Meeting Climate Change Targets – necessary adjustments and challenges for Brazilian beef industry

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Abstract
Brazil is an important player in the global beef market exporting throughout the world. The Brazilian livestock sector contributes to about 3% of the national GDP, and it has the potential for further increasing its beef exports; only about 1/5 of its beef production currently goes for export – at the same time domestic beef consumption has been rising. It has various competitive advantages compared to other major exporters but it has faced questions in recent years on the adverse impact of the beef industry has on the environment – particularly in relation to GHG emissions. Historically, the main challenge has come from criticism that the increased land needed for higher beef production levels has caused greater deforestation. However, this is no longer the case as Brazil is increasing its production by improvements in productivity rather than devoting more land to cattle farming. This paper shows the contribution that improvements in stocking rates, calving intervals and increasing of the age of slaughter are making to improvements in the productivity of beef production without causing such damaging GHG emission impacts.

Introduction

Brazil is an important beef producing and exporting country, presently ranked second in beef production and first as exporter (Beef2Live, 2015) in the world. About 1/5 of the country´s beef production is exported (CEPEA, 2015; SECEX/MDIC, 2015), especially to emerging markets, predominantly China (IMS, 2015), where new habits of meat consumption and increased disposable income have guaranteed a steady outlet for the Brazilian meat. Domestic beef consumption is the third highest per capita beef consumption in the world (OECD, 2015) and demand was kept buoyant even during the recent economic recession as the population, instead of cutting down on meat consumption tended to substitute prime beef cuts for cheaper ones, as suggested by De Zen and Santos (2016).

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Agriculture in general and the livestock sector in particular contribute to a fair share of the country's GDP. In 2014, according to the Centre for Advanced Studies in Applied Economics (CEPEA), the share of the Agribusiness sector accounted for 22.5% of total Brazilian Gross Domestic Product (GDP) of US$ 2,346.12 billion (World Bank, 2015) of which the beef sector alone made up 12.76% of the Brazilian Agribusiness GDP (CEPEA, 2015).

The country's sheer land mass and the predominant tropical climate in most of its territory contributes to it having a comparative advantage over other beef exporters. The total pasture area occupies 177,700,472 ha, half of the Brazilian total arable land, and comprises of mostly grassland (FAO, 2006), where cattle is mostly raised extensively. Santos (2015) analysed that other factors also contribute to the country's performance, such as the relatively low cost of labour, on average 1.2 times the Brazilian national minimum salary, and the relative low land value.

In recent years, the impact the Brazilian beef production has had on the natural environment has attracted some attention, particularly in beef produced near the Amazon forest. Cattle grazing is the first economic activity after the primal forest cover is removed and timber is sold. Cattle grazing thus acts as a means of occupying and securing the possession of the land. In the process, the Land Use Change (LUC) tends to contribute to increased release of greenhouse gas (GHG) emissions, not to mention the fact that livestock-related activities contribute to further GHG emissions, primarily in the logistics and transportation sectors (Bartholomeu and Caixeta Filho, 2009).

Yet, the Land Use Change is also a major contributor to pasture degradation. It is estimated that from 50% to 70% of pastures in Brazil present some degree of degradation (Dias-Filho, 2011) which could be attributed to the inadequate management of the pastures, little or no use of fertilization to replace the natural fertility, as well as overstocking (Vilela *et al*., 1998). As a result, addressing problems of efficiency in the beef sector is considered of utmost importance as a factor in contributing to environmental improvement.

This discussion paper aims at investigating the challenges faced by the Brazilian beef industry and the necessary adjustment to meeting climate change targets. Firstly, a review of the literature will be presented below, addressing change of land use, pasture degradation and GHG emissions. Following that, data from 59 farms considered typical has been analysed using the database of Centre for Advanced Studies in Applied Economics of the University of São Paulo (Cepea-Esalq/USP). And finally recommendations will be presented regarding the necessary adjustments required to address these issues.

The Effects of Deforestation and Land Use Change (LUC)

Land ownership in Brazil, following its long historic process of conquest and occupation of the hinterland, has created a mix of legal land demarcation and land grab rights which is open to boundary disputes and land registration problems (Guedes and Reydon, 2012). Since 1999, the National Institute for Colonization and Agrarian Reform (INCRA) has attempted to redress this problem of governance of the land. However, only more recently satellite imaging and geo-referencing mapping (Reydon, 2014) has more effectively begun to address the problem. Meanwhile, the agricultural frontier line has gradually moved northwards and westwards into some key biomes, which are unique in the world, such as the Amazon and the Cerrados. The Amazon biome comprises of nine states, or ‘provinces’ as highlighted Figure 1 below. Mato Grosso (MT) is the state with the largest concentration of cattle in Brazil, 13.5%, followed by the states the states of Maranhão (MA), Pará (PA), Tocantins (TO) and Rondônia (RO) which together make up another 36.3% of the country’s herd. The Brazilian agricultural frontier is predominant along these states and representative of 89% of the Amazon biome deforestation. Once the forest cover is removed and the timber is sold, beef production is the first economic activity to take place on virgin land. This happens because livestock is relatively easy to be relocated, it is easily adaptable to newly opened areas, requires low level of initial investment, little or no management of the soil and presents fewer restrictions regarding the landscape (Rivero *et al*, 2009). As a result, beef cattle production has been emblematic in representing the main economic activity in the Amazon region (Margulis, 2003).

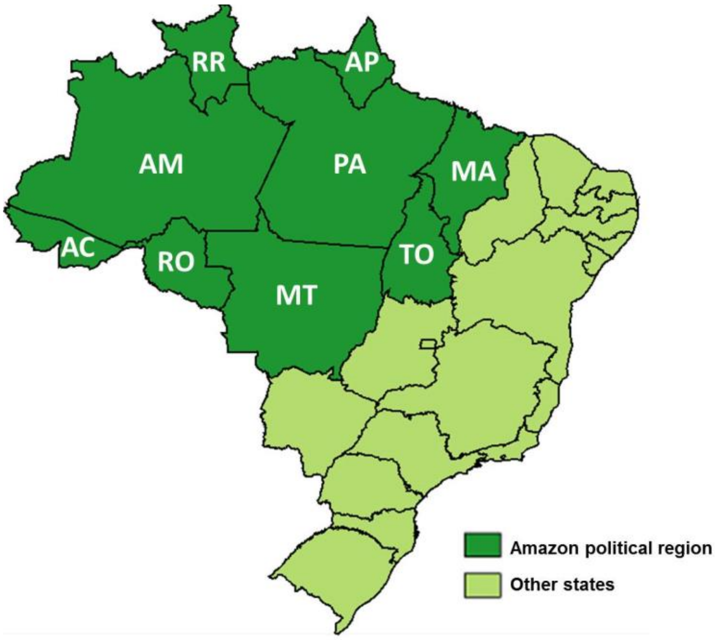

Figure 1 – Map of Brazil with the Amazon Region
Source: Authors' own (2016)

Figure 2 below depicts the deforestation rate in the Amazon, which has decreased by 68% by 2015. Much of it is due to recent Land Use Legislation ruling on the control of land title deeds aided by satellite imaging and geo-referencing mapping. In the Amazon biome, the Land Use Legislation allows only 20% for new areas to be converted into agriculture, thus limiting up to 80% of the virgin land to be kept as natural reserve. In other biomes, the respective proportion of land to be set aside or allowed into cultivation varies. Figure 2 also shows that during 2014 and 2015 deforestation actually increased by 16.3% year-on-year, although the reasons for that are not yet clear.

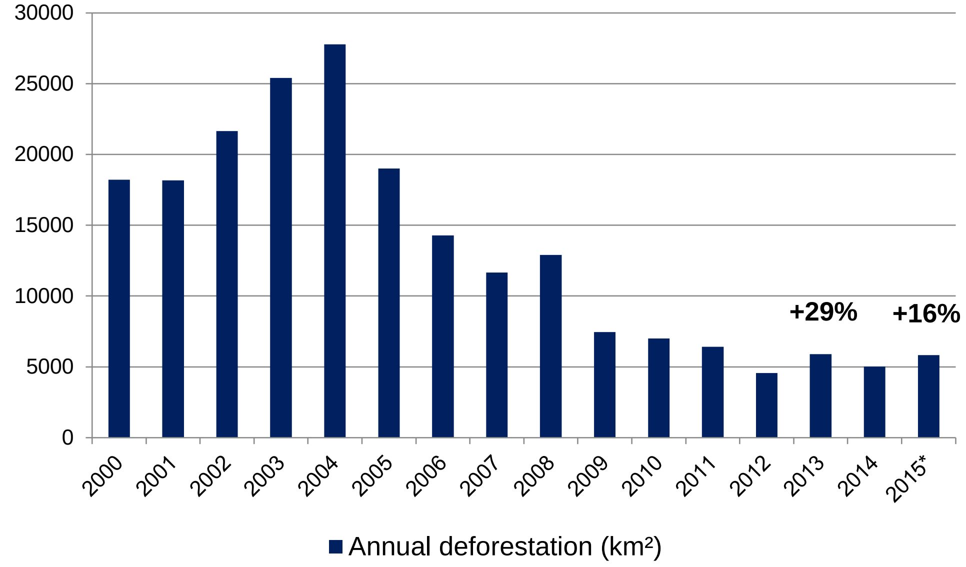

Figure 2 - Annual deforestation (km²) in the Brazilian Amazon Rainforest
Source: Prodes – MCT/Brazil (2016)

In the last forty years, the Cerrados, which is the second largest Brazilian biome, and where most of commercial beef production is based, has also felt the brunt of the expansion of the agricultural frontier. Presently, more than a half of the Cerrados' original area has been given over to livestock and annual crop production, especially soya and maize, (Machado *et al.,* 2004) with most the soya produced to be exported.

Figure 3, below, show Brazil's GHG emissions being 1,841.79 Mt of equivalent CO_2 for Agriculture and Land Use Change and Forestry in 2012. That represented 68% of the total Brazilian GHG emissions (CAIT, 2016).

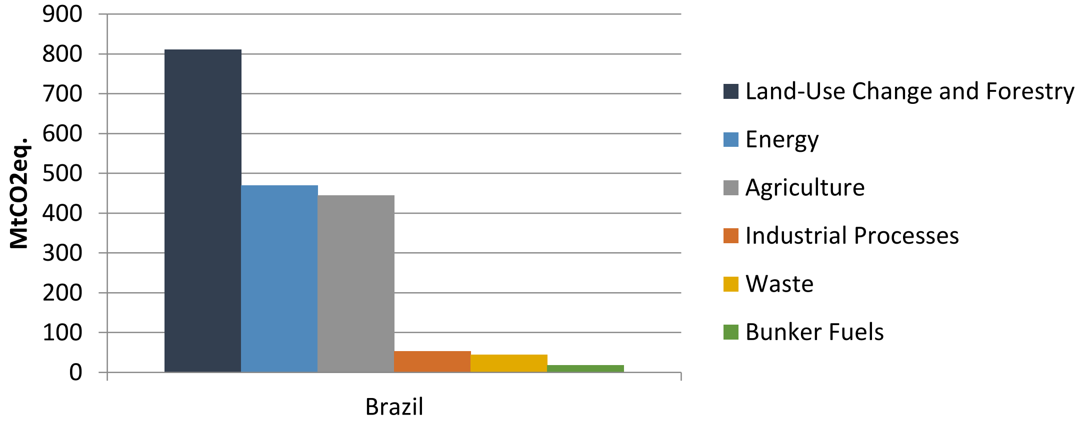

Figure 3: Greenhouse Gas (GHG) emissions in Brazil – $MTCO_2$ in 2012
Source: CAIT (2016).

Livestock production contributes to the release methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (NO_2) gases. Methane alone is responsible for some 67% to 83% of GHG emissions from cattle (Cerri *et al*, 2015; Siqueira and Duru, 2015) resulting from enteric fermentation (57Kg of CH_4/head/year) (IPCC, 2009), manure deposition and management (Schroeder *et al*., 2012). It has a global warming potential 25 times greater than CO_2 and its lifetime in the atmosphere is estimated to last between nine to fifteen years (IPCC, 2006).

GHG emissions during the initial years of LUC caused by deforestation have a great CO_2 releasing potential (Siqueira and Duru, 2015) until the soil reaches a new carbon balance. Conversely, beef production systems based on grassland can also sequestrate CO_2, hence reducing and even cancelling net GHG emissions (FAO, 2011). Furthermore, another consequence associated LUC is soil degradation. In degraded pastures, there is firstly a drop in the availability of forage, reduced field support capacity and slower animal weight gain. Secondly, a poor degraded soil has reduced capacity to produce good quality forage, not to mention problems in water infiltration and water holding capacity due to soil compaction (Macedo *et al*., 2013). The resulting effect is soil erosion and silting of springs, lakes and rivers.

Evidence from appropriate management of soil and pasture shows that when pasture rotation (Silva *et al.,* 2015), fertilizer supplementation (Ruviaro *et al*., 2014), land use intensification coupled with genetic selection of animals is used, GHG emissions per kg of meat produced from 2% to 57% (Mazzeto *et al*., 2015) can be reduced with also the shortening of the time the animals take to slaughter. Moreover, Silva *et al.* (2015) estimated that the use of feed supplements and feedlot finishing of animals could also reduce sector emissions by 24% per cent by 2030.

Yet, most of the environmental impact Brazilian livestock production generates is due to the sector's low productivity (De Zen *et al.*, 2008). Thus, the cattle stocking rate serves as one of the most important indicators of the Brazilian beef cattle productivity. According to Dias-Filho (2014), in 2006 the pasture stocking rate was calculated to be 1.2 animals/ha based on 1 Animal Unit representing 450 kg of live weight/ha. Correa and Santos (2003) mentioned that higher stocking rates could be found on improved pastured reaching 5-8 AU/ha during the rainy season, despite the pasture capacity decreasing during the dry season. However, Correa and Santos (2003) claimed that stock capacity could be maintained during the dry season with some pasture management. In spite of low stocking rates in general for Brazil, there has been some improvement in such an index more recently. Martha Jr. *et al*. (2012) argue that since 1985, the aggregate gains in productivity have not been realized based on the expansion of the livestock activity over new land as depicted in Figure 4, below. This means that in more established areas the gains in productivity have been significant and have not put pressure for the need to open new pastures' areas, especially along the agricultural frontier line.

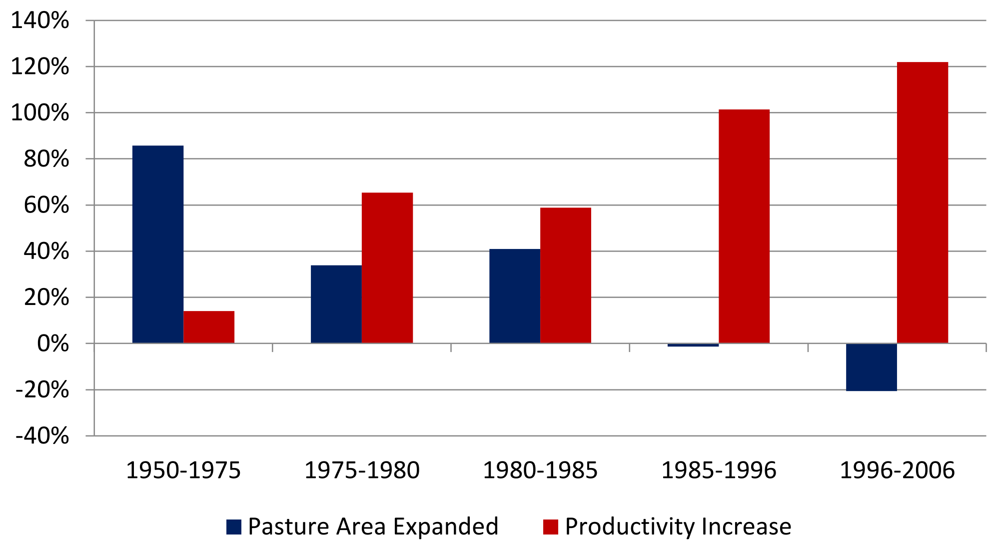

Figure 4: Factors explaining beef production growth in Brazil, 1950 – 2006.
Source: adapted from Martha Jr. *et al*., (2012)

In Figure 5 below, Santos *et al*. (2015) compared the years 2003 and 2013 and found that the stocking rates for each of the highlighted regions had actually increased. Nonetheless, the increased stocking rates, does not necessarily represent an increase in meat productivity, which is about total live weight gain per hectare. Yet, in the Brazilian case, since the overall productivity is very low, the stock rate can be increased without causing the animals a nutritional deficit.

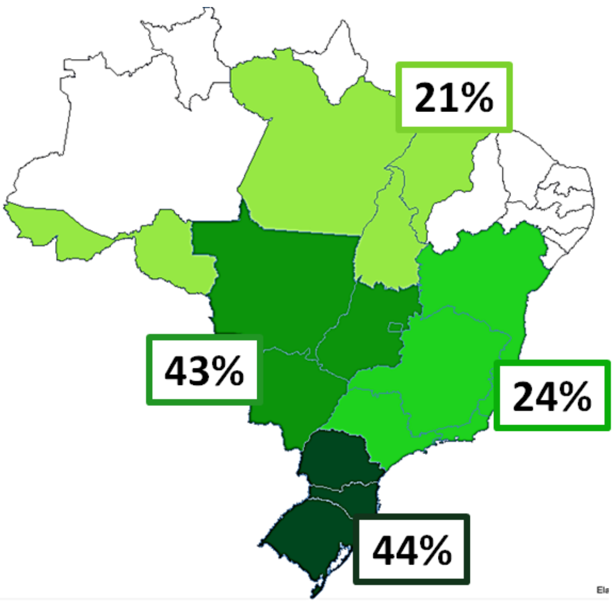

Figure 5: Stocking rate variation in the typical beef farm – comparison between 2003 and 2013.
Source: Santos *et al*. (2015)

Methodology

For the purpose of this discussion paper, a mixed methodology approach was chosen using a Typical Farm as the unit of investigation. This is a widely used theoretical model which characterizes the mode of production in one region (Carey, 2015). This model describes all stages of production and provides information such as the total area, human resources, and technologies employed and productivity achieved (Elliot, 1928; Plaxico and Tweeten, 1963; Feuz Skold, 1991; Deblitz *et al*., 1998; Santos *et al*., 2014). Data from CEPEA's time series database, which consists of 213 typical beef farms located in thirteen states in Brazil, was used. The surveyed area represents 90% of the Brazilian herd. The states of Goiás (GO), Mato Grosso (MT) and Mato Grosso do Sul (MS) were selected because these currently account for 37.5% of the total cattle slaughtered in that country and representing the mid-west region of Brazil. Representing the Amazon region, the states of Rondônia (RO), Tocantins (TO) and Pará (PA) were chosen. These account for some 17% of the total cattle slaughter. In total, 54.5% of the Brazilian cattle slaughtered, including cows and bulls, was representative of this sample. The sample covered 59 pairs of typical farms spread in 26 localities, as illustrated in the Figure 6, below, and detailed in the Appendices**.** In some localities, along the time series, the farm activities have changed from Total Cycle into more specialized Beef Finishing and Cow-Calf. As shown in the

Appendices, in some localities there has been variation in the periods the survey data was collected. During the ‘Early Years’ data was collected in 2002 (Mato Grosso do Sul), 2003 (Pará, Goiás and Mato Grosso) and 2006 (Tocantins). As to the ‘Later Years’ data, it was collected in 2012 (Pará), 2013 (Goiás), 2014 (Mato Grosso do Sul) and 2015 (Mato Grosso and Tocantins).

For the purpose of this discussion paper, three indicators have been analysed: Stocking Rate, Age at Slaughter and Calving Interval. These represent how gains in livestock productivity have improved as a result of production specialization which have contributed to the need to take the activity further into the rain forest, consequently with positive effects in curbing deforestation, and the reduction of GHG emissions a contributing factor to climate change.

1. The Stocking Rate - based on 450 kg livre weight per hectare. There is a direct correlation between stocking rate and productivity;
2. Age of Slaughter - there is an inverse correlation between the age of slaughter and productivity;
3. Calving Interval - there is an inverse correlation between the calving interval and productivity. Cows stand pregnant for 9 months and, in well managed systems, require two to three months in order to become pregnant again.

Further work is in progress to enable effective quantification of overall productivity improvements and facilitate international comparisons.

Figure 6: Location of Farms Sampled
Source**:** Santos (2016)

RESULTS

According to the time series, based on the surveys carried out in the early years, in 9 localities and 18 farms, there has been a process of specialization of production. Total Cycle as the predominant modal production system being replaced in late years giving room for more specialized production systems which favoured predominantly two modal systems: Cow-Calf and Beef Finishing. However, specialization happened in different farms either catering for Cow-Calf or Beef Finishing. Another key finding was the emergence of the Crop and Livestock Integration (CLI) as modal production systems as it can be seen from Table 2 in the Appendices.

Stocking Rate

When comparing Stocking Rate between Early and Late Years, for all the cases it has gone up 62.5% of the cases. The most significant improvement was found in Mato Grosso do Sul, in the locality of Naviraí, where the land productivity increased by

136%. The absolute Stocking Rate value for that locality was also the highest for the Late Years period, showing a Stocking Rate of 2.17 AU/hectare as depicted in Figure 7, below.

It is worth mentioning that such a productivity was achieved under a Crop and Livestock Integrated (CLI) system. In such a system, the rotation with soybean allowed for nitrogen fixation in the soil which, when replaced in subsequent years by pasture, the grasses take advantage of the good soil condition. The second highest productivity under CLI system supported 1.60 AU/hectare. Conversely, the lowest productivity obtained was 0.33 AU/hectare from a typical farm in the Pantanal region which is located in the Wetland biome. Under that condition, the annual floods cover the farm area during half of the year. That was followed by a typical farm in Paranaiba, located in Mato Grosso do Sul, with a minimum 0.52 AU. When taking out the lowest value which represented a typical farm under wetland, the average CLI for all the properties in the Late Years was 0.99 AU/hectare.

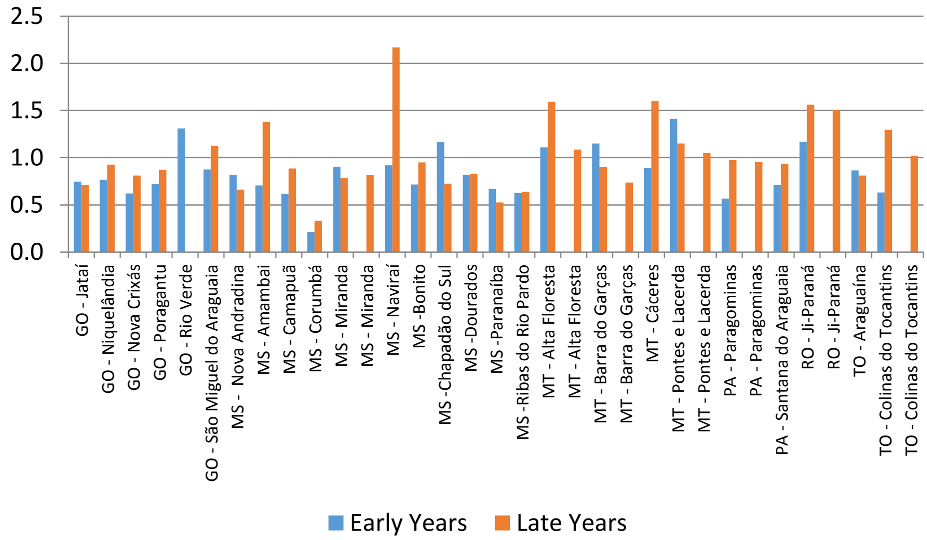

Figure 7: Stocking Rate in the typical farm – comparative between Early and Late Years survey
Source: Research results.

Calving Interval

Considering the Early and Late Years, Total Cycle and Cow-Calf were the modal production system in 34 typical farms. In order to analyze the total productivity gain, it was considered those localities where Total Cycle or Cow-Calf were maintained as modal systems. That was typical of 13 localities. It was observed that in 69% of those localities the calving interval decreased as shown in Figure 8.

When considering all farms, in the Early Year survey, the calving interval has an average of 16 months. Yet, in the Late Year survey it was 15.2 months. The best productivity observed was 13.5 months in a typical farm located in Ribas do Rio Pardo in the State of Mato Grosso do Sul, and the worst was 17.1 months in Niquelândia in the state of Goias. These numbers demonstrate that, although there has been some improvement, the values remains above the ideal 12 months calving interval mentioned by the literature.

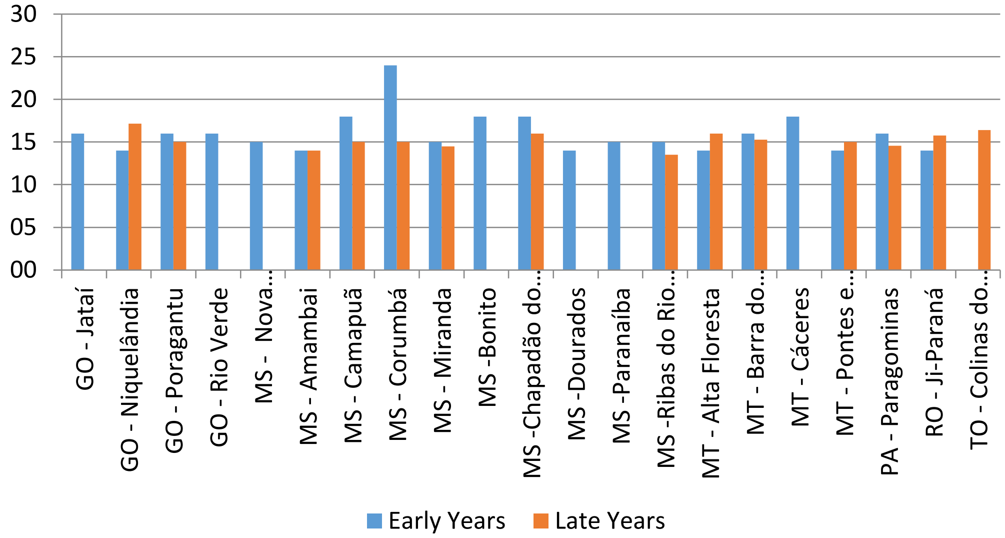

Figure 8: Calving Interval in the typical farm – comparative between Early and Late Years survey

Source: Research results.

Age of Slaughter

Considering all localities and Early and Late Years survey and accounting for Total Cycle and Beef Finish, it was observed that the age of slaughter had reduced by 71%. The most significant improvement was found to be Cáceres, in the state of Mato Grosso, here the age of slaughter reduced by 35%. In the Early Years the average age of slaughter was 40 months, yet, in the Last Year survey it was 26 months as shown in Figure 9. Despite the considerable improvement in such an indicator, there are still localities where the average age of slaughter has remained 40 months, which is significantly high. The average of all localities during the Late Years survey was 34.3 months.

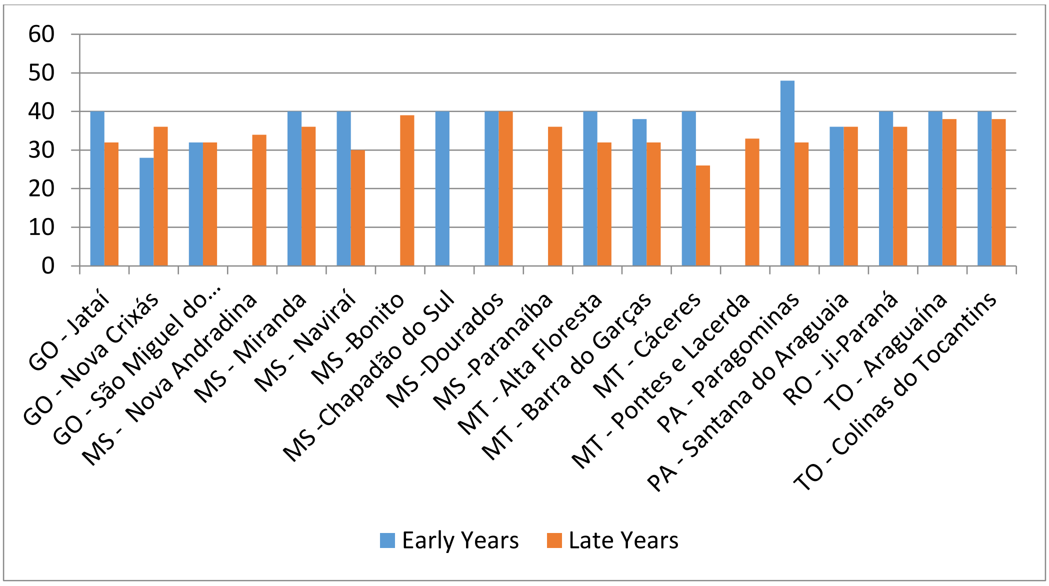

Figure 9: Age of slaughter in the typical farm – comparative between Early and Late Years survey
Source: Research results.

Conclusion

This discussion paper aimed at analysing the challenges and highlight the needs for the Brazilian beef chain in the light of climate change. Firstly, the review of the literature address the key factors contributing to GHG emissions. It can be concluded that LUC is the major contributor of GHG emissions and that still very recently the deforestation of the Amazon biome despite a long decline in the activity it is still taking place. After the logging of timber and speculation regarding the value of the land as a reserve of capital, beef cattle production is the first activity to be established aster the forest is cleared. Gains in productivity can balance out the GHG emissions resulting from the methane being produced by the livestock as well as LUC. The indices analyses indicate that during the last decade, there have been gains in productivity, however, such gains are still below those set out for Brazil to reach its GHG emission targets. Brazil has the potential to supply the potential world meat demand. Nonetheless, the Brazilian beef industry, in order to produce meat more sustainably would still face great challenges. More adequate agricultural policies together with a stronger land control and governance system is needed. As a next stage for discussion, a framework for effective quantification will be developed to enable comparisons to be made with other countries.

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Appendices

Table 1: Year and region of survey to characterized Brazilian beef typical farm

Year of the first and last survey	State – Municipality
2002/2014	MS - Nova Andradina
2002/2014	MS – Camapuã
2002/2014	MS – Corumbá
2002/2014	MS – Amambai
2002/2014	MS – Naviraí
2002/2014	MS – Miranda
2002/2014	MS – Bonito
2002/2014	MS - Chapadão do Sul
2002/2014	MS – Dourados
2002/2014	MS – Paranaíba
2002/2014	MS - Ribas do Rio Pardo
2003/2012	PA – Paragominas
2003/2012	PA – Paragominas
2003/2012	PA – Paragominas
2003/2012	PA - Santana do Araguaia
2003/2012	PA - Santana do Araguaia
2003/2013	GO – Jataí
2003/2013	GO – Niquelândia
2003/2013	GO - Nova Crixás
2003/2013	GO – Poragantu
2003/2013	GO - Rio Verde
2003/2013	GO - São Miguel do Araguaia
2003/2015	MT - Alta Floresta
2003/2015	MT - Barra do Garças
2003/2015	MT – Cáceres
2003/2015	MT - Pontes e Lacerda
2003/2015	RO - Ji-Paraná
2006/2015	TO – Araguaína
2006/2015	TO - Colinas do Tocantins

Source: CEPEA (2015)

Table 2: Production System in each region – First and last survey

Year of the survey	State - City	Production System
2003	GO - Jataí	Total Cycle
2013	GO - Jataí	Beef-Finishing
2003	GO - Niquelândia	Cow-Calf
2013	GO - Niquelândia	Cow-Calf
2003	GO - Nova Crixás	Beef-Finishing
2013	GO - Nova Crixás	Beef-Finishing
2003	GO - Poragantu	Cow-Calf
2013	GO - Poragantu	Cow-Calf
2003	GO - Rio Verde	Cow-Calf
2013	GO - Rio Verde	Feed Lot
2003	GO - São Miguel do Araguaia	Beef-Finishing
2013	GO - São Miguel do Araguaia	Beef-Finishing
2002	MS - Nova Andradina	Cow-Calf
2014	MS - Nova Andradina	Beef-Finishing
2002	MS - Amambai	Cow-Calf
2014	MS - Amambai	Cow-Calf
2002	MS - Camapuã	Cow-Calf
2014	MS - Camapuã	Cow-Calf
2002	MS - Corumbá	Cow-Calf
2014	MS - Corumbá	Cow-Calf
2002	MS - Miranda	**Total Cycle**
2014	MS - Miranda	Beef-Finishing
2014	MS - Miranda	Cow-Calf
2002	MS - Naviraí	Beef-Finishing
2014	MS - Naviraí	Beef-Finish – CLI
2002	MS -Bonito	Cow-Calf
2014	MS -Bonito	Beef-Finishing
2002	MS -Chapadão do Sul	**Total Cycle**
2014	MS -Chapadão do Sul	Cow-Calf
2002	MS -Dourados	**Total Cycle**
2014	MS -Dourados	Beef-Finishing
2002	MS -Paranaíba	Cow-Calf
2014	MS -Paranaíba	Beef-Finishing
2002	MS -Ribas do Rio Pardo	Cow-Calf
2014	MS -Ribas do Rio Pardo	Cow-Calf
2003	MT - Alta Floresta	**Total Cycle**
2015	MT - Alta Floresta	Beef-Finishing
2015	MT - Alta Floresta	Cow-Calf
2003	MT - Barra do Garças	**Total Cycle**
2015	MT - Barra do Garças	Beef-Finishing
2015	MT - Barra do Garças	Cow-Calf

2003	MT - Cáceres	**Total Cycle**
2015	MT - Cáceres	Beef-Finishing
2003	MT - Pontes e Lacerda	Cow-Calf
2015	MT - Pontes e Lacerda	Beef-Finishing
2015	MT - Pontes e Lacerda	Cow-Calf
2003	PA - Paragominas	**Total Cycle**
2012	PA - Paragominas	Beef-Finishing
2012	PA - Paragominas	Cow-Calf
2003	PA - Santana do Araguaia	Beef-Finishing
2012	PA - Santana do Araguaia	Beef-Finishing
2003	RO - Ji-Paraná	**Total Cycle**
2015	RO - Ji-Paraná	Beef-Finishing
2015	RO - Ji-Paraná	Cow-Calf
2006	TO - Araguaína	Beef-Finishing
2015	TO - Araguaína	Beef-Finishing
2006	TO - Colinas do Tocantins	Beef-Finishing
2015	TO - Colinas do Tocantins	Beef-Finishing
2015	TO - Colinas do Tocantins	Cow-Calf

Source: CEPEA (2015)