CLIMATE & ENVIRONMENTAL SUSTAINABILITY OF BRAZILIAN AGRICULTURE

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Agriculture has changed in recent decades. The adoption of mechanization and new technologies enabled an increase in food productivity, as well as the possibility of cultivation in areas where that had not been possible before. But even with the new technological means, a global concern is the sustainable development of agricultural activities. This is because such activity is very sensitive to climatic and environmental factors, in addition to generating environmental damage, such as soil degradation and both soil and air contamination.

On that account, this study aims to present the efforts and results of sustainable solutions in the Brazilian agricultural sector focusing on: low-carbon agriculture programmes; better practices in agricultural carbon sequestration; carbon farming incentive and better practices in conservation agriculture.

LOW-CARBON AGRICULTURE PROGRAMMES

The agricultural and cattle-raising sectors play an important role in the composition of Brazilian economy and job generation, as well as in its technological development. It is estimated that agriculture grew by 8.36% in 2021 compared to 2020, and its share in Brazil Gross Domestic Product was equivalent to 27.4% (CNA. 2022, p. 1).

However, the growth of this sector is also seen with concern because agribusiness is viewed as one of the main responsible for the increase of greenhouse gases (GHG) in the atmosphere, thus accelerating the process of climate change, which is at the heart of international discussions regarding sustainable economy. In fact, both climate change and unsustainable land use have direct impact on agricultural production, once they lead to soil depletion and reduced efficiency in planting and grazing. Furthermore, pressures on the international market for goods which production is ecologically adequate are also growing.

Such scenery has led Brazil to assume a role of global leadership with regard to the implementation of policies that encourage agriculture and livestock with low carbon emissions. The Country signed a commitment to reduce greenhouse gas (GHG) emissions at the 15th Conference of the Parties (COP15), held in Copenhagen in 2009.

On the occasion, the Brazilian government committed to develop measurements to mitigate the emission of greenhouse gases, with the objective of reducing between 36.1% and 38.9% of its projected emissions by agricultural and cattle raising sectors up to 2020.

In order to achieve such goal, the "National Policy of Climate Change" (known as PNMC in Portuguese) was enacted in 2009 as well as the "Sectoral Plan for Mitigation and Adaptation to Climate Change for the Consolidation of an of Low Carbon Emissions in Agriculture and livestock" (known simply as the "ABC Plan"), this last one with regard specially to agriculture and livestock.

The listed technologies considered in the ABC Plan for the expansion of low carbon agriculture and livestock are: (1) recovery of degraded pasture; (2) no-tillage system; (3) planted forests; (4) agro-silvipasture and agro-pasture systems; (5) biological nitrogen fixation; and (6) animal waste management.

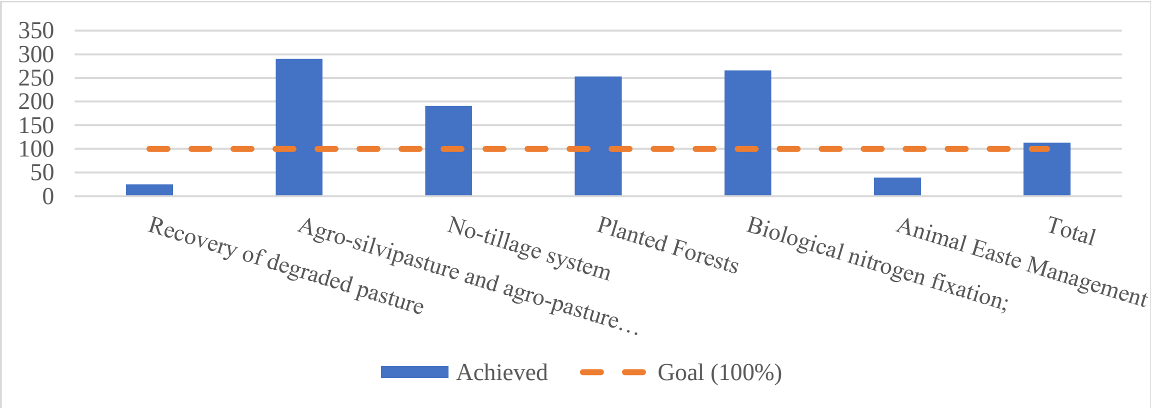
Although the initial purpose of the ABC plan was to expand these agricultural production techniques by 35.5 million hectares between 2010 and 2020, according to a study published by the Institute for Research in Applied Economics (IPEA, as in portuguese) (TELLES *et al.*, 2021, pp. 29 and 30), such goal was surpassed, expanding to 54.8 million hectares total. The highlight of the expansion was the integrated production system, which final growth reached 13.8 million hectares (with the initial target of 4 million hectares), followed by the no-tillage system which expansion occurred in 16.7 million hectares (against a forecast of 8 million hectares) and for the biological nitrogen fixation, which expanded by 14.6 million hectares (with an initial perspective of increasing to 5.5 million hectares).

Also according to a study published by the Institute for Research in Applied Economics (in portuguese: IPEA), the implementation of such techniques, along with the planting of forests and the recovery of pastures between the years of 2010 and 2020 alone led to the mitigation of about 152.93 million tons of CO2eq (equivalent to the consumption of 29.9 million gasoline-powered cars over a year), making Brazil reach 113% of the target It had committed to achieving at COP15 (TELLES et al., 2021, p. 31). In the same period, it is estimated that the integrated production systems and the agroforestry system mitigated the production of approximately 52.14 million tons of CO2eq[1], while the no-till system reduced approximately 30.63 million tons of CO2eq[2]

[1] Equivalent to the consumption of 10.1 million gasoline-powered cars over the course of a year.
[2] Equivalent to the consumption of 6 million gasoline-powered cars over the course of a year.

and the expansion of the biological nitrogen fixation technique helped reduce the production of CO2eq by agriculture by 26.63 million tons[3], as shown in Graph 1.

Graph 1 - CO2 mitigation goals and achievements in relation to the Sustainable Development Goals in international terms (in million tons)



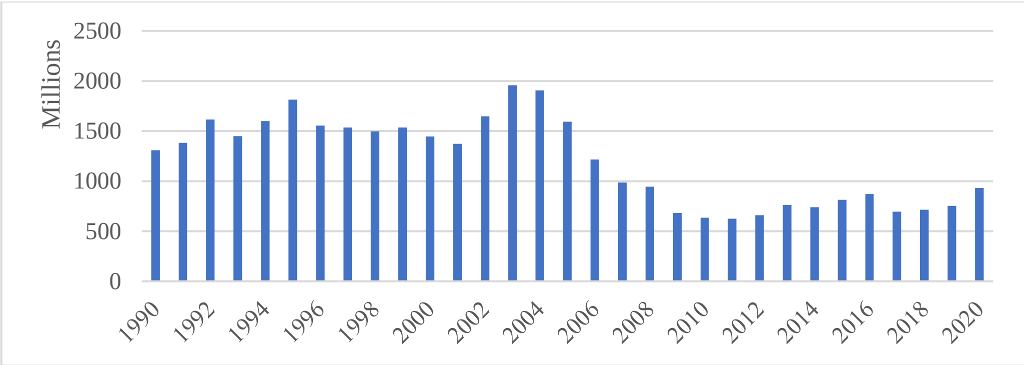
Source: deveoped by the author based on the study by Telles et al. (2021, p. 31).

As one can note, the only points that performed less than expected for the reduction of CO2eq emission were the recovery of pastures and the treatment of animal waste. However, for the latter, data were found only between the years of 2013 and 2018, so a much greater amount is projected in the reduction of greenhouse gases (GHG) through this measurement in the period that comprises the validity of the ABC plan (2010-2020) (TELLES *et al.*, 2021).

According to Graph 2, analyzing the data available between the years 1990 and 2020, the impact of policies to mitigate the emission of greenhouse gases in the agricultural sector showed a tendency to increase such gases until 2003, the year with the largest recorded emission, of 1.96 billion tons of CO2eq. From 2004 onwards, there was a progressive decrease, with a period of stabilization between 2009 and 2020, and reaching the lowest level recorded in 2011, despite the productive growth experienced by the Brazilian agricultural sector in the period.

[3] Equivalent to the consumption of 5.2 million gasoline-powered cars over the course of a year.

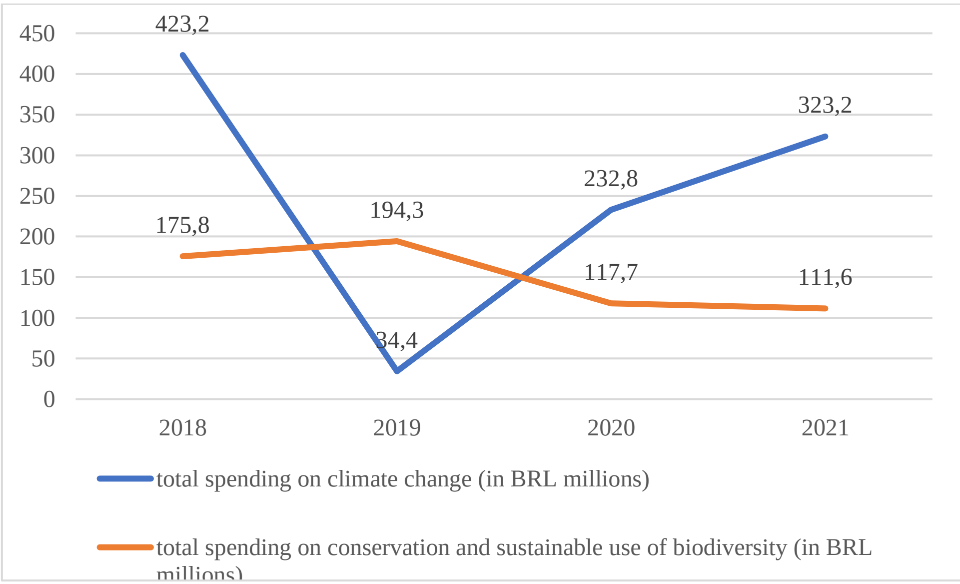
Graph 2 - CO2eq emission due to Land Use Changes (in million tons)



Source: developed by the author based on SEEG data (2022).

As for the specific government expenses to tackle climate change, BRL 1.013 billion were spent between 2018 and 2021, according to data from the "Portal da Transparência" (government website aimed at disclosing all government expenditures to the public), with BRL 444.6 million being provisioned for the year of 2022. In addition, the amount committed to policies for the conservation and the sustainable use of biodiversity totaled BRL 599.4 million in the same period, with the 2022 budget at BRL 73.0 million. The details of such policy are shown in the Graph 3 below.

Graph 3: Total Brazilian government spending on climate change policies and the preservation and sustainable use of biodiversity



Source: elaborated by the author based on "Portal da Transparência" data.

The second stage of the Brazilian policy to reduce greenhouse gases (GHG) began through the "ABC+ Plan" in 2021, which aims on decreasing the emission of CO2 generated by the Brazilian agricultural activity by 1.1 billion tons (equivalent to the consumption of 215 million gasoline-powered cars over a year), as well as expanding the areas that use sustainable technologies for planting and raising animals to 72 million hectares (area equivalent to 87,2 million soccer fields[4], or nearly half of the country's arable area), both by the year 2030.

The conclusion that one might reach from the above is that there was indeed a concern in the reduction of greenhouse gases (GHG) by both the Brazilian government and the agricultural sector on the analyzed period. As a consequence, the policies developed for this purpose, such as the ABC plan, were able to achieve their goals and present good indicators, justifying their continuity for the upcoming decade, in which an even greater growth of the Brazilian rural economy is expected.

BETTER PRACTICES IN AGRICULTURAL CARBON SEQUESTRATION AND CARBON FARMING INCENTIVE SCHEMES

Carbon sequestration is basically the process by which CO2 is removed from the atmosphere and inserted into the soil. Initially, such process is performed by plants through the photosynthesis, which captures carbon dioxide from the air and, making it react with water, produces organic material (specially carbohydrates) and oxygen (ASSAD, 2019, p. 161).

The problem that has been posed to agriculture lies on what to do with the residual plant material from crops, as it is rich in carbon and, if not properly treated, it goes through a rapid process of fragmentation by macroorganisms and decomposition by microorganisms, resulting in the return of the carbon to the atmosphere. From this point of view, it would be necessary to review the practices of the traditional planting system, which involves, among other techniques, the integral soil turning, burning of straw from the previous harvest , as well as the large-scale use of mineral compounds as fertilizers, which provide the rapid decomposition of the carbon-rich plant material present in the soil, resulting in its depletion and in water contamination (ASSAD, 2019, p. 161).

Therefore, in order to maintain this carbon in the soil, several agropastoral techniques have been developed, incorporated by the “Sectoral Plan for Mitigation and Adaptation to Climate Change for the Consolidation of a Low Carbon Economy in Agriculture”, known as the ABC plan, among others from which we stand out: crop-

[4] Considering a soccer field with 8250m².

livestock-forest integration, no-tillage, pasture recovery, forest planting and biological nitrogen fixation.

As a means to allow rural producers larger access to the inputs and tools necessary for the implementation of different carbon sequestration techniques, the Brazilian State, through the ABC plan, has been offering credit lines with lower interest rates than those usually practiced by the market, aimed at producers who want to implement sustainable practices on their rural properties. This policy is summarized in Table 1, developed with data provided by the Central Bank of Brazil from 2013 onwards.

As one might see from Table 1, between 2013 and 2021, approximately 24 thousand financing contracts were signed for the implementation of the main techniques, all encouraged by the ABC program (pasture recovery; agro-silvipasture integration; no-tillage; forest management and animal waste management), totalizing an investment of approximately BRL 11 billion. The other financing contracts were also aimed at the implementation of ABC plan techniques, but focused on attending biological/social particularities of some regions of the Country. Among the crops covered by this financing line, açaí, cocoa, olive and walnut farming had 70 financing contracts signed between development agencies and producers, totalizing almost BRL 19 billion.

Table 1 - Credit contracted via ABC Plan from 2013 to 2020.

Subprogram from ABC Plan	Implementation área (ha)	Number of contracts	Amount (BRL)
Recovery of degraded pasture	1,721,584.76	16,705	5,319,314,629.18
No-till farming	1,809,755.90	5,631	4,865,781,897.97
Agro-silvipasture, Agro-Pasture and agroforest systems	1,224,537.52	1,161	711,138,560.60
Forests	103,194.68	905	638,588,567.18
Ambiental regularization and/or adequation	69,062.85	409	239,142,472.32
Animal waste management	244.11	126	76,500,417.96
Soil management	21,844.71	60	48,345,942.17
Açaí, cocoa, olive and walnut farming	1,859.23	70	18,975,923.92
Biological nitrogen fixation	5,001.51	25	18,975,596.57
Organic farming systems	1,455.13	43	15,917,114.46
Bioimputs e biofertilizers	27.00	4	434,076.23
Others	31,669.38	31,422	7,528,545,656.36
Total	4,990,236.78	56,561.00	19,481,660,854.92
Total rural credit		19,187,828	1,596,997,346,366.64

Source: developed by the author based on Sicor – Bacen data (2022).

Alongside the ABC plan, there have been specific programs, such as the National Program for the Strengthening of Family Agriculture (PRONAF, in portuguese), aimed at financing small rural properties, operated almost exclusively by members of the same family with occasional assistance from employees. This sort of line of credit is important because family farming usually is a means of production that has less capital and, consequently, reduced investment capability. Nevertheless, between 2013 and 2021, approximately BRL 1.3 billion were allocated to finance practices in sustainable agriculture in this specific area, as can be seen from Table 2.

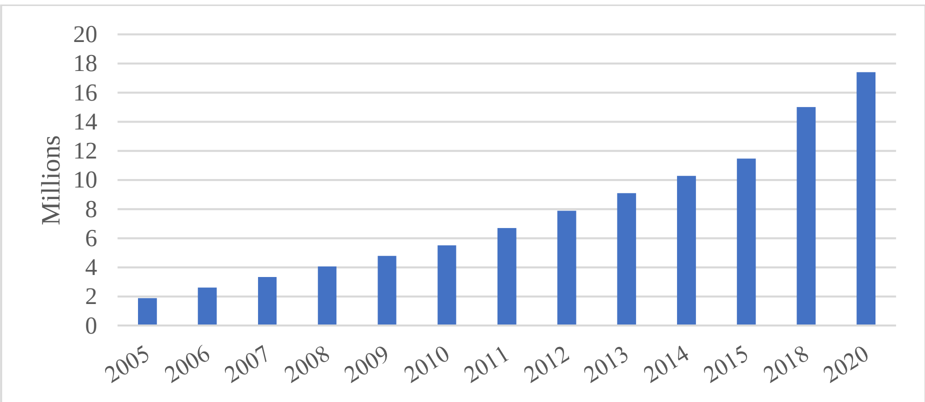
Table 2 - PRONAF contract credits from 2013 to 2020.

Subprogram	Implementation área (ha)	Number of contracts	Amount (BRL)
ECO (renewable energy and environmental sustainability)	11.734,61	14.07	786.209.314,43
Forests	105.384,91	15.82	299.506.936,59
Bioeconomy	584,88	2.80	180.822.212,56
Agroecology	2.407,90	1.94	39.610.919,45
Oriented production	4.429,19	5.71	18.747.317,00
Total	124.541,49	40.34	1.324.896.700,03

Source: developed by the author based on Sicor – Bacen data (2022).

As a result of the dissemination of sustainable agriculture practices through the ABC plan, which include those aimed at carbon sequestration, and the credit facilitation policy for their implementation in rural areas, there was an increase in properties that used agro-silvipasture integration (ILPF, in portuguese), especially in the period between 2010 and 2020, when the total area in which this technique was used grew from 5.51 million to 17.4 million hectares (equivalent to 21 million soccer fields), as shown in Graph 3.

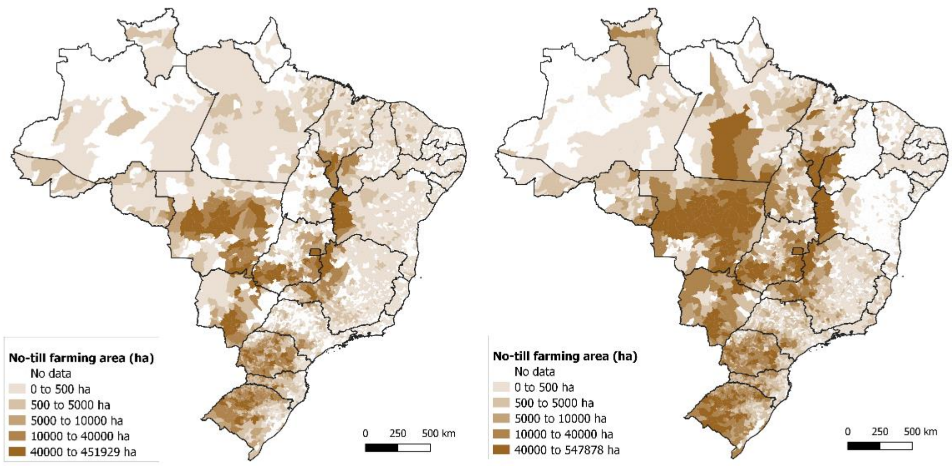
Graph 3 - Area (ha) of ILPF adoption (in ha)



Source: Prepared by the author based on the ILPF Network data (2022).

As for the total area in which the no-till technique was used, it increased from 1.7 million to 33 million hectares (area equivalent to 40 million soccer fields) between 2006 and 2017, according to census surveys carried out by the Brazilian Institute of Geography and Statistics (IBGE, 2022) in both years. As shown in Graph 4, from 2010 to 2020 the expansion of the area of this technique (no-tillage) was almost 17%, surpassing the target of 8% estimated by ABC Plan. As far as the territorial distribution of use of the no-tillage technique, one might note that the intensification of the practice occurred throughout the Brazilian territory, but with greater intensity in the central-west, north and south regions of the country, as shown in Figure 1.

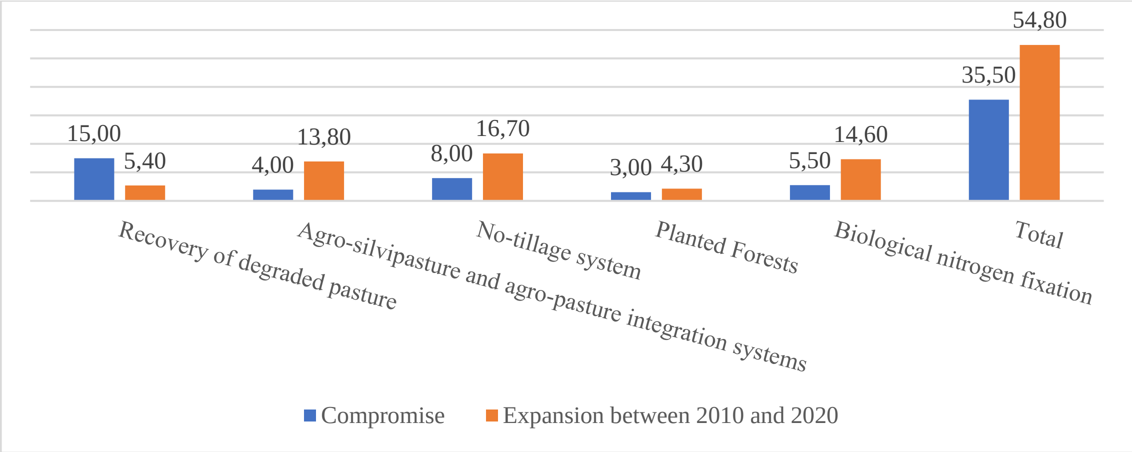
Figure 1 - Maps of the areas (ha) which use of the no-tillage technique (2006 and 2017 respectively)



Source: developed by the author with data from the 2006 and 2017 Agricultural Censuses (IBGE, 2022)

As for the biological nitrogen fixation, there was an increase in the area where the practice was used, from 5.5 million hectares in 2010 to 14.60 million hectares in 2020 (area equivalent to 17.7 million soccer fields) (TELLES et al., 2021). It is also verified an increase of 4.3 million hectares in areas dedicated to planting forests. Thus, considering the goals set by Brazil in the expansion of such practices through ABC Plan, the results are shown in Graph 4 as follows.

Graph 4 - Commitment and results in the expanding the area of low carbon technologies (in million ha)



Source: developed by the author based on the study by Telles et al. (2021, p. 30).

As a conclusion, considering the above data, it is possible to verify a trend towards an increase in the techniques that assist on the carbon sequestration in Brazil. Based on the international commitment made by the Brazilian government at COP15, it is also possible to infer that all those technologies reached the expansion goals outlined at that time, except for the recovery of degraded pastures which, despite showing some growth, was below the initially set goal, as shown in Graph 4.

BETTER PRACTICES IN CONSERVATION AGRICULTURE

Conservation agriculture is commonly defined as the one in which techniques for the preservation and recovery of natural resources are brought together in a systemic way and based on three main axes: maintenance of vegetal cover, minimal intervention in the soil and diversification of planted crops. This topic is intended to analyze the total area, in hectares, where some of these practices of conservation agriculture were adopted in Brazil (FORTINI, 2018, p. 96 *et seq*).

As one might see in table 3, developed according to data from the agricultural census carried out by the Brazilian Institute of Geography and Statistics (IBGE), in 2017 the total area of properties in which at least one of the conservation agriculture techniques was used was 377,845,413 hectares, the most widespread ones being crop rotation (83,753,770 hectares), level planting (71,400,076 hectares) and fallow soil (60,631,363 hectares). Regarding the geographic distribution of the Brazilian territory, it can be seen that conservation agriculture techniques are further-reaching in the

Center-West (129,736,601 hectares), Southeast (92,768,229 hectares) and South (69,907,989 hectares) regions.

Table 3 – Conservationist practices area (ha) in Brazil in 2017

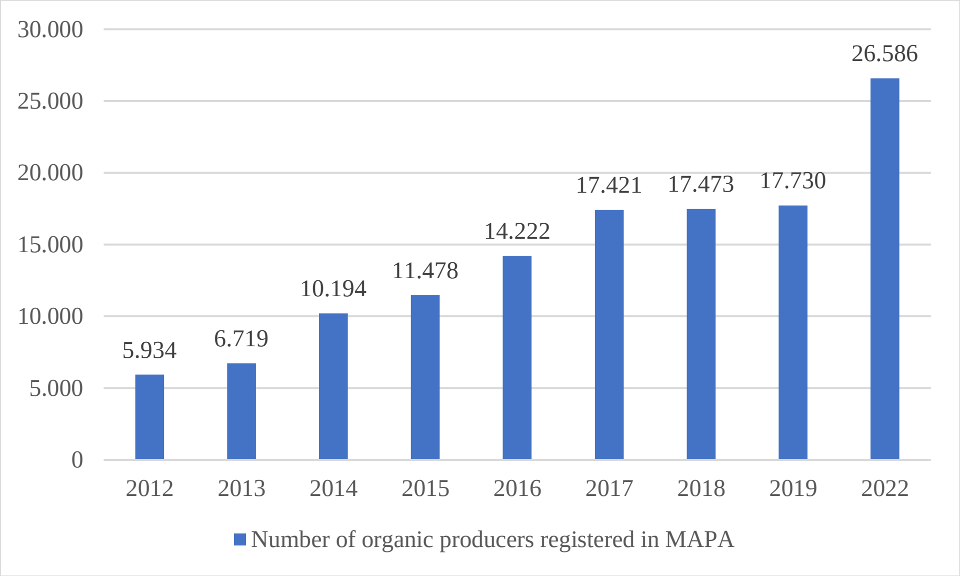
Agricultural Practices	Brazil	North	Northeast	Southeast	South	Center-West
Level planting	71,400,076	3,335,041	7,439,652	21,914,411	12,139,656	26,571,316
Crop rotation	83,753,770	6,641,637	13,614,891	15,633,370	21,612,419	26,251,453
Fallow soil	60,631,363	5,754,620	15,461,056	12,802,574	8,563,674	18,049,439
Protection and/or conservation of slopes	49,938,753	4,386,262	6,533,219	11,650,541	8,876,186	18,492,546
Buffer strips recovery	37,675,512	3,061,022	4,051,321	10,127,690	6,043,254	14,392,224
Reforestation for springs protection	32,415,221	2,664,350	2,937,464	10,266,970	4,885,646	11,660,791
Gully stabilization	19,135,339	986,352	2,402,790	4,879,754	3,370,028	7,496,414
Forest management	22,895,379	3,369,056	2,793,860	5,492,919	4,417,126	6,822,418
Total	**377,845,413**	**30,198,340**	**55,234,253**	**92,768,229**	**69,907,989**	**129,736,601**

Source: developed by the author using data from the 2017 Agricultural Census (IBGE, 2022)

Another area of agriculture with sustainable practices that has been gaining prominence in Brazil is organic agriculture. In Brazil, for qualifying a farmer as an “organic producer”, he must fulfill certain requirements, which demand the non-use of pesticides, chemical fertilizers and transgenics, but require sustainable techniques of land use. These requirements are evaluated and approved by private certifiers accredited by the Ministry of Agriculture, Livestock and Supply (MAPA, in Portuguese). After receiving a certificate, the producer is registered at MAPA and is allowed to identify his production with the “Brazilian organic product” stamp.

According to the data provided by the Ministry of the Environment (MAPA), until May 2022, Brazil had 26,500 farmers registered as organic producers. A growth of 49% when compared to the number of registered producers in 2019, and 449% compared to 2012, when only 5,900 farmers had the registration. Despite the MAPA numbers, it is estimated that the number of organic producers in the country may be higher, considering that in the rural census carried out by IBGE in 2007, ninety thousand rural farmers already declared themselves as organic producers.

Graph 5 - time series of organic producers registered at MAPA



Source: elaborated by the author based on the data available in MAPA

The growth in the number of farmers registered as organic producers is accompanied by the expansion of this market in Brazil. According to the data collected by Organic Promotion Association (ORGANIS, as in portuguese), the organic food market moved BRL 5.8 billion in 2020 alone, a growth of 30% compared to 2019. Also according to the same association, the projection to this sector was to keep growing in the year of 2021, although at a less intense pace due to the economic impacts of the COVID-19 pandemic on the income of Brazilian families..

As for the geographic distribution of organic producers in Brazil, according to the data provided by MAPA for the year 2020, 40% of registered organic producers were located in the South region of the country, followed by the Northeast region, with 24%, and the Southeast region, with 22%. The North and Midwest regions account for 9% and 4%, respectively, as shown in figure 2.

Figure 2 - Geographic distribution of organic producers in Brazil in the year 2020

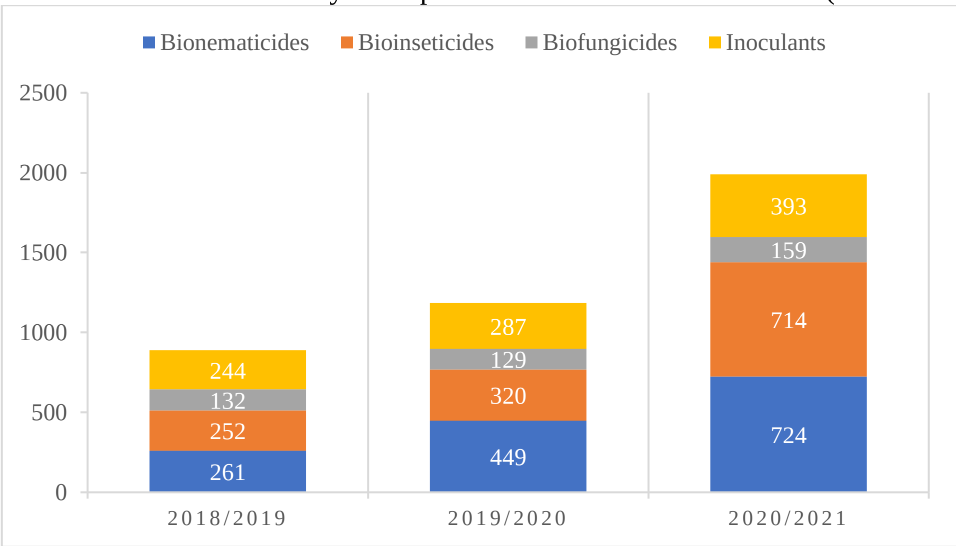
Source: Dall'agnol; Seixas (2021).

Following the growth trend, a field research carried out by ORGANIS has revealed that the expectations of organic producers in Brazil were optimistic for the year 2021, despite the impact of the COVID-19 pandemic on the purchasing power of Brazilians. In that year, 69% of the agents in the Brazilian organic market reported sales growth, 11% declared stabilization on sales and 20% informed a decline. Furthermore, 77% of the producers interviewed had expectation of growth for the rest of that year.

Alonside these phenomena, a survey carried out by Spark Inteligência Estratégica pointed to a growth in the use of bio-inputs by Brazilian agribusiness, constituting a market that moved BRL 1.7 billion in the 2020/2021 cycle, a growth of 37% when compared to the 2019/2020 cycle, when an estimated volume of operations of BRL 1.3 billion was recorded. According to the Brazilian legislation, bio-input is any product, process or technology of plant, animal or microbial origin intended to use in the production, storage and improvement of agricultural products. It is therefore an important resource for the replacement of pesticides and chemical fertilizers with more sustainable means of production.

Also according to the aforementioned report, operations involving biopesticides and bionamaticides lead the bio-input market, with a 43% share of the total amount handled by this field in the 2020/2021 cycle (BRL 724 million), followed by biofungicides, with 9% (BRL 159 million). Bioenoculants, in turn, moved R$ 393 million in the same period, a fraction equivalent to 23% of the entire market. The growth of the bioinput market between the years 2018 and 2021 can be seen in Graph 6.

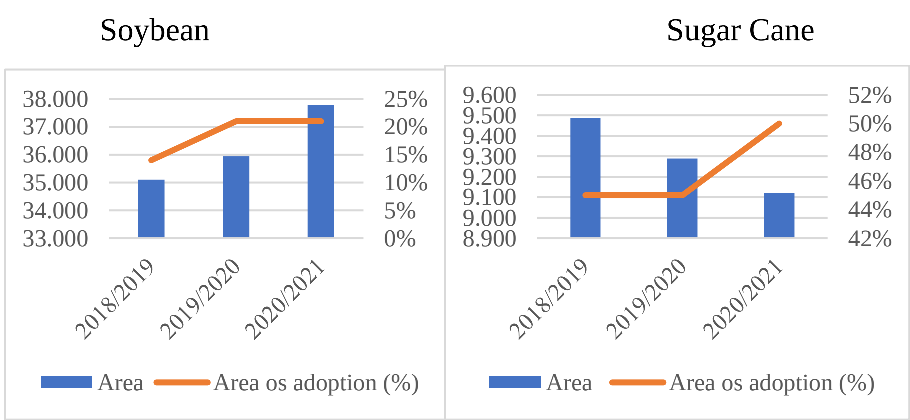
Graph 6 – Total amount handled by bioimputs between 2018-2021 in Brazil (in BRL millions)

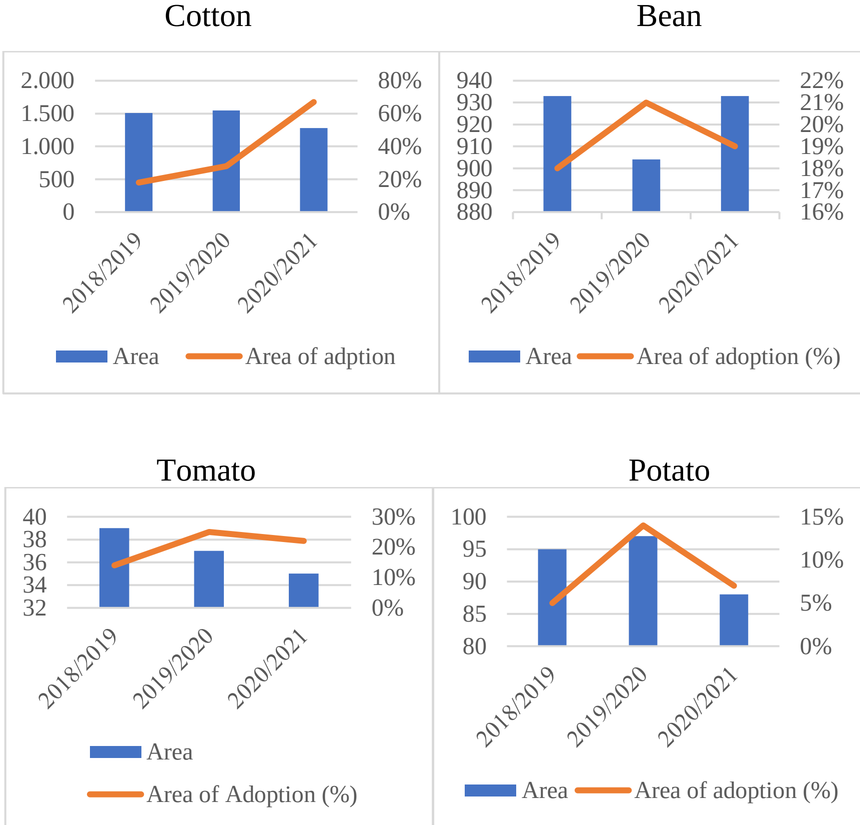


Source: BIP Spark – Market overview – Biological products (SPARK INTELIGÊNCIA ESTRATÉGICA, 2021)

As for areas and crops that use bio-inputs, the Spark report highlights that biopesticides are used in 21% of soybean crops (7.9 million ha), 50% of sugarcane crops (4.5 million ha), and 67% of cotton crops (857 thousand ha). In other kinds of harvests, the report pointed out that the application of pesticides is used by 19% of bean crops (145,000 ha), 5% of coffee crops (102,000 ha), 22% of tomato crops (7,700 ha) and 7% of potato crops (6.16 thousand ha). The growth of each of these bio-inputs between the years 2018 and 2021 is also illustrated by the graphs that follow.

Graph 7 – Area of adoption of bio-inputs in Brazil by crop between 2018 and 2021





Source: BIP Spark – Market overview – Biological products (SPARK INTELIGÊNCIA ESTRATÉGICA, 2021)

On the other hand, the growth of organic agriculture and the use of bio-inputs by the Brazilian agribusiness was not accompanied by a reduction in the usage of fertilizers in the Country. In this scenario, data provided by the Department of Foreign Trade of the Federal Government (MDIC, in Portuguese) indicate that the import of such inputs by Brazil increased from US$ 8.5 billion and 18.8 tons in 2012 to US$ 15.1 billion and 41.5 million tons in 2021. The biggest increase occurred precisely between the years of 2020 and 2021, an 88.9% increase in the amount handled by the importation of these products, while the volume of fertilizers rose 21.39%.

Table 4: Brazilian import of chemical fertilizers

Year	Imports (US$)		Year variation (%)	imports (Kg)	Year variation (%)
2012	$	8,583,863,539.00	-	18,889,124,908	-
2013	$	8,883,485,540.00	3.49	22,676,595,616	20.05
2014	$	8,436,860,994.00	-5.03	24,891,340,718	9.77
2015	$	6,602,676,701.00	-21.74	19,809,853,228	-20.41
2016	$	6,001,878,361.00	-9.10	23,809,188,637	20.19
2017	$	7,327,031,166.00	22.08	28,595,657,605	20.10
2018	$	8,618,214,712.00	17.62	29,539,122,859	3.30

Year		Imports (US$)	Year variation (%)	imports (Kg)	Year variation (%)
2019	$	9,145,642,238.00	6.12	31,139,974,010	5.42
2020	$	8,027,715,871.00	-12.22	34,247,774,434	9.98
2021	$	15,164,542,404.00	88.90	41,572,778,096	21.39

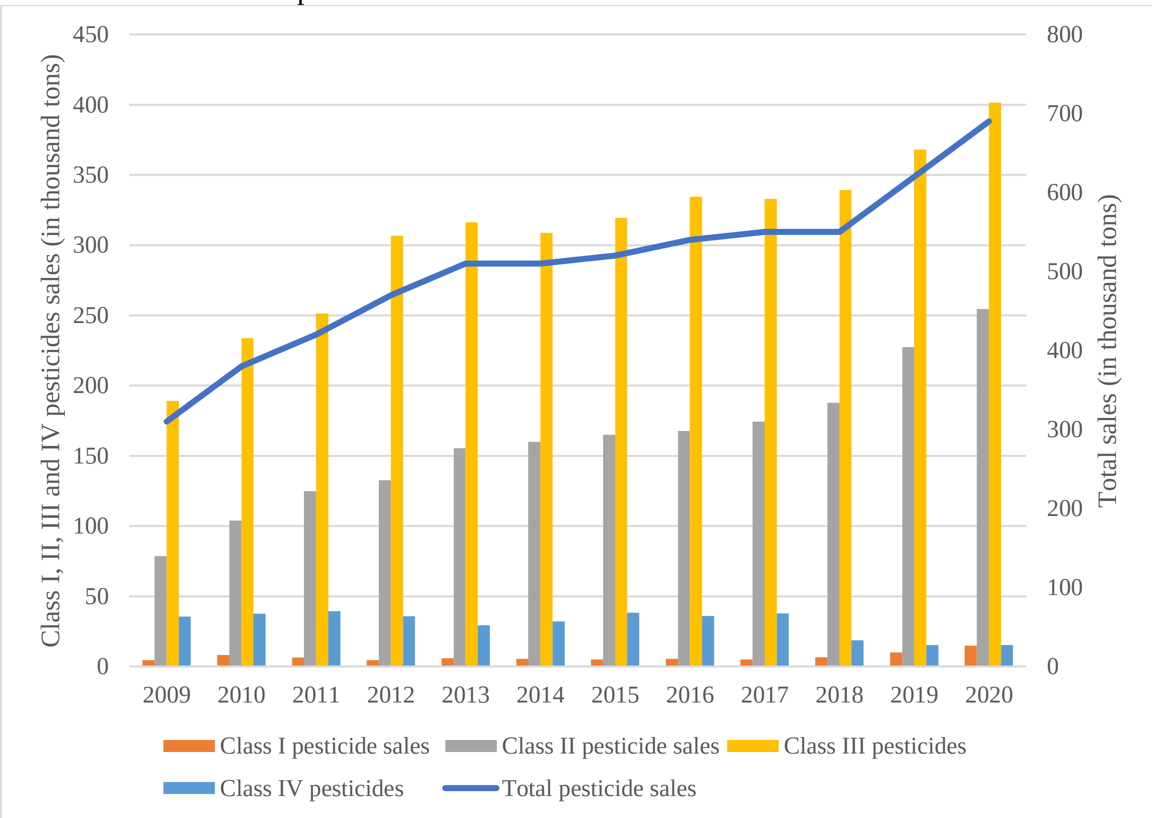
Source: elaborated by the author based on the data available in COMEX STAT - MDIC (2022)

The same upward trend is observed in the usage of pesticides between 2009 and 2020. In total terms, 2009 saw the sale of 0.31 million tons of pesticides, reaching 0.69 million tons in the year 2020. In Brazil, pesticides are classified according to their aggressiveness to the environment by the Roman numerals from I through IV, being “I” is the most aggressive and “IV” is the least aggressive[5].

From such perspective, and in total terms, there was a period of increase in the commercialization of pesticides between 2009 and 2013, going through a period of relative stability between 2014 and 2018, followed by a new period of increase from the year 2019 onwards. Evaluating each pesticide classification stratum, it appears that the pesticides of environmental classification I (the most dangerous to the environment) went from 6.7 thousand tons sold in 2018, reaching 14 7 thousand tons in 2020. The same is observed in relation to pesticides of environmental classification II and III, with only pesticides of environmental classification IV (less aggressive) being the ones which had a reduction in the amount sold, from 38 thousand tons in the year of 2017 to 15.3 million tons in the year of 2020. These trends are best illustrated by the graphs below:

[5] This classification was changed in 2019 by the National Health Surveillance Agency (ANVISA, in portuguese), now having 6 different categories, in which category 1 is the most aggressive to the environment and category 5 is the least aggressive, with products that are not even classified as dangerous because it is understood that they do not pose any environmental risk. Nevertheless, the data provided by the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA, in portuguese) still uses the previous classification, based on 4 categories.

Graph 8: Pesticide sales in Brazil between 2009-2020



Source: elaborated by the author based on data available in IBAMA (2022).

In conclusion, a significant growth of sustainable practices is shown in Brazilian agriculture, especially over the last decade. Likewise, the production of organic food in the Country has increased, as well as the usage of bio-inputs as measurements of sustainable rural production. However, even with the increase in such practices, there has also been an increase in the use of traditional pesticides and fertilizers, possibly due to the spread of their use by rural producers.

REFERENCES

ASSAD, E. D.; MARTINS, S. C.; CORDEIRO, L. A. M.; EVANGELISTA, B. A. Sequestro de carbono e mitigação de emissões de gases de efeito estufa pela adoção de sistemas integrados. **ILPF: inovação com integração de lavoura, pecuária e floresta.** Brasília: Embrapa, p. 153-167, 2019.

COMEX STAT – MDIC. Ministério da Indústria, Comércio Exterior e Serviços. Sistema para consultas e extração de dados do comércio exterior brasileiro, Available online: < http://comexstat.mdic.gov.br/pt/home>. Accessed on: 22/05/2022.

CONAB – Companhia Nacional de Abastecimento. **Série Histórica das Safras**. Available online: <https://www.conab.gov.br/info-agro/safras/serie-historica-das-safras>. Accessed on: 18/04/2022.

DALL'AGNOL, A.; SEIXAS, C. **Produção de orgânicos no Brasil**. 2021. Available online: < https://blogs.canalrural.com.br/embrapasoja/2021/09/06/producao-de-organicos-no-brasil>. Accessed on: 21/05/2022.

FORTINI, R. M. **Adoção de práticas agrícolas conservacionistas e eficiência produtiva na agricultura brasileira.** 2018. 120 f. Dissertação (Mestrado em Economia Aplicada) - Universidade Federal de Viçosa, Viçosa. 2018.

IBAMA - Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis. Available online: <Painéis de informações de agrotóxicos (ibama.gov.br)>. Accessed on 22/05/2022

IBGE – Instituto Brasileiro de Geografia e Estatística. Available online: < https://www.ibge.gov.br/>. Accessed on: 20/04/2022.

MAPBIOMAS BRASIL. Mapas e dados. Available online: < https://mapbiomas.org/>. Accessed on: 18/04/2022.

ORGANIS – Associação de Produção de Orgânicos – Organis aponta crescimento do mercado de orgânicos no 1° semestre de 2021. Available online: <Organis aponta crescimento do mercado de orgânicos no 1° semestre de 2021 – Organis>. Accessed on: 22/05/2022.

Portal da transparência – Despesas do Ministério do Meio Ambiente. Available online: < Ministério do Meio Ambiente - MMA - Portal da transparência (portaltransparencia.gov.br)>. Accessed on: 22/05/2022

REDE ILPF. ILPF em números. Available online: < https://www.redeilpf.org.br/index.php/rede-ilpf/ilpf-em-numeros>. Accessed on: 19/04/2022.

SEEG - Sistema de Estimativas de Emissões e Remoções de Gases de Efeito Estufa. Emissões Totais. Available online: < https://plataforma.seeg.eco.br/total_emission>. Accessed on: 19/04/2022.

SICOR – BACEN – Sistema de Operações do Crédito Rural e do Proagro do Banco Central do Brasil. Available online: < https://www.bcb.gov.br/estabilidadefinanceira/creditorural>. Accessed on: 21/04/2022.

SILVA, Rafael O. S.; BARIONI, Luis G.; MORAN, Dominic. "Fire, deforestation, and livestock: When the smoke clears," *In*: **Land Use Policy**, 2021, Elsevier, vol. 100.

SPARK INTELIGÊNCIA ESTRATÉGICA. BIP Spark – Market overview – Biological products. Available on: <BIP Spark mostra aumento de 37% na movimentação do mercado de produtos biológicos, para R$ 1,7 bilhão | MAIS SOJA - Pensou Soja, Pensou Mais Soja>. Accessed on: 22/05/2022

TELLES, T. S.; VIEIRA FILHO, J. E. R.; RIGHETTO, A. J.; RIBEIR, M. R. **Desenvolvimento da agricultura de baixo carbono no Brasil.** No. 2638. Texto para Discussão, Instituto de Pesquisa em Economia Aplicada – IPEA, 2021.