10992.2	11389.6	10211.8	9791.6	9399.6	10336.1	10902.9	10468.8

Source: Ministry of Agricultural Development and Irrigation of Peru (MIDAGRI) [50,51].

the participation of owners, tenants, and sharecropper in the total area harvested with cane in 2017 was 49.46, 23.68, and 26.48% respectively. This indicates that more than 50% of harvested sugarcane area is with agrarian contract of leasing and sharecropping. In Midwest region, the participation of owners, tenants, and sharecroppers in the total area harvested with cane in 2017 was 68.68, 22.60, and 8.44%, respectively.

Figure 2 shows the number of agricultural establishments in 2017 and 2006 and the number of establishments occupied for tenants and sharecroppers for Brazil and regions. The vertical axis in Figure 2 is in logarithmic scale. The total number of establishments in Brazil conducted by tenant represents 3.25 and 6.45% of the establishments in 2017 and 2006, respectively. The establishments conducted by of sharecroppers represent 2.34 and 3.6% in 2017 and 2006, respectively. The total number of establishments for Brazil is 4,919,250 and the total number of establishments harvested with sugarcane in Brazil is 92,511 in 2017 that represents 1.88%. In addition, Figure 2 shows the total number of establishments harvested with cane in 2017 in Brazil that were conducted by owners, tenants, and sharecroppers that represent 83.18, 3.15, and 1.92%, respectively. This indicates that only 5.07% of establishments harvested with cane is from land accessed by agrarian contracts. This contrasts with the percentage of area harvested with cane. This indicates that the establishment with major area is preferred for leasing or sharecropping.

Table 3 presents the number of establishments and area, according to the producer's profile per group of total area – Brazil (2006 and 2017). From Table 3, it can be seen

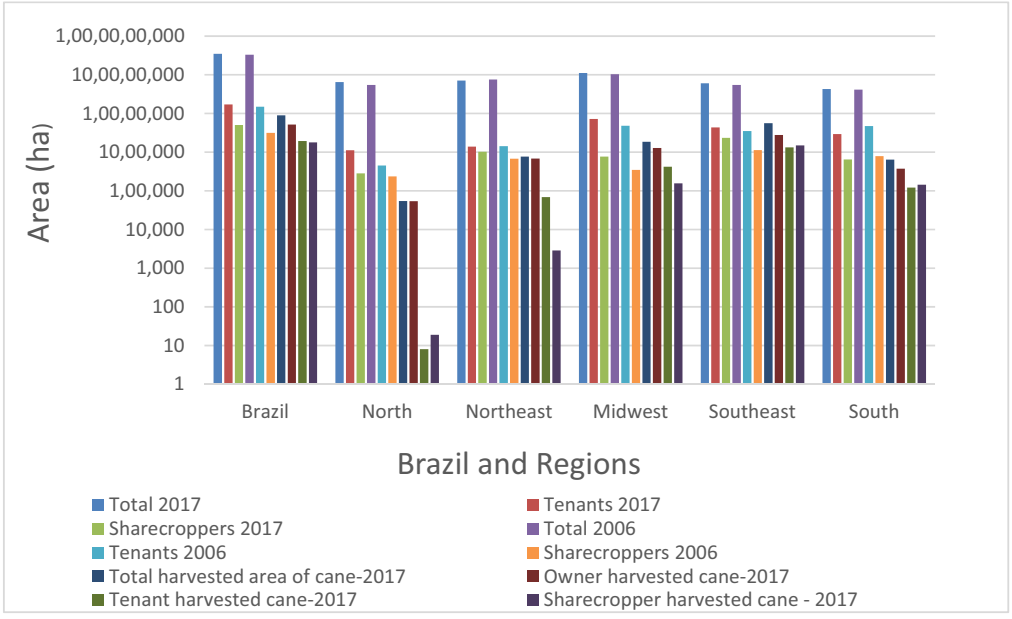

Figure 1: Comparison of total area of agricultural establishments 2017/2006 and the total harvested area of sugarcane in 2017 according to the condition of the producers for Brazil and regions. Source: Own elaboration from ref. [47].

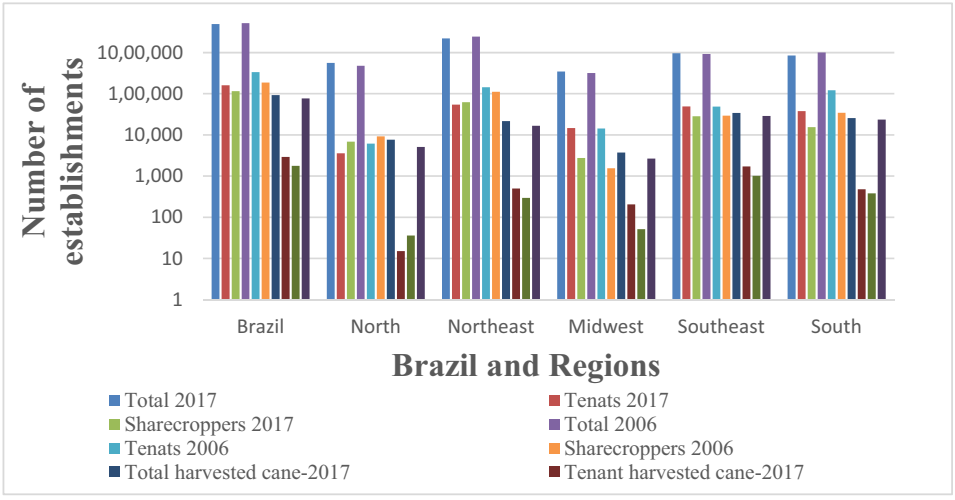

Figure 2: Comparison of numbers of establishments 2017/2006 and the total harvested establishments of sugarcane in 2017 according to the condition of the producers for Brazil and regions. Source: Own elaboration from ref. [47].

that in the case of tenants, establishments smaller than 100 ha decreased while establishments between 100 and 1,000 ha increased by 22.7%; also, in the range between 1,000 and 10,000 ha, they increased by 63.7%. Finally, in terms of 10,000 to more hectares, the increase was 82.6%. In the case of sharecropping, only establishments smaller than 10 ha showed a decrease (29.6%), while establishments in the other strata of total area increased. The area occupied by sharecropping establishments in the ranges from 10 to 100 ha, from 100 to 1,000 ha, and from 1,000 to 10,000 ha and in the range of 10,000 and more hectares increased by 33.2, 37.3, 85.6, and 71.1%, respectively.

Figure 3 shows the main economic activities according to the condition of the producers in relation to land for Southeast region in 2017. It can be noted that the production of sugarcane is the most important economic activity in the rural sector of the Sao Paulo State and in the second place is the livestock activity. According to previous studies, the most lucrative lease and sharecropping contracts are found in Sao Paulo State [30,32].

In Minas Gerais, livestock and sugarcane production are the two main economic activities of the tenants. Although to a lesser extent, the sharecroppers in Minas Gerais State also have livestock and sugarcane

Table 3: Number of establishments and area, according to the producer's profile per group of total area – Brazil (2006 and 2017)

Group of total area (ha)	Condition of producer							
	Tenant				Sharecropper			
	Establishments[1]		Area		Establisments[1]		Area	
	2006	2017	2006	2017	2006	2017	2006	2017
Total	230,121	160,124	9,055,048	17,010,495	142,534	115,208	1,985,841	5,120,094
<10	156,844	90,786	360,564	241,018	124,512	87,616	252,039	265,402
10 to <100	58,171	49,421	1,810,628	1,670,792	14,994	22,663	440,086	658,808
100 to <1,000	14,023	17,063	3,890,341	5,032,368	2,875	4,156	715,536	1,141,062
1,000 to <10,000	1,051	2,688	2,384,760	6,567,719	135	717	300,729	2,094,693
10,000 and more	32	166	608,755	3,498,598	18	56	277,451	960,129

[1]Were excluded from the agricultural establishments without a declaration of area, as [52].
[2]The 2006 and 2017 Agricultural Census data adopts the following legend: (–) absolute zero, not resulting from a calculation or rounding; (×) inhibited value so as not to identify the informant.
Source: Own elaboration from ref. [47].

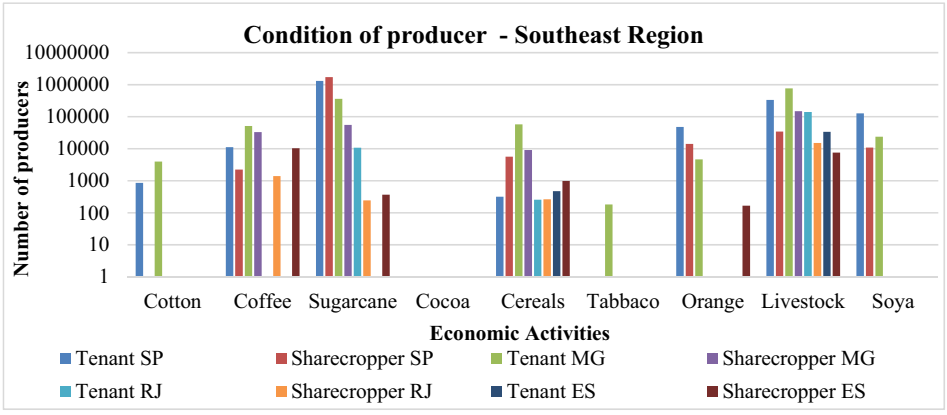

Figure 3: Main economic activities in the rural sector according to the condition of the producers in relation to land (in hectares) – Southeast region (2017) Source: Own elaboration from ref. [47].

production as their main economic activities, while in Rio de Janeiro and Espírito Santo, the main economic activity of tenants and sharecroppers is livestock.

For the sake of brevity in this article, below, we present results in more detail for the sugar-energy sector in the state of São Paulo, the largest producer of sugarcane in Brazil. The other sugarcane-producing states follow approximately a similar profile, but with their regional differences.

Table 4 shows that the total number of establishments in leasehold in São Paulo state, from 2006 to 2017, increased by 12.9%, while the total number of sharecropping establishments increased by 20.0% in the same period. The total area occupied by leaseholders increased by 44.8%, while for sharecroppers it was 81.8%. It is important to highlight the fact that, with regard to both lease holding and sharecropping, from 2006 to 2017, smaller establishments grew slightly while larger establishments grew strongly. For example, the area occupied by leasehold establishments smaller than 10 ha increased by 16.5%, while the area occupied by sharecropping establishments smaller than 10 ha showed a decrease of 0.7%. On the other hand, the area occupied by leasehold establishments and by sharecropping establishments that were between 1,000 and 10,000 ha increased, respectively, by 55.1 and 92.4%. The total area of establishments occupied by tenants and the area of establishments occupied by sharecroppers, which were 10,000 and more hectares, increased by 79.2 and 67.5%, respectively.

Table 4: Number of establishments and area, according to the producer's profile for the total area of São Paulo (2006 and 2017)

Group of total area (ha)	Condition of producer							
	Tenant				Sharecropper			
	Establishments[1]		Area		Establishments[1]		Area	
	2006	2017	2006	2017	2006	2017	2006	2017
Total	16,343	18,774	1,158,431	2,098,134	2,659	3,324	347,749	1,913,384
<10	6,604	8,270	28,907	34,621	1,555	1,571	5,423	5,386
10 to <100	8,007	8,279	267,662	273,247	865	923	28,425	29,381
100 to <1,000	1,597	1,925	412,399	523,593	203	462	58,587	165,319
1,000 to <10,000	127	268	346,796	772,160	25	337	92,762	1,212,964
10,000 and more	8	32	102,667	494,513	11	31	162,552	500,334

[1]Were excluded from the agricultural establishments without a declaration of area, as [52].
[2]The 2006 and 2017 Agricultural Census data adopts the following legend: (–) absolute zero, not resulting from a calculation or rounding; (×) inhibited value so as not to identify the informant.
Source: Own elaboration from ref. [47].

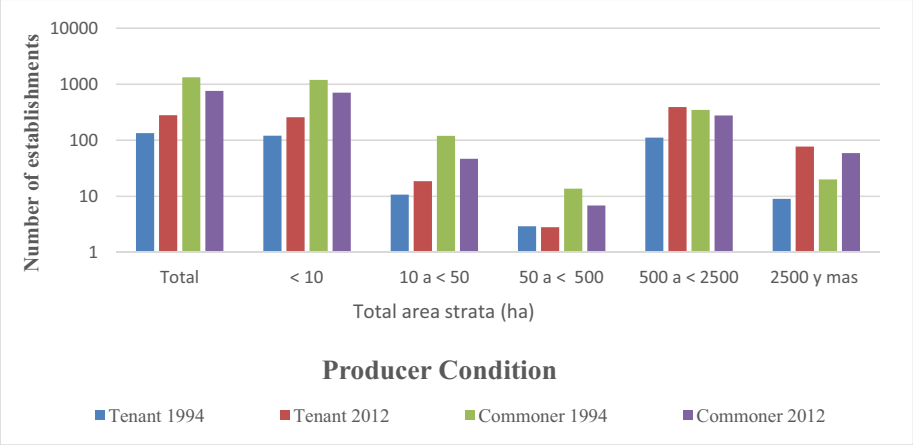

Figure 4: Number of establishments in Peru by area strata managed by tenants and commoner in 1994 and 2012. Source: Own elaboration from ref. [51].

4.2 Peruvian data treatment and results

To better understand the forms of access to land in Peru (notably, tenants and community ownership), data from the Agricultural Censuses of 1994 and 2012 are used. The total area of the agricultural sector was 38.74 million ha. Figures 4 and 5 show the number of establishments and respective area, according to the condition of the producer, by stratum of total area, based on data from the Agricultural Censuses of Peru (1994 and 2012). Vertical axis is in logarithmic scale. Table 5 shows the numeric values in detail. In general, from 1994 to 2012, the number of establishments and the tenant area increased, while the number of establishments and the common area decreased.

It can be seen that the total number of establishments and the total area relating to tenants in Peru, from 1994 to 2012, increased, respectively, by 109 and 43.8%, while the total number of establishments and the total area relating to commoners decreased, respectively, by 42.8 and 40.7%. The area occupied by tenants with under 10 ha under cultivation increased by 91.3%, while the area occupied by commoners with less than 10 ha under cultivation decreased by 47.5%. The areas under cultivation

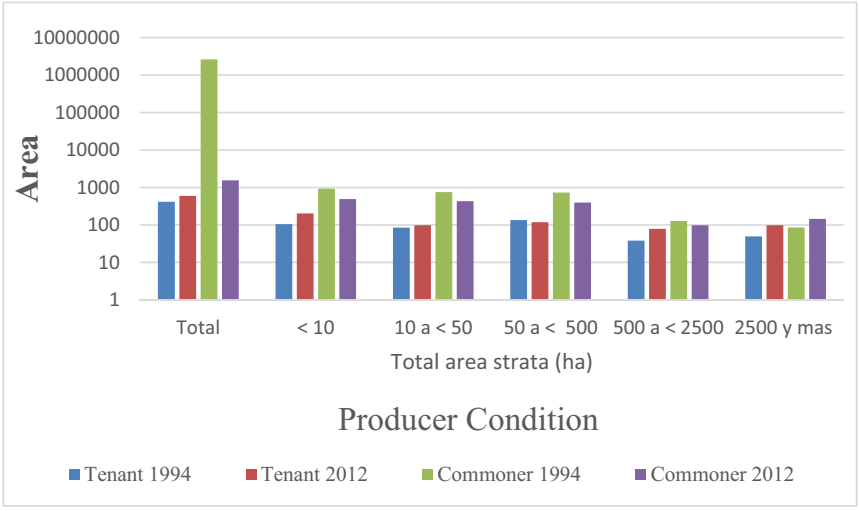

Figure 5: Area total of establishments in Peru by area strata managed by tenants and commoner in 1994 and 2012. Source: Own elaboration from ref. [51].

Table 5: Number of establishments and area, according to the producer's profile for the total area of Perú (1994 and 2012)

Group of total area (ha)	Condition of producer							
	Tenant				Commoner			
	Establishments		Area		Establishments		Area	
	1994	2012	1994	2012	1994	2012	1994	2012
Total	133,760	279,622	413741.3	594958.2	1,327,011	759,349	2624351.31	1555134.3
< 10	120,012	257,799	105249.28	201375.3	1,192,988	705,290	932691.26	489491.4
10 to < 50	10,714	18,555	85244.12	97625.5	119,978	46,889	749038.87	427805.1
50 to < 500	2,914	2,802	135802.85	118764.9	13,678	6,834	730045.92	395194.6
500 to < 2,500	111	389	37932.62	78406.0	347	277	127027.38	97998.6
2,500 and more	9	77	49512.47	98786.3	20	59	85547.88	144644.5

Source: Own elaboration from ref. [51].

occupied by tenants from 500 to 2,500 ha and 2,500 ha and more increased by 106.7 and 99.5%, respectively. The area occupied by commoners from 500 to 2,500 ha under cultivation decreased by 22.9%, while the area occupied by commoners of 2,500 ha and more under cultivation increased by 69.1%.

From Agricultural Censuses of Peru (1994 and 2012) it is not possible to extract accurate information about the production and type of producer for the sugarcane sector. Additional data from sugarcane production are collected from the Ministry of Agrarian Development and Irrigation of Peru in ref. [36]. Table 4 shows the production, harvested area, and yield of sugarcane in Peru and principal producer regions in 2012 and 2020. Sugarcane production data for 2012 compiled in reference [53] are to complete the others information extracted from agricultural census of 2012. Comparing data of 2012 and 2020 [53], few variations are observed in production, harvested area, and yield of sugarcane.

From data shown in Table 6, the major sugarcane producer is La Libertad region. No accurate secondary data about the producer condition in the sugarcane sector can be found, but from a preliminary qualitative field research and the bibliographic review, participation of tenants and commoners in the agricultural sector of Peru and also in the sugarcane sector was found. The region of La Libertad was selected for a more detailed analysis phenomenon of land access in the agricultural sector in Peru, to serve as a reference for the sugarcane sector.

Table 7 shows the number of establishments and area cultivated, according to the producer condition for La Libertad region in 1994–2012. The total number of establishments and the total area cultivated by tenants increased, respectively, by 139.6 and 28.7%, while the total number of establishments and the total area cultivated by commoners decreased, respectively, by 51.8 and 76.9%. The most significant positive percentage variations in the size of the area cultivated by tenants occurred, respectively, in the strata of between 500 and 2,500 ha (188.1%) and in the strata of area less than 10 ha (73.4%). The most significant negative percentage variations in the size of the area cultivated by commoners occurred, respectively, in the strata of area between 50 and 500 ha (93.2%) and from 10 to 50 ha (85.3%).

To give complementary information about the practice the land leasing and other forms of agrarian contract, two cases in La Libertad are presented briefly. According

Table 6: Production, harvested area, and yield of sugarcane in Peru and principal producer regions in 2012 and 2020

Region/subregion	Year	
	2012	2020
Sugarcane production (t)		
Total Peru	10,368,866	10,468,800
Lambayeque	2,767,051	2,184,189
La Libertad	5,234,476	5,344,455
Ancash	722,001	975,401
Lima	1,582,958	1,378,391
Sugarcane harvested area (ha)		
Total Peru	81,126	84,590
Lambayeque	25,710	23,382
La Libertad	37,043	38,826
Ancash	5,684	7,098
Lima	12,089	10,899
Sugarcane yield (kg/ha)		
Total Peru	127,812	123,760
Lambayeque	107,625	93,412
La Libertad	141,307	137,652
Ancash	127,022	137,424
Lima	130,939	126,472

Source: Own elaboration from ref. [53].

Table 7: Number of establishments and area, according to the producer's profile for the total area of La Libertad region (1994 and 2012)

Group of total area (ha)	Condition of producer							
	Tenant				Commoner			
	Establishments		Area		Establishments		Area	
	1994	2012	1994	2012	1994	2012	1994	2012
Total	4,605	11,032	19113.23	24595.3	27,255	13,146	85638.86	19818.1
<10	3,882	9,548	7504.75	13016.3	21,646	12,072	41789.8	14544.5
10 to <50	639	1,289	5545.61	6585.2	5,286	1,030	31474.21	4617.8
50 to <500	83	158	5462.87	3265.4	312	44	9647.45	655.8
500 to <2,500	1	37	600	1728.4	11	—	2727.4	—
2,500 and more	—	—	—	—	—	—	—	—

Source: Own elaboration from ref. [51].

to ref. [43], estimates that in 2006, mills were able to lease 420 ha in the small district of Santa Elena in La Libertad region. This means approximately 20% of the agricultural area of this district and the inclusion of more than 80 farmers in these contracts. In addition, to examine the practice of the agrarian contract by mills located in traditional agricultural areas, the case of the San Jacinto mill is reported. The San Jacinto agroindustry in its 2019 Board Report indicates that it produced 702,469 t of sugarcane on its own land and the mill ground 1,015,139 t of sugarcane [54], and likewise, reports the land leasing practice, but no quantitative information is provided. However, from this information, it can be seen that about 30% of the milled raw cane if from agrarian contracts, possibly from leasing land and from independent producers.

In addition to other factors, due to the great fragmentation of the land in Peru, the figure of the intermediary collector appears between the producers and the agroindustry. This intermediate collector supplies the sugarcane to the agroindustry, buying from many small producers. To obtain more information about the agrarian contracts in the sugarcane agroindustry, we conducted interviews with these agents in La Libertad and Lambayeque regions. The production of both La Libertad and Lambayeque regions in 2020 was 7,528,644 t of sugarcane in an area of 62,208 ha, with an average productivity of 121 t/ha (see Table 4). A brief questionnaire was prepared and applied.

From the information collected, it is estimated that there are between 12 and 15 intermediate collectors working in these two regions. Only three of the intermediate collectors interviewed provide precise information on the amount of their own sugarcane production, both on their own land and on rented land, as well as information on the amount of sugarcane they collect from third parties. These three intermediate collectors declared to have a production of approximately 501,999 t of sugarcane per year and to collect approximately 300,000 t of sugarcane from third parties. This represents a total of 801,999 t of sugarcane per year, which is equivalent to 10.65% of the total production and it covers a 6,628 ha area. The sugarcane marketed by each intermediate collector is in media about 167,333 t per year of own production and 100,000 t per year of third parties. Considering that there are 12 middlemen with the same average production and commercialization, which is closer to reality based on the information gathered in the interviews, there is a total production of 3,207,000 t of sugarcane of own production and of third parties. This would be equivalent to 42% of the total production and would correspond to an area of 26,512 ha. This indicates that the mills use raw sugarcane, approximately 42% of which comes from leased land or from independent producers. This estimative agree with San Jacinto board report [54].

5 Discussion

Comparing the cane production of both countries, we have that the annual Brazilian sugarcane production is about 65 times higher than the Peruvian sugarcane production. In Brazil, the annual harvest is usually 8 or 9 months with a cane productivity of 70 t/ha on average, while the mills in Peru have an annual harvest of twelve months with a cane productivity of 130 t/ha on average. In general, the mills in Brazil are more modern and thermally efficient; however, the recently installed mills in Peru with modern equipment may have a better economic performance than an equivalent mill in Brazil due to the higher productivity of the fields and the continuous availability of raw material along the year.

It was found that the total number of rural establishments in Brazil with subscribed lease and sharecropping contracts decreased by 30.4 and 19.2%, respectively, from 2006 to 2017. The analysis by area stratum of this fact indicates that leasing and sharecropping contracts for areas less than 10 ha decreased by 42.2 and 29.7%, respectively, from 2006 to 2017. On the other hand, lease and sharecropping contracts in areas greater than 100 ha increased, respectively, by 31.8 and 62.8% from 2006 to 2017. This resulted in the fact that during this same period, the areas occupied by tenants and sharecroppers increased 46.8 and 61.3%, respectively.

On the other hand, in the Peruvian case, in general, in the rural sector, according to data from the 1994 and 2012 Peruvian censuses, the number of establishments and the area cultivated by tenants and sharecroppers increased 109 and 43.8%, respectively, in this period. The most significant positive percentage variations in the size of the area cultivated by tenants and sharecroppers occurred in the strata of 500–2,500 ha (188.1%) and in the strata of area of less than 10 ha (73.4%). This comparison shows that in percentage terms, the Peruvian rural sector in the case of leasing and sharecropping was more dynamic than in Brazil. This can be explained considering that there was a period of contraction or stagnation in the rural sector of Peru in years prior to 1990. However, in another important part of the Peruvian rural sector, the number of establishments and the area of land cultivated by the community members in Peru decreased 51.8 and 76.9%, respectively.

In the Brazilian rural sector, the total area of the establishments conducted by tenant represents 4.87 and 4.52% of the total area in 2017 and 2006, respectively. The area total of sharecroppers represents 1.44 and 0.96% of total area in 2017 and 2006 respectively. In 2017, the total area of establishments was 351.29 million ha and the total area of establishments harvested with sugarcane in Brazil was 8.95 million ha that represents the 2.55%. In addition, the total area harvested with cane in 2017 conducted by owners, tenants, and sharecroppers that represents 57.76, 21.17, and 20.05%, respectively. This indicates that in Brazil, 41.23% of area harvested with cane is from land accessed by agrarian contracts. In Peru, in 2012, the total area of the agricultural sector was 38.74 million ha and the total area harvested for sugarcane was 81,126 ha, which represents 0.21% and compared to the area harvested for sugarcane in Brazil represents 0.9%. Based on data from the Agricultural Censuses of Peru (1994 and 2012), it is not possible to extract precise information on production by the type of producer for the sugarcane sector, but it was found that of the total number of farmers registered, 23.5% of farmers are not owners. Furthermore, in a recent empirical study in Peru [46], it is estimated that 30–40% of the total cane milled in the mills comes from third-party producers, that is, tenants, sharecroppers, and small owners. Intermediaries channel this production to the mills.

According to the Brazilian censuses of 2006 and 2017 and CONAB reports until 2021, the most important Brazilian region in the sugarcane sector is the Southeast region. In relation to the amount of land used by the sugarcane sector in the Southeast region in 2017, the two main states are São Paulo and Minas Gerais. In addition, it was found that sugarcane production is the most important economic activity in the rural sector of the State of São Paulo and is the main economic activity of the largest number of tenants and sharecroppers in the State of São Paulo. In the State of Minas Gerais, the production of sugarcane is the second activity where the largest number of tenants and sharecroppers works. On the other hand, according to the 1994 and 2012 Peruvian censuses and the MINAGRI reports up to 2020, the most important sugarcane-producing region in Peru is the north coast. All reports indicate that the Departments of La Libertad and Lambayeque are the largest producers of sugarcane, reaching around 70–80% of the total sugarcane produced. There is a certain similarity in both countries with regions that concentrate cane production. Furthermore, related to the expansion of cane production, in Brazil, the state of Goiás to the north of the states of São Paulo and Minas Gerais has strongly increased its cane production in the last decade. In a similar trend in Peru, in the last decade, the Department of Piura to the north of the departments of La Libertad and Lambayeque started cane production in new agricultural frontiers with high productivity and became the third largest producer of cane.

The state of São Paulo is the largest producer of sugarcane in Brazil. It is important to highlight the fact that, with regard to both lease holding and sharecropping, from 2006 to 2017, smaller establishments grew slightly while larger establishments grew strongly. The area occupied by leasehold establishments and by sharecropping establishments that were in the stratum from 1,000 to 10,000 ha increased, respectively, by 55.1% and 92.4%. The total area of establishments occupied by tenants and the area of establishments occupied by sharecroppers, in the stratum of more than 10,000 ha increased by 79.2–67.5%, respectively.

On other hand, in Peru, based on recent empirical studies in the region of the departments of La Libertad e Lambayeque [46], it was found that third-party producers, who work mainly as tenants or sharecroppers using different types of agrarian contracts, supply approximately 30–40% of the cane used by the mills.

One of the problems with leasing in the sugar and alcohol sector in São Paulo is choosing the cultivation, leasing or autonomous production system that offers the greatest economic advantages for owners and tenants. Many of the inferences of the previous articles in literature review can be corroborated from the processed data of the agricultural censuses. A decade ago, ref. [40] observed that the agricultural activities that were replaced by sugarcane did not generate sufficient economic income in many properties. This is reflected in the increase in leasing or sharecropping establishments that is verified from the data of the 2017 agricultural census. Furthermore, the growing urbanization and industrialization in the sugarcane regions have contributed to the expansion of agribusinesses. Together, these factors have favored sugarcane expansion via tenancy/sharecropping, not only in São Paulo but also in other Brazilian regions.

6 Conclusions

The review of the literature indicates that, in Brazil, the relationship between sugar mills and landowners tends to favor the increase of leased or sharecropped land between these two agents, mainly with the entry into this market of landowners with areas greater than 100 ha. In the sugar sector, lease and sharecropping contracts for lands smaller than 100 ha are practically maintained due to the old and reasonable relationship of trust already established between the mills and their land or cane suppliers. This is reflected in the increase in area and establishments under lease or sharecropping found in the results of data processing from agricultural censuses.

According to data from the Brazilian Agricultural Censuses (2006 and 2017) and Peru (1994 and 2012), it is possible to outline a profile of the possible forms of access to land (in particular, leasing and sharecropping) by the sugarcane industries in these two countries. In Brazil, the presence of agrarian contracts was observed practically throughout the country. In particular, in the states of São Paulo, Minas Gerais, Mato Grosso, Goiás and Paraná, the production of sugarcane constitutes one of the main economic activities of the agricultural establishments occupied by tenants and sharecroppers.

The data from the Brazilian Agricultural Census showed, among other aspects, a concentration of access to land in the country, through lease and sharecropping contracts. This meant that, from 2006 to 2017, the area related to small tenant establishments and/or sharecropping decreased, and the area related to large tenant establishments and/or sharecropping increased. It is also worth mentioning the growth in sugarcane production during this period, mainly in the Center-South region of the country. In Brazil, particularly in recent years, the new plants in the Center-South region of the country prefer to enter into sharecropping contracts rather than lease contracts, due the high tax costs of contractual relationships.

From the data from the Agricultural Censuses of Peru, it is observed, that from 1994 to 2012, the commoners gave way to tenants. That is, there was a concentration of land in the hands of tenants. It was found that in Peru most of the tenant establishments (257,799) were of less than 10 ha in size and comprised a total area of 201,375 ha. It is estimated that of the total sugarcane processed by the traditional mills, approximately 60–70% is from own land and approximately 30–40% is from third-party land, whether they are tenants, sharecroppers, or independent producers. On the other hand, the new sugarcane mills that were installed in the new agricultural frontiers opened in the last 10 years on the north coast of Peru mainly use their own land to supply cane for their industrial process. Currently, they marginally buy cane from other producing areas to complement their raw material needs. Thus, it can be foreseen that in the future these sugar mills, to expand their activities, will have to buy more land or they will have to enter the leasing and sharecropping market.

In both countries, leasing and sharecropping represent an alternative for access to land by mills and cane producers to guarantee and increase the supply of raw material for the mills' operation.

Future works will focus on the identification and selection of agents directly related to agrarian contracts established by sugarcane agribusinesses in Brazil and Peru to better identify and analyze the main conditions associated with these contractual relationships.

Acknowledgments: The authors acknowledge the financial support of the Project Concytec (Peru) - World Bank "Improvement and expansion of services of the national system of science, technology and technological innovation" 8682-PE, through its executing unit ProCiencia (Contract 010-2019-Fondecyt).

Funding information: The authors acknowledge the financial support of the Project Concytec (Peru) – World Bank "Improvement and expansion of services of the national system of science, technology and technological innovation" 8682-PE, through its executing unit ProCiencia (Contract 010-2019-Fondecyt).

Author contributions: P.J.A.: conceptualization, methodology, investigation, data curation, formal analysis, writing – original draft preparation, writing – reviewing and editing. C.T.S.: conceptualization, data curation, formal analysis, supervision, writing – reviewing and editing, funding acquisition. L.R.: investigation, data curation, visualization. C.A.C.: investigation, validation.

Conflict of interest: The authors state no conflict of interest.

Data availability statement: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

[1] Figueroa-Rodríguez KA, Hernández-Rosas F, Figueroa-Sandoval B, Velasco-Velasco J, Rivera NA. What has been the focus of sugarcane research? A bibliometric overview. Int J Environ Res Public Health. 2019;16(18):3326.

[2] Birru E, Erlich C, Martin A. Energy performance comparisons and enhancements in the sugar cane industry. Biomass Convers Biorefinery. 2019;9:267–82.

[3] Marcelo-Aldana DM, Bizzo WA, Viera MVA. Evaluación del potencial energético de los residuos de la caña de azúcar en el Perú. Paper Presented at the XXIII Simposio Peruano de Energía Solar y del Ambiente (XXIII-SPES). Huancayo: 2016.

[4] Miranda ICde. Energy use from biomass residues: sugarcane bagasse and straw. Thesis (Master's degree) - Chemistry school. Federal University of Rio de Janeiro -UFRJ, Rio de Janeiro-Brazil. In Portuguese; 2009.

[5] Gonçalves MGC, Veraszto EV. Cana de açúcar e seu impacto em áreas de cultivo de alimentos: uma análise comparativa entre culturas selecionadas no escritório de desenvolvimento rural de Mogi Mirim no período de 1997 a 2007. Universitas; 2008;1(1):93–117. Ano 1 - N.° 1 - Julho/Dezembro.

[6] Conab – Companhia Nacional de Abastecimento. Perfil do setor do açúcar e do etanol no Brasil. Brasília: Conab; 2013. Anual.

[7] Rudorff BFT, Aguiar DA, de, Silva WF, da, Sugawara LM, Adami M, Moreira MA. Studies on the rapid expansion of sugarcane for ethanol production in São Paulo state (Brazil) using Landsat Data. Remote Sens. 2010;2(4):1057–76.

[8] Domingues AT, Júnior AT. A territorialização da cana-de-açúcar no Mato Grosso do Sul. Cad Prudentino de Geogr. 2012;1(34):138–60.

[9] Perosa BB. Setor sucroalcooleiro impactos da expansão canavieira. Janeiro: Agroanalysis; 2014. p. 24–6.

[10] Oliveira MDM, Nachiluk K. Custo de produção de cana-de-açúcar nos diferentes sistemas de produção nas regiões do Estado de São Paulo. Inform Econ. 2011;41(1):5–33.

[11] Bezerra TL, Ragauskas AJ. A review of sugarcane bagasse for second-generation bioethanol and biopower production. Biofuels Bioprod Bioref. 2016;10:634–47.

[12] Lopes MU. Modelo de viabilidade para tomada de decisão sobre arrendamento de terras: estudo de caso em usina de cana-de-açúcar no Triângulo Mineiro. Dissertação (Mestrado), São Paulo, Fundação Getúlio Vargas, Escola de Economia de São Paulo; 2018.

[13] Postal AM, Kamali FP, Lotte Asveld L, Osseweijer P, da Silveira JM. The impact of sugarcane expansion in Brazil: Local stakeholders' perceptions. J Rural Stud. 2020;73:147–62.

[14] Saenger C, Torero M, Qaim M. Impact of third-party enforcement of contracts in agricultural markets–A field experiment in Vietnam. Am J Agric Econ. 2014;96(4):1220–38.

[15] Ruml A, Ragasa C, Qaim M. Contract farming, contract design and smallholder livelihoods. Australian J Agric Resour Econ. 2021;59:1–20.

[16] Neupanea PR, Marasenib TN, Köhla M. The sugarcane industry in Nepal: Opportunities and challenges. Environ Dev. 2017;24:86–98.

[17] Lima Filho RR, Aguiar GAM, Torres JAM. Sugarcane: Rent or produce. Agroanalysis. 2014;34(5):26–7 (in Portuguese).

[18] Guedes SNR, Terci ET, Peres MTM. O arrendamento como estratégia para enfrentar mudanças institucionais: um estudo com fornecedores de cana do Estado de São Paulo. Organ Rurais Agroind. 2007;9(2):229–40.

[19] Sant'Anna AC, Granco G, Bergtold J, Caldas MM, Xia T, Masi P, et al. Os desafios da expansão da cana-de-açúcar: a percepção de produtores e arrendantes de terras em Goiás e Mato Grosso do Sul. In: Santos G.R.dos (org.). Quarenta Anos de Etanol em larga escala no Brasil: desafios, crise e perspectivas. Brasília: Instituto de Pesquisa Econômica Aplicada – Ipea; 2016. p. 113–42.

[20] Cudlínová E, Sobrinho VG, Lapka M, Salvati L. New forms of land grabbing due to the bioeconomy: The case of Brazil. Sustainability. 2020;12(8):3395.

[21] Escobal J, Ricardo F, Zegarra E, (eds.). Peruvian agriculture: new perspectives from the Agricultural Census. Lima - Peru, GRADE; 2015 (in Spanish).

[22] Raurau ALA. Tierra y poder en tiempos de agroindustrias: el caso del Centro Poblado Santa Elena en Virú. La Lib Anthropia. 2014;12:57–67 (Dossier).

[23] Méndez EZ, Salcedo R. La industria azucarera peruana en el contexto internacional y la posible firma del TLC con los Estados Unidos. Perú: Ministerio de Comercio Exterior y Turismo; 2004.

[24] Marshall A. El Proyecto Especial Chavimochic: contratos agrarios entre agroexportadores y pequeños agricultores en los valles de Virú y Chao. In: Damonte G, Fulcrand B, Gómez R, editors. Perú: El problema agrario en debate. Sepia XII - Seminario Permanente de Investigación Agraria, Lima; 2008. p. 553–84.

[25] Stiglitz JE. Incentives and Risk Sharing in Sharecropping. Rev Econ Stud. 1974;41:219–55.

[26] Sadoulet E, Murgai R, De Janvry A. Access to land via land rental markets. In: De Janvry A, et al. editors. Acess to land, rural poverty, and public action. New York: Oxford University Press; 2001.

[27] Vogelgesang F. Los derechos de propiedad y el mercado de la tierra rural en América Latina. Rev de la Cepal. 1996;58:95–114.

[28] Deininger K, Jin S. Land rental markets as an alternative to government reallocation?: Equity and efficiency considerations in the chinese land tenure system. Policy Research Working Paper 2930. Washington, D. C: World Bank, Development Research Group, Rural Development; 2002.
[29] Almeida PJ, Buainain AM. Os contratos de arrendamento e parceria no Brasil. Rev Direito GV. 2013;9(1):319–43.
[30] Almeida PJ. Leasing and Sharecropping in Brazilian Agriculture: Determinants, Contracts and Operation. Thesis (Doctoral), University of Campinas, (UNICAMP/IE) – Brazil; 2009 (in Portuguese).
[31] Almeida PJde. Arrendamento e Acesso à Terra no Brasil. Campinas: IE/UNICAMP; 2002 (Dissertação de Mestrado).
[32] Almeida PJ, Buainain AM. Land Leasing and Sharecropping in Brazil: determinants, modus operandi and future perspectives. Land Use Policy. 2016;52:206–20.
[33] Peres AM, de P. O arrendamento de terras na pequena propriedade fundiária canavieira: o caso do Município de Piracicaba-SP. Campinas: UNICAMP/IE; 2003 (Dissertação de Mestrado).
[34] Matos PF, Marafon GJ. O setor sucroenergético no Brasil: efeitos e contradições. In: Marafon GJ, Arias LQ, Sánchez MA. *Estudos territoriais no Brasil e na Costa Rica* (online). Rio de Janeiro: EDUERJ; 2018. p. 41–59. orgs. Apresentação. ISBN 978-85-7511-499-5. doi: 10.7476/9788575114995.0003.
[35] Margarido LAC. Sistema de Arrendamento de Terras no Setor Sucro-Alcooleiro do Estado de São Paulo. Dissertação (Mestrado). Piracicaba, ESALQ/USP; 1987.
[36] Frate CL, Brannstrom C. Will Brazil's ethanol ambitions undermine its agrarian reform goals? A study of social perspectives using Q-method. J Rural Stud. 2015;38:89–98. doi: 10.1016/j.jrurstud.2014.10.007.
[37] Mohr A, Bausch L. Social sustainability in certification schemes for biofuel production: An explorative analysis against the background of land use constraints in Brazil. Energy Sustainability Soc. 2013;3(1):1–4.
[38] Paulillo LF, Soares SS, Feltre C, Marques CFDSP, Vian CEF. As transformações e os desafios do encadeamento produtivo do etanol no Brasil. In: Santos GR. dos (org.): Quarenta anos de etanol em larga escala no Brasil: desafios, crises e perspectivas, Brasília, Ipea. Vol. 7, 2016. p. 187–224 (in Portuguese).
[39] Buainain AM, Almeida PJ. Access to Land in Brazil v*ia Leasing and s*harecropping. In: Teixeira JE, Mattos LB, Leite CAM, editors. As Questões Agrária e da Infraestrutura de Transporte para o Agronegócio, Minas Gerais. Viçosa: Universidade Federal de Viçosa, Departamento de Economia Rural; 2011. p. 129–68 (in Portuguese).
[40] Ficarelli TRA, Ribeiro H. Dinâmica do arrendamento de terras para o setor sucroalcooleiro: estudo de casos no Estado de São Paulo. Inform Econ. 2010;40(1):44–54.
[41] Ávila SRA. Socioeconomic effects of sugarcane expansion in the São Patrício valley. Thesis (Master's degree). Brasília: University of Brasília – Brazil; 2009 (in Portuguese).
[42] Picanço Filho AF, Marin JOB. Contratos de fornecimento de cana-de-açúcar: as assimetrias de poder entre os agentes. Interações. 2012;13(2):191–202.
[43] Raurau ALA. Tierra, trabajo y dominación en tiempos de agroindústrias: el caso del Centro Poblado Santa Elena, en el valle agroindustrial de Virú, La Libertad. Lima: Pontificia Universidad Católica del Perú; 2016. Tesis para optar por el título de Licenciada en Antropología.
[44] Klaren PF. Formación de las haciendas azucareras y orígenes del APRA. Instituto de Estudios Peruanos; 1976. IEP ediciones.
[45] Zegarra E. El mercado de tierras en el Perú: análisis institucional y económico. Serie Desarrollo Productivo. Santiago: Comisión Económica para América Latina. Volumen I: Análisis institucional. Volumen II: Análisis económico; 1999. p. 62–3.
[46] Almeida PJ, Salinas CT, Pérez-Huiman OJ, Watanabe RRR, Marcelo-Aldana D. Agrarian contracts, relations between agents, and perception on energy crops in the sugarcane supply chain: The Peruvian case. Open Agriculture. 2022;7(1):581–95. doi: 10.1515/opag-2022-0112.
[47] Instituto Brasileiro de Geografia e Estatística (IBGE). Censos Agropecuários do Brasil; 2006 y 2017.
[48] Conab, Acompanhamento da safra brasileira de cana, v. 7-Safra 2020/21, n. 4 - Quarto levantamento, Brasília, p. 1–57 maio de 2021, ISSN 2318-7921 (in Portuguese).
[49] Ministerio de Agricultura y Riego del Perú (MINAGRI) [Internet]. Observatorio de Commodities 2020 Azúcar. Boletín trimestral enero marzo, Ministerio de Agricultura y Riego, Dirección General de Políticas Agrarias - Dirección de Estudios Económicos e Información Agraria. [cited 2021 Apr 10]. https://www.gob.pe/institucion/midagri/informes-publicaciones/482921-commodities-trimestral-2020. Spanish.
[50] Ministerio de Desarrollo Agrario y Riego del Perú (MIDAGRI) [Internet]. Observatorio de Commodities 2020 Azúcar - Boletín de publicación trimestral octubre - diciembre. [cited 2021 Apr 10]. https://cdn.www.gob.pe/uploads/document/file/1767326/Commodities%20Az%C3%BAcar%3A%20oct-dic%202020.pdf. Spanish.
[51] Instituto Nacional de Estadística e Informática (INEI). Censos Agropecuários del Perú; 1994 y 2012.
[52] Hoffmann R. Distribuição da renda e da posse da terra no Brasil. In: Ramos P. (org.) Dimensões do Agronegócio Brasileiro: políticas, instituições e perspectivas. Brasília: Ministério do Desenvolvimento Agrário, (Nead Estudos, 15); 2007. p. 172–225.
[53] Ministerio de Desarrollo Agrario y Riego del Peru. Observatorio de Commodities, AZUCAR. Boletín de Publicación Trimestral (Octubre – Diciembre); 2020. https://cdn.www.gob.pe/uploads/document/file/1767326/Commodities%20Az%C3%BAcar:%20oct-dic%202020.pdf. Accessed 24 august 2021.
[54] Agroindustrias San Jacinto SAA (2020). Report of the Board of Directors for 2019 - Memoria del Directorio año 2019. Cartavio; July 13, 2020 – Peru. In Spanish.