

Article

## Dynamics of Sheep Production in Brazil

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**Abstract:** Sheep production is present on all continents and has been practiced in Brazil since the colonization. In this study, the multitemporal dynamics of sheep production in Brazil is examined using official government data (Brazilian Institute for Geography and Statistics-IBGE) from 1976 to 2010. Maps of flock growth rates and growth acceleration maps by municipality were elaborated. The Southern states are seen to show a reduction in production mainly due to the wool crisis in the 1970s and 80s. The Northeast is seen to be important for meat production. More recently, centerwest and northern states have shown an increase in growth rates but this is still incipient. The maps of growth, acceleration and midpoint for sheep production showed a noticeable return to an increase in production in the South in recent years. The midpoint of production flow was in the northeast direction, which has stagnated. There was great dynamics in sheep production over the whole Brazilian territory, which affected supply chains due to the expansion of domestic and

foreign markets. Areas with higher fluctuations in production are more vulnerable in terms of investment policies.

**Keywords:** production level; multitemporal analysis; risk; GIS

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## 1. Introduction

In Brazil, sheep farming has been practiced since the colonization, and is found throughout the country [1]. Currently, Brazil has the 8th largest flock worldwide with an estimated flock size of approximately 16.05 million head [2]. The Northeast region has 56% of the Brazilian sheep while the South has 32% and Southeast is third with 3.4% [3]. According to [4], this has been accompanied by research focused on the production and processing of animal products, organization of farmers, increasing use of technology by farmers, participation of financial institutions to facilitate access to credit and higher demand for by-products from sheep and goats.

However, production still tends to be informal, making it difficult to consolidate data on the sector [5]. This needs to be a sustainable activity due to its high socio-economic impact [6,7] especially in marginal land areas and low income rural families.

There is a large deficiency in national availability of sheep products, with insufficient production and a trade volume that does not support the industrialization of lamb which seriously affects the abattoirs working with small ruminants [8]. Despite these difficulties, sheep farming can be profitable and is important for all production scales, especially with the increasing demand for healthy foods and preference for products with higher protein lower in cholesterol, saturated fats and calories [9].

The purpose of this paper was to analyze the spatial dynamics of sheep production in Brazil from 1976–2010 using official sheep production data from the Brazilian Federal Government [10]. Specific objectives included: (1) generate maps of sheep production within each municipality in the five major regions of Brazil, (2) determine rate of growth and acceleration within each municipality, and (3) evaluate the spatial pattern and direction of changes in sheep production.

## 2. Material and Methods

Brazil is a continental sized country with distinct environmental characteristics, especially differences in latitude and relief [11,12]. This study considered all municipalities in the five (North, Northeast, Centerwest, South and Southwest) regions of Brazil (totaling 5,561 municipalities). Brazilian sheep production was obtained from the Brazilian Institute for Geography and Statistics [10] from 1976 and 2010.

Maps were generated with the number of animals (production) for each year and then converted to raster format (GRID) and processed in ENVI software (Version 4.5, ITT Visual Information Solution, www.itvis.com). To analyze the dynamics of production growth, maps were drawn for relative growth rate (%) of production by municipality in ArcGis 10 (ESRI, Redlands, CA: Environmental Systems Research Institute). For this, the time interval analyzed was divided in to seven equal periods with intervals of 5 years (sum of the five years of production in each period considered: 1976 to 1980,

1981 to 1985, 1986 to 1990, 1991 to 1995, 1996 to 2000, 2001 to 2005, and 2006 to 2010). Relative growth rate was calculated as:  $((PPsP - PPvP)/PPvP) \times 100$ , where PPsP is the Production in Present Period and PPvP is the Production in Previous Period. Relative growth rate resulted in six maps.

Acceleration of growth rate was obtained by relative differences in the images resulting in five maps, calculated as  $GRPsP - GRPvP$ , where GRPsP is the Growth Rate in Present Period and GRPvP is the Growth Rate in Previous Period.

The spatial mid point of production in the country was calculated for each year to assess the direction of production in the country. The latitude and longitude midpoint were obtained by multiplying the sum of the geographic coordinates of the municipality and their production divided by the number of municipalities for each year as the equations  $\sum(\text{latitude} \times \text{production})/\text{Number of municipalities}$ , for the latitude midpoint, and  $\sum(\text{longitude} \times \text{production})/\text{Number of municipalities}$ , for the longitude midpoint.

The geographic coordinate represents the localization based on the mean longitude and latitude, and production represents the mean production of all municipalities in a certain year. Data was available on a municipality basis and not individual farmer. Therefore the midpoint of production is weighted by the municipal mean sheep production for that year.

Municipalities were clustered according to their production level in 1976. Three clusters were formed using PROC FASTCLUS of SAS® v.93 (Cary, NC, USA). Summary statistics of growth rates and acceleration of production by municipality were calculated.

### 3. Results

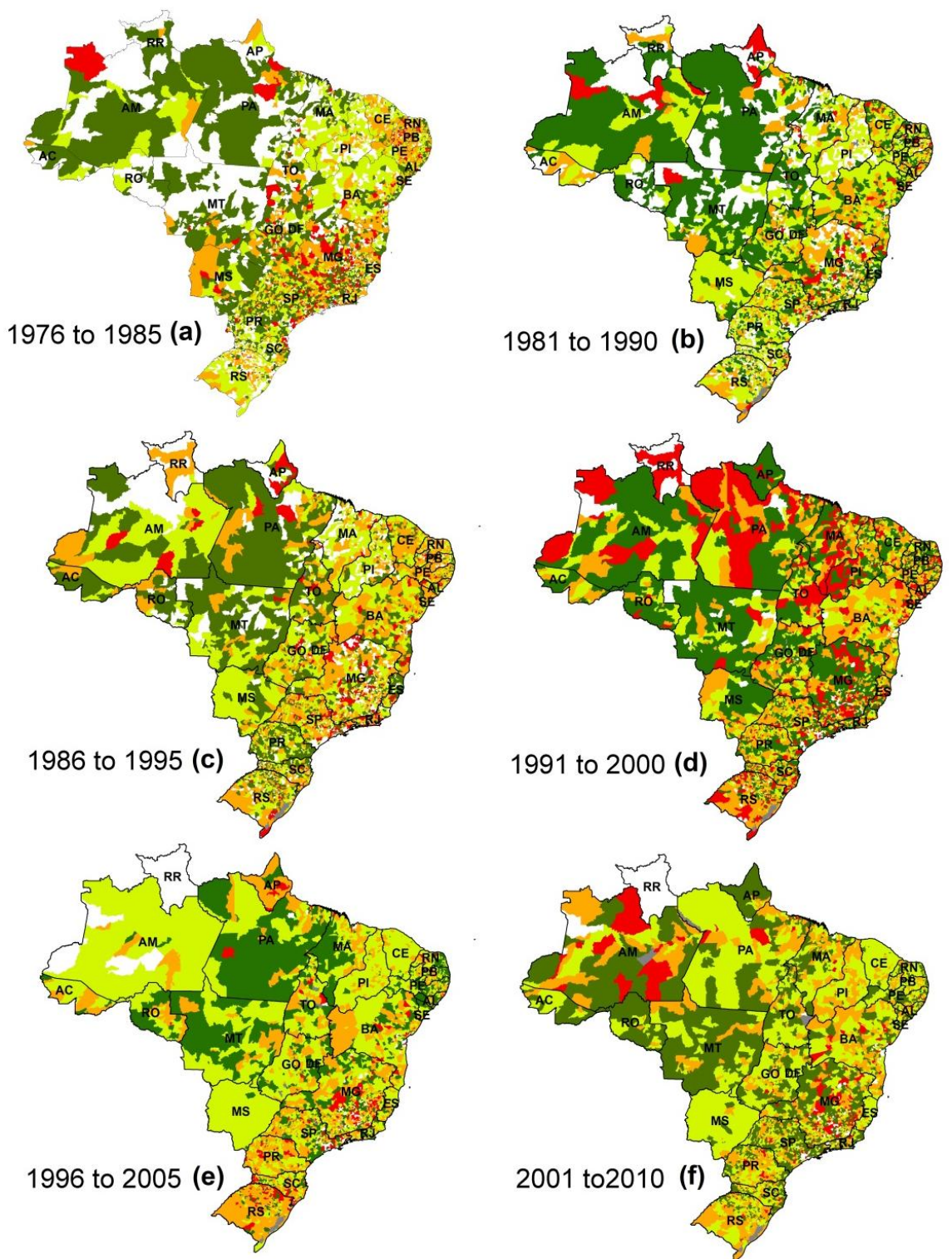
From the 1970s and 1980s, municipalities with high growth in sheep production were seen throughout Brazil, with many municipalities were also stagnant. Between 1986 and 1995, there was a reduction in the growth of sheep production in the south, which up to then was the largest production region (Figure 1c). The municipalities of the North and Midwest from 1986 to 1995 showed higher growth, while the southern counties continue their decline (Figure 1c,d), with a country-wide reduction in growth from 1990–1995 (Figure 1d).

From 1996 to 2010 growth in Northeastern municipalities are highlighted, this region being currently responsible for almost half the sheep flock in Brazil [10,13] (Figure 1e,f). The last period analyzed also points to the resurgence of growth in production of municipalities in the south (Figure 1f). Changes over the whole period (Figure 2) indicate high relative growth in dark green seen in municipalities of the North, Midwest and Northeast. Light and dark red highlight the reduced growth in the South. Table 1 demonstrated these results.

**Table 1.** Number of Brazilian municipalities—sheep production growth.

Period	No Production	Reduction		Stagnation	Growth	
		High	Low		Low	High
1976–1985	1,602	378	993	7	1,219	1,367
1981–1990	1,322	219	959	11	1,554	1,501
1986–1995	863	315	1,451	21	1,457	1,459
1991–2000	218	908	1,478	12	992	1,958
1996–2005	192	386	1,561	26	2,182	1,219
2001–2010	172	260	1,299	16	2,102	1,717

**Figure 1.** Brazilian sheep production growth rates from 1976 to 2010. (a) 1976 to 1985; (b) 1981 to 1990; (c) 1986 to 1995; (d) 1991 to 2000; (e) 1996 to 2005; (f) 2001 to 2010.



### Legend

— State boundary

High reduction (>50%)

Low reduction (<50%)

Low growth (<50%)

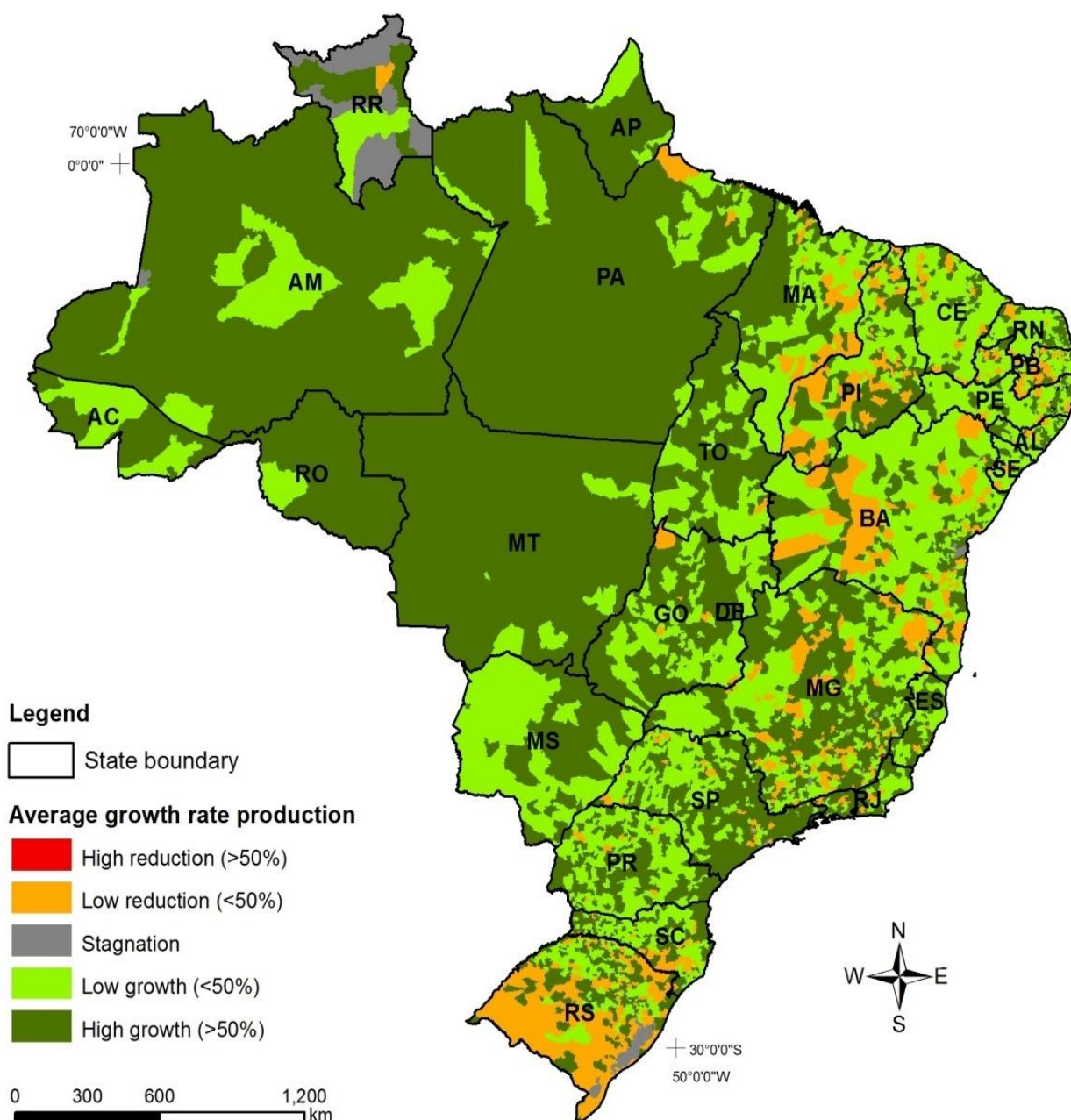
High growth (>50%)

Stagnation

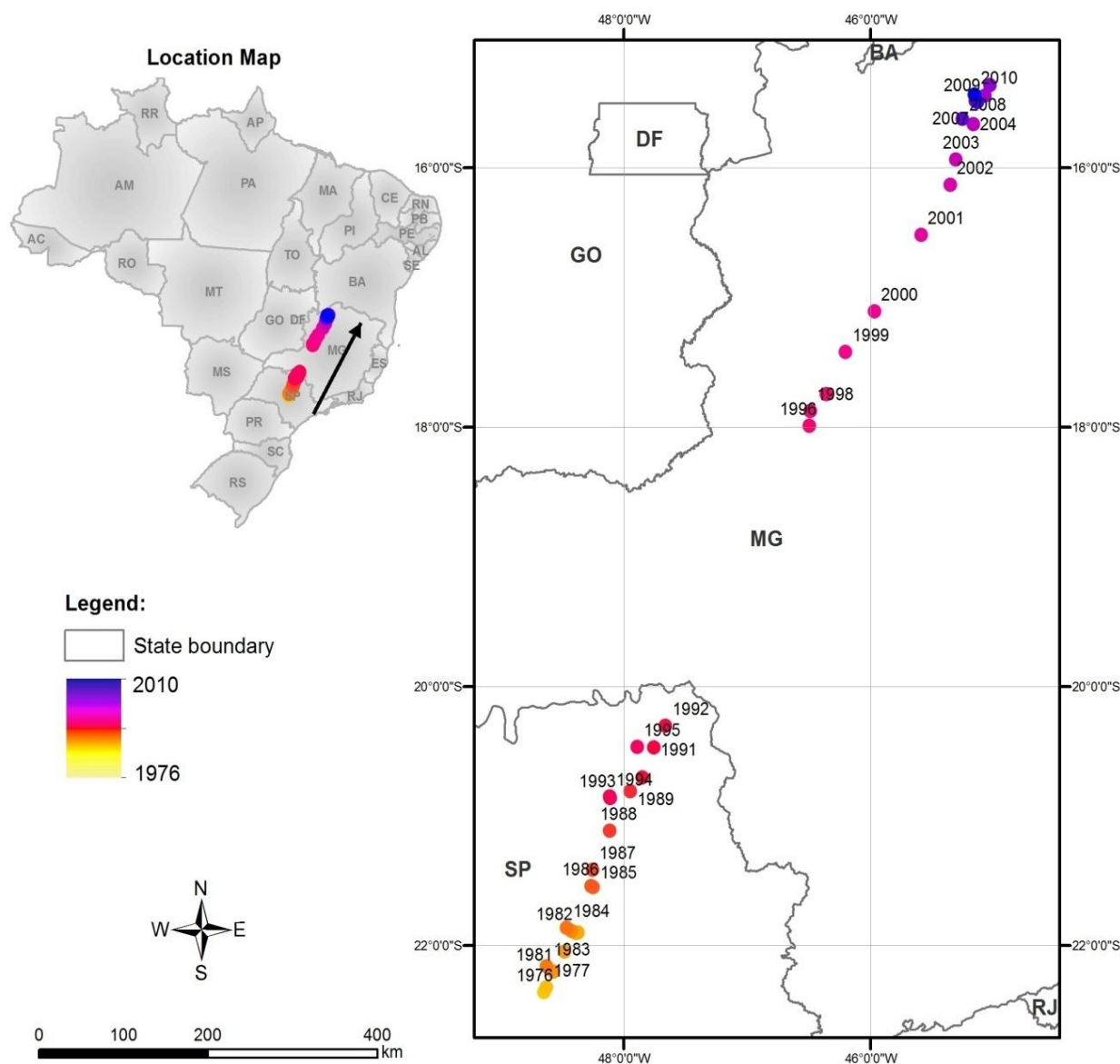
No productio

0 750 1,500 3,000 km



**Figure 2.** Average growth rate of sheep production in Brazil between 1976 and 2010.

This shift in production of sheep toward the northeast of Brazil can be seen on the map of average point of production over the period analyzed (Figure 3), confirming that the dynamics of production move this activity to municipalities in the Northeast of the country. The distance is approximately 860 km (34 km per year), in a steady North-eastern direction. Especially evident is a large jump in production from 1995 to 1996. While up to 2003 the move to the Northeast is relatively fast, in more recent years it has stagnated (2006–2010).

**Figure 3.** Spatial mid-point of average sheep production in Brazil from 1976 to 2010.

Acceleration in production growth confirms the observations described above. In Figure 4 a high deceleration in dark brown is seen in Southern municipalities, in light blue acceleration of growth is represented in many municipalities in the Northeast as well as in the North and Midwest. Dark blue is mainly seen in the Northeast (Figure 4b) following the down turn of production in the south; however, there are a few municipalities in blue indicating an acceleration of production. It is worth noting the large number of stagnant municipalities in Figure 4a,b. In Figure 4c acceleration is seen in municipalities in Clara and Mato Grosso do Sul and in Figure 5d a resurgence of acceleration in the municipalities in the South. Figure 4e expresses a deceleration in several municipalities in the Northeast and South, with a notable slowdown in the limits between Bahia and Piauí

**Figure 4.** Acceleration of growth rates in sheep production in Brazil. (a) 1976–1990; (b) 1981–1995; (c) 1986–2000; (d) 1991–2005; (e) 1996–2010.

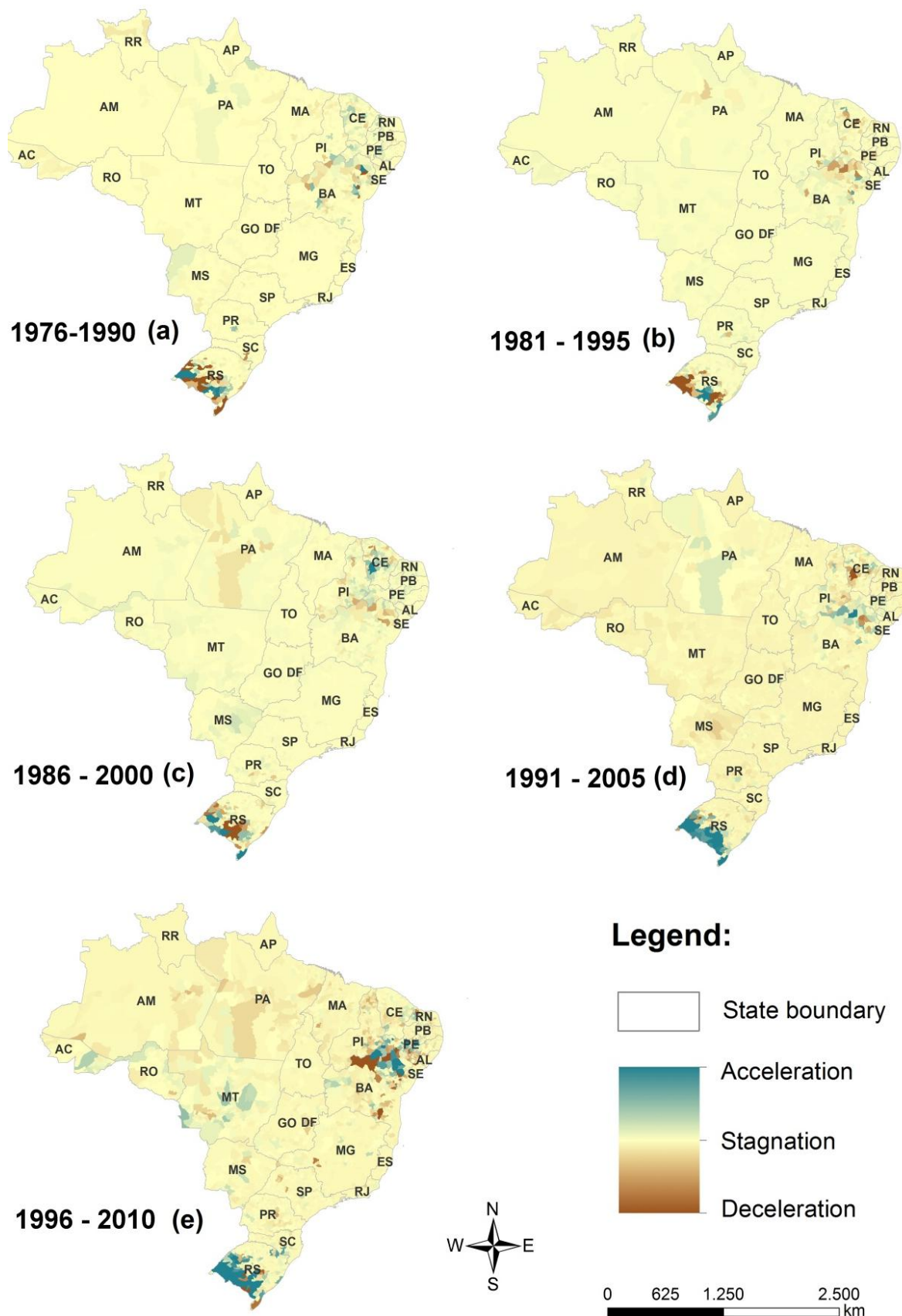
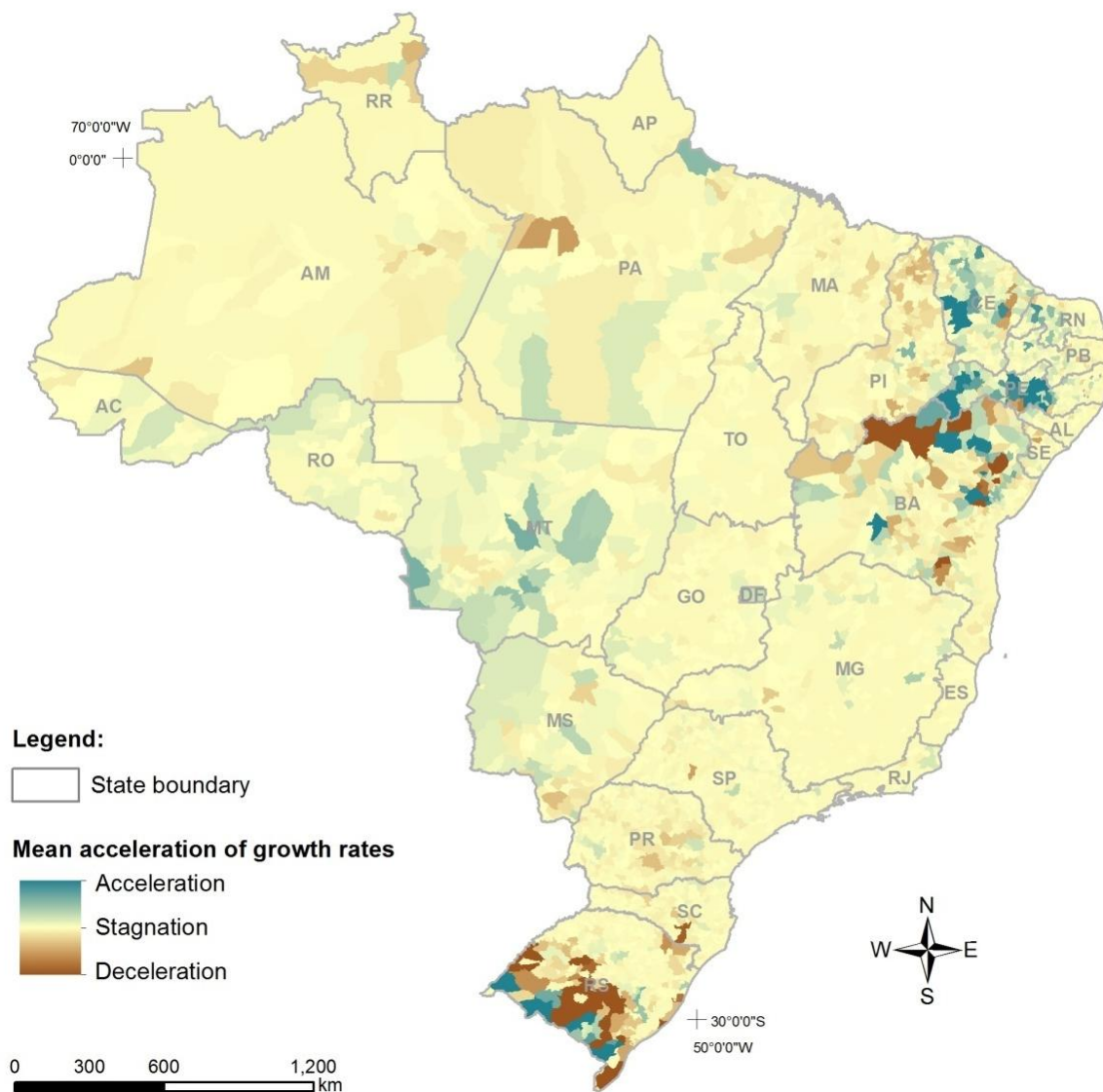


Figure 5 shows the average acceleration of sheep production over the full period analyzed. The municipalities with greater acceleration in production growth are located in the Northeast region. It is also possible to observe that in the South there are a smaller number of municipalities with high acceleration and less intense acceleration occurred in large areas of the Midwest (Mato Grosso) and North (Par ).

**Figure 5.** Mean acceleration of growth rates in sheep production in Brazil between 1976 and 2010.



Quantitative analysis of data showed that 948 municipalities were within the group of large producers of sheep (annual production from 5,638 to 5,609,001 head), 947 in the group of smallest producers (production from 1 to 404 animals) and 1,892 in the group of average producers (production from 406 to 5,624 head). Fluctuations in mean growth are greater in the average producing municipalities (Table 2). The larger farmers are reducing in size while in general the smaller and average are increasing in flock size. Nevertheless, the larger producing municipalities continue to produce much more sheep than the other groups.

**Table 2.** Growth and production averages for municipalities producing sheep in Brazil.

Variable	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
	Largest			Smallest			Average		
Growth 1976–1985	6.	−81.4	535.1	189.1	−98.7	4,685.7	45.2	−99.8	1,892.6
Growth 1981–1990	13.6	−88.6	1,100.6	559.0	−99.6	295,000	135.7	−99.8	83,400
Growth 1986–1995	−1.4	−99.9	397.4	186.5	−99.9	39,600	148.6	−99.9	220,000
Growth 1991–2000	126.3	−99.9	114,140	679.6	−99.7	55,920	207.9	−99.8	94,320
Growth 1996–2005	27.9	−99.9	3,000	422.5	−99.4	82,600	78.3	−99.9	25,600
Growth 2001–2010	427.7	−81.4	335,060	992.9	−99.8	184,000	439.1	−99.6	156,300
Acceleration of growth 1976–1990	801.7	−1,666,552	2,025,560	0.1	−3,804	14,835	94.4	−19,498	43,788
Acceleration of growth 1981–1995	−14,053.4	−4,801,695	750,869	−154.1	−29,500	4,743	−423.6	−87,506	18,950
Acceleration of growth 1986–2000	−13,937.8	−5,405,812	757,247	52.5	−16,893	15,742	−424.0	−51,281	55,315
Acceleration of growth 1991–2005	23,526.9	−339,844	3,481,311	143.7	−14,250	39,216	725.4	−51,718	50,467
Acceleration of growth 1996–2010	6,310.3	−498,779	728,605	246.2	−55,605	19,677	654.9	−45,100	42,826

#### 4. Discussion

According to [14], meat production from small ruminants in Brazil depends on several components of the supply chain (inputs, production, processing, commercialization and the final consumer). Problems with any one of these sectors may affect the production level nationally or regionally. The analysis of changes in sheep production in Brazilian municipalities shows that the dynamics over the period between 1976 and 2010 varied greatly, especially when analyzed in different periods. These dynamics also influence future investments and confidence of members in the supply chain to have confidence and invest in the enterprise. While some farmers use more modern techniques of rearing, in the vast majority there still persists those who carry out this activity in the traditional manner, using animals with no breed standard in marginal areas. The latter are responsible for approximately 90% of the meat produced in Brazil [15]. This low level of productivity is directly related to genetic and nutritional management, forage availability, inadequate funding and management systems for various stages of rearing, empowerment of the producer and low organization capacity. Although there has been an evolution in the number of inputs specific to the activity, there are still some basic items that are insufficient and inadequate to fully meet economic needs of the farmer in Brazil. For example, some types of feeds, mineral supplements and even machinery and equipment, still show questionable effectiveness and cost/benefit [16].

In the 1980s and 1990 the large production in the South was based on wool production but the entry of synthetic fabrics onto the market and also the use of restrictive measures to protect Australia's wool production, caused extensive damage to other producing countries such as Brazil, resulting in a large reduction in sheep production at the time [17]. Many farmers, in subsequent years, left the activity which caused a drastic reduction in the flock, especially in wool breeds. These farmers started investing in other more profitable sectors, giving room for the growth of specialized beef breeds [6] in

this region. This reduction is also attributed to problems such as foot rot, sanitary problems and reproductive problems such as high lamb mortality and low fertility [18]. The shift towards the northeast also reflected a change in breed type, away from wool animals towards hair sheep which are generally less productive due to the lack of breeding programs [19], slower growth rates and produce with meat with different chemical and sensorial qualities than the wool breeds [20].

The average herd size for sheep in Brazil is approximately 29 animals. This varies regionally with those in the Northeast considerably smaller (Northeast—24; Centerwest—41; North—31; South—29; Southeast—37). Here average farm size is 13 ha, with 90% being classified as family farms. Over 50% is of natural pastures and these produce less than 30% of the total animal production. Farmers in this region of Brazil have few options which include crops such as cassava, corn, beans and pasture. Of these, small ruminants on pasture were shown to be the less labor intensive and therefore favor opportunities for farmers or family members to seek off-farm employment either for short periods or seasonally while still maintaining their farm [21]. Therefore most of these farms are subsistence with little use of technology and investment, which makes them even more vulnerable to climatic factors thereby contributing to the fluctuations in production in the region. Northeast Brazil is seriously influenced by insufficient and unreliable rainfall. Adverse natural conditions, combined with underdevelopment in the region (low IDH scores, few industries, little infrastructure, high distances between urban centers) mean the rural population cannot support itself, especially in drought years [22]. Other studies in the Northeast of Brazil [21,23] also showed a positive but low economic return for sheep farming in the semiarid. In this region, the opportunity cost is practically zero. The producers do not have many options and with small areas of land available, many of them uncultivable, sheep have advantages over other activities such as cattle. This is one of the reasons why these animals have been used by these smallholders for many decades.

The slowdown in production in some municipalities in the limit between Bahia and Piauí States may be a consequence of the construction of the Sobradinho dam, responsible for a large part of electricity generator in the Northeast. The dam was built in the late 70s and 4,214 km<sup>2</sup> were flooded, forcing the relocation of approximately 12,000 families, interfering directly with economic activities in the region [24]. Part of the sheep production in the region is still exploited by low productivity traditional and subsistence farmers, linked to a low level of technology, which results in high mortality of animals maintaining productivity low [25,26]. Thus, production is vulnerable to fluctuations in the economy and the action of speculators, especially in isolation, without the support of efficient associative structures. According to [27], from the socioeconomic point of view, the activity is negatively affected by the low level of managerial training of the farmer and lack of organizational structure. Although authors have pointed out that the Brazilian Northeast stands out in the farming of small ruminants, with a vocation for this kind of activity [27,28] animals are slaughtered at one year of age [21] compared to six months in the centerwest [19,20] or even four months of age in intensive systems. This affects acceptability of the product in many markets.

The lack of reliable information sources leads farmers to take decisions conditional on their experience, the tradition, the region's potential and the availability of financial resources and man power. When profitability is low, the farmer realizes this, but it is difficult to quantify and identify the bottlenecks of the production process [29]. Farmers in Brazil over the last 20 years have been actively encouraged to invest in sheep farming, especially in regions where it is not traditional such as the

centerwest and north. However, sheep are not small cattle and management systems should take this into account. This also affects questions such as where to buy input and sell the output as slaughterhouses are few and far between. This can be seen in Figures 1 and 4 where the centerwest and northern regions show high fluctuations (increase and decrease, acceleration and deceleration) over the period studied. This fluctuation means that confidence in the enterprise is low by investors and investments in construction of slaughterhouses and supply networks are not being developed.

Although abattoirs, slaughter houses and some meat processing industries have been installed, the maintenance of these is difficult. However, due to the seasonality in supply of animals and the quality of these, many of these establishments are closed or working with less than 50% of its capacity [14]. This is mainly related to seasonal supply of low quality animals for slaughter; Competition with informal slaughter; high logistical costs mainly in collecting animals; Lack of tax laws that are suitable for installations of slaughterhouses; High sanitary inspection costs; Deficiency in technologies for a better use of meat in the making of sausages and derivatives.

An analysis of the Agroindustrial Management System (AMS) [15] looking at market and governance structure for sheep production, confirmed the lack of coordination in the system. The low quality of product information, a symmetry in the system, the presence of intermediaries, technological bottlenecks, sanitary barriers, lack of security of supply over the year, unfair competition with illegal slaughtering, lack of product flow between state markets, are consequences of lack of coordination between members of the AMS all influence the system. According to [30], outside Rio Grande do Sul State, most slaughter does not undergo federal inspection making marketing of the product more difficult, but it also shows a high variation in official slaughter numbers, variations which affect investments and confidence in the supply chain. As [31] found, 22.2% of retail establishments selling mutton derived from illegal slaughter. These authors indicated that the main commercialization problems include lack of association between farmers, making it impossible to establish partnerships; Lack of logistics in the trade of animals and meat, and sector modernization; Insufficient production scale to meet the permanent market; Inefficiency of health surveillance, essential to curb the informal slaughter and Lack of a differentiated policy price for quality carcasses. This is reflected in the maps produced here and seriously affects farmer and retail confidence in the system.

According to [32] the main concern of policy competitiveness practiced by different states in Brazil seems to be to attract businesses. It is, therefore more an attempt to offer advantages in order to displace flow of investment than effectively create conditions for improving the competitiveness of existing businesses. When taxes are used as instruments to modernize the livestock sector, usually incentives via tax cuts for the adoption of certain technologies, experience has shown that the impact of tariff reduction turns out to be small, depending on the magnitude of illegal slaughter [33]. This means that several players do not remain in the business for a long period of time leading to lack of confidence and therefore fluctuations in production levels.

Notable differences appear among the populations of different countries and within a country, between regions and social classes in their preferences for animal products. The preferences depend on the habits consumption, culinary traditions and education in consumer tastes. Consumption of sheep meat (lamb or mutton) is not traditional outside the northeast and south of Brazil. A sector of the population of large cities is sporadically adopting the habit of consuming meat from small ruminants. Moreover, these consumers demand product of better quality. For [34], the quality criterion for meat is

extremely varied in space (country, region, culture, *etc.*) and time (time, years, *etc.*). It is therefore not simple to define “quality”. From the producer to the consumer, the concept of quality acquires different meanings. This makes it more difficult for the establishment of new industries in non-traditional areas and accounts for the fluctuations in production. The type (hair or wool, age, feeding and management) of animals produced in different regions of Brazil varies widely meaning that incipient consumers may be put off by fluctuations in perceived quality and variations in the product offered.

According to [6] that also shows that the set of structural and cyclical changes undergone by the sheep activity in recent decades is reflected in the prices paid for their products, whether in the decline phase (1973 to 1994) as well as recovery (1995 to 2005), due to the economic stabilization of the Monetary Real Plan and its consequences on the domestic market.

From 1995 to 1996 there was a large jump in production towards the north-eastern states with a decrease in the South, represented by a high spatial distance between the points. This may be due to a small degree to some methodological changes in how these data were collected but this was not seen in other animal production systems. From 2004, production midpoint stagnated again, probably due to increased production in the South (slaughter lamb production) as well as some increase in flocks to the North and Midwest.

As noted, there was a great dynamics in sheep production over the whole Brazilian territory, which affected supply chains due to the expansion of domestic and foreign markets [35]. However, according to [7], the seasonality of production, the lack of a steady market, the demand for a steady supply of animals, the need for market scale and the increasing demand for young animals by the abattoirs are difficulties that farmers face when marketing their animals for slaughter.

## 5. Conclusion

The use of maps showed a clear picture of the dynamics of sheep production in the municipalities of Brazil between 1976 and 2010. Municipalities in the South and Northeast remained at high levels throughout the period of production, reaffirming the tradition of sheep breeding in these regions. Nevertheless, the maps of growth acceleration and midpoint showed a noticeable reduction and slowing production in the South with a return to increase in more recent years. The Northeast has faced several problems with productivity but has shown stable production over the years.

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## Conflict of Interest

The authors declare no conflict of interest.

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