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BRAZILIAN AGRIBUSINESS: COMPETITIVE AND SUSTAINABLE

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SUMMARY

PRESENTATION

Maintaining the leading position in the world's agro-energy sector, Brazil has developed a Low Carbon Emissions Agricultural Plan (ABC Plan). Outlined within the context of the 15th Conference of Parties (COP-15) of the United Nations Organization Climate Conference in 2009, the plan is in accordance with the commitment taken on by the country to reduce Greenhouse gas (GHG) emissions by 36.1% to 38.9% before 2020, compared to what it would emit if nothing was done.

Through a process coordinated by the Chief of Staff, the Ministry of Agriculture, Livestock and Food Supply (MAPA) and the Ministry of Agrarian Development (MDA), carried out in partnership with government and non-government institutions and the private sector, the ABC Plan will allow for a reduction from 133 million to 166 million tons of carbon gas (CO_2) equivalent during the period.

Due to its scale and complexity, the ABC is by far the most ambitious plan of the last few years geared TOWARDS the mitigation of climate changes in agriculture.Its strategy for the reduction of emissions consists in pasture regeneration technologies, crop-livestock integration (iLP); crop-livestock –forest integration (iLPF); nitrogen biological fixation; direct cultivation systems and treatment of animal residues and planted forests. Pasture regeneration, by itself, has the potential to reduce emissions from 83 million to 104 million tons of CO_2 equivalent through the recovery of 15 million hectares of degraded grasslands.

To execute the actions foreseen the ABC Program was created to execute the actions foreseen by the Plan. The Program consists of a series of credit lines for farmers to convert their production processes into low carbon emission systems, allowing for the granting of credit and financing in the accrued amount of R$ 13 billion in the 2010-2014 period.

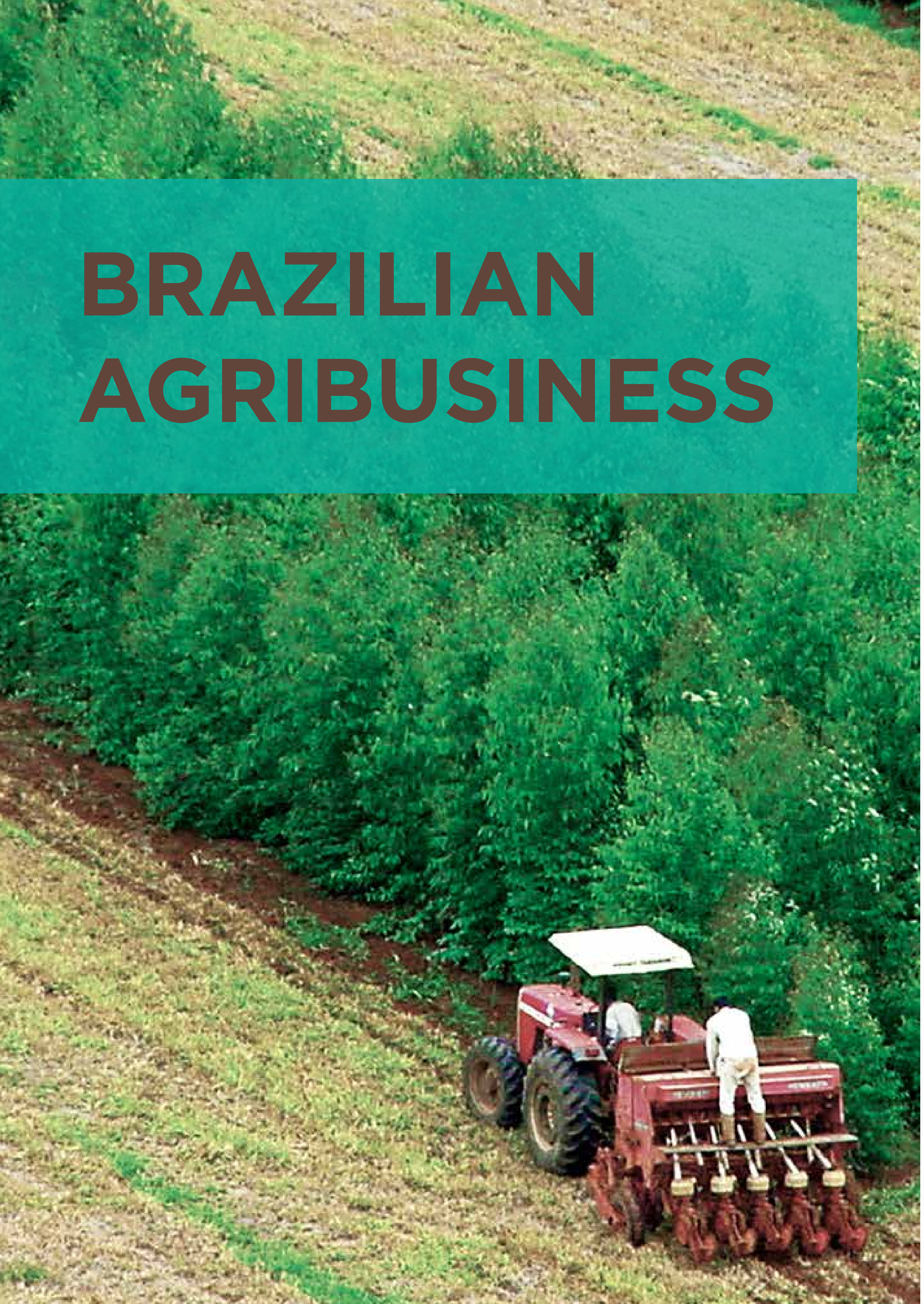
The food production potential through more intensive and sustainable technologies is enormous. There are currently over 120 million hectares of degraded area currently in the country, including degraded pastures and deforested areas in the Legal Amazonia. With the regeneration of those areas, through technologies such as iLPF, we could produce approximately 360 million tons of grain, fiber and meat.

The Getulio Vargas Foundation, in its position as the principal Brazilian Think Tank, set up the ABC Observatory in 2013, an initiative aimed at engaging society in the debate over low carbon emissions agriculture. This publication presents a summary of the results of the ABC Plan, as gathered by our observatory.

Enjoy the reading!

Cesar Cunha Campos
Director
FGV Projetos

BRAZILIAN AGRIBUSINESS

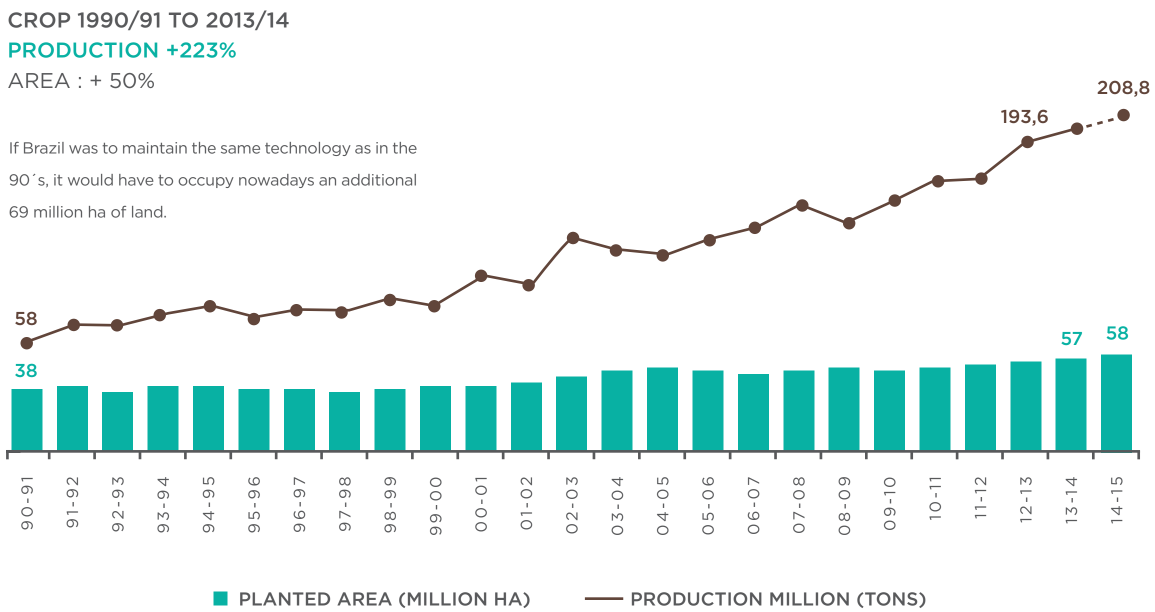


1. INTRODUCTION AND OBJECTIVE

Based on an admirable tropical technology, the Brazilian rural sector has been achieving several quantum leaps both qualitatively and quantitatively, reaching new records year after year in production and productivity. Through the graph below it is possible to see that since 1990, the area cultivated with grains in the country grew 50%, whilst production increased 234%. This figure alone is already spectacular, but underlying it there is an ever more notable phenomenon: if currently we had the same productivity per hectare as that 23 years ago, it would be necessary to have 69 million additional hectares, besides the 56 million cultivated presently with grains, to collect in the 2013/14 harvest. In other words, these 69 million were preserved, granting a sustainability status to the technology applied by Brazilian producers. Thanks to the productivity per area cultivated cerrados or forests were not deforested in this total figure.

PANORAMA

FIGURE 1. BRAZILIAN GRAIN PRODUCTION (HARVESTS1990/91 TO 2012/13)



Source: CONAB. Elaboration: GV Agro

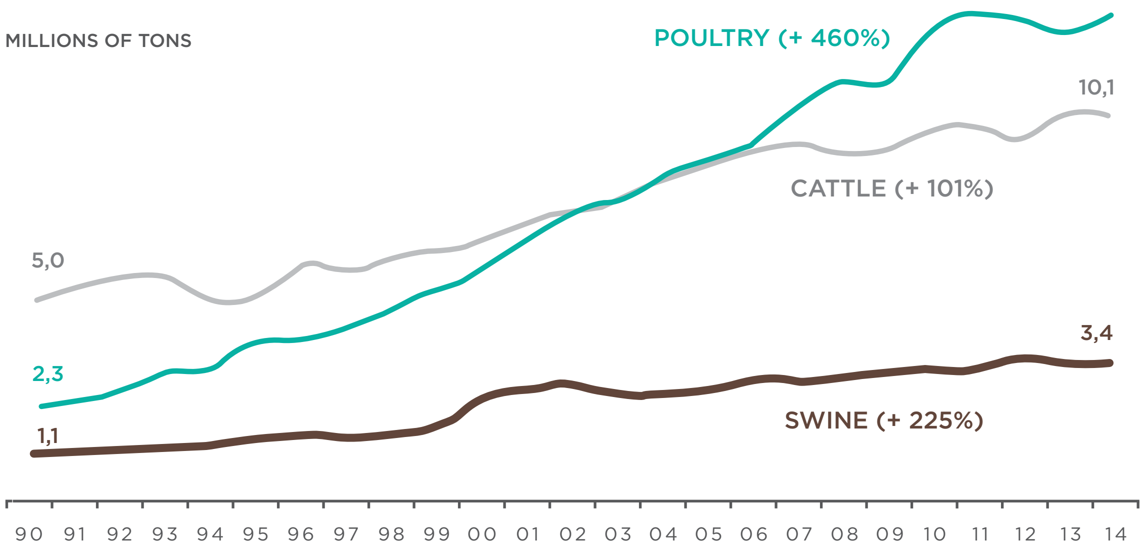
Evidently it was not technology alone giving way to this impressive advance. Other public policies have been of great help, especially Moderfrota, an official program a little over ten years old that financed the exchange of the totally scrapped mechanized fleet in Brazilian farms. This factor contributed to an increase in productivity as well, partially because of the reduction in waste, much greater in the older harvesters, nowadays replaced with the state-of-the-art equipment of the developed world.

The increase in resources and the decrease in interest rates for rural credit throughout these 23 years have played an important role in this change in the agricultural production in Brazil.

And it was not only in the grain sector. The growth in the meat sector is also significant, as can be seen in the graph below: in the same period beef production increased more than 100%, that of pork 225% and poultry 460%.

BRAZILIAN MEAT PRODUCTION

MILLIONS OF TONS



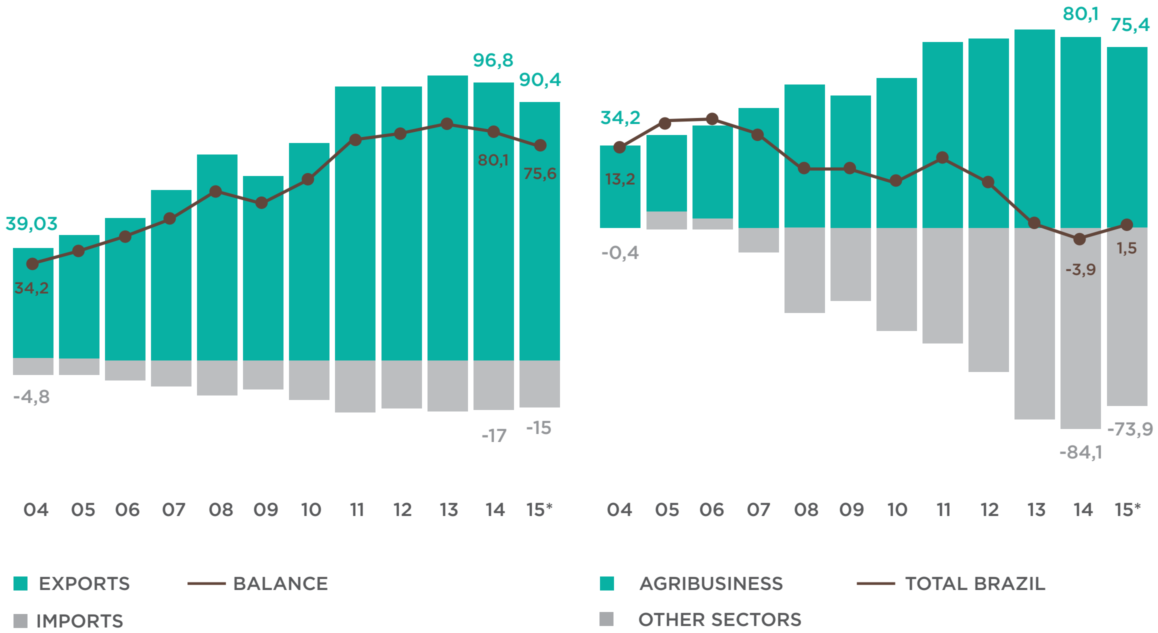
Source: ABIEC, UBABEF, ABIPECS

With this productive performance, the agro sector became ever more competitive, advancing safely not only in terms of domestic supply but also in terms of exports. Moreover, from the graph below what can be verified is the agribusiness trade balance that has been increasingly positive, until it reached 80 billion dollars in 2014, vis-à-vis a total country balance that is negative in 3.9 billion.

BRAZILIAN FOREIGN TRADE PERFORMANCE

BRAZILIAN AGRIBUSINESS TRADE BALANCE

BRAZILIAN TRADE BALANCE



Source: MAPA and MDIC. Note: 2015* – accumulated Jun/2014 – May/2015 . Prepared by GV Agro

What is perhaps of greater interest is that this growth in exports has been greater for emerging countries, where populations grow more and the per capita income increases more than in the wealthier countries. And this is the great opportunity that lays before us: demand for countries under development will continue to grow, inaugurating huge opportunities for Brazil to become the main food, fibers and energy supplier in the near future. A survey produced by FAO jointly with the OECD shows that up to 2020 the worldwide food production will have to grow 20% to fulfill demand, and for that to happen, Brazil will have to increase its production by 40%.

Agroenergy is another very promising sector: the National Alcohol Plan launched in 1975 was the largest program for an alternative to gasoline, after the dire oil shocks of the ´70´s in the last century. Ethanol produced based on sugarcane reduces CO_2 emissions of gasoline by 89%, with an effective contribution to the reduction of global warming. Brazil are now heading towards the second generation ethanol, using cane bagasse itself to produce ethanol or bioelectricity based on the burning of powerful boilers.

The biodiesel program currently is making great strides, as well as the gasoline consumed throughout Brazil that has 27% ethanol, all of the diesel already has 7% biodiesel. Bio-refineries that use ethanol as raw material to replace oil by-products is another opportunity that has been put in place by domestic industries with the use of foreign technology.

The pulp and paper sector has undergone considerable expansion, leading to the expansion of the area with planted forests that already attain 7.7 million hectares, on its way to 10 million in a few years. Eucalyptus trees in tropical regions of Brazil can already be felled at 7 years of age.

All of this thanks to the tropicalized technologies developed by national public research institutions, the schools for agrarian sciences, or state research agencies, with the aid of the private sector that has been making heavy investments in innovation, in the quest to reduce demand for pesticides and fertilizers, water and fuels, decreasing the emission of greenhouse gases and granting the Brazilian agribusiness an outstanding role in the global scenario for sustainable production.

LOW CARBON EMISSION AGRICULTURE

One of the prime examples of this is the ABC Plan, whose goal is to reduce GEE (greenhouse gas emissions) in agriculture by applying production systems and good agricultural practices, which once again, puts Brazil at the forefront of the world discussion referring to climate change. There is an important change in paradigm in terms of credit and financing, that is, one as well as the other as necessarily linked to a production system or to a technology that will help mitigate GEE´s, besides fostering the increase in efficiency in agricultural production and cattle raising.

The plan was outlined in 2009, within the context of the United Nations Conference on Climate held in Copenhagen, COP-15. That year, with the intent of breaking the deadlock that threatened the concretion of an international agreement against climate changes, Brazil adopted a bold stance and proposed voluntary objectives for the reduction of emissions throughout its economy. The country made the commitment to reduce its greenhouse gas emissions from 36.1% to 38.9%, if compared to what it would emit in 2020 if nothing was done. To attain the objective proposed, the country listed a series of mitigation actions (known as Namas, or nationally appropriated mitigation actions) for CO2 and other gases, listed below:

TABLE 1 - BRAZILIAN PROPOSAL FOR THE MITIGATION OF GEE EMISSIONS (PRESIDENT´S CABINET, HOME SECRETARY, BRASILIA 2009 AND NOTIFICATION FROM BRAZIL TO UNFCC, COPENHAGEN AGREEMENT)

MITIGATION ACTIONS	2020 TRENDS	BREADTH OF REDUCTION MILLION TONS CO_2 EQUIV		PROPORTION OF REDUCTION (5)	
USE OF LAND	1.064	669	669	24,7	24,7
AMAZON DEFORESTATION (80%)		564	564	20,9	20,9
DEFORESTATION OF CERRADO ($)%)		104	104	3,9	3,9
CATTLE RAISING	627	133	166	4,9	6,1
PASTURE REGENERATION		83	104	3,1	3,8
OLP, ILPF. SAF		18	22	0,7	0,8
DIRECT PLANTATION		16	20	0,6	0,7
BIOLOGICAL NITROGEN FIXATION		16	20	0,6	0,7
ENERGY	901	166	207	6,1	7,7
ENERGY EFFICIENCY		12	15	0,4	0,6
USE OF BIOFUELS		48	60	1,8	2,2
ENERGY EXPANSION WITH HYDROELECTRIC ENERGY		79	99	2,9	3,7
ALTERNATIVE SOURCES		26	33	1,0	1,2
STEEL INDUSTRY	92	8	10	669	6,4
TOTAL	2.704	876	1.052	669	38,9

Source: Casa Civil da Presidência da República, BRASILIA, BRAZIL 2009, and Notification UNFCCC Copenhagen Deal

The Copenhagen goals, enshrined in the Law for the National Policy on Climate Change (Law no 12.187/2009), expanded an effort initiated in 2008, when Brazil published its National Plan on Climate Change, for the first time admitting that it would adopt a numerical commitment for mitigation: reducing the deforestation of the Amazon Region by 80% vis-a-vis a predetermined reference value.

The agricultural and cattle raising sector was left out of the plan. However, in 2008 discussions were well underway on this issue in academia, and thereafter Brazilian agriculture was included in the plan.

POTENTIAL FOR MITIGATION

The different practices foreseen in the ABC plan were selected in accordance to their potential to reduce greenhouse gas emissions in Brazilian agriculture, and are described below:

1. Degraded pastures recovery: with the advancement of the pasture degradation process, what is verified is a loss of vegetable coverage and the reduction in the organic matter content in the soil, causing the CO2 emissions into the atmosphere. With the regeneration of pastures, through seeding, fertilizing and appropriate management, the process is inverted and the soil begins to store or accumulate carbon. Thus, there is a reduction of at least 60% in CO2 emissions in the production system.

TABLE 2. ANNUAL CO2EQ EMISSIONS PER LWG (LIVE WEIGHT GAIN) UP TO SLAUGHTER IN 4 MANAGEMENT SCENARIOS (RESULTS OBTAINED IN EMBRAPA AGROBIOLOGY EXPERIMENTS).

SYSTEM	CO2 EMISSION EQ /KG GPV				
PASTURE	WEIGHT GAIN (g/cab/day)	CH_4 EMISSION (g)	EMISSION OF N_2O (g)	EMISSION OF CO_2 (g)	TOTAL GEE EMISSIONS (kg)
1 - DEGRADE Brachiaria decumbens	137	26.880	4.086	1.355	32.3
2 - GOOD MANAGE. WITHOUT N B. decumbens	191	13.714	2.675	847	17.2
3 - CONSORTIUM B. decumbens and Stylosanthes guianensis	364	7.226	1.921	684	9.8
4 – WTIH 150KG N Panicum maximum	904	2.036	470	638	3.2

Source: Embrapa

The amount of biomass produced increases as well, which, in its turn, allows for an increase in heads of cattle per hectare.

Currently, in Brazil, the average of the so called support capacity of a pasture, in animal units (AU, a standard measure that corresponds to a 450 kg animal) is of 0.4 AU per hectare.

In regenerated pastures, this can reach 1 AU/ha or more, which simultaneously increases the producer´s income and decreases the pressure for more land for cattle raising, avoiding deforestation. This is the so called Earth sparing effect. Methane emissions decrease consequently, as animals obtain a better quality diet, and the time of slaughter drops.

2. Integrated crop-livestock systems – ICLS and integrated crop-livestock-forest systems - ICLF: are strategies for sustainable production that integrate in the same area agricultural activities, cattle raising and forestry activities, in a crop consortium, in succession or through a rotation system. The high content of organic matter (OM) on the soil´s surface is one of the main benefits of the integrated system, as this enhances the soils´ physical, chemical and biological conditions. The goal of the ABC Plan is to foster the adoption of the iLP in 4 million hectares. This corresponds to a reduction of emissions from 18 million to 28 million of t CO2eq or more.

3. No-Till Farming System: this technology consists of a set of practices aimed at preserving the soil and its coverage, avoiding excessive tilling, as happens in the traditional preparation of soil for cultivation. This contributes to preserving both the soil and water, to an increase in fertilizer efficiency, an increment in organic matter content in the soil, a reduction in the use of pesticides and consumption of fossil fuel, as the demands of agricultural machinery such as tractors and ploughs is reduced.

   Up to 2008, when the goal for the ABC was calculated, in Brazil there were approximately 25 million hectares under direct cultivation. The objective was to expand those 25 million hectares to 33 million ha. This increase would allow for the reduction of emissions from 16 to 20 million tons of CO2 eq. In 2011, the country had already attained 31 million hectares under no-tillage system.

4. Biological nitrogen fixation: The biological fixation of nitrogen is a process through which the atmospheric N2 gas is captured by bacteria and converted into nutrients for plants. The success of soy in Brazil is linked to the biological fixation of nitrogen, able to provide all of the nitrogen needed by the plant, even for the high yield varieties. Its use results in an annual savings with nitrogenized fertilizers of around US$ 7 billion. BNF plays a relevant role in the reduction of greenhouse gas emissions relating to the manufacture and use of chemical fertilizers, of which Brazil is heavily dependent upon. The goal is to increase BNF in the production of 5.5 million hectares and reduce emissions of 10 million tons of CO2 equivalent up to 2020.

5. Planted Forests: the commitment to reforestation with species from the Pinus and Eucalyptus genres in Brazil in the coming decade is of 3 million hectares. Considering this goal, at the end of ten years the contribution of the sector will have been to reduce approximately between 8 million to 10 million t CO2eq, sequestering it from tree biomass.

6. Animal waste treatment: The correct destination of effluents originating from the breeding of animals has become an important conditioning for environmental compliance in rural properties. The bio-digestion and composting processes are already known and allow for reductions in production costs, as they avoid energy consumption, chemical inputs and decrease environmental risks, as well as reducing greenhouse gas emissions, besides generating energy by means of the production of biogas. The goal is to manage 4.39 million m3 of animal waste until 2020, which would lead to a reduction in emissions of approximately 6.9 million t CO2eq.

   When fully applied, this Plan will be responsible for compliance with the goals of Brazil with the IPCC.

POTENTIALITIES

Additionally, it is worthwhile underscoring that Brazil still has land available. Currently, less than 80 million hectares of national territory are cultivated with crops and 172 million with pasture-adding up to about 30 percent of the total.

With the sustainable tropical technology, with competent and competitive rural producers that have undergone a painful economic adjustment as a consequence of the plans to stabilize the economy from 1990 and 1994, Brazil in truth is fully apt to take advantage of the huge opportunity that arises with the growing worldwide demand for agribusiness products.

The potential for food production by intensifying production is immense. It has been estimated that more than 60 million hectares of pastures are currently degraded in the country. According to data from Prof. Eduardo Assad, an Embrapa Researcher, the regeneration of these 60 million ha of degraded grasslands with iLPF could allow for the production of 180 million tons of grains, fibers and meat[1].

Added to this, the Terraclass/Inpe study informs us that the Legal Amazonia has 60 million hectares of deforested areas where with the iLPF it would also be possible to produce another 180 million tons of food.

[1] Considering a productivity of 3000Kg/ha in the iLPF system, in na área with 60 million hectares we would have 180 million tons as the final production (grains, meat and fibers)

Therefore, with the regeneration of degraded pastures and the areas already deforested in Legal Amazonia with the iLPF system we could produce approximately 360 million tons of grains, fiber and meat.

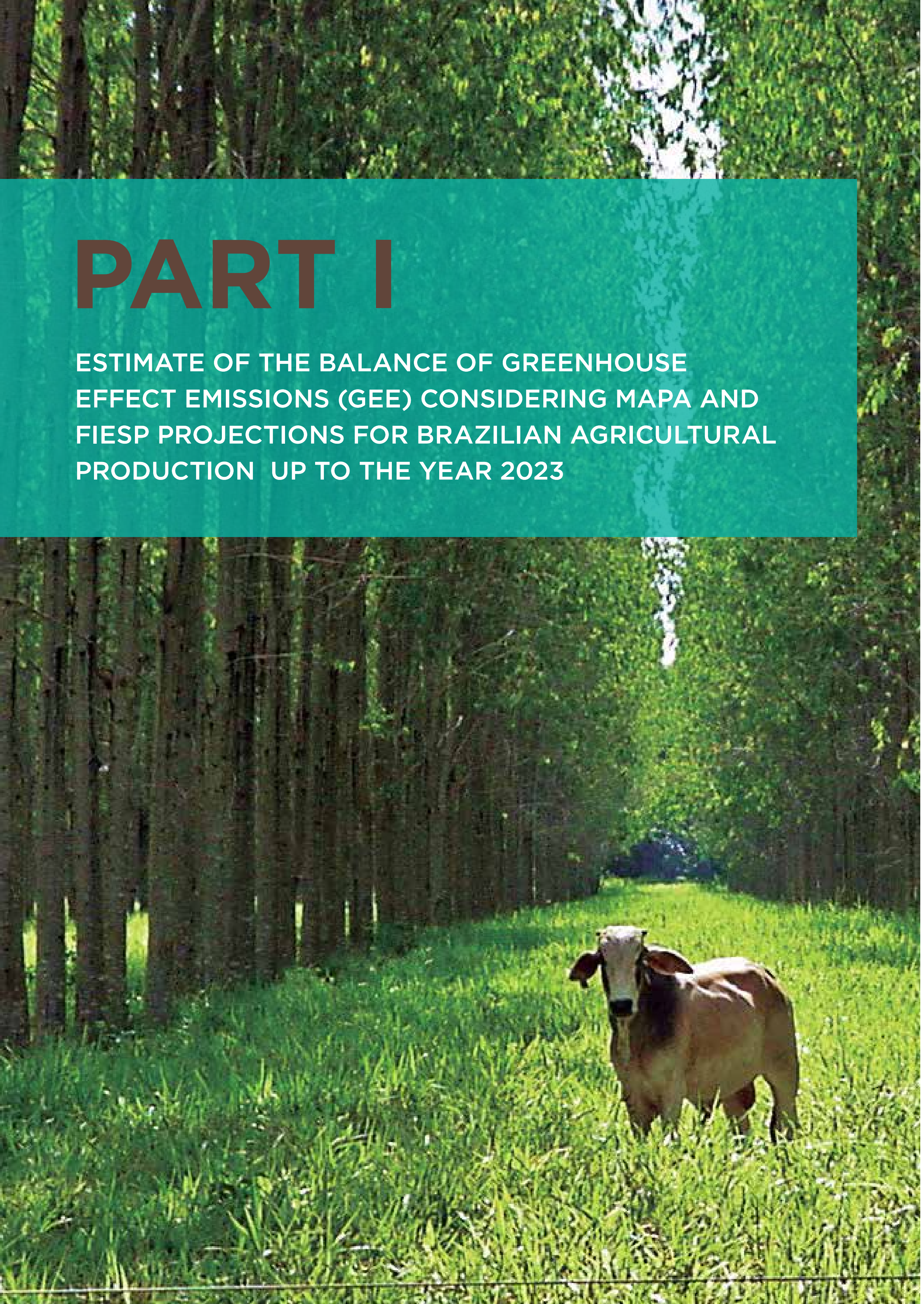
Brazil can become the great worldwide supplier of food and, additional or renewal energy. With this it would become the great harbinger of Universal Peace.

Roberto Rodrigues

Coordinator of the Agribusiness Center at FGV, Special Ambassador for the FAO for Cooperatives and Chairman of LIDE Agronegócio

INVERTING THE CARBON SIGN IN BRAZILIAN LIVESTOCK AND AGRICULTURE

* EDUARDO ASSAD, EDUARDO PAVÃO, MARILENE DE JESUS AND SUSIAN CHRISTIAN MARTINS



PART I

ESTIMATE OF THE BALANCE OF GREENHOUSE EFFECT EMISSIONS (GEE) CONSIDERING MAPA AND FIESP PROJECTIONS FOR BRAZILIAN AGRICULTURAL PRODUCTION UP TO THE YEAR 2023

1. INTRODUCTION AND OBJECTIVE

The present study has the aim of estimating which would be the Greenhouse Gas Emissions (GEE) for Brazilian livestock up to 2023, in the case carbon emission technologies are not adopted, as advocated by the ABC Plan, considering the projections for a rise in livestock production carried out by the Ministry of Agriculture, Livestock and Food Supply (MAPA, 2013) and by the Outlook from the Federation of Industries of the State of São Paulo (Fiesp, 2013). This information will make possible the identification of states and regions with a greater potential for growth in cattle breeding production up to 2023, crops with the greatest potential for emission, and to verify the evolution of production and its emissions throughout an eleven harvest year period (2012/13 to the 2022/23 harvest). Part II of this study, in its turn, presents projections for a reduction in livestock emissions based on the adoption of the low GEE emission technologies.

This data is strategic for the economy and for food safety in Brazil, due to the fact that the livestock sector is the second main emitter of GEE, accountable for 32% of the total national emissions. Between 2005 and 2010, the sector´s emissions had a hike from 415.754 million to 472.734 million tons of CO_2 equivalent, according to the 3rd Brazilian Inventory for Emissions (BRASIL, 2015). With the growing world demand for food under constant pressure and the expansion of livestock, these emissions will tend to grow ever more.

On the other hand, livestock, due to its characteristics and sensitivity to climate is also one of the sectors with greater vulnerability to climate change. Considering that agribusiness accounts for 25% pf the GDP and more than 30% of the jobs in Brazil, moving it in the direction of agriculture with low carbon emissions (ABC) and mobilizing resources to finance this transition is urgent and fundamental.

The objective of this first part of the report was to estimate GEE emissions, taking into account the Brazilian agricultural production as per MAPA and Fiesp, from 2012 to 2023, without the adoption of the practices advocated by the ABC plan. The following sources of emission were considered for the sector:

- Emissions in agriculture with synthetic and organic nitrogen as the origin (N)[2] arising from animals in pastures, the N of crop residues, the N coming from waste management (except pastures), the atmospheric deposition of volatilized N (direct emission), the burning of crop residues for sugarcane in the Northeast;
- Methane emissions, due to rice crops, the enteric fermentation, waste management, burning of sugarcane residues in the Northeast;

[2] Emissions of organic N (applied as a fertilizer) and from the burning of agricultural cotton residues were not considered, due to: i) there is no scale application of organic fertilizers for the crops considered in this report; and ii) the burning of cotton residues does not represent, currently, the Brazilian agricultural reality.

- Nitrous oxide emissions due to the application of urea in the soil and carbon dioxide emission due to soil systems and management practice for conventional cultivation[3];

2. METHODOLOGY

Calculations of the balance of GEE emissions in livestock and agriculture were based on the guidelines of the Second Brazilian Inventory of Anthropic Emissions for GEE – A Reference Report from the General Coordination of Global Climate Changes from the Ministry of Science, Technology and Innovation, published in the year 2010. In its turn, this report is based on the technical guidelines of the documents drafted by the IPCC: "Revised 1996 IPCC Guidelines for National Greenhouse Inventories" (Guidelines 1996), published in 1997; and "2006 IPCC Guidelines for National Greenhouse Gas Inventories" (Guidelines 2006), published in 2006[4]. The aim was to also make use of the same parameters applied for the calculation of the official goals for the ABC Plan, as the emission of a head of cattle by enteric fermentation, nitrogenized fertilization doses and the emission factor of nitrogen applied.

Therefore, the present work considers the balance of emissions in agriculture and livestock, that is, all of the emissions and all of the CO2eq. sinks resulting from the production system[5], differently from the methodology of the Brazilian Emissions Inventory, that considers merely the emissions from the activity in a broken down form. For example, for the livestock activity, the Inventory considers emissions per animal (only N2O and CH4), not considering the possible carbon stored in the soil in well managed productive systems, as it reports the CO2 emissions in the Change in Land Usage Inventory.

[3] Emission of carbon dioxide due to the application of limestone in the soil was not considered, as the growth of cattle breeding in the scenario considered in this report takes place without the adoption of technologies or an adequate low carbon emission management.

[4] Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/

[5] In the cattle breeding activity, carbon dioxide (CO2) is emitted by the crop in the soils and also by the use of fossil fuel in agricultural operations, including that associated to inputs such as rations, fertilizers, insecticides, among others. Methane (CH4) is emitted through enteric fermentation which, and in a lesser amount through animal feces. Finally, nitrous oxide (N2O) is mainly emitted by the nitrogenized fertilization - fertilization and by animal urine and feces. The quantification of emissions and the importance of key factors involved in emissions have not been sufficiently assessed in Brazil and still represent one of the priorities for research globally (Cardoso, 2012).

CROPS AND THE REGIONAL SELECTIONS CONSIDERED

For the production growth projections and those of GEE emissions up to 2023, the following crops were considered: soy, maize, rice, beans, cotton, wheat, sugar cane and pastures.

These crops account for the largest part of cultivated area and consequently, are the most representative of the emissions scenario in the livestock sector.

In Brazil, around 63 million hectares are destined to the plantation of temporary crops, being that the crops selected for the present work total 58.89 million hectares, representing more than 93% of this total (IBGE, 2012). Areas planted with each crop selected are: 25.09 million ha for soy; 15.07 million ha for maize; 9.75 million ha for sugar cane; 3.18 million ha for beans; 2.44 million ha for rice; 1,94 million ha for wheat; 1.42 million ha for cotton, (IBGE, 2012)[6].

To make it possible to compare GEE emissions from livestock with and without the adoption of the low carbon emission technologies, this study analyzed merely a part of the Brazilian territory. It was deemed that the agricultural expansion projected up to 2023 would take place only in the degraded pasture areas, those with the ability to support a capacity lower or equal to 0.75 UA/ha[7]. Throughout the entire country, these areas represent 52.32 million hectares in 1.285 municipalities (from the total 5.570 in Brazil). To calculate emissions, the agricultural areas for the crops selected only in the municipalities with degraded pastures were taken into account. In the case of livestock, to calculate emissions, the constant effective bovine herds and the low capacity for support up to 2023 were considered, in municipalities with degraded pastures. Emissions for deforestation were not calculated, as the production expansion would take place only in pasturelands.

[6] The oleraceous crops were not considered due to: i) the absence of information on their management, mainly on the type of fertilization (mineral or organic), making it impossible to correctly calculate the GEE emissions for these crops; and ii) to the national emissions inventory that does not take into account the oleraceous emissions separately.

[7] Animal Unit per hectare (UA/ha): measure used to standardize the weight of the animals of a herd and that corresponds to a 450 kg animal in 1 hectare.

RECOMMENDATIONS FOR FUTURE ESTIMATES FOR LIVESTOCK EMISSIONS NATIONWIDE

The methodology to calculate GEE emissions for national livestock in the Brazilian Inventory (BRASIL, 2015) does not consider the beef herd production system; for their estimates in livestock emissions, what is considered is merely the animal´s enteric fermentation. Notwithstanding this, it is known that the management system has a direct influence on GEE emissions on cattle production. For example, with the advance of the degradation process, what is verified is a loss of vegetable coverage and a reduction in the soils´ organic matter content, causing the emission of CO2 into the atmosphere, while, with the regeneration of pastures, this process is inverted and the soil goes on to accumulating carbon, reducing the CO2eq. emissions by almost 60% in the production system.

Additionally, the regeneration and maintenance of productivity of pastures that contributes to mitigating GEE emissions also results in a significant increment in biomass production. That, in its turn, allows for an increase in the support capacity[8] of these pastures for 1 or more animal units per hectare (UA/ha), reducing the pressure in conversion of new pasture areas. On the other hand, there is the replenishment of nutrients in the pasture, ensuring a better quality diet for the cattle, reducing the time to slaughter and consequently, the emission of methane gas (CH4) for enteric fermentation (KURIHARA, MAGNER, HUNTER, & McCRABB, 1999) per kilo of meat produced. The more complex integrated systems, such as ICLFS can generate even greater emission reduction values, due to the fixation of additional carbon in forest biomass and in the soil. This fact inaugurates important pathways to reduce non-tariff barriers and seek environmental certification for Brazilian beef. Faced with this, with the aim of portraying the reality in the fields in the future national inventories for GEE emissions, it is necessary to incorporate production management systems as well, as a change in the livestock paradigm coming about with the implementation of the Plan and the ABC Program, since the 2010/11 harvest. However, this will only be possible if Brazil begins to adopt the 2006 Guidelines referring to the agricultural sector, forests and other land usage. This could reduce emissions reported in livestock significantly.

[8] Support capacity: function for the availability of fodder (DM, or dry matter) in the pastureland and the consumption of dry matter (DM) by the animals.

3. RESULTS

Below the GEE estimates will be presented without the adoption of the low carbon emission technologies, for the main agricultural crops and livestock, between the harvest years 2012/13 up to 2022/23, according to the agricultural growth projections carried out by MAPA and Fiesp for that precise period.

AGRICULTURAL GROWTH PROJECTIONS: MAPA X FIESP

Upon analyzing agricultural growth projections, what can be noted is that there are substantial differences between them, however, for all of the crops analyzed, the trend was for an increase in production between 2012/13 and 2022/23 (Table 1).

According to MAPA projections, crops with the highest growth rates are cotton, sugarcane and maize, in decreasing order, followed by wheat, beans and rice, in that order as well. Nevertheless, Fiesp presents a classification of the production growth rates that are different from those of MAPA when it comes to cotton, wheat and soy, leading the list, in decreasing order, ahead of sugarcane, beans , maize and rice. All in all, in both projections cotton and soy appear among the first three crops in the ranking, pointing to the high potential to increase the production of these crops in the harvest-years analyzed.

TABLE 1 – AGRICULTURAL GROWTH PROJECTION UP TO THE HARVEST YEAR 2022/23, ACCORDING TO MAPA AND FIESP

SYSTEM	MAPA				FIESP			
	2012/13	2022/23	VARIATION	ANUAL RATE	2012/13	2022/23	VARIATION	ANUAL RATE
	THOUSAND TONS		%		THOUSAND TONS		%	
COTTON	1,35	2,53	87,60	8,76	1,30	638	2,50	9,23
RICE	12,37	13,75	11,10	1,11	11,70	638	12,90	1,03
BEANS	2,86	3,26	14,20	1,42	2,80	638	3,60	2,86
MAIZE	78,00	93,62	20,00	2,00	81,00	638	93,00	1,48
SOY	81,51	99,25	21,80	2,18	81,00	638	120,00	4,81
WHEAT	5,94	6,98	17,60	1,76	4,10	638	6,70	6,34
CANE	589.13	833,17	41,40	4,14	652,00	638	862,00	3,22

Source: FIESP and MAPA

For rice, maize and sugarcane, the production growth potentials, according to MAPA, were 0.84%, 5.19% and 9.19% greater than the Fiesp projections, respectively, while for cotton, beans , soy and wheat, these rates were 4.71%, 14.37%, 26.35% and 45.81% lower, also respectively.

DEGRADED PASTURES

For the present report, the agricultural expansion projected up to 2023 was considered in degraded pastures. In Table 2, what can be verified is the expansion of these areas in each state, totaling 52.32 million hectares in the Country of pastures with a support capacity lower than 0.75 UA/ha. In these degraded pasturelands, there is a total of 39.791.956 heads of cattle, that is, about 20% of the heads of beef cattle in Brazil in the 1.285 municipalities selected.

Livestock occupies 25% of Brazil´s total area. This corresponds to 220 million hectares, of which it is estimated that about 50% are in a process of degradation and 25% have low support capacity, as verified in Table 2. The majority of this cattle breeding is still extensive, due to the large pasture area still existing in Brazil.

The reduction of productivity and quality of grasses and the carbon stocks in the soil, and the low level of productivity per animal lead to more emissions per unit of product in this system.

The region that is a priority for the regeneration of pastures or the advance of low carbon emission agriculture is the Midwest (Mato Grosso do Sul, Mato Grosso and Goias), that concentrates 34.4% of the national hers, and the states of Minas Gerais, Bahia and Pará, presenting larger areas of degraded grazing land.

TABLE 2 – DEGRADED PASTURE AREA IN THE BRAZILIAN STATES

REGION	STATE	DEGRADED PASTURES (HA)
N	AC	221.490
N	AM	588.313
N	AP	32.569
N	PA	2.851.837
N	RO	70.677
N	RR	102
N	TO	987.584
NE	AL	319.912
NE	BA	8.629.957
NE	CE	1.321.240
NE	MA	1.037.182
NE	PB	876.461
NE	PE	1.096.545
NE	PI	1.791.900
NE	RN	741.435
NE	SE	179.586
CO	DF	142.781
CO	GO	3.088.527
CO	MS	5.174.972
CO	MT	3.739.181
SE	MG	17.600.344
SE	RJ	790.933
SE	SP	638.967
S	PR	171.684
S	RS	212.373
S	SC	17.773
TOTAL	52.324.324	

Source: Embrapa

HOW TO EXPRESS EMISSIONS: BY COMPARING THE GTP AND GWP METRICS

Emissions from the agricultural crops analyzed and from the beef herds for the time horizon of eleven years (2012/13 to 2022/23) were calculated using the Global Temperature Potential (GTP) and Global Warming Potential (GWP) metrics.

The GWP metric considers the influence of gases in changes in the Earth´s energy balance and the GTP, the influence of temperature rises. Both are measured for a one hundred year period, with the GWP being used more commonly. For example, 1 ton of methane (CH4) corresponds to 21 tons of carbon equivalent (CO2eq.) GWP or 5 tons of CO2eq. GTP (Observatório do Clima, 2014). Table 3 presents GWP and GTP comparatively for the main GEE.

TABLE 3 – EMISSION CONVERSION INTO GWP-100 AND GTP-10

GAS	GTP	GWP
CO_2	1	1
CH_4	5	25
N_2O	270	298
HFC-125	1.113	3.500
HFC-134[a]	55	1.300
HFC-143[a]	4.288	1.430
HFC-152[a]	0,1	124
CF_4	10.052	7.390
C_2F_6	22.468	12.200
SF_6	40.935	22.800

Source: IPCC

Emissions for the livestock and agriculture sector using the GWP metric are approximately four-fold greater when compared to the GTP metric (see Table 4 to Table 7).

As international climate policies use the GWP metric to calculate each country´s contribution to global warming, the rest of the discussions ahead in the present report will also be based on the emissions quantified by the GWP, however, the respective emission values using the GTP can be viewed in the same tables.

GEE EMISSIONS ACCRUED BETWEEN 2012/13 AND 2022/23 IN AGRICULTURE AND LIVESTOCK

Below is the presentation of the main results for GEE emissions calculated for the harvest year 2012/13 and accrued up to the harvest year 2022/23 (eleven-year time frame), in accordance to the growth projections by MAPA and Fiesp for the following agricultural crops: rice, cotton, beans, maize, soy, wheat and sugarcane. Emissions accrued in livestock for the same period will also be shown.

A) NATIONAL SELECTION

Emissions accrued by agriculture and livestock in the selected municipalities, considering growth projected for agricultural production and that of beef cattle in the period considered (eleven years), according to MAPA and Fiesp projections, were of 670.47 million tCO2eq. and 669,93 million tCO2eq., respectively (Table 4 and Table 5).

Accrued emissions originating from beef cattle were of 647 million tCO2eq., and those that originate from agricultural activity, for both institutions in eleven years, were of approximately 22 million tCO2eq.

Notably, bovine herds are the main source of emissions in the present work, corroborating the data from the Brazilian Emissions Inventory (BRASIL, 2015).

Nonetheless, the values of emissions arising from the management of agricultural crops vary substantially. Maize was the main source of GEE emissions among the crops analyzed, contributing with approximately 9 million tCO2eq. between 2012/13 and 2022/23. Ensuing this, we have sugarcane and rice, with emissions of 8.6 million and 2.6 million tCO2eq., respectively. And, after this, beans and cotton, contributing with 1.1 million tCO2eq. to 700 thousand tCO2eq., respectively. Finally, wheat is responsible for emissions between 89 thousand and 109 thousand tCO2eq.

Soy, due to biological nitrogen fixation (BNF), contributes very little to GEE emissions. The success story itself of soy beans in Brazil refers back to the BNF, with the capacity of supplying all of the nitrogen needed, even for high yield varieties. Technology is currently adopted in all of the areas cultivated with soy beans in Brazil, about 24 million hectares, and its use results in annual savings of around US$ 7 billion in nitrogenized fertilizers.

The use of nitrogenized fertilizer is the main cause for GEE emissions in agricultural crops. Fertilizers contribute with 38% of the N2O[9] emissions (BRASIL, 2015), and, based on this fact, it is necessary to consider reducing the agricultural emissions through a reduction in the use of synthetic fertilizers, especially nitrogenized ones. Furthermore, rice crops contributed with an emission of 464.2 Gg of methane in 2010, as most of their production takes place in flooded areas.

Additionally, the area for maize plantation, compared to the rest of the crops, in the municipalities selected for the current paper is significantly greater, being 3.3 million hectares, with a production of 17 million tons for the 2012/13 harvest, leading to a accentuated demand for nitrogenized fertilizers and consequently, to greater GEE emissions. Wheat, with a smaller area cultivated in the municipalities selected, contributed to the lowest GEE emissions between 2012/13 and 2022/23.

Annual emissions estimated in the present report, taking into account only bovine herds and the seven agricultural crops analyzed in municipalities with degraded pastures (1.285 municipalities) represent around 13% of the total emissions from all of the activities in agriculture and livestock considered in the National Emissions Inventory (BRASIL, 2015).

TABLE 4 – ACCRUED EMISSIONS (2012/13 TO 2022/23) IN TCO2EQ. USING THE GWP METRIC AND MAPA PROJECTIONS

REGION	RICE	COTTON	BEANS	MAIZE	WHEAT	SOY	CANE	TOTAL CROPS	LIVESTOOK (ANNUAL)	LIVESTOOCK (11 YEARS)	CROP + LIVESTOOCK ACC
MW	151.897	424.378	208.156	5.412.951	4.972	2.135	1.054.039	7.258.527	18.604.903	204.653.927	211.912.455
N	191.971	0	64,785	351.012	0	108	53.798	661.674	10.610.812	116.718.934	117.380.609
NE	75.558	257.117	437.444	988.061	0	287	5.482.013	7.240.486	9.623.475	105.858.229	113.098.715
S	2.175.293	0	35.490	445.522	49.130	62	164.631	2.870.329	988.136	10.869.900	13.795.829
SE	37.414	19.138	330.855	2.157.394	35.086	192	2.062.295	4.642.378	19.062.884	209.691.727	214.334.104
TOTAL	2.632.132	700.633	1.076.729	9.354.941	89.188	2.785	8.816.986	22.673.394	58.890.211	647.792.318	670.465.712

Source: ABC Observatory

TABLE 5 – ACCRUED EMISSIONS (2012/13 TO 2022/23) IN TCO2EQ. USING THE GWP METRIC AND FIESP PROJECTIONS

REGION	RICE	COTTON	BEANS	MAIZE	WHEAT	SOY	CANE	TOTAL CROPS	LIVESTOOK (ANNUAL)	LIVESTOOCK (11 YEARS)	CROP + LIVESTOOCK ACC
MW	149.788	424.378	209.504	5.180.259	5.444	2.369	1.032.356	7.004.104	18.604.903	204.653.928	211.658.032
N	191.772	0	64.785	337.411	0	120	51.854	645.942	10.610.812	116.718.934	117.364.877
NE	75.558	257.117	437.874	979.182	0	318	5.287.319	7.037.371	9.623.475	105.858.229	112.895.600
S	2.175.025	0	38.695	435.337	62.696	69	160.316	2.872.139	988.136	10.869.500	13.741.639
SE	36.849	19.138	336.679	2.117.486	40.830	213	2.026.768	4.577.963	19.062.884	209.691.727	214.269.689
TOTAL	2.628.992	700.633	1.087.538	9.049.676	108.970	3.090	8.558.612	22.137.519	58.890.211	647.792.318	669.929.837

Source: ABC Observatory

TABLE 6 – ACCRUED EMISSIONS (2012/13 TO 2022/23) IN TCO2EQ. USING THE GTP METRIC AND MAPA PROJECTIONS

REGION	RICE	COTTON	BEANS	MAIZE	WHEAT	SOY	CANE	TOTAL CROPS	LIVESTOOK (ANNUAL)	LIVESTOOCK (11 YEARS)	CROP + LIVESTOOCK ACC
MW	144.427	403.496	197.919	5.146.809	4.727	1.935	1.002.210	6.659.597	4.171.926	45.891.182	52.550.779
N	182.529	0	61.594	333.749	0	98	51.149	614.160	2.377.293	26.150.227	26.764.387
NE	71.840	244.468	415.925	939.472	0	260	5.034.134	6.519.384	2.149.527	23.644.799	30.164.184
S	499.179	0	33.743	423.614	46.714	57	156.723	1.161.750	220.285	2.423.134	3.584.884
SE	35.562	18.195	314.562	2.051.285	33.360	174	1.960.852	4.352.743	4.265.545	46.920.998	51.273.742
TOTAL	933.537	666.159	1.023.744	8.894.927	84.800	2.523	8.205.068	19.307.635	13.184.576	145.030.340	164.337.975

Source: ABC Observatory

[9] The warming potential of N2O is 298 times greater than that of CO2.

TABLE 7 – ACCRUED EMISSIONS (2012/13 TO 2022/23) IN TCO2EQ. USING THE GTP METRIC AND FIESP PROJECTIONS

REGION	RICE	COTTON	BEANS	MAIZE	WHEAT	SOY	CANE	TOTAL CROPS	LIVESTOOK (ANNUAL)	LIVESTOOCK (11 YEARS)	CROP + LIVESTOOCK ACC
MW	144.427	403.496	197.919	5.146.809	4.727	1.935	1.002.210	6.901.522	4.171.926	45.891.182	52.792.704
N	182.529	0	61.594	333.749	0	98	51.149	629.119	2.377.293	26.150.227	26.779.346
NE	71.840	244.468	415.925	939.472	0	260	5.034.134	6.706.097	2.149.527	23.644.799	30.350.897
S	499.179	0	33.743	423.614	46.714	57	156.723	1.160.029	220.285	2.423.134	3.583.163
SE	35.562	18.195	314.562	2.051.285	33.360	174	1.960.852	4.413.991	4.265.545	46.920.998	51.334.989
TOTAL	933.537	666.159	1.023.744	8.894.927	84.800	2.523	8.205.068	19.810.759	13.184.576	145.030.340	164.841.099

Source: ABC Observatory

B) REGIONAL SELECTION

Among the regions in the Country, the Southeast was the main emitter in a scenario without an expansion of ABC technologies. The total GEE emissions accrued in the region in the period between 2012/13 and 2022/23 was of 219,6 million tCO2eq. As a second runner, there is the Midwest (218 million tCO2eq.), followed by the Northeast (125 million tCO2eq.), by the North (117 million tCO2eq,) and by the South (14 million tCO2eq.).

In all cases, bovine herds are the main source of emissions, with the states with the largest area of degraded fields leading the ranking in each region. Minas Gerais was the main emitter of the Southeast and of Brazil, with 194 million tCO2eq. accrued. After this comes Mato Grosso do Sul (103 million tCO2eq.), Pará (73 million tCO2eq.), Mato Grosso (71 million tCO2eq.) and Bahia (50 million tCO2eq.). As they have few areas with degraded pastures, the states in the Southern region contribute little to the emissions[10]. The table below summarizes emissions accrued from agriculture, livestock and the total per region in the Country between the harvest years 2012/13 and 2022/23.

[10] The information from Tables 4 to 7 have been broken down by state of the Federation in the Full Report, available at the site ABC Observatory (www.observatorioabc.com.br).

TABLE 8 – ACCRUED EMISSIONS PER FEDERATION REGION

	EMISSIONS FROM AGRICULTURE	EMISSIONS FROM LIVESTOCK	TOTAL
	MILLION TCO2EQ. ACCRUED BETWEEN 2012 AND 2023		
SOUTHEAST	4,6	215	219,6
MIDWEST	7,0	211	218,0
NORTHEAST	7,0	118	125,0
NORTH	0,6	117	118,0
SOUTH	3,0	11	14,0

Source: ABC Observatory

AGRICULTURAL EMISSIONS IN BRAZIL AND IN THE REGIONS BETWEEN THE 2012/13 HARVESTS AND 2022/23, ACCORDING TO PROJECTIONS FOR PRODUCTION GROWTH

RICE

With a growth of 11.1% of rice production projected by MAPA, due mainly to the increase in productivity between the 2012/13 and 2022/23 harvests, the GEE emissions that used to be of 237.3 thousand tCO2eq., grew to 242.4 thousand tCO2eq. According to the Fiesp projection of 10.26% increase in production for rice in eleven years, these emissions have increased to 239.8 thousand tCO2eq.

COTTON

Cotton crops are the ones presenting the highest growth rates in production estimated by MAPA and by Fiesp, attaining 87.6% and 92.3% between 2012 and 2023, respectively. Despite the substantial increase in production, emissions have remained at a level of approximately 63 thousand tCO2eq., considering projections from both institutions.

BEANS

Bean crops are the ones presenting the lowest growth rates in production estimated by the MAPA and by Fiesp: 14.2% and 28.6% between 2012 and 2023, respectively. Notwithstanding this fact, for 2022/23 projections point to an area occupied with beans remaining constant, at the 3.1 million hectares (FIESP, 2013). Thus, the increase of production will necessarily depend on productivity gains, also pressured by the growth of the population.

MAIZE

The maize crop presents production growth rates estimated by MAPA and by Fiesp of 20.0% and 14.8% between 2012 and 2023, respectively. In the 2012/13 harvest, GEE emissions estimated in the selected municipalities were of 744.2 thousand tCO2eq. With growth projections extending up to 2022/23 by MAPA and Fiesp, emissions increased to 940.9 thousand tCO2eq. and 909.4 thousand tCO2eq., respectively.

WHEAT

In the 2012/13 harvest, the emissions estimated in the selected municipalities were of 7.4 thousand tCO2eq. With growth projections up to 2022/23 from MAPA and Fiesp, emissions increased to 8.6 thousand tCO2eq. and 12.9 thousand tCO2eq., respectively, as the growth projections for wheat production were of 17.6%, according MAPA, and of 63,41%, according Fiesp.

SUGAR CANE

Projections for sugar cane growth between 2012/13 and 2022/23 from MAPA and Fiesp are different, leading to differences in GEE emissions projected for 2023. In 2012/13, the crop planted in municipalities with poorly managed pastures emitted 275.9 thousand tCO2eq., whilst in 2022/23, with the inclusion of the growth rates projected by MAPA and Fiesp in calculations, the crop will emit 978 thousand tCO2eq. and 928 thousand tCO2eq., respectively. Jointly with maize, sugarcane is the main GEE emitter in a scenario with no mitigation.

SOY

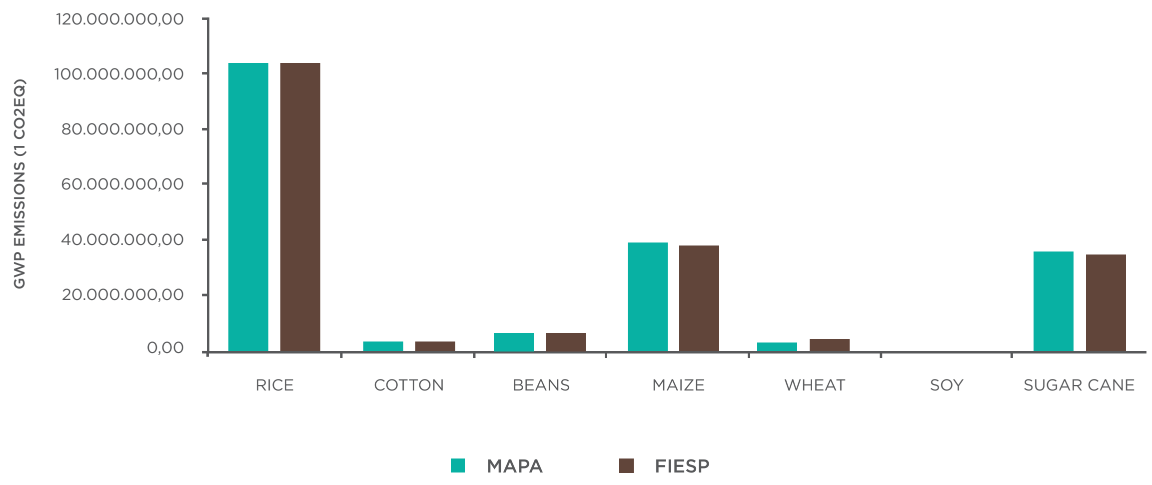
Soy, due to BNF, does not present significant GEE emissions in the plantation in Brazil, compared to the other crops. Its emissions come solely from the residue decomposition and reach 279 tons (MAPA) and 339 tons (Fiesp) of CO2eq. in 2023.

4. FINAL CONSIDERATIONS

PART I

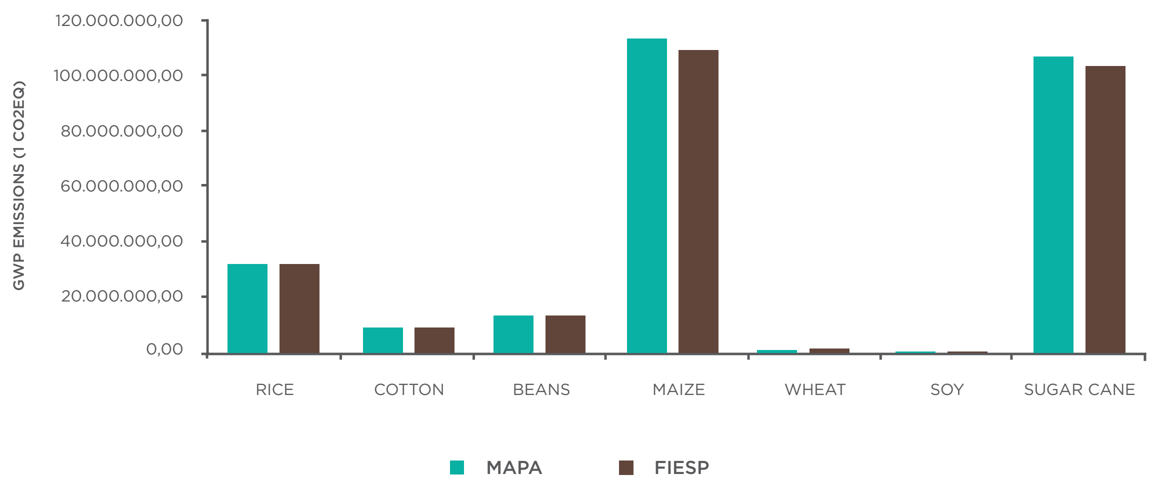
In the present work, total emissions for Brazil for agriculture, calculated by the GWP metric were of 187.2 million tCO2eq. (Fiesp) and 188.3 million tCO2eq. (MAPA) and can be seen in Figure 1. The agricultural emissions only in the degraded pastures are summarized in Figure 2.

FIGURE 1. CO2EQ. EMISSIONS IN BRAZILIAN AGRICULTURE BETWEEN 2012/13 AND 2022/23 CONSIDERING THE FOLLOWING AGRICULTURAL CROPS: RICE, COTTON, BEANS, MAIZE, WHEAT, SOY AND SUGAR CANE AND GROWTH PROJECTIONS FROM MAPA AND FIESP



Source: ABC OBSERVATORY

FIGURE 2. CO2EQ. EMISSIONS IN AGRICULTURE BETWEEN 2012/13 AND 2022/23 CONSIDERING THE FOLLOWING CROPS: RICE, COTTON, BEANS, MAIZE, WHEAT, SOY AND SUGAR CANE AND GROWTH PROJECTIONS BY MAPA AND FIESP ONLY IN AREAS WITH DEGRADED PASTURES

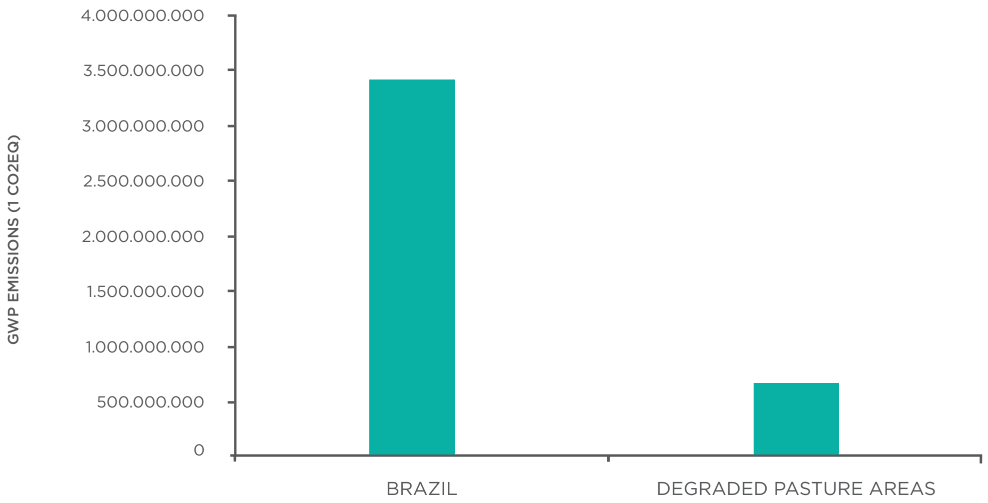


Source: ABC OBSERVATORY

In the national ranking, rice appears in the first place, corroborating the high value of methane emissions for the crop, as described in the National Emissions Inventory (BRASIL, 2015). However, when considering the agricultural production growth solely in degraded pasture areas, rice drops to the third position in the ranking; because the rice production in Brazil is mainly concentrated in Rio Grande do Sul, a state with a small area of degraded pasture land (only 212.373 hectares).

Emissions for livestock (beef cattle) accrued in eleven years were of 3.45 billion tCO2eq. for Brazil as a whole and of 647.79 million tCO2eq. (Figure 3) in the degraded pasture areas (Table 2). Emissions accrued in eleven years for livestock and agriculture together in Brazil were of approximately 3.63 billion tCO2eq. and considering exclusively degraded pasture areas, of 665 million tCO2eq. (Figure 4)[11].

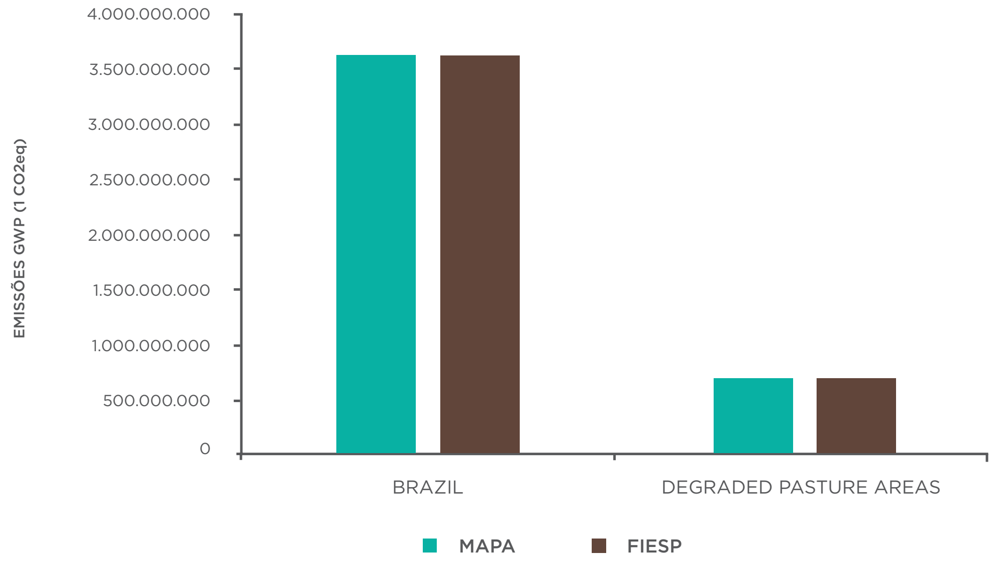
FIGURE 3. CO2EQ. EMISSIONS FOR LIVESTOCK BETWEEN 2012/13 AND 2022/23 CONSIDERING THE GROWTH IN BRAZIL AND ONLY IN DEGRADED PASTURE AREAS



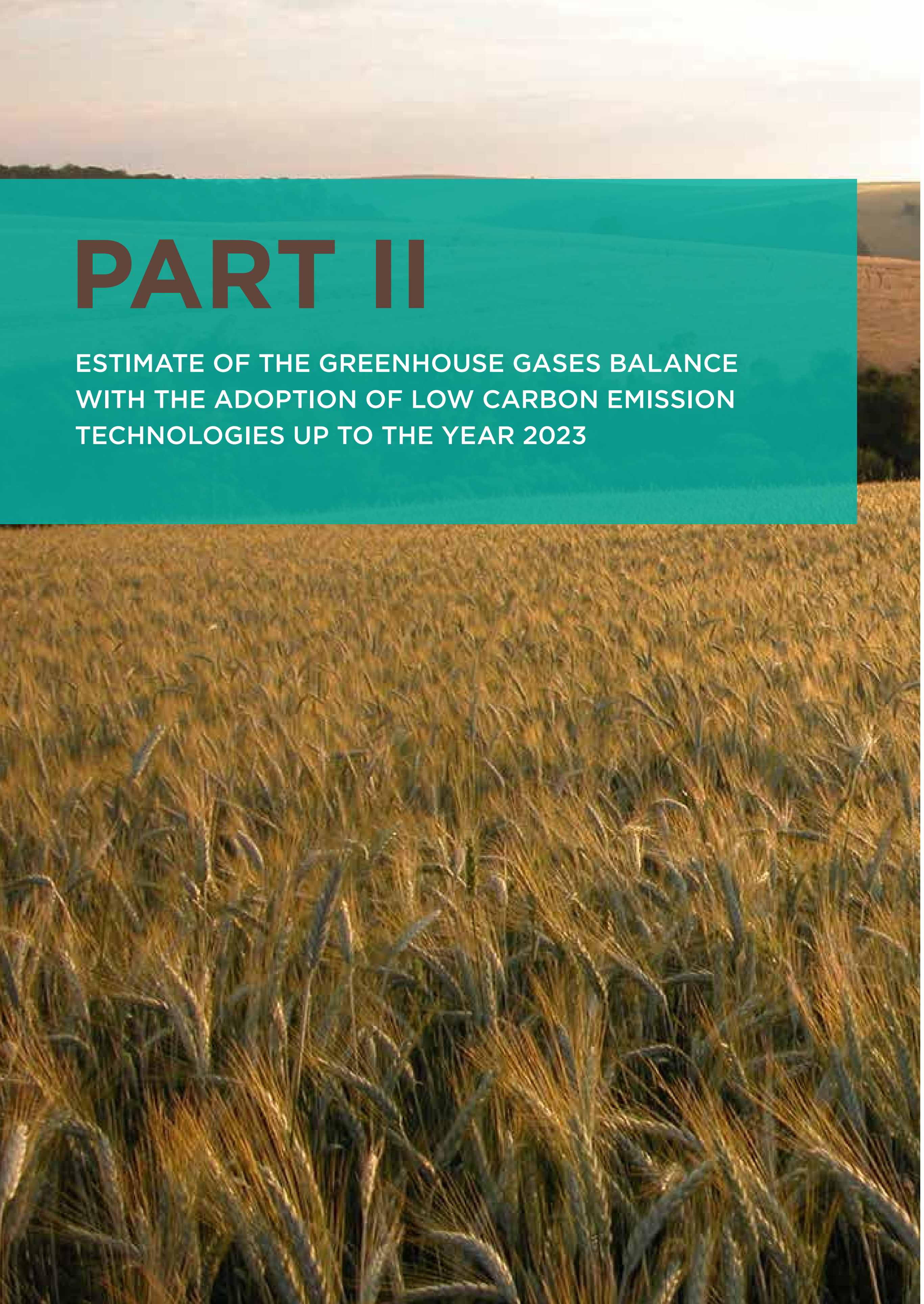
Source: ABC OBSERVATORY

[11] Both projections for accrued emissions in livestock and agriculture took into account the growth estimates by the MAPA and FIESP, however, the different institutional estimates did not interfere significantly in emissions, as can be verified in Figure 4.

FIGURE 4. CO2EQ. EMISSIONS FOR LIVESTOCK AND AGRICULTURE BETWEEN 2012/13 AND 2022/23 CONSIDERING THE GROWTH IN BRAZIL AND ONLY IN THE DEGRADED PASTURE AREAS



Source: ABC OBSERVATORY



PART II

ESTIMATE OF THE GREENHOUSE GASES BALANCE WITH THE ADOPTION OF LOW CARBON EMISSION TECHNOLOGIES UP TO THE YEAR 2023

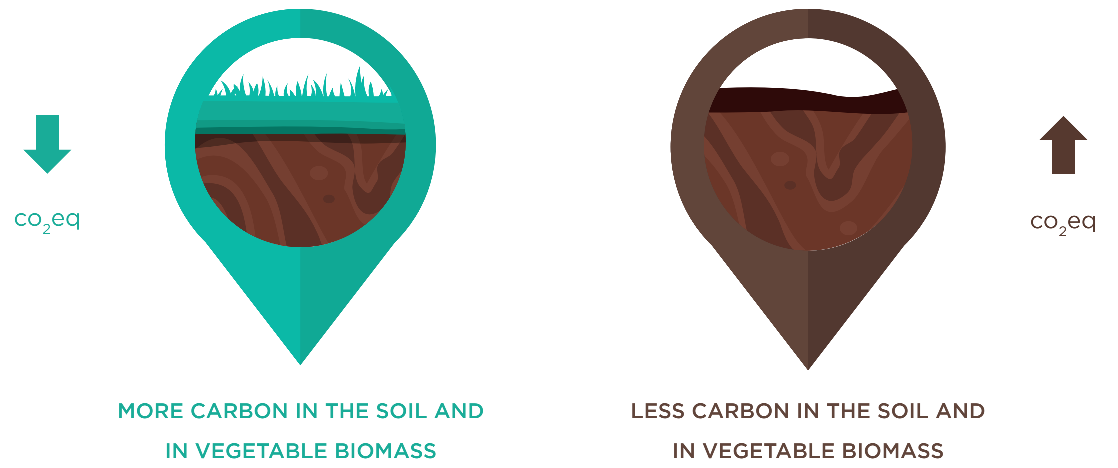
1. INTRODUCTION AND OBJECTIVE

In this part of the study, the GEE emissions from the agriculture and livestock sector were projected considering the adoption of three low carbon emission technologies advocated by the ABC Plan; regeneration of pastures, integrated crop-livestock systems – ICLS - and the integrated crop-livestock-forest systems - ICLFS. As in the first part of this study projections for growth in cattle raising were considered up to the year 2023, made by the Ministry of Agriculture, Livestock and Food Supply (MAPA, 2013) and by the Outlook from the Federation of Industries of the State of São Paulo (FIESP, 2013) as a growth scenario for physical production.

The quest was also to define priority areas for the expansion of low carbon emission technologies, especially the regeneration of pastures and ICLS/ICLFS in the Legal Amazonia, considering the results of the TerraClass Project, executed by the INPE (National Institute for Space Research) and by Embrapa (Brazilian Company for Agricultural and Livestock Research), that aims at mapping the use of the land covering in deforested areas of Legal Amazonia.

To exemplify the reduction in GEE emissions in the agricultural and livestock sector, pasture regeneration was considered as a benchmark. The technique provides the system with a larger carbon stock when compared to a degraded pasture, as the root system for grasses in that condition is more abundant, and the accumulation of organic matter in the soil decreases the loss of CO2 to the atmosphere, as illustrated in Figure 5.

FIGURE 5. GRAPH REPRESENTING PASTURE DEGRADATION



Source: Embrapa Agrobiology

In Brazil, the estimate is of 52 million hectares of degraded pastures. Therefore, the potential for mitigation could be, at the least three-fold greater than the potential financing for such activity set forth by the ABC Plan, in which what is contemplated is only 15 million hectares that are degraded up to the year 2020. By allying to the regeneration of pastures the implementation of systems such as the ICLS and the ICLFS, this potential could be five times higher.

2. METHODOLOGY

Besides the methodological aspects discussed in Part I of the study, what can be added here are some aspects and specificities present only in Part II, as the latter takes into account the adoption of low carbon emission practices. These aspects are presented below.

CROPS AND REGIONAL SELECTIONS

For estimates of the emission balances and/or GEE carbon sinks up to 2023 by the national livestock and agriculture, the following crops were considered: soy, maize, rice, beans, wheat and pastures[12]. These crops that may make up the ICLS and ICLFS systems are far more representative when compared to the cultivated area[13] and consequently, in the scenario of livestock and agricultural sector emissions.

EXPANSION OF AGRICULTURE AND LIVESTOCK WITH LOW GEE EMISSIONS

TECHNOLOGIES CONSIDERED

For estimates of GEE emissions considering the projections for Brazilian agriculture made by MAPA and Fiesp and the adoption in this sector of low carbon emission technologies up to the year 2023, the following low carbon emission technologies were considered as advocated by the ABC Plan:

- Pasture regeneration;
- Integrated production systems – ICLS and ICLFS

[12] In Part II of the study, sugarcane and cotton crops were not considered due to the fact that they are not part of the ICLS and ICLFS.

[13] Crops such as cotton, beans, soy, maize and wheat represent over 90% of the cultivated area of 57.1 million hectares in Brazil for the 2013/14 harvest (CONAB, 2015). Cultivated pastures occupy about 190 million hectares in Brazil (FERREIRA, SOUZA, & ARANTES, 2014).

Furthermore, the fixation of biological nitrogen (BNF) was considered in the entire area planted with soy in Brazil. The BNF provides a reduction in the use of agricultural inputs, such as synthetic fertilizers[14].

Notwithstanding this, it is important to underscore that there already exists an BNF technology for beans and it is under development for a varieties of forage grasses and maize. Despite this, the latter was not considered for such crops, as it is necessary what is needed is going beyond investments in research, as initially advocated by the ABC Plan, for studies with BNF for all maize varieties and grasses, as well as other crops in the country. Additionally, there is a limited number of contracts from the ABC Program with BNF, as reported in previous reports from the ABC Observatory (Observatório ABC, 2014).

However, the BNF potential in Brazil is enormous, as there are 190 million hectares of cultivated pastures (FERREIRA, SOUZA, & ARANTES, 2014) and 15.8 million hectares of area cultivated with maize in the 2013/14 harvest (CONAB, 2015). Considering only the bean crop, what can be observed is that, throughout the cultivated area, had the BNF technology been used, more than half of the ABC Plan goal for that technology would have been attained, with a savings of 82.5 thousand tons of nitrogenized fertilizers per year.

AREA CONSIDERED

What was deemed is that the agricultural and livestock expansion projected up to 2023 will take place linearly, only in the degraded pastures, totaling 52.32 million de hectares. In these degraded pasture areas, there is a total of 39.791.956 heads of cattle, that is, around 20% of the total bovine herds of Brazil in the 1.285 municipalities selected, from a total of 5.570 Brazilian municipalities (IBGE, 2014).

[14] According to the National Association for the Dissemination of Fertilizers (ANDA), during 2013 30.5 million tons of fertilizers will be delivered throughout the Country, representing an increase of 4% vis-a-vis the year 2012. According to the National Sanitary Surveillance Agency (Anvisa), the country is responsible for one fifth of the worldwide consumption of pesticides.

CALCULATION OF THE BALANCE OF EMISSIONS FOR AGRICULTURE AND LIVESTOCK

The assumption in the present report is that the expansion of low carbon emission agriculture would take place in degraded pasture areas. In that case, the following changes would occur in soil usage:

- Degraded pastures or in the process of degradation for regeneration and/or productive pastures;
- Degraded pastures or in the process of degradation to integrated production systems, such as ICLS and ICLFS.

For calculations of emissions referring to this change in soil usage, what was considered was a rate of alteration of the carbon in the soil of 1 tC/ha/year for the conversion of degraded pastures into productive pastures and of 1.5 tC/ha/year for the conversion of degraded pastures into ICLS and ICLFS.

Work published on surveys of carbon stocks in the soil in different locations in Brazil show a difference of 10 tC ha-1 between the carbon stock in degraded pastures and in well managed pastures (1 tC ha-1 year-1), as well as field work by Embrapa that points to a difference in the carbon stock in the soil between poorly managed pastures and integrated systems of 15 to 17 tC ha-1 (1.5 a 1.7 tC ha-1 year-1)15, both in a ten year period (ROSA, SANO, & ROSENDO, 2014) (ASSAD, et al., 2013) (PINTO & ASSAD, 2014) (COSTA, et al., 2009) (CARVALHO, et al., 2010).

DEFINITION OF THE PRIORITY AREAS IN LEGAL AMAZONIA FOR THE EXPANSION OF LOW CARBON EMISSION TECHNOLOGIES

The definition of priority areas for the adoption and/or expansion of the low carbon emission technologies- regeneration of pastures and ICLS/ICLFS – in the Amazon Region was done by crossing the IBGE municipal network with a mapping on the use of land coverage in the deforested areas of Legal Amazonia from the TerraClass Project, put in place by the INPE and Embrapa.

Nine classes of land use in each municipality of the Legal Amazonia were set forth, as follows: deforestation, forest, clean pastures, dirty pastures, mosaic of occupations, pastures with exposed soil, regeneration with pastures, secondary vegetation, others. Municipalities with high pasture areas, that is to say, more than 50% of the total of the area occupied by humans and agriculture, mainly pastures with exposed soil 16 were deemed as a priority.

[15] Work carried out by Embrapa and by Unicamp, with the support of the British Embassy in 2012 – "Mitigando Mudanças Climáticas no Setor Agrícola – PSF LCHG 0663" – point to a difference in the carbon stock in the soil between degraded pastures and iLP/iLPF between 16 to 17 tC ha-1 in a ten-year horizon, which corresponds to an annual rate of 1.6 to 1.7 tC ha/year.

[16] Areas that after the shallow cutting of the forest and the development of some agropastoral activity present a coverage of at least 50% exposed soil (TERRACLASS, 2012).

3. RESULTS

BALANCE OF THE GEE ACCRUED EMISSIONS (2012/13 TO 2022/23) FROM AGRICULTURE AND LIVESTOCK WITH THE ADOPTION OF LOW CARBON EMISSION TECHNOLOGIES

A) NATIONAL SELECTION

Considering that in an eleven year time frame, it would be possible to attain an average value of the difference between the carbon stock in degraded pastures or in the process of degradation and in integrated systems (1.5 tC/ha/year) or recovered (1.0 tC/ha/year), and that the productivity of these pastures would increase from 0.75 to 1.5 AU/ha17 in recovered pastures and to 2.5 AU/ha in ICLS and in ICLFS, it is possible that:

- Avoiding the emissions of 670 million tCO2eq., considering the projections for growth in agriculture by MAPA and Fiesp and the GWP metric, and furthermore storing around 1.10 billion tCO2eq. in the soil (approximately 100.2 million tCO2eq./year) with the regeneration of pastures in 75% of the degraded pasture area and with the implementation of the ICLS and ICLFS in 25% of the degraded pasture area;
- Avoiding emissions of 164 million tCO2eq., considering projections for the growth of agriculture by MAPA and Fiesp and the GTP metric, and furthermore storing approximately 1.88 billion tCO2eq. in the soil (approximately 171 million tCO2eq/year.) with the regeneration of pastures in 75% of the degraded pasture area and with the implementation of the ICLS and ICLFS in 25% of the degraded pasture area (Table 10 and Table 12).

Besides this, it is possible to estimate the number of additional heads that could become part of the Brazilian productive system in these 52 million hectares of degraded pastures or in the process of degradation.

With the regeneration of pastures, there would be an additional 0.75 AU/ha (0.75 to 1.5 AU/ha) in 39 million ha (75% of the degraded pasture area estimated in the present report), reaching an additional 29.3 million heads and, more importantly, with the emissions neutralized and with the advantage of stocking more carbon in the system and without opening new areas – the so called earth sparing effect.

[17] Considering 1 AU = 450kg of live weight = 1 ox. The average weight of early slaughter is of 400 to 450 kg of live weight. Early slaughter fosters a reduction in the GEE emissions per unit of meat produced, corroborating the objectives of the ABC Plan and Program.

If all of the degraded pasture area remaining and available for agricultural expansion were placed under integrated systems such as the ICLS and ICLFS, that have greater productivity than pastures in monocultures (BALBINO et al, 2011) (EMBRAPA, 2011), the capacity rate could go from 0.75 AU/ha to 2.5 AU/ha in 13 million ha (25% of the degraded pasture area). This would bring an ever greater increase in the number of heads of cattle in the productive system: over 22.8 million, with their emissions neutralized and with additional carbon in the soil.

TABLE 9 – BALANCE OF THE GEE ACCRUED EMISSIONS (2012/13 TO 2022/23) FOR AGRICULTURE AND LIVESTOCK IN TCO2EQ. WITH THE ADOPTION OF LOW CARBON EMISSION TECHNOLOGIES IN DEGRADED PASTURE LANDS (75% IN PASTURE REGENERATION AND 25% IN ICLS/ICLFS) USING THE GWP METRIC AND THE MAPA PROJECTIONS

REGION	RICE	BEANS	MAIZE	SOY	WHEAT	TOTAL ICLS/ICLFS	TOTAL PASTURE REGENERATION	TOTAL CROPS IN ICLS/ICLFS AND PASTURE REGENERATION
MW	-3.220.877	-8.445.097	-50.745.814	-105.635.418	-18.288	-156.845.225	-114.821.909	-271.667.134
N	-6.978.796	-8.417.204	-24.482.647	-16.790.366	0	-52.278.472	-44.265.372	-96.543.844
NE	-4.657.529	-95.059.041	-64.325.018	-4.968.113	0	-154.233.856	-140.616.487	-294.850.342
S	1.777.997	-361.022	-2.064.296	-1.232.398	-291.315	-1.799.814	-3.400.026	-5.199.840
SE	-2.458.069	-73.961.491	-168.084.584	-33.287.691	-832.314	-261.043.552	-173.125.864	-434.169.417
TOTAL	-15.537.274	-186.243.855	-309.702.360	-161.913.986	-1.141.917	-626.200.919	-476.229.659	-1.102.430.578

Source: ABC Observatory

TABLE 10 – BALANCE OF THE GEE ACCRUED EMISSIONS (2012/13 TO 2022/23) FOR AGRICULTURE AND LIVESTOCK IN TCO2EQ. WITH THE ADOPTION OF LOW CARBON EMISSION TECHNOLOGIES IN DEGRADED PASTURE LANDS (75% IN PASTURE REGENERATION AND 25% IN ICLS/ICLFS) USING THE GTP METRIC AND THE MAPA PROJECTIONS

REGION	RICE	BEANS	MAIZE	SOY	WHEAT	TOTAL ICLS/ICLFS	TOTAL PASTURE REGENERATION	TOTAL CROPS IN ICLS/ICLFS AND PASTURE REGENERATION
MW	-8.394.071	-8.459.436	-51.121.402	-105.836.348	-18.619	-162.610.167	-284.912.059	-447.522.226
N	-18.210.238	-8.421.425	-24.506.526	-16.800.627	0	-63.548.495	-111.354.327	-174.902.822
NE	-12.789.812	-95.083.221	-64.386.802	-4.995.127	0	-162.479.854	-373.079.238	-535.559.091
S	-640.318	-363.539	-2.095.497	-1.238.349	-294.613	-4.261.114	-9.346.495	-13.607.610
SE	-6.502.900	-73.984.236	-168.236.428	-33.305.897	-834.611	-265.284.353	-445.061.123	-710.345.476
TOTAL	-46.537.339	-186.311.857	-310.346.655	-162.176.348	-1.147.843	-658.183.982	-1.223.753.243	-1.881.937.225

Source: ABC Observatory

TABLE 11 – BALANCE OF THE GEE ACCRUED EMISSIONS (2012/13 TO 2022/23) FOR AGRICULTURE AND LIVESTOCK IN TCO2EQ. WITH THE ADOPTION OF LOW CARBON EMISSION TECHNOLOGIES IN DEGRADED PASTURE LANDS (75% IN PASTURE REGENERATION AND 25% IN ICLS/ICLFS) USING THE GWP METRIC AND THE FIESP PROJECTIONS

REGION	RICE	BEANS	MAIZE	SOY	WHEAT	TOTAL ICLS/ICLFS	TOTAL PASTURE REGENERATION	TOTAL CROPS IN ICLS/ICLFS AND PASTURE REGENERATION
MW	-3.102.843	-8.760.920	-47.952.622	-108.486.678	-20.694	-157.103.488	-114.821.909	-271.925.397
N	-6.877.643	-8.829.812	-23.637.788	-17.530.563	0	-52.485.266	-44.265.372	-96.750.638
NE	-4.636.635	-97.210.645	-62.081.753	-5.106.010	0	-154.259.197	-140.616.487	-294.875.683
S	1.778.070	-377.744	-1.990.720	-1.266.681	-301.709	-1.787.564	-3.400.026	-5.187.590
SE	-2.427.043	-77.163.471	-163.284.372	-34.880.252	-948.490	-261.123.029	-173.125.864	-434.248.893
TOTAL	-15.266.093	-192.342.593	-298.947.255	-167.270.183	-1.270.893	-626.758.543	-476.229.659	-1.102.988.202

Source: ABC Observatory

TABLE 12 – BALANCE OF THE GEE ACCRUED EMISSIONS (2012/13 TO 2022/23) FOR AGRICULTURE AND LIVESTOCK IN TCO2EQ. WITH THE ADOPTION OF LOW CARBON EMISSION TECHNOLOGIES IN DEGRADED PASTURE LANDS (75% IN PASTURE REGENERATION AND 25% IN ICLS/ICLFS) USING THE GTP METRIC AND THE MAPA PROJECTIONS

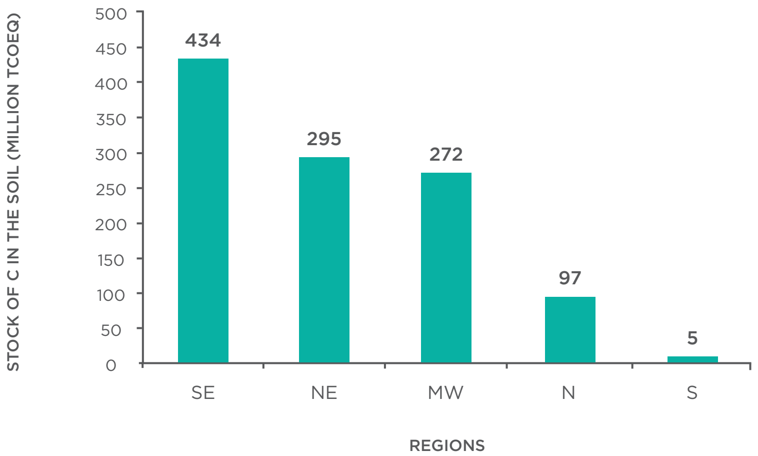
REGION	RICE	BEANS	MAIZE	SOY	WHEAT	TOTAL ICLS/ICLFS	TOTAL PASTURE REGENERATION	TOTAL CROPS IN ICLS/ICLFS AND PASTURE REGENERATION
MW	-8.093.243	-8.775.585	-48.314.286	-108.709.577	-21.065	-162.694.046	-284.912.059	-447.606.105
N	-17.950.935	-8.834.096	-23.660.846	-17.541.940	0	-63.597.496	-111.354.327	-174.951.824
NE	-12.733.001	-97.234.965	-62.142.790	-5.135.976	0	-162.471.624	-373.079.238	-535.550.862
S	-639.508	-380.467	-2.021.208	-1.273.278	-305.841	-4.249.101	-9.346.495	-13.595.596
SE	-6.420.749	-77.186.886	-163.433.214	-34.900.441	-951.178	-265.312.747	-445.061.123	-710.373.870
TOTAL	-45.837.436	-192.411.998	-299.572.344	-167.561.213	-1.278.084	-658.325.015	-1.223.753.243	-1.882.078.257

Source: ABC Observatory

B) NATIONAL SELECTION

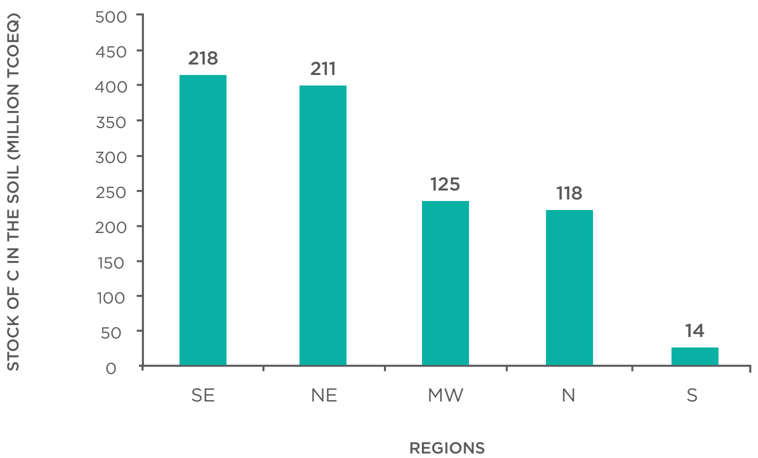
The graphs below show the amount of carbon stocked in the soil and the emissions avoided in the period between the 2012/13 and 2022/23 harvest years in each of the Country´s regions[18].

FIGURE 6 - CO2EQ STOCK IN THE SOIL FOR THE DEGRADES PASTURE AREAS (AU/HA < 0,75) WITH THE PASTURE REGENERATION AND ICLS/ICLFS BETWEEN 2012/13 AND 2022/23 IN THE DIFFERENT REFIONS IN THE COUNTRY.



Source: ABC Observatory

FIGURE 7. CO2EQ. EMISSIONS AVOIDED BY THE REGENERATION OF DEGRADED PASTURES AND BY ICLS/ICLFS BETWEEN 2012/13 AND 2022/23.



Source: ABC Observatory

[18] The information in Tables 9 to 12 have been broken down by State of the Federation in the Full Report available in the Observatory ABC site

PRIORITY AREAS FOR LEGAL AMAZONIA

To prioritize areas in the Legal Amazonia for the adoption or expansion of low carbon emission technologies advocated by the ABC Plan and Program, classes of land use and coverage were determined and the respective maps were drafted in all of the municipalities in the region.

What can be observed is that the states in Legal Amazonia with the largest pasture areas, especially with pasture with exposed soil and dirty soil, priority classes for pasture regeneration, are Mato Grosso and Pará, priorities for the implementation of actions and the resources arising from the ABC Plan and Program, respectively.

Additionally to the large pasture area, the state of Mato Grosso also counts upon a chain of actors involved with the ABC Plan and the branched Program, with suppliers of raw materials, technical assistance, cooperatives etc., as reported in previous studies of the ABC Observatory (Observatório ABC, 2013). Nevertheless, the state of Pará continues to present significant gaps and barriers that need to be resolved for the advance of low carbon emission technologies, such as the regularizing of the environmental and land ownership situation, limited action by technical assistance, among others.

TABLE 13 – TERRITORIAL EXTENSION IN HECTARES (HA) OF THE USAGE CLASSES AND LAND COVERAGE IN DEFORESTED AREAS IN THE STATES OF THE LEGAL AMAZONIA.

STATE	DEFORESTATION	FOREST	MOSAIC OF OCCUPATIONS	PASTURE WITH EXPOSED SOIL	CLEAN PASTURE	DIRTY PASTURE	REGENERATION WITH PASTURE	SECONDARY VEGETATION	OTHERS
AC	27.129,05	14.683.795,10	99.953,98	0,00	1.215.575,25	45.573,16	62.856,71	471.898,49	74.574,01
AM	59.079,23	124.729.239,90	282.037,11	969,98	409.336,74	186.897,73	209.689,20	1.629.074,97	9.705.814,60
AP	7.457,35	4.555.912,80	10.830,70	10,72	14.094,91	7.152,99	31.713,31	96.650,97	3.043.067,18
MA	69.856,85	3.505.757,75	465.604,55	883,77	2.772.456,52	1.547.355,61	1.606.858,75	1.966.470,77	8.962.898,24
MT	82.291,50	28.119.957,91	101.434,61	30.979,83	11.305.421,92	784.262,09	775.629,56	3.167.853,28	40.351.666,08
PA	344.140,98	87.871.156,09	660.062,89	3.803,00	10.070.060,72	2.122.651,05	2.887.041,55	6.574.877,12	14.412.081,20
RO	45.116,81	12.670.804,79	154.506,33	201,69	5.198.209,50	708.817,41	450.632,83	1.481.471,36	3.042.462,37
RR	24.625,41	13.053.997,20	75.028,24	230,90	188.583,39	106.723,41	114.345,72	351.208,44	6.096.713,10
TO	5.679,94	991.061,36	8.429,14	438,52	1.976.778,04	141.014,32	127.798,69	698.413,05	8.946.483,10
TOTAL	665.377,12	290.181.682,89	1.857.887,55	37.518,41	33.150.516,99	5.650.447,77	6.266.566,32	16.437.918,45	94.635.759,88

Source: Terraclass (Inpe and Embrapa)

When it comes to the ten main municipalities in the Legal Amazonia Legal with the largest territorial extensions in hectares (ha) of pastures with exposed soil and with pastures with dirty soil, what can be observed is that a large part of this group belongs to Pará, however, in the list what appears is Bom Jardim and Santa Luzia, both in Maranhão, and Porto Velho in Rondônia (Table 14).

TABLE 14 – MUNICIPALITIES IN THE LEGAL AMAZONIA WITH THE LARGEST TERRITORIAL EXTENSIONS IN HECTARES (HA) OF PASTURES WITH EXPOSED SOIL AND DIRTY GRASSLANDS.

STATE	MUNICIPALITY	PASTURES WITH EXPOSED SOILM OR DIRTY GRASSLANDS (HA)
PA	ÁGUA AZUL DO NORTE	1
PA	PACAJÁ	25
PA	BRASIL NOVO	298
PA	BREJO GRANDE DO ARAGUAIA	3.500
MA	BOM JARDIM	1.300
RO	PORTO VELHO	1.430
PA	CAMARU DO NORTE	124
PA	ALTAMIRA	7.390
MA	SANTA LUZIA	12.200
PA	SÃO FÉLIX DO XINGU	22.800

Source: Terraclass (Inpe and Embrapa)

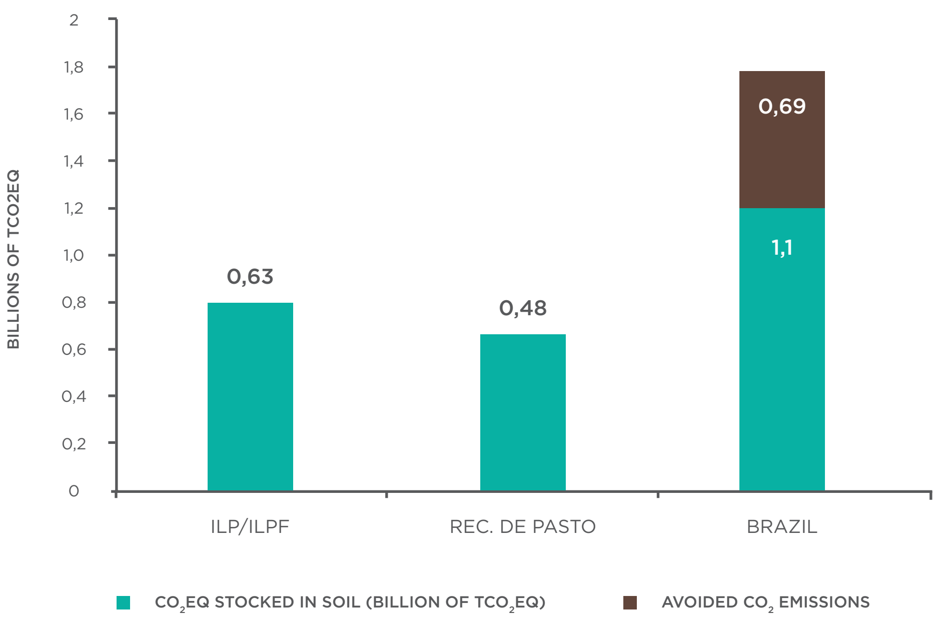
4. FINAL CONSIDERATIONS

In the present work what can be observed is that the total emissions of Brazil of 0.69 billion tCO2eq. by agriculture calculated by the GWP metric (Figure 8) between 2012/13 and 2022/23 can be neutralized, due to the increase in carbon stock in the soil of 1.0 t/ha/year for the regeneration of pastures and of 1.5 t/ha/year in the soils under integrated systems such as ICLS and ICLFS.

Besides the emissions avoided, for the same period, there is significant storage of carbon in the soils in degraded pasture areas or in the process of degradation, with the adoption of the low carbon emission technologies advocated by the present report.

After eleven years of adopting regeneration and maintaining pastures in 75% of the degraded pasture area considered in the present study, the gain in carbon stock in the soil could reach 0.48 billion tCO2eq., considering slaughter and above all the emissions from enteric fermentation and due to nitrogenized fertilization in production systems. When referring to integrated systems such as the ICLS and ICLFS, the carbon stock in the soil could attain 0.63 billion tCO2eq. in eleven years (Figure 8).

FIGURE 8. BALANCE OF CO2EQ. EMISSIONS BETWEEN 2012/13 AND 2022/23 IN AGRICULTURE AND LIVESTOCK WITH THE ADOPTION OF LOW CARBON EMISSION TECHNOLOGIES – REGENERATION OF DEGRADED PASTURES AND ICLS AND ICLFS.



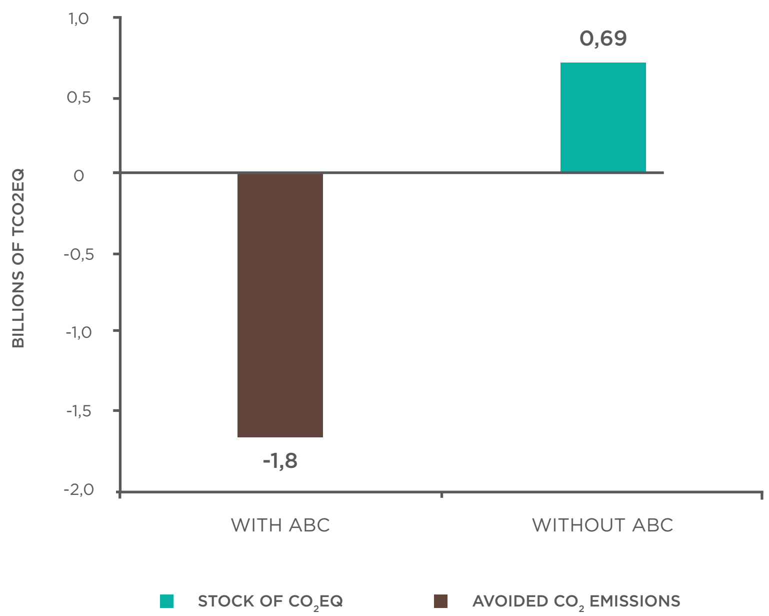
Source: ABC Observatory

Emissions in agriculture and livestock are neutralized by the low carbon emission technologies, regardless of the increase in the number of animals in the production system. This means to say that despite the increase in emissions due to enteric fermentation, the latter are neutralized by the carbon storage in the soil due to correct management of these low emission technologies, when compared to the carbon stock in the soil of degraded pastures.

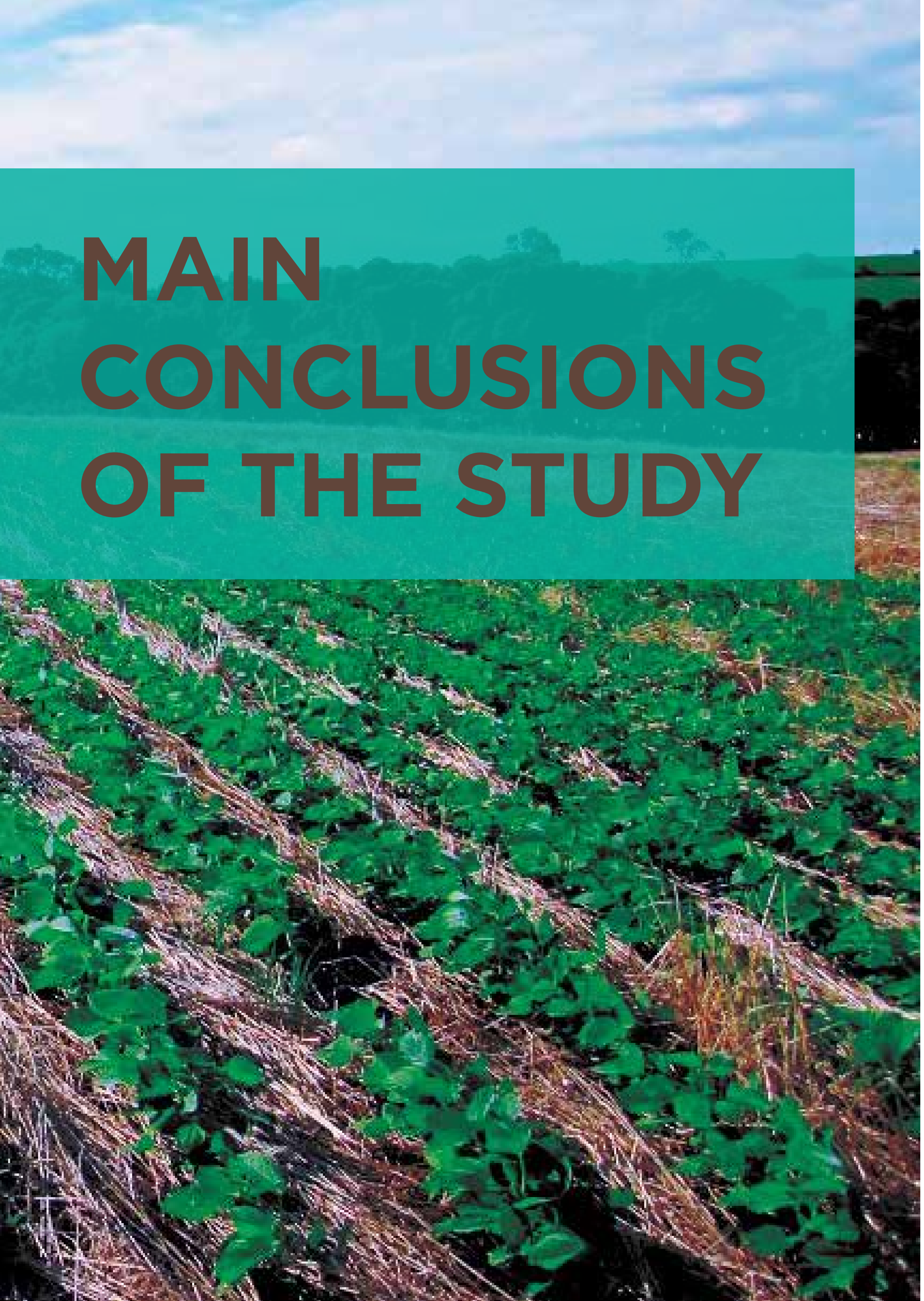
With the regeneration of pastures and with ICLS and ICLFS , there is a significant improvement in the productivity of production systems, going from 0.75 AU/ha to up to 2.5 AU/ha. The increase in the number of animals in the national production system could reach 52 million heads, with their emissions neutralized and with additional carbon in the soil.

Finally, what can be noted is that the potential to mitigate GEE emissions in agriculture and livestock of 1.8 billion tCO2eq. (emissions avoided plus the stock of CO2eq. in the soil) in eleven years, through the regeneration of pastures and implementation of the ICLS and ICLFS (Figure 9) in 52 million hectares of grasslands with low support capacity (< 0,75 AU/ha) in the Country is much greater than the goal set forth in the ABC Plan in ten years, pointing to the fact that Brazilian agriculture and livestock could be transformed from a strong emitter of greenhouse gases into an efficient mitigating activity.

FIGURE 9. BALANCE OF CO2EQ. EMISSIONS BETWEEN 2012/13 AND 2022/23 IN AGRICULTURE AND LIVESTOCK WITH AND WITHOUT THE ADOPTION OF LOW CARBON EMISSION TECHNOLOGIES.



Source: ABC Observatory



MAIN CONCLUSIONS OF THE STUDY

- The potential to mitigate Greenhouse Gas Emissions (GEE) from Brazilian livestock and agriculture is more than ten-fold the goal set forth by the ABC Plan (Low Carbon Emission Agriculture). Between 2012 and 2023 it will be possible to reach 1.8 billion tons of CO2 equivalent (tCO2eq.), by adding the emissions avoided and the carbon stored in the soil, simply through the adoption of three technologies advocated by ABC (regeneration of pastures, integrated crop-livestock systems – ICLS - and the integrated crop-livestock-forest systems - ICLFS) in 52 million hectares of degraded pasture land.

- The calculation is conservative, as it does not consider other technologies of the ABC, such as biological nitrogen fixation in crops beyond those of soy , and encompasses only the 1.285 Brazilian municipalities with degraded pasture land (that support up to 0.75 animal units per hectare), considering bovine herds and seven agricultural crops: rice, maize, wheat, sugar cane, beans, cotton and pastures. This universe corresponds to 13% of the total emissions from the entire livestock and agricultural sector, accountable for 32% of the CO2eq. emissions in Brazil, reaching the amount of 472.734 million tCO2eq. in the year 2010.

- To calculate the mitigation potential of ABC technologies, this study has sought to estimate which would be the sector emissions when not adopting the technologies. For this purpose, it considered the growth projection of agricultural production and of the bovine herds in these eleven years, according to MAPA (Ministry of Agriculture, Livestock and Food Supply) calculations and those of Fiesp (Federation of Industries of the State of São Paulo).

- Without slaughter, the accrued emissions for livestock and agriculture throughout the Country in the period analyzed would amount to 3.63 billion tons of CO2 equivalent (3.45 billion tons merely for livestock).In municipalities with degraded pastures, they would attain 670.47 million tCO2eq. (projected based on MAPA data) and 669.93 million tCO2eq. (based on data from Fiesp). The accrued emissions originating from bovine herds would be of 647 million tCO2eq., and those arising from agricultural activity, for both institutions, of about 22 million tCO2eq.

- Due to a larger planted area, maize was the main source of GEE emissions among the crops analyzed, contributing with approximately 9 million tCO2eq. between 2012/13 and 2022/23. Ensuing this, there is sugar cane and rice, with emissions of 8.6 million and 2.6 million of tCO2eq., respectively. Subsequently, beans and cotton contributing with 1.1 million tCO2eq. and 700 mil tCO2eq., respectively. Wheat is responsible for emissions ranging between 89 thousand and 109 thousand tCO2eq.

- Soy, the main agricultural crop for exports in the Country did not have significant emissions, as it uses biological nitrogen fixation (BNF), a technology that does not require the use of nitrogenized fertilizers (main source of GEE direct emissions) for this plantation.
- Among the Country´s regions, the Southeast was the main emitter in the scenario without an expansion of ABC technologies. Total GEE emissions accrued in the region during the period of 2012/13 and 2022/23 was of 219.6 million tCO2eq. As a second runner we have the Center West (218 million tCO2eq.), followed by the Northeast (125 million tCO2eq.), the North (117 million tCO2eq.) and the South (14 million tCO2eq.).
- In all cases, beef cattle is the main source of emissions, with the States with the greatest area of degraded pastures leading the ranking in each region. Minas Gerais was the main emitter in the Southeast and of Brazil, with 194 million tCO2eq. accrued. Ensuing this comes Mato Grosso do Sul (103 million tCO2eq.), Pará (73 million tCO2eq.), Mato Grosso (71 million tCO2eq.) and Bahia (50 million tCO2eq.). As the degraded pasture area is smaller, the states in the Southern region contribute little to emissions.
- With the technology to regenerate pastures applied in 75% of the degraded pasture land area and with the implementation of the ICLS and ICLFS in the remaining 25%, it would be possible to avoid the emission of 670 million tons of CO2 equivalent and further store 1.10 billion tons of CO2 in the soil (about 100.2 million tons per year), according to the GWP (Global Warming Potential) calculation metric adopted by the IPCC[20] for this type of analysis.
- Adopting another metric, the GTP (Global Temperature Potential), the same technologies applied in the same area during the same period would make it possible to prevent emissions of 164 million tCO2eq. and to store 1.88 billion tCO2eq. in the soil (171 million tons per year). Nevertheless, this is not the official metric used by the IPCC.
- Additionally, it is possible to estimate the additional number of heads of cattle that could become part of the Brazilian production system in these 52 million hectares of degraded pasture or in the process of degradation. With the regeneration of pastures, there would be an additional 0.75 animal unit per hectare in 39 million hectares (75% of the degraded pasture area), reaching an additional 29.3 million heads of cattle.

[20] Intergovernmental Panel on Climate Change.

These additional heads would have their emissions neutralized, with the additional advantage of stocking more carbon in the system, without opening up new areas – the so called spare the earth effect.

- In the breakdown per region, considering the GWP metric, the Southeast could avoid the emission of 210.6 million tCO2eq. and store around 434 million tCO2eq. in the soil with the regeneration of pastures. The Midwest contributes with 218 million of tCO2eq. avoided and would have an additional carbon in the soil of 272 million tCO2eq. The Northeast would have 125 million tCO2eq. neutralized and 295 million tCO2eq. stored in the soil. The North would follow, with 118 million tCO2eq. of emissions avoided and 97 million tCO2eq. stored in the soil in eleven years. The South would neutralize its 14 million tons of CO_2 of emissions and additionally store 5 million tons in the soil. The states that would most emit in a scenario without the expansion of ABC technologies are the ones that most neutralize emissions in the mitigation scenario.

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