CONTAG
agricultura familiar e clima

Family farming and food systems: carbon removal and just transition

OBSERVATÓRIO DO CLIMA
SEVEN PUBLICAÇÕES ACADÊMICAS 2025
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EDITOR-IN-CHIEF
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AUTHORS

Ana Luisa Araujo de Oliveira
Agronomist, Doctor in Rural Development
Professor of Higher Education Ceagro/Univasf (Collegiate of Agronomic Engineering/ Federal University of Vale do São Francisco)
E-mail: ana.luisaoliveira@univasf.edu.br

Anderson Cassio Sevilla
Biologist, Doctor in Science
Researcher in Ecology at Embrapa Genetic Resources and Biotechnology
E-mail: anderson.sevilha@embrapa.br

Antônio Lacerda Souto
Pedagogue, Master in Environment and Rural Development
Social Policy Advisor at CONTAG
Email: lacerda@contag.org.br

Carlos Eduardo Pacheco Lima
Environmental Engineer, Doctor in Soils and Plant Nutrition
Researcher in Global Climate Change at Embrapa Vegetables
E-mail: carlos.pacheco-lima@embrapa.br

Eduardo Delgado Assad
Agricultural Engineer, Doctor in *Hydrologie Et Mathematique*
Advisor to the Climate Observatory
E-mail: edu.assad@gmail.com

Evandro Vasconcelos Holanda Junior
Veterinarian, Doctor in Animal Science
Researcher in Sustainable Production Systems
E-mail: evandro.holanda@embrapa.br

Francisco Eden Paiva Fernandes
Animal Technician, Doctor in Animal Science
Technology Transfer Analyst at Embrapa Goats and Sheep
E-mail: eden.fernandes@embrapa.br

Givanilson Porfirio da Silva
Social Scientist, Advisor to the Presidency of CONTAG
Email: givanilson@contag.org.br

Hebert Cavalcante de Lima
Agronomist, Doctor in Food Science
Researcher in Food Science and Technology at Embrapa
E-mail: hebert.lima@embrapa.br

João Paulo Guimarães Soares
Animal Technician, PhD in Animal Science
Researcher in Organic Agriculture and Agroecology at Embrapa Cerrados
E-mail: jp.soares@embrapa.br

João Roberto Correia
Agronomist, Doctor in Soil Science
Researcher in Pedology and Ethnopedology at Embrapa
E-mail: joao.roberto@embrapa.br

Joel Henrique Cardoso
Agronomist, Doctor in Agroecology, Sociology and Sustainable Rural Development
Researcher in Sustainable Production Systems at Embrapa Tropical Agroindustry
Email: joel.cardoso@embrapa.br

Raul Zoche
Technologist in Environmental Management, Specialist in Environmental Management in municipalities
Environmental Advisor of the National Confederation of Rural Workers and Family Farmers (CONTAG)
E-mail: raulzoche@contag.org.br

Walter José Rodrigues Matrangolo
Agronomist, Doctor in Ecology and Natural Resources
Researcher in Agroecology and Organic Production at Embrapa Maize and Sorghum
Email: walter.matrangolo@embrapa.br

PUBLISHER

Carlos Eduardo Pacheco Lima
Environmental Engineer, Doctor in Soils and Plant Nutrition
Researcher in Global Climate Change at Embrapa Vegetables
E-mail: carlos.pacheco-lima@embrapa.br

Felipe Betim Paes Leme Rubinstein
Graduated in International Relations
Master in Journalism and Postgraduate in ESG and Sustainability Management
Editor of the Climate Observatory
Email: felipe.betim@gmail.com

Joana de Barros Amaral
Forest Engineer, Master in Development, Society and International Cooperation
Coordinator of Engagement and Mobilization at the Climate Observatory
Email: joana@oc.eco.br

Leila Salim Leal
Graduated in Social Communication, PhD in Communication
Journalist at the Climate Observatory
Email: leila@oc.eco.br

Raul Zoche
Technologist in Environmental Management, Specialist in Environmental Management in municipalities
Environmental Advisor of the National Confederation of Rural Workers and Family Farmers (CONTAG)
E-mail: raulzoche@contag.org.br

Sandra Paula Bonetti
Secretary of the Environment of CONTAG
06084693946
Email: sandrapaula@contag.org.br

PRESENTATION

The book **"Family Farming and Food Systems: Carbon Removal and Just Transition"**, organized by CONTAG in collaboration with the Climate Observatory, discusses the challenges and opportunities of family farming in the context of the global climate crisis. The publication highlights the strategic role of family farmers in mitigating climate change, emphasizing regenerative production practices, which promote carbon sequestration and the sustainability of food systems.

Family farming accounts for a large part of food production in Brazil and in the world while presenting conditions of increasing climate vulnerability and low financing for adaptation to the new climate reality. The book points out that, although small producers are responsible for relatively low emissions, they are among the most affected by extreme weather events, such as prolonged droughts, intense rainfall, and changes in temperature regimes. These changes directly impact the productivity of crops essential for maintaining food and nutritional security, as well as the rural economy, such as cassava, corn, beans, and vegetables.

By addressing the role of family farming in carbon removal, the work explores how agroecological practices, a no-tillage system for vegetables, an organic system, agroforestry systems, extractivism, family livestock, and sustainable pasture management can contribute to the capture and storage of carbon in soil and plant biomass. The book highlights that biodiverse production systems, such as agroforestry systems and the regeneration of degraded pastures, are effective alternatives to reduce emissions from the agricultural sector and increase the resilience of family farmers in the face of climate change.

However, for this potential to be widely used, more robust public policies and investments directed at family farming are needed. The publication highlights the limitations of the ABC Plan (Low Carbon Agriculture), which, despite its ambitious goals, still lacks specific mechanisms to support small and medium-sized producers. In addition, the lack of technical assistance, infrastructure, and access to credit are obstacles to the adoption of regenerative agricultural practices.

The book also emphasizes the importance of scientific research in obtaining sustainability indicators, measuring the potential for mitigating greenhouse gas emissions, and developing regenerative practices and strategies for adapting family agricultural production systems to global climate change. The absence of systematized data on carbon stock in different production systems, for example, makes it difficult to implement evidence-based policies that can recognize and encourage the practices already adopted by family farmers, as well as those that may be developed.

Among the solutions discussed, the strengthening of agroecology and the bioeconomy emerges as a viable path for the just transition of agriculture. Projects such as Vista Alegre and Crioulo, mentioned in the work, illustrate how valuing traditional knowledge and rescuing local varieties can contribute to food sovereignty and environmental conservation, promoting production chains with low climate impact.

In summary, **"Family Farming and Food Systems: Carbon Removal and Just Transition"** highlights that family farming can be a protagonist in mitigating the climate emergency, as long as it receives the necessary support to expand its positive impact.

SUMMARY

The Family Farming Law (Law nº. 11,326/2006)[1] defines a family farmer and rural family entrepreneur as someone who practices activities in rural areas, in areas of land of up to four fiscal modules, directing the establishment under a family regime, predominantly using labor from the family itself, and whose agricultural activities represent a significant percentage of family income. Under the terms of Decree No. 9,064, of May 31, 2017[2], at least 50% of this income must come from the establishment's economic activities.

Under the terms of the law, family farmers are considered to be foresters (those who cultivate or manage native or exotic forests with a view to environmental sustainability); aquaculture farmers who occupy a total area of up to 2 hectares or 500 m³ of water; extractivist who carry out artisanal activities in rural areas (excluding miners and sparklers); fishermen and fisherwomen who carry out fishing activity by hand; in addition to indigenous people, members of remaining communities of rural quilombos and other traditional peoples and communities that meet the requirements defined by legislation.

According to the 2023 Family Farming Yearbook[3], produced by the National Confederation of Rural Workers and Family Farmers (Contag) in collaboration with the Inter-Union Department of Statistics and Socioeconomic Studies (Dieese), Brazilian family farming, if it were a country, would be the eighth largest food producer in the world. It is present in all regions of Brazil. The Northeast concentrates 46.6% of the Brazilian family farming establishments, followed by the Southeast (16.5%), South (16.0%), North (15.4%) and Central-West (5.5%). It accounts for 3.9 million establishments (77% of the total number of rural establishments) with only 23% of the rural area in Brazil, which shows that Brazil maintains a high concentration of land.

Family farming employs 67% (10.1 million) of the people working in agriculture in the country, accounts for 23% (R$ 107 billion) of the gross value of production, the income of 40% of the economically active population of the country, and the economic dynamism of 90% of Brazilian municipalities with up to 20 thousand inhabitants (68% of the total), according to the 2017 Agricultural Census carried out by the Brazilian Institute of Geography and Statistics (IBGE).

[1] BRASIL. **Lei Nº 11.326, de 24 de julho de 2006.** Brasília: Presidência da República, 2006. Available at: https://www.planalto.gov.br/ccivil_03/_ato2004-2006/2006/lei/l11326.htm. Accessed on: 11 Feb.2025.
[2] BRASIL. **Decreto Nº 9.064, de 31 de maio de 2017**. Brasília: Presidência da República, 2017. Available at: https://www.planalto.gov.br/ccivil_03/_ato2015-2018/2017/decreto/d9064.htm. Accessed on: 11 Feb.2025.
[3] CONTAG. **Anuário Estatístico da Agricultura Familiar - 2023 / Ano 2.** Brasília: 2023. Available at: https://ww2.contag.org.br/documentos/pdf/17916-696048-anua%CC%81rio-agricultura-2023-web-revisado.pdf. Accessed on: 13 Nov. 2024.

According to the Brazilian Agricultural Research Corporation (Embrapa) "the sector stands out for the production of corn, cassava root, dairy cattle, beef cattle, sheep, goats, vegetables, beans, sugarcane, rice, pork, poultry, coffee, wheat, castor beans, fruit crops, and vegetables". The agency also indicates that, "in permanent crops, the segment accounts for 48% of the value of coffee and banana production; in temporary crops, they are responsible for 80% of the production value of cassava, 69% of pineapple and 42% of the production of beans". [4] In socio-biodiversity products, this percentage is approximately 83.9%, considering the production, for example, of babassu, Brazil nuts, cupuaçu, pupunha, and açaí[5] (IBGE, Census

The relevance of family farming for the planet is reflected in data from the Food and Agriculture Organization of the United Nations (FAO). According to this UN agency, "there are more than 608 million family farms worldwide, occupying between 70% and 80% of agricultural land and producing about 80% of the world's food in terms of value" and 35% of the total food produced in the world (FAO, 2021). It is no coincidence that the United Nations Decade for Family Farming (UNOAF 2019-2028) was declared.

With its multifunctionality and multidimensionality, family farming is strategic for food and nutritional sovereignty and security, the generation of occupations and income, environmental protection, and the identity of rural culture.

However, the production of healthy and sustainable food is threatened by climate change. The world has become warmer as a result of the emission of greenhouse gases into the atmosphere by human activities, especially since the Industrial Revolution of the eighteenth century. Capable of threatening the very existence of life on Earth, there is a scenario of imminent catastrophe that challenges governments and society around the world — both those of developed countries, historically the largest emitters of greenhouse gases, such as those of developing countries, which are generally less resilient to climate change.

Although global, the effects of climate change are not felt equally. Acting as a vector for deepening inequalities, the climate crisis has the characteristic of hitting hardest those who have been least responsible for it. One of the sectors strongly affected by the disruption of climate systems resulting from global warming is agriculture, an activity sensitive to environmental factors. Worldwide, changes in rainfall patterns, intense rainfall, flooding, droughts, heat waves, and other increasingly frequent and intense events affect crops, animal husbandry, and socio-biodiversity,

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[4] EMBRAPA. **Agricultura Familiar**. s/d. Available at: https://www.embrapa.br/tema-agricultura-familiar/sobre-o-tema. Accessed on: 11 Feb.2025.

[5] IBGE. **Censo agropecuário: resultados definitivos 2017**. Rio de Janeiro, 2019. Available at: https://censoagro2017.ibge.gov.br/templates/censo_agro/resultadosagro/pdf/agricultura_familiar.pdf. Accessed on: 11 Feb.2025.

causing significant losses in crops, putting at risk the livelihoods of rural workers, food sovereignty, and local economies. This phenomenon is already happening in Brazilian agriculture.

In the countryside, family farmers are the most vulnerable and most affected, even though their activities are not the main emitters of gases that cause the warming of the planet. Typical Brazilian crops, such as cassava, corn, and beans, will be seriously impacted by the loss of productivity due to climate anomalies, thus compromising food sovereignty and security. With increasingly high temperatures, global warming manifests itself in more frequent and severe periods of drought, in the increase in the number of fires, in the loss of crops, in more intense storms, in the melting of glaciers in various parts of the world and in the rise in sea levels, which also threaten the activities of family farming developed in coastal regions. All these phenomena have become part of the lives of family farmers more frequently and are being felt in the countryside, in the forest, in the waters, and the cities.

Data from the Ministry of Science, Technology and Innovation (MCTI), compiled by the Amazon Environmental Research Institute (Ipam),[6] Showed that 762 Brazilian cities have a high risk to food security in the event of drought, with a concentration in the Northeast region. In an optimistic projection for 2030 (considering the reduction in the concentration of greenhouse gases in the atmosphere and the control of global warming), this number would rise to 1,883 cities.

Family farming, through its biodiverse production systems, has low emissions and great potential for carbon removal and should be understood as part of the solution to climate change. Among its strengths is the development of food systems based on traditional and sustainable production practices, with crops and management, integrated with the natural dynamics of the biomes, the optimization of production in a harmonious way with low dependence on external inputs, and the supply of food in short chains, among other factors.

However, to scale up this potential, historical guidelines of family farming need to be met. Among them are the implementation of public policies for the universalization of technical assistance, the guarantee of technology and agricultural research aimed at sustainable biodiverse food systems, support for short marketing chains, the expansion of credit, and easy access to crop insurance and guarantees. It is also important to consider a fair and inclusive land policy that guarantees access to land for farmers, who are currently pressured by the advance of agribusiness and its extensive crops.

Access to knowledge and the development of advanced scientific methods is urgent to qualify and quantify the role of different ecosystems and agrifood systems in mitigating greenhouse gas emissions and adapting to climate change. This data is fundamental to confronting conventional

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[6] IPAM. **Mudanças climáticas e nossa alimentação**. Disponível em: https://mailchi.mp/ipam/a-crise-climtica-tambm-uma-crise-alimentar?e=45a995fc91Accessed on: 11 Feb.2025.

agribusiness production systems and their sustainability narratives. They are also important to guide decisions on charging for the effects of the negative externalities produced by these systems – such as excessive water consumption, silting of rivers, contamination of soils, water, people and elimination of pollinators by the indiscriminate use of pesticides, among other factors – since these losses are socialized with the State and society, while profits are private.

The exodus of rural workers and the dismantling of support systems for family farming are a wake-up call. Without changing the orientation and priority of public policies for the countryside, Brazil will continue to fuel the climate catastrophe, sacrificing the opportunity to be a global leader in combating the crisis and putting the country's food sovereignty at risk.

Despite the inequalities and difficulties in accessing production and marketing technologies, credit, technical assistance, and infrastructure, family farming produces 23%[7] Of the gross value of agricultural production 23% of the areas of rural establishments, present a productive efficiency equivalent to that of agribusiness, which has a list of public policies to stimulate production with little or no restrictions.

Precisely for this reason, family farming is fundamental not only for the self-consumption and direct reproduction of rural workers and their families, but also for the guarantee of Brazilian food sovereignty and security. By affecting agriculture, especially family farming, the climate crisis also expresses a crisis of food and nutritional security and the worsening of social inequalities in Brazil.

The combination of climate change, losses in agriculture, and a Brazil that has once again been ravaged by hunger is explosive. A report by the Food and Agriculture Organization of the United Nations (FAO), published in July 2023,[8] Showed that 21.1 million people went hungry in Brazil in the previous year and were in a situation of severe food insecurity. Another 70.3 million were in a state of moderate food insecurity, which indicates difficulty in feeding themselves.

[7] IBGE. **Censo agropecuário: resultados definitivos 2017**. Rio de Janeiro, 2019. Available at: https://censoagro2017.ibge.gov.br/templates/censo_agro/resultadosagro/pdf/agricultura_familiar.pdf. Accessed on: 11 Feb.2025

[8] FAO. **The State of Food Security and Nutrition in the World 2023.** 2023. Available at: https://openknowledge.fao.org/server/api/core/bitstreams/f1ee0c49-04e7-43df-9b83-6820f4f37ca9/content/cc3017en.html. Accessed on: 13 Nov. 2024.

2.1 GLOBAL WARMING AND GEOPOLITICAL CONTEXT

A scenario of imminent catastrophe, capable of threatening the very existence of life on Earth, challenges governments around the world. The international community, under the leadership of the United Nations (UN), is racing against time to avoid the worst-case scenarios predicted by science – while still adopting vacillating and timid stances to contain its emissions, by avoiding, for example, setting a clear horizon for the end of fossil fuels, or failing to fulfill the promise to finance the energy transition of developing countries.

Climate change is mainly caused by emissions from the burning of fossil fuels for energy generation, which intensifies the greenhouse effect and warms the planet. According to the UN's Intergovernmental Panel on Climate Change (IPCC), [1]Which brings together scientists from around the world to monitor global warming, about 80% of global greenhouse gas emissions come from the energy, industry, and transport sectors. The remaining 20 percent comes from agriculture, forestry, and other forms of land use, especially deforestation.

This proportion is reversed in the Brazilian case: changes in land use, such as deforestation and the conversion of native vegetation into pasture and production areas (mainly *commodities*) for agriculture, account for most of the gross emissions — 46% in 2023. Adding these emissions to that of the agricultural sector itself, it is concluded that agriculture as a whole account for 74% of the greenhouse gases released by Brazil into the atmosphere, as shown in the report of the Greenhouse Gas Emissions Estimation System of the Climate Observatory (SEEG) released in 2024.[2]

In its synthesis report released in 2023[3], the IPCC issued the following warning: "Global surface temperature was 1.09°C higher in the decade 2011–2020 than in 1850–1900 [pre-industrial levels], with greater increases over land (1.59°C) than over the ocean (0.88°C)". Also according to the IPCC, "global surface temperature has increased faster since 1970 than in any other 50-year period, at least in the last 2,000 years".

The rapid increase in global temperature since the end of the nineteenth century is an unprecedented phenomenon, which can only be explained by human activities. The average global temperature is higher today than in other warm periods in at least 100,000 years, according to scientists. Science refutes the idea that solar activity or volcanic eruptions, as well as changes in the

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[1] IPCC. **AR6 Synthesis Report: Climate Change 2023**. 2023. Available at: https://www.ipcc.ch/report/sixth-assessment-report-cycle/. Accessed on: 11 Feb. 2025.

[2] SEEG, 2024. **Análise Das Emissões De 1970-2023: Gases De Efeito Estufa e suas Implicações Para as Metas Climáticas Do Brasil.** 2024. Available at: https://oc.eco.br/wp-content/uploads/2024/11/FINAL_SEEG_emissoes_2024_v7.pdf. Accessed on: 13 nov. 2024..

[3] IPCC, ref 8, chapter 1.

planet's orbit, natural phenomena that could influence the climate, are responsible for the rapid increase in global temperature.

Several international meetings and agreements in recent years have sought to reduce emissions. The most important of these, the Paris Agreement[4], signed in 2015 during the Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC), recognized that climate change was already inevitable, but determined that countries should keep the increase in global temperature "well below" 2°C compared to pre-industrial levels (1850-1900) and strive to limit this increase to 1.5°C, to ensure the survival of species — including humans — and biodiversity.

To this end, signatory countries were urged to present comprehensive targets for reducing their emissions, through the so-called Nationally Determined Contribution (NDC). These NDCs can be reviewed and updated at any time (as long as the shift is to more ambitious targets), although a renewal of commitments is expected every five years.

To achieve the goal of limiting the temperature increase to 1.5°C, the UN estimates that global emissions must be reduced by 45% by 2030 compared to 2019 levels, until reaching the level of zero net emissions in 2050[5] – reducing gas emissions as much as possible and compensating for what cannot be eliminated. This long-term campaign is called "Net Zero 2050" by the UN and seeks to mobilize countries around its larger goal of achieving carbon neutrality by mid-century.

The Paris Agreement also recognized, based on the principle of common but differentiated responsibilities, that developing countries will take longer to achieve this goal. For this reason, it was established that developed countries, which have contributed the most to global warming (and which have benefited the most from the economic model built from large-scale greenhouse gas emissions), must provide financial resources and mobilize other sources of financing to assist developing nations in actions to mitigate and adapt to climate change.

At the time, rich nations committed to developing countries to make contributions of US$100 billion per year to contribute to this energy transition. The commitment, which should have been implemented from 2020, however, was not materialized.

Weeks before COP29, the UNFCCC released a report.[6] Stating that, without the contribution of rich countries, current climate goals would lead to a 0.8% increase in greenhouse gas emissions in

[4] UNFCC. **Paris Agreement to the United Nations Framework Convention on Climate Change**. Paris, December 12, 2015. Disponível em: https://unfccc.int/sites/default/files/english_paris_agreement.pdf. Accessed on: 11 Feb. 2025.
[5] ref 8, chapter 1.
[6] UNFCCC. **Nationally determined contributions under the Paris Agreement. Synthesis report by the secretariat**. Available at: https://unfccc.int/documents/641792. Accessed on: 11 Feb. 2025.

2030. In the same period, the United Nations Environment Program (UNEP) showed[7] That greenhouse gas emissions hit a new record in 2023 and reached 57.1 gigatons of CO2 equivalent (CO2e), an increase of 1.3% compared to the previous year.

Even if at a slower pace than during the signing of the Paris Agreement, the discharge of greenhouse gases into the atmosphere continues to increase. This slowdown in the increase in emissions, the agency warned, is insufficient, since only a drastic reduction in climate pollution will give the planet a chance of reaching the goal of limiting warming to 1.5ºC above pre-industrial levels. At the current pace of emissions, UNEP said, we are heading for a "catastrophic" warming of 3.1ºC by the end of this century.

The consequences of climate inaction are increasingly visible: in December 2024, the European climate observatory Copernicus confirmed[8] 2024 is the warmest year on record, with the global temperature exceeding the pre-industrial level (1850-1900) by more than 1.5°C. Exceeding 1.5º in one year does not (yet) mean that the Paris Agreement has been definitively violated (the goal refers to the sustained temperature in the long term, and not in a specific year). But it indicates, according to Copernicus, that ambitious climate action is "more urgent than ever".

2.2 BRAZILIAN EMISSIONS

As mentioned, changes in land use and agriculture accounted for 74% of Brazilian emissions in 2023, according to SEEG.[9] On the one hand, deforestation generates emissions of polluting gases, mainly by releasing carbon that is stored in trees, and forests lose the ability to absorb carbon dioxide from the atmosphere. On the other hand, food systems involve activities that generate carbon dioxide and methane emissions.

In detail, the SEEG report showed that, in 2023, changes in land use were responsible for 46% of total Brazilian emissions; Next comes the agricultural sector, which accounts for 28% of total emissions. Then comes energy production, with 18%, waste management, with 4%, and industrial processes, with 4%.

Emissions from deforestation and agriculture gain prominence in the Brazilian context due to the weight of agribusiness production chains — which represented, in 2022, 24.8% of the country's Gross Domestic Product (GDP), according to the calculation of the Center for Advanced Studies in

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[7] PNUMA**. Emissions Gap Report**. 2024. Available at: https://www.unep.org/resources/emissions-gap-report-2024. Accessed on: Feb. 2025.

[8] OBSERVATÓRIO DO CLIMA. Dados de novembro confirmam 2024 como ano mais quente. 2024. Available at: https://www.oc.eco.br/dados-de-novembro-confirmam-expectativa-de-2024-como-o-ano-mais-quente/. Accessed on: Feb. 25.

[9] IPCC. **AR6 Synthesis Report: Climate Change 2023**. 2023. Available at: https://www.ipcc.ch/report/sixth-assessment-report-cycle/. Accessed on: 11 Feb. 2025.

Applied Economics (Cepea/Esalq/USP) in partnership with the Confederation of Agriculture and Livestock of Brazil (CNA). The calculation uses a different methodology from the IBGE: according to the agency, agriculture accounts for 7.14% of the Brazilian GDP (2023 data).[10]

Of the total gross emissions from land use change in 2023, 98% came from deforestation (1.04 billion CO_2 equivalent). Of this total, 65% (678 million tons) are the result of deforestation in the Amazon, followed by the Cerrado, with 19% (202 million tons).

Driven by the production model of part of Brazilian agribusiness, deforestation is linked to the expansion of the agricultural frontier and the opening of pastures, practices adopted by extensive monoculture models, and the production of *commodities*, such as soybeans and meat, for export. According to the 2023 Deforestation Report, by Mapbiomas, only 0.96% of the properties registered in the CAR had deforestation records last year, but they accounted for 89.1% of the entire deforested area in the country.[11]

Agriculture, the second most emitting sector in Brazil, recorded its fourth consecutive record and dumped 631 million tons of CO_2 equivalent into the atmosphere in 2023. The figure represents an increase of 2.2% compared to the previous year, when 618 million tons of CO2e were emitted by the sector.

This includes emissions resulting from digestion by herds of ruminant animals (a process known as "ox belching"), which emits methane gas, from the treatment and disposal that the waste of these animals receives, from the cultivation of rice in the irrigated regime, from the burning of agricultural residues from the cultivation of sugarcane and cotton, and from the way agricultural soils are managed, which includes the use of inputs to increase nitrogen.

Of the sector's total emissions, agriculture accounted for 20% (127.6 million tons of CO_2e), and livestock, 80% (503.5 tons of CO_2e), with an increase of 5% and 1%, respectively, compared to 2022.

2.3 BRAZILIAN POLITICAL CONTEXT

Amid international efforts to limit global warming, Brazil is ahead as it is historically one of the countries with a strong presence of renewable energy in its electricity matrix. While the share of renewables in the world is still around 30% of all electricity produced, in Brazil this number was

[10] IBGE, 2024. **Cálculo do PIB**. Available at: https://www.ibge.gov.br/explica/pib.php. Accessed on: Feb. 25.
[11] MAPBIOMAS, 2024. **RAD 2023 - Relatório Anual do Desmatamento no Brasil.** Available at: https://brasil.mapbiomas.org/2024/05/28/matopiba-passa-a-amazonia-e-assume-a-lideranca-do-desmatamento-no-brasil/. Accessed on: 19 nov. 2024.

89.2%, if considering the share imported from Itaipu, and 93% considering only the National Interconnected System (SIN), according to data from the National Energy Balance (BEN) 2024.[12]

Even so, the country is the fourth largest historical emitter of greenhouse gases and currently the fifth largest global emitter, with a net emission of 1.65 billion tons of CO2e, according to SEEG data for 2023. When analyzing gross emissions, that is, without the removal of carbon from the atmosphere, the figure reaches 2.3 billion tons of CO2e.

By ratifying the Paris Agreement in the National Congress, on September 12, 2016, Brazil made official the initial goal of reducing, by 2025, greenhouse gas emissions by 37% below 2005 levels. The next commitment would be to cut emissions by 43% by 2030 compared to 2005 levels.

"To this end, the country has committed to increasing the share of sustainable bioenergy in its energy matrix to approximately 18% by 2030, restoring and reforesting 12 million hectares of forests, as well as achieving an estimated 45% share of renewable energy in the composition of the energy matrix in 2030," says the Ministry of the Environment.[13]

Under the Jair Bolsonaro government (2019-2023), Brazil aligned itself with climate denialism, promoting accounting maneuvers in its NDC that would result, in practice, in a commitment to lower emissions reductions. The course was corrected in the third government of Luiz Inácio Lula da Silva (2024 – current). In September last year, at the UN General Assembly, the president announced, in another update of the NDC, that Brazil should reduce its emissions by 48% by 2025 and by 53% by 2030, based on the 2005 levels updated in the latest inventory of Brazilian emissions. The government also reiterated the goal of achieving net-zero emissions by 2050 and pledged to zero deforestation in the Amazon by 2030, achieving so-called net-zero deforestation — in which new deforested areas are offset by recovered forest areas.

This commitment to zero deforestation in the Amazon, together with incentives for low-carbon agriculture via the Crop Plan and other public policies, which cover all biomes and regions, was made after years of setbacks in the fight against deforestation. If successful, these initiatives bring enormous potential to reduce Brazilian emissions.

The data show that Brazilian emissions peaked in 2003 and began to fall in the following years, following the drop in deforestation. They rose slightly again with the return of the devastation process from 2013 onwards. The graphs below (figures 1, 2, and 3) indicate how these two processes went together.

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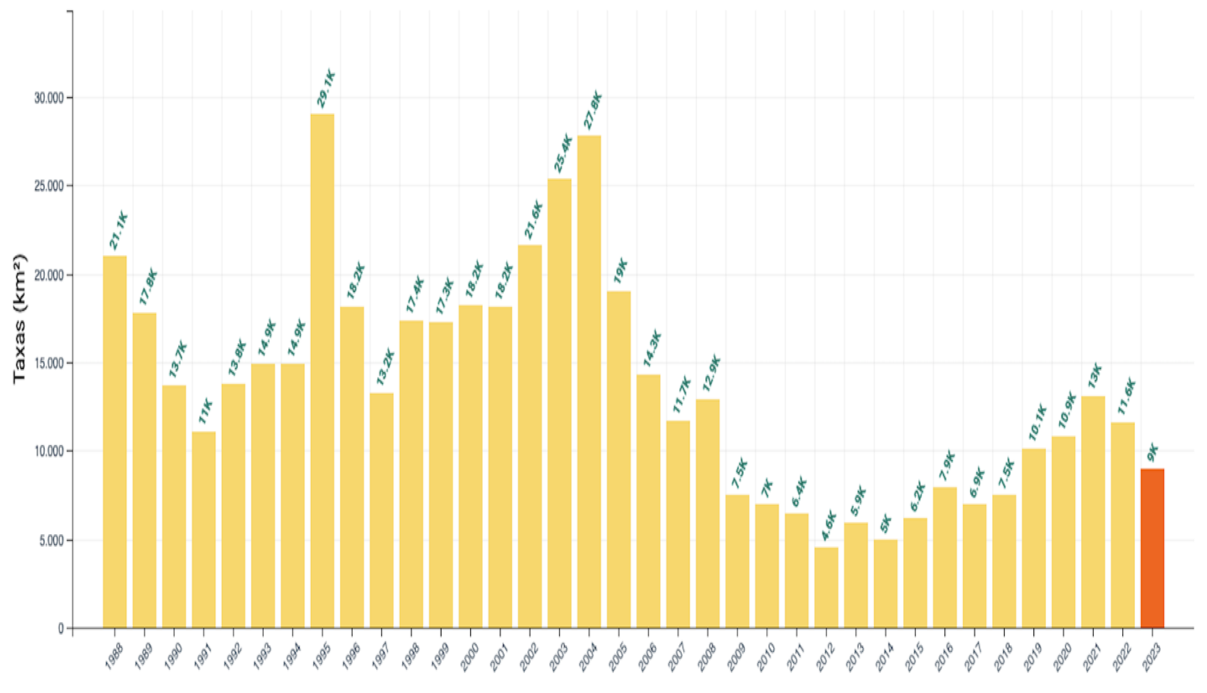
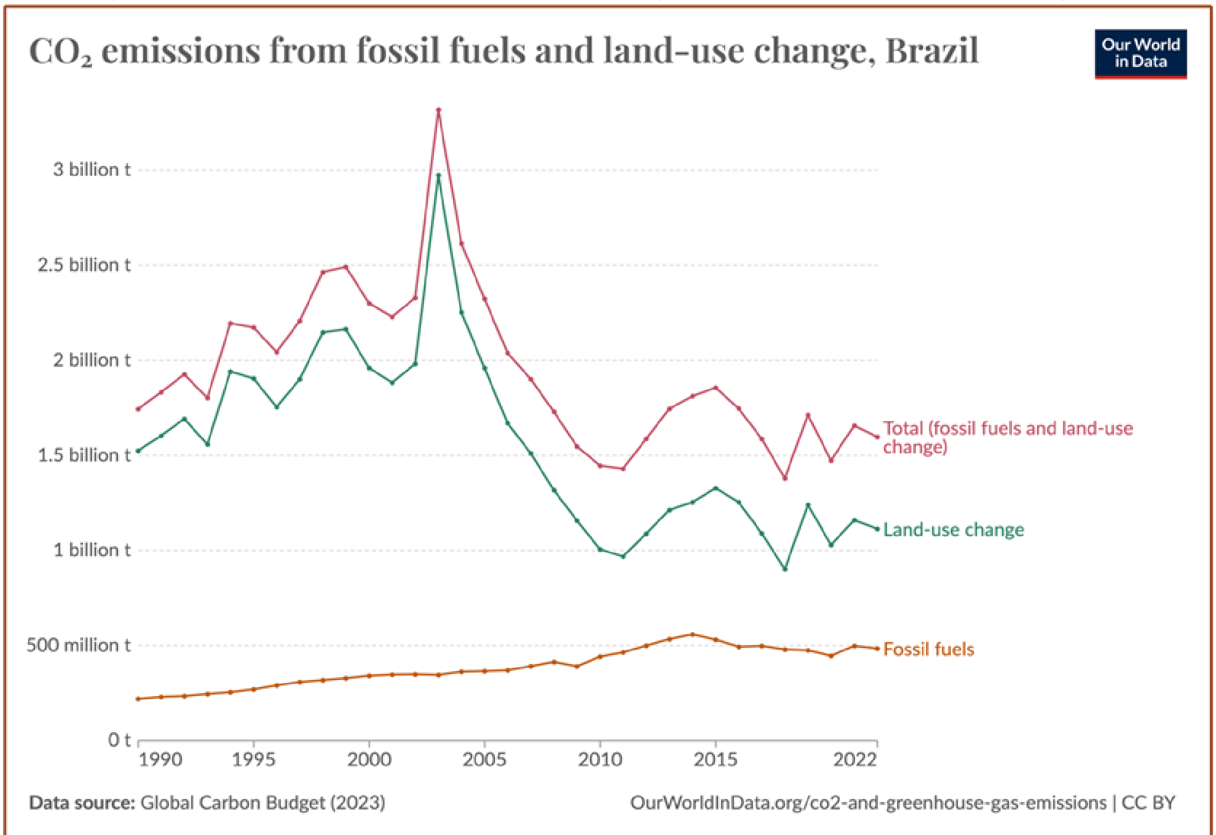
[12] EPE, 2024. **National Energy Balance (BEN) 2024 - Synthesis Report.** Available at: https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-819/topico-715/BEN_S%C3%ADntese_2024_PT.pdf. Accessed on: 13 nov. 2024.
[13] MMA, 2025. **Paris Agreement.** Available at: https://antigo.mma.gov.br/clima/convencao-das-nacoes-unidas/acordo-de-paris.html. Accessed on: 13 Nov. 2024.

Figure 1 - Deforestation in the Amazon between 1988 and 2023.



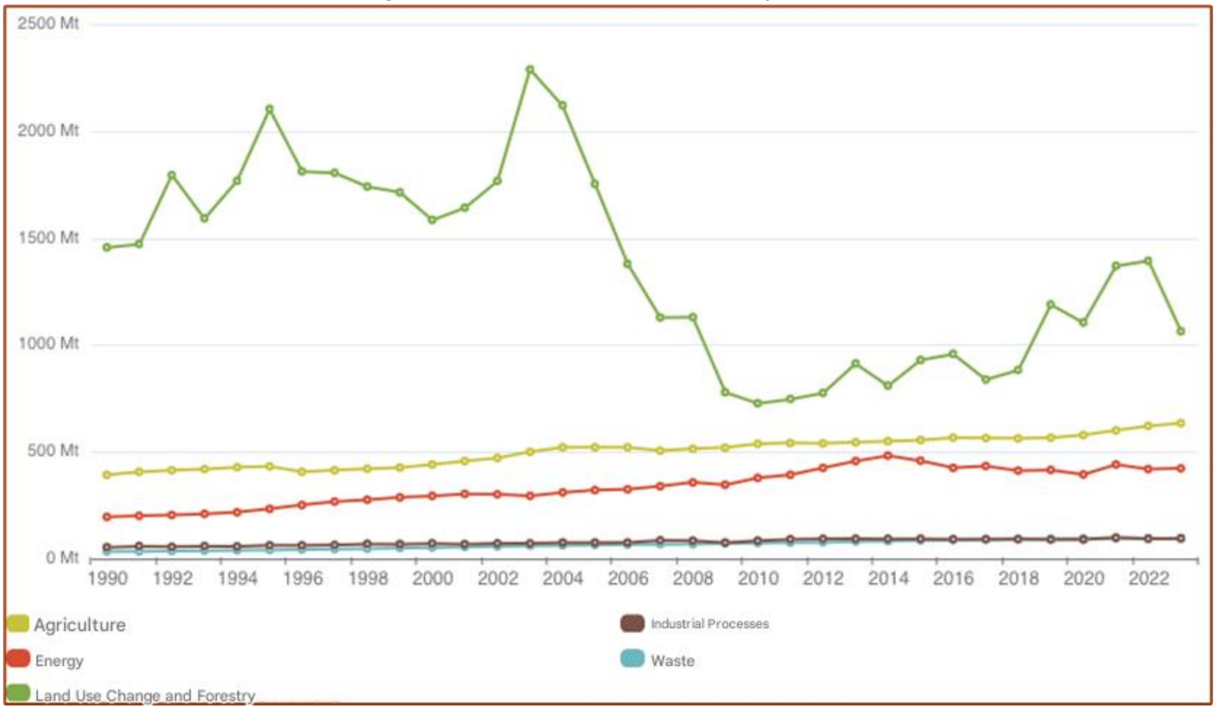
Source: Prodes/INPE.

Figure 2 - Brazilian emissions from fossil fuels, changes in land use, and the two sectors together.



Source: Global Carbon Budget.

Figure 3 - Gross emissions in Brazil by sector.



Source: SEEG.

As most of the Brazilian electricity matrix is already composed of renewable sources, with hydroelectric plants consolidated for decades and the recent advance of wind and solar sources – with a series of socio-environmental impacts that need to be faced, it should be noted – it is possible to conclude that Brazil has been focusing its efforts on combating deforestation and promoting low-carbon agriculture to reduce its emissions.

But even these efforts may be in vain if the country does not make the energy transition, as the country is still very dependent on fossil fuels. When looking at the energy matrix in its entirety – that is, all the energy produced, including that directed to the transport sector, the industrial sector, and others – Brazil still has 50.9% of non-renewable sources.[14] Therefore, even though it is a renewable energy power for electricity generation, non-renewable sources still represent more than half of the energy produced in the country.

As shown in Figure 3, emissions from the energy sector have practically doubled since 1990 and have stabilized at a level close to 500 million tons of CO_2e.[15], contradicting the Brazilian discourse and the image of global leadership in the fight against climate change that the country wants to project.

[14] EPE, 2024. **Balanço Energético Nacional (BEN) 2024 - Relatório Síntese.** Available at: https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-819/topico-715/BEN_S%C3%ADntese_2024_PT.pdf. Accessed on: 13 nov. 2024.

[15] IPCC. **AR6 Synthesis Report: Climate Change 2023**. 2023. Available at: https://www.ipcc.ch/report/sixth-assessment-report-cycle/. Accessed on: 11 Feb. 2025.

On the first day of COP29, Brazil committed to limiting, in 2035, its net emissions in a "range" ranging from 59% to 67% reduction compared to 2005 levels (about 2.5 billion tons of CO_2e). This translates into a limit, in 2035, of 1,050 million tons of CO_2e (less ambitious) to 850 million tons of CO_2e (more ambitious). These numbers are consolidated in the new Brazilian NDC.[16]

For the Climate Observatory, Brazil's NDC should be even more ambitious. The organization advocates that Brazil adopt the commitment to reduce its net emissions by 92% by 2035, in order to ensure that the planet's global temperature does not exceed 1.5oC. This would mean a commitment to limit Brazilian net emissions to 200 million tons of CO_2e in 2035, considering carbon in agricultural soils and without taking into account removals by protected areas.[17]

The Climate Observatory also believes that, due to the strong presence of renewable energy in Brazil, our country can become the first major economy in the world to capture more greenhouse gases than it emits. Thus, instead of reaching zero net emissions in 2050, Brazil has the potential to become carbon-negative by 2045.

2.4 VULNERABILITY OF FOOD SYSTEMS AND THE NEED FOR MITIGATION AND ADAPTATION TO CLIMATE CHANGE

The last 30 years have been marked by the progressive intensification of extreme weather events in all regions of Brazil. In the Northeast, prolonged droughts have become stronger and more frequent, directly affecting food production and access to water by family farming. In the North, the Amazon has been hit by unprecedented droughts, which have significantly reduced the riverbed, compromising life in the forest and local communities. In the Midwest, the Cerrado, which had well-defined periods of drought and rainfall, is now getting hotter and drier, with less climate predictability.

In the South and Southeast regions, droughts are more frequent and intense, since rainfall is concentrated in short periods, which causes landslides and floods. In 2023, the state of Rio Grande do Sul experienced nine extratropical cyclones in a three-month interval. The following year, it suffered torrential rains that caused floods and landslides, which resulted in the largest flood in history. In addition to the economic losses and loss of life, these events have caused a serious risk to food production in family farming.

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[16] OBSERVATÓRIO DO CLIMA. **Breve análise da segunda NDC do Brasil.** 2024. Available at: https://oc.eco.br/wp-content/uploads/2024/11/BREVE-ANALISE-DA-SEGUNDA-NDC-DO-BRASIL-1.pdf. Accessed on: 13 Nov. 2024.

[17] OBSERVATÓRIO DO CLIM. **Proposta do Observatório do Clima para a Segunda Contribuição Nacionalmente Determinada (NDC) do Brasil no âmbito do Acordo de Paris (2030-2035).** 2024. Available at: https://oc.eco.br/wp-content/uploads/2024/08/NDC-do-OC_2024-template.pdf?swcfpc=1. Accessed on: 13 Nov. 2024.

While the climate is changing for everyone, extreme events impact populations differently. Family farming, with its populations in the countryside, the forest, and the waters, is more vulnerable and has its challenges multiplied, as it depends on the climate to exist and to produce food. It should also be considered that the most impoverished families, black and indigenous populations, and, especially, women and children are even more vulnerable.

The irregularity in the climate has affected natural cycles and directly impacted family farming in food production. With the increase in evaporation associated with global warming, Brazil is drying up, according to a recent study by the National Institute for Space Research (INPE) and the National Center for Monitoring and Alerts of Natural Disasters (CEMADEN).[18]

The study finds that, in the last 30 years, there has been an expansion of semi-arid areas throughout the country at an average rate of more than 750 thousand hectares per year, except in the southern region. However, in the Northeast region, where practically half of the family farming is located, the situation is more critical, as almost 6 thousand hectares of areas defined as arid have already been identified, covering at least six municipalities in the north of Bahia.

With the country becoming more arid, the demand for water for irrigation only increases. According to data from the National Registry of Water Resources Users (CNARH), 99% of all water collected is used by only 1% of the grantees, characterizing the concentration of the use of the resource in large consumers. The Irrigation Atlas published in 2021 by the National Water and Basic Sanitation Agency (ANA) points out that irrigation is responsible for about 50% of water withdrawal in Brazil, while animal watering accounts for about 9%. Urban supply, in turn, accounts for 24% of the total withdrawal.[19]

These data warn of the concentration of the use of water resources and reinforce the trend of land concentration in Brazil. It is no coincidence that, in the last 30 years, there has been an emptying of the countryside. While some agribusiness entrepreneurs appropriate the rivers, family farming depends on the increasingly uncertain climate to produce.

In 2008, a pioneering study conducted by researcher Eduardo Assad brought together researchers from the University of Campinas (Unicamp) and the Brazilian Agricultural Research Corporation (Embrapa) to test climate models and estimate the impact of global warming on agriculture. The study, to date considered the most comprehensive in the area, investigated how the

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CEMADEN, INPE, 2023. **Nota Técnica: Elaboração dos Mapas de índice de Aridez e Precipitação Total Acumulada para o Brasil**. Available at: https://www.gov.br/cemaden/pt-br/assuntos/noticias-cemaden/estudo-do-cemaden-e-do-inpe-identifica-pela-primeira-vez-a-ocorrencia-de-uma-regiao-arida-no-pais/nota-tecnica_aridas.pdf . Accessed on: Feb. 25.

[19] ANA. **Atlas de Irrigação 2021.** 2024. Available at: https://dadosabertos.ana.gov.br/datasets/78603a9cf4514c8c84ebf620ec5cbf84_0/about. Accessed on: 13 nov. 2024.

climate emergency will affect cotton, rice, beans, coffee, sugarcane, sunflower, cassava, corn, and soybean crops, as well as pastures and beef cattle, in warming scenarios projected for 2020, 2050, and 2070.

A "pessimistic" scenario of a 2ºC to 5.4ºC increase in temperature by 2100 was considered, and an "optimistic" one, of 1.4ºC to 3.8ºC of warming by the same date. The research pointed out, at that time, that global warming could cause a significant change in the map of Brazilian agriculture, generating a reduction in producing areas and economic losses of about R$ 7.4 billion in 2020 and R$ 14 billion in 2070.[20]

However, as other researchers point out, the pioneering study had agribusiness as its main object and looked mainly at large crops and large producers. Family farming appeared in the analysis of corn, beans, sunflower and cassava crops.

In turn, researcher Haroldo Machado Filho, from the United Nations Development Program (UNDP), led a team of scientists who, in 2016, sought to contribute to filling this gap, specifically researching the impacts of extreme events and climate variability on family farming in the North and Northeast regions of Brazil.

In the study's literature review, the scientists listed findings from previous research. Among them, we highlight: that 95% of the losses in the Brazilian agricultural sector occur due to floods or droughts; there is a general trend of reduced rainfall for the North and Northeast regions over time; Embrapa projects, as the main losses in the rural environment, that of arable land; the semi-arid regions of the Northeast will become drier and the east of the Brazilian Amazon will suffer "forest dieback"; drought can induce a decrease in food security; cassava may disappear from semi-arid regions; and corn production may be severely impacted in the northeastern agreste.

Based on this review, the authors elaborated an overview of the potential impacts of climate change for specific crops present in the North and Northeast regions, seeking to emphasize those that are most relevant for family farmers and those whose impact on production will translate into the deterioration of food security. Among the results obtained, it should be noted that cassava and corn crops are negatively affected in the Northeast, while cotton, coffee, beans, and pineapple suffer negative impacts in the two regions analyzed.

In addition, considering possible changes in temperature (according to the two main scenarios estimated by the IPCC's Fifth Assessment Report) and precipitation patterns, the scientists came up with four simplified scenarios to indicate which crops would be negatively affected.

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[20] EMBRAPA. **Estudo avalia impacto do aquecimento global na agricultura.** 2008**.** Available at: https://www.embrapa.br/busca-de-noticias/-/noticia/18032326/estudo-avalia-impacto-do-aquecimento-global-na-agricultura. Accessed on: 13 nov. 2024.

One of the main concerns is precisely the future production of cassava, one of the most relevant products of family farming, with more emphasis on the Northeast. As the authors point out, "Cassava is a fundamental 'anchor' and an important part of the regional culture". The most serious scenario occurs with the combination of extreme temperature (pessimistic projection of warming) and decreased rainfall.

Another more recent effort (2020) to map the impacts of the climate crisis on family farming reached similar conclusions. The modeling study developed by researcher Tarik Tanure, from the Federal University of Minas Gerais (UFMG), estimated the loss of productivity in different crops and regions of Brazil considering the warming scenarios designed by the IPCC.

The results revealed that the productivity of family farming is more sensitive to climate change. Cassava, corn and bean crops, typical of family farming, would be impacted by the loss of productivity.

The research also concludes that the impact of climate change on family farming can contribute to the worsening of inequalities and the deterioration of food security conditions in Brazil, by affecting food cultivation and affecting, mainly, the less economically developed regions. According to the study, changes in temperature and precipitation directly affect agricultural productivity levels, making agriculture one of the sectors most affected by the phenomenon of global warming. The text also highlights that, according to FAO, the food supply may be compromised, as well as food security, forming a new geography of agricultural production.

2.5 PUBLIC POLICIES AND THE LIMITATIONS OF THE ABC PLAN

Adapting agricultural production to climate change and transitioning to carbon-removing agriculture is imperative to ensure farmers' reproduction, food security, and the future of the planet. Family farming practices, as indicated, are historically associated with the sustainable management of the countryside, waters, and forests. We must consider that the historically inherited practices come from the original communities and peoples, who for millennia have understood the intrinsic correlations between production and local biodiversity. Therefore, the provision of ecosystem services has the potential to lead these transformations, while lacking incentives and public policies capable of consolidating and expanding it.

As pointed out, this potential can only be realized with effective, well-structured, transversal public policies that place agricultural production for carbon removal at the center of priorities for the area. As the latest edition of the Crop Plan shows, there are still many challenges in this regard.

In July 2024, the federal government announced the allocation of R$ 400.59 billion to finance the Brazilian agricultural sector. The 2024/2025 Crop Plan for corporate agriculture, coordinated by the Ministry of Agriculture and Livestock (Mapa), is 10% larger than the previous one. On the other hand, the Family Farming Crop Plan received R$ 76 billion, an increase of 6% compared to the last edition. About 85% of the amount allocated by the federal government for agricultural production went to agribusiness.

It is also important to highlight that most of the resources of the Crop Plan are aimed at the production of *commodities*, even in family farming, especially in the southern region. According to the Central Bank's rural credit matrix[21], in the 23/24 harvest, 62% of the Pronaf funding values were contracted by the southern region; in this region, almost 60% of the amounts were allocated to the cost of soybean, corn, and wheat commodities.

Based on data from the Central Bank, in the 2022/2023 Harvest, R$ 33.06 billion were invested in Pronaf Costing, 62% for agriculture and 38% for livestock. It is observed that, despite the diversity of productive activities of family farming, with more than 136 products financed, only four crops (soybeans, corn, wheat, and coffee) took 84% of the resources of agricultural costing – with emphasis on soybeans, with 34% of the total.

In livestock costing, the concentration is even greater. Beef and dairy cattle farming activities accounted for 95% of the resources, with a concentration in five states (SC, RS, RO, MG, MT), accounting for 63% of the credit.

Researchers highlight, among the "climate-friendly" characteristics of family farming, the greater diversity of plants, with greater biomass production and soil protection — which increase carbon absorption and develop more adapted cultivation systems with greater resilience to extreme events. Diversified production, which involves vegetables, fruit trees and animals, also increases the capacity to respond to climate variations.

In addition, the use of organic fertilizers, frequent in family establishments, enhances the absorption of carbon by the soil and reduces the use of chemical fertilizers, commonly imported by Brazil and whose production and transportation is high in fossil emissions.

In the search for solutions to reduce emissions, in 2010 Brazil formulated the Low Carbon Agriculture Plan (ABC), the main climate policy for the agricultural sector. The plan brought credit lines and innovative technological solutions. However, according to Garcia *et al.* (2015),[22] no specific strategies or goals were defined for family farming — which did not have, for example, access to ABC credit lines.

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21 BRASIL, 2024. Matriz de Crédito Rural do Banco Central.

22 EMBRAPA. **Agricultura familiar de baixa emissão de carbono no Brasil.** 2022. Available at: https://seer.sede.embrapa.br/index.php/RPA/article/view/1791/pdf. Accessed on: 13 Nov. 2024.

It was to develop the so-called low-carbon agriculture that Embrapa delivered many research results from the implementation of the ABC Plan in 2010. However, the focus of research on this public policy has been concentrated on production systems of *commodities* that occupy the largest extensions of the Brazilian agricultural territory. These technologies have brought breath to the sustainability aspect of monoculture systems, from the adoption of practices that try to imitate traditional production systems, such as the introduction of tree species to monocultures and, especially, the maintenance of soil cover with straw and crop rotation, ensuring increased productivity and reduced use of inputs in conventional agriculture.

In 2021, the ABC plan underwent a reformulation, being renamed ABC+. In this second cycle, which covers the period from 2020 to 2030, ABC+ was reformulated and started to include new Sustainable Production Systems, Practices, Products, and Processes (SPSABC), expanding the scope of the plan with the Integrated Landscape Approach (AIP). Although family farming is mentioned several times in its operational plan, it still has no specific goals. Without new contributions of resources, PRONAF's sustainable lines only gained the addition of ABC+ in the name, being renamed Pronaf ABC+ Forest, Pronaf ABC+ Agroecology, and Pronaf ABC+ Bioeconomy.

In this new cycle, Embrapa included technologies that deserve to be highlighted for family farming, such as the no-tillage system in vegetables (NTS), which has great potential for carbon storage and is considered a gateway to the agroecological transition, in addition to simplified agroforestry arrangements.

In addition, it is important to highlight that, although family farming could adopt some practices of the ABC Plan, the technologies offered as solutions were not enough to consider the diversity and, especially, the biodiversity of production systems such as agroecology, family livestock and socio-bioeconomy production systems that traditionally already have a high carbon stock, but they lack technological solutions for their development.

Diverse family farming offers more interesting solutions when compared to monocultures. Diverse systems bring together greater carbon fixation in highly biodiverse systems, bringing environmental and social sustainability due to the greater occupation of labor with distributed income and food sovereignty.

3.1 CARBON REMOVAL AGRICULTURE AND CARBON SEQUESTRATION AND STORAGE AGRICULTURE

There are several forms of agriculture, especially family farming, which, due to their characteristics, can be part of the climate solution, ensuring productive diversity and the maintenance of biodiversity in the region, while sequestering more carbon than it emits.

By sustainably developing agriculture, it is possible to remove carbon from the atmosphere and fix it in the form of organic matter through photosynthesis, emitting oxygen. According to Assad *et al.*,[1] when molecules of an atmospheric carbon dioxide react with water in plants in the presence of light, the carbon element present in the gas is transformed into solid-state organic compounds (carbohydrates). As a result of this process, plant structures such as leaves, stems and roots of plants are formed, releasing oxygen into the atmosphere.

Corporate agriculture has advanced a lot in the solutions presented by the ABC plan, betting, for example, on the recovery of degraded pastures and integration systems for *commodities*. However, family farming offers more interesting solutions in mitigation, which bring together greater capacity for carbon sequestration in highly biodiverse systems when compared to monocultures, with greater generation of employment, income, security, and food sovereignty. However, these solutions have yet to be recognized in their forms of production.

As pointed out by several experts, the way out lies in recognizing and prioritizing these alternatives in the face of destructive models of nature, food sovereignty, and climate.

> Investing, therefore, in the development of more appropriate technologies for family farming has the potential to create synergies with possible existing microscale economies and improve the productivity and profitability per area of cultivation systems less practiced in large agricultural establishments, such as some types of polycultures, more labor-demanding forestry systems and less accustomed to mechanization.[2]

In this context, it is important to have conditions for the maintenance and expansion of the productive capacity of the territories based on landscape redesigns that make them more resilient. For this, it is desirable to insert in the systems of multifunctional native perennial legumes (baru, cratília, guapuruvu, ingá, jatobá, and mulungu, for example) that expand nutrient cycling, soil protection, and water conservation.

EMBRAPA. **Sequestro de carbono e mitigação de emissões de gases de efeito estufa pela adoção de sistemas integrados.** 2024. Available at: https://ainfo.cnptia.embrapa.br/digital/bitstream/item/202491/1/PL-SequestroCarbono-Assad.pdf. Accessed on: 13 nov. 2024.

[2] CASTRO, César Nunes de. **Agricultura familiar no Brasil, na América Latina e no Caribe: institucionalidade, características e desafios.** IPEA, 2024. Available at: https://repositorio.ipea.gov.br/bitstream/11058/14052/9/Agricultura_familiar_no_Brasil_na_America_Latina_e_Caribe.PDF. Accessed on: 13 Nov. 2024.

Based on public policies, family farming can enhance sustainable and biodiverse production systems, which accumulate intergenerational knowledge, such as agroecology, organic agriculture, family livestock of cattle, goats, sheep, and other animals, agroforestry systems, socio-biodiversity chains, and others.

Embrapa's actions, in this item, may include, on its farms, shared activities for the establishment and creation of community seed banks and matrices to multiply seeds and seedlings of these species (for agroforestry, pastoral systems, and recovery of degraded areas) and distribute them to the surrounding communities.

3.2 AGROECOLOGY

Agroecology is a multidisciplinary science that provides the basic ecological principles based on a set of essential, modern, and ancestral knowledge and practices to ensure sustainable development with production, income, and quality of life for people in the countryside and the city. Its practices must be "culturally sensitive, socially just, and economically viable",[3] in order to provide a sustainable agroecosystem, free of pesticides. In addition, it promotes highly biodiverse systems with an abundance of biomass (carbon).

We must consider that agroecology practices must be based on the science of ecology, which gives great relevance to ecological literacy as an environmental education strategy to support the transition of practices. Agroecology as a practice seeks to work in harmony with nature, with food sovereignty as a pillar, as well as the reduction of inputs external to production and the regeneration of the productive capacity of soils.

Agroecological management is based on the natural system of each location, involving the soil, climate, living beings, and the interrelationships between these components. In an agroecological production system, farmers take advantage of the resources available in the establishment itself, so that there is practically no dependence on external inputs. In this sense, agroecological management depends on the wisdom of each farmer and must be built from their observations and local experiences.

According to Decree No. 7,794/2012, which instituted the National Policy on Agroecology and Organic Production (PNAPO), agroecological-based production is that which "seeks to optimize the integration between productive capacity, use and conservation of biodiversity and other natural resources, ecological balance, economic efficiency and social justice".[4]

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[3] CATI. **Agroecologia – Conceitos.** 2024. Available at: https://www.cati.sp.gov.br/portal/produtos-e-servicos/publicacoes/acervo-tecnico/agroecologia-conceitos. Accessed on: 13 nov. 2024.
[4] BRASIL. **Decreto nº 7.794, de 20 de agosto de 2012.** 2012. Available at: https://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/decreto/d7794.htm. Accessed on: 13 nov. 2024.

According to the Coordination of Integral Technical Assistance (CATI) of the government of São Paulo, these are the basic principles of agroecology:

- Conserve and expand the biodiversity of ecosystems, to establish numerous interactions between soil, plants, and animals, expand the self-regulation of the property's agroecosystem;
- Ensure the living conditions of the soil that allow the maintenance of its fertility and the healthy development of plants, through practices such as:
    - Permanent ground cover (live or *mülching*);[5]
    - green manure;
    - protection against the winds;
    - soil conservation practices (erosion control);
    - crop rotation;
    - intercropping of crops; and
    - cultivation in strips, among others;
- Use species or varieties adapted to local soil and climate conditions, minimizing external requirements for good development of the crop;
- Ensure sustainable crop production without using chemical inputs that can degrade the environment, making use of organic fertilization, poorly soluble mineral products (rock phosphate, limestone, rock dust, among others), and phytosanitary management that integrates cultural, mechanical and biological practices for the control of pests and diseases;
- Diversify the economic activities of the property, seeking integration between them to maximize the use of endogenous resources and thus reduce the acquisition of inputs external to the property; and
- To favor the self-management of the producing community, respecting its culture and stimulating its social dynamics.

In a text for Embrapa,[6] consultant José Maria Gusman Ferraz explains:

> The transition to an agroecological agriculture model does not only represent a return to the model of agriculture that was practiced before the Industrial Revolution. Although combinations of traditional management methods and the physical, chemical, and biological balance of the agroecosystem are used, it can include new technologies, such as the rescue of management and techniques used in similar ecosystems, water conservation practices, and animal management, among others.

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[5] Also called "mulching", mulching is a technique of covering the soil with organic and inorganic materials, beneficial to the environment and helping to increase productivity.

[6] FERRAZ, José Maria Gusman. **Agroecolog**y. Embrapa, 2021. Available at: https://www.embrapa.br/en/agencia-de-informacao-tecnologica/tematicas/agricultura-e-meio-ambiente/politicas/agroecologia. Accessed in Feb. 2025.

Such a process implies the construction of inclusive and egalitarian relationships between men, women, young people and the elderly in rural areas, promoting the production of healthy food, respect for biodiversity and the appreciation of local production as alternative forms of commercialization.

Family integration is fundamental in agroecology, as it requires a procedural management of the property that involves the participation of all family members. In addition, agroecology contributes positively to rural succession processes, with an emphasis on women's participation.

Committing to agroecology means rethinking the ways of producing food, establishing a direct relationship between healthy production, quality of life, production and consumption patterns, and the conservation of life on the planet.

3.3 THE EXAMPLES OF THE VISTA ALEGRE PROJECT AND THE CREOLE PROJECT

Created in 2012, the Vista Alegre Project emerged on Lucas Sousa's family farm in the city of Capim Branco, in the interior of Minas Gerais. Lucas is an agronomist and joined Marcone Xavier, who is from the third generation of a family of farmers. Both had the same philosophy of life: the love of the countryside and the dream of bringing real food to many families, combining technology with agriculture, and bringing people back to their roots and to the community with more resources. Today, the project involves more than 30 families.[7]

To strengthen the work of raising awareness about organic production, five years ago, Lucas began to dedicate himself to expanding the cultivation of biodiversity in the garden with vegetables, vegetables and with the rescue and multiplication of native seeds, especially corn.

Creole seeds are vital for organic production. They differ from commercial ones because they have not undergone any chemical treatment (such as fungicides, for example) or genetic modification in the laboratory (such as hybrids or transgenics). They have a unique molecular structure, the result of years of adaptation to the local soil and climate, which reinforces our option to be an active agent of change.

The first seeds came into the hands of Lucas and Marcone through family farmers neighboring the farm. They had access to two varieties of corn seeds: a red one, with large grains and good potential for cornmeal, and another of black popcorn corn, with small grains.

[7] Information about the Vista Alegre Project is available at: https://www.vivavistaalegre.com.br/; https://www.instagram.com/projetovistaalegre. Accessed on: 19 Nov. 2024.

In April 2019, of the six kilos sown, 800 kilos of grains were harvested, between red and black. In the same month, the partnership with Anna Guasti was started. A customer and friend since 2010, biodiversity and gastronomy were already part of her life. With the arrival of Casa Guasti, the tripod of the Creole Project was formed: agriculture, communication, and commerce. The Creole Project's Instagram was created on April 17, 2019. From then on, the day-to-day life at Fazenda Vista Alegre and the results of the dishes created, with Creole corn, by *chefs* linked to Brazilian biodiversity, began to be followed by increasingly numerous and engaged followers.

The work of the Creole Project has a long way to go. More than increasing the supply of organic products, the idea of the action is to expand and strengthen the network of local farmers neighboring the farm. Corn was the first of many other crops that, in addition to generating income, will be able to preserve biodiversity and expand food diversity. The process of multiplying Creole beans is already underway in a transparent, educational, and sharing way.

The Creole Project is being created by several hands. Hands that work the land, giving life to the ancestral grains that are being mined from north to south. Hands that write stories and help rescue the history of these foods, which are often confused with the history of various civilizations. Hands that transform these foods into gastronomic jewels, bringing new possibilities and incredible flavors, which make you travel through time and cultures.

> It was noticed that the soil management adopted in the planting of organic Creole corn has maintained the biological quality and very high capacity of cycling, storage, and supply of nutrients in the soil. It was also found that the use of the bio-input BiomaPhos increased production by 22%. The grains harvested in the systems studied, regardless of the use of the bio input, fit the best classification established by the Technical Regulation of Corn, which is Type 1, and its characteristics indicate that the native cultivar has good potential for commercial grain production.
>
> The production of Creole corn in organic format shows that the activity is profitable, with a very favorable net income, signaling as an opportune market potential for producers. The use of native material and the production of their own seeds by farmers are factors of great relevance to reduce the cost of production.
>
> The system also provides the environmental conservation of the production unit and, the efficiency required by potential markets. There was no need for inputs to control insects harmful to corn. The diversity of the conserved landscape around the production area may have favored natural biological control. However, some challenges remain, such as the control of spontaneous plants, which, in this case, is one of the factors that may be limiting the achievement of higher yields. In this sense, the results reinforce the importance of expanding research and rural extension actions in the productive units, to increase knowledge and promote the dissemination of scientific information.[8]

[8] CAMPANHA, M., MATRANGOLO, W., DUARTE, J. D. O., PIMENTEL, M., SHP, C., de SOUZA, F. A., ... & MAMEDES, A. D. S. **Avaliação econômica e aspectos da produção orgânica de milho crioulo na Fazenda Vista Alegre. Embrapa**. 2023. Available at: https://www.infoteca.cnptia.embrapa.br/infoteca/handle/doc/1157842. Accessed on: 13 Nov. 2024.

Food production is one of the main activities developed by human beings throughout the history of their existence, since it is an essential element for their survival. As a result, different techniques were developed and improved to obtain food in the necessary quantity for the entire population.

However, some actions ended up causing imbalances that bring their effects to the present day. In this sense, Assis and Romeiro (2002) point out that agricultural production, as it is closely linked to the environment, is conditioned to ecological restrictions, which led to the development of techniques that made it possible to overcome them. According to the authors, the first agricultural technologies implemented were crop rotation and the integration of animal and plant production, so as not to harm the environment and to overcome its ecological limitations, using the laws of nature as tools.

Animal husbandry is an integral part of family production units, as there is diversity and environments close to the natural ecosystem in these units. The integrated participation of animals and plants contributes to the environmental balance and the maintenance of soil biodiversity, since they complement each other, favoring the supplementation of nutrients and natural resources.

Although the activities of family producers are more frequently linked to fruits, vegetables, and cereals, livestock is also present in production units in all Brazilian states. Tosetto, Cardoso, and Furtado list at least three positive factors that demonstrate the importance of the presence of animals in production systems:

- **Manure production on the property:** contributes to ensuring the organic and economic sustainability of the system, as it reduces or eliminates the need to buy chemical fertilizers, or even manure from other sources that may contain traces of pesticides;
- **Diversity in production:** animal products are rich in protein and can contribute to the family's food security and generate income through the sale of surplus products, such as eggs, meat, milk, and derived products; and
- **Service:** animals are important in helping and performing daily tasks, constituting significant elements in complementing the workforce

According to Guelber, small animal husbandry and family farming are closely related topics. The diversity of products offered and the functions performed by small farmers play a fundamental role in reinforcing the technical-economic rationality of family farming, which is expressed as a production unit focused on the market and domestic consumption. It is precisely this focused production logic that explains the widespread presence of small animals on family farms.

Feeding the farming families themselves is, without a doubt, one of the primary functions of small farms. Coming from different animal species and the most varied compositions and flavors, products such as honey, meat, fish, shellfish, offal, fats, eggs, and milk have high nutritional and nutraceutical quality — the presence of substances with therapeutic and preventive properties against diseases.

In this respect, they are fundamental for the food security of families and particularly important for urban agriculture, which, in general, has small spaces, but is capable of supporting small-scale farms aimed at providing food for families with limited access to animal products, whose cost is relatively high.[1].

The small farms also contribute with other products, such as tallow, skins, feathers, threads, fibers, bones, and various substances used in an industrial or artisanal way in the manufacture of garments, medicines, and various utensils, with an important contribution to the family economy. Manure, in turn, contributes to the continuity of soil nutrient cycles, whose reproduction of fertility is the basis for sustainable agriculture. In addition, small animals are a strategic saving, which can be mobilized in times of crisis or important events in family life.

The need to integrate empirical and regional knowledge related to animal husbandry has always been linked to the environment. The first farmers already had knowledge about vegetables, soil and climate, as well as about the seasons of the year, to make the best decisions about the timing of planting, seed selection and soil preparation, among other aspects, and this knowledge was used and passed on to several generations.

4.1 ORGANIC AND AGROECOLOGICAL ANIMAL SYSTEMS

Family Farming should be understood as agriculture and livestock, whose capital belongs to the family and regardless of the size of the production units and their income-generating capacity. The characteristics are "entirely compatible with an important participation in the agricultural supply".[2] Organic or agroecological-based systems are systems that are more adapted to the conditions of the family producer, since the sizes of the properties are better adapted to the management of conversion and agroecological transition.

According to preliminary data from the 2017 Agricultural Census, carried out by the IBGE, of the 68,716 agricultural establishments certified for organic production, 39,643 were dedicated to plant production, 18,215 to animal production and 10,858 establishments had organic plant and

[1] GUELBER, 2019.
[2] ABRAMOVAY. 1997

animal production. However, data released by Mapa[3] (in its National Register of Organic Producers (CNPO), which registers certified organic producers – individuals or legal entities – present a number much lower than that of the IBGE, of 22,427 producers, distributed in all Brazilian regions.

The organic ruminant production system constitutes part of animal production within organic production systems. Organic systems framed in Ordinance No. 52 of the Ministry of Agriculture and Supply (Mapa), of March 15, 2021, should be seen as a rural property or a rural space where everything produced in it obeys the principles of organic production. Normally, organic production systems are made up of some agricultural and livestock activities that complement each other in the use and replacement of natural resources and nutrients, within that space under organic management.[4].

In ruminant production, the organic system presents itself as a productive alternative to increase the quality and added value of both meat and milk from cattle, goats, and sheep. The organic system of animal production is anyone who maintains a holistic view of the property, integrating animal and plant production. It does not allow the use of pesticides, chemical medicines, synthetic hormones, and transgenics; restricts the use of chemical fertilizers; includes actions for the conservation of natural resources; and considers ethical aspects in the internal social relations of the property and in dealing with animals.[5].

Organic products, such as meat and milk from ruminant species such as cattle, goats and sheep, must be produced, stored, processed, processed and marketed in accordance with specific rules of Law No. 10,831/2003, certified by an accredited certifier or by an accredited participatory body and the instructions of Ordinance No. 52.

4.2 AGROFORESTRY SYSTEMS OF THE AGROSILVOPASTORAL TYPE

The agrosilvopastoral system is an agroforestry model that integrates forestry, agriculture, pasture, and livestock, making it ideal for productive family farming units. In this system, the producer can obtain forest products, maintain agricultural activities, and also promote various interactions, economic advantages, and environmental services.[6].

The economic benefits of diversified income have been the main reason for the implementation of agroforestry systems, but the success of these systems depends on planning and strategic analysis in the implementation phase[7]. Integrated agroforestry and agroforestry systems can

[3] VILELA et. al. 2019.
[4] SOARES et. al. 2021b
[5] FIGUEIREDO E SOARES, 2012.
[6] SOARES *et al*, 2022.
[7] OLIVEIRA NETO et al., 2010

contribute to sustainable production, as they are based on plant succession, sustainability, and longevity of the production base through natural regeneration mechanisms[8].

The adoption of conservationist management practices in the Caatinga using agroforestry systems not only helps to maintain carbon stock in the soil but promotes its increase compared to that observed in natural vegetation, contributing to the mitigation of greenhouse gas emissions. This is the main conclusion of [9]the study.

Carried out at Embrapa Goats and Sheep (CE), the results of which were published by the *Journal of Environmental Management*. The results indicate that soil carbon stocks in agroforestry systems increase by up to 30.9% in rotational management, compared to natural vegetation.

This study considered data from a long-term experiment (25 years) implemented in Sobral (CE), in the Brazilian semi-arid region, and the adoption of the Century model, software that simulates the dynamics of organic matter in the soil. The study compared agricultural practices traditionally used in the region — itinerant land use, deforestation, and burning — to agroforestry systems, observing different fallow periods (zero, seven, fifteen, thirty, fifty, and one hundred years).

The results indicate that, in the cultivation with slash and burn, carbon losses in the soil decreased from 74.7% (with management without fallow) to 28.7%, in seven years of fallow land after cultivation.

In the scenario of slash and burn of vegetation, the adoption of longer fallow periods increases the carbon stock in the soil, but only after thirty years of rest does the percentage equal to the values of natural vegetation; and fifty years of fallow lead to a 4% increase in carbon stocks, compared to natural vegetation in equilibrium.

In the agroforestry systems, simulations were made both in permanent and rotational management, comparing with the natural vegetation in balance and with the slash and burn system, adopting fallow for seven years. The results indicate that carbon stocks in agroforestry systems increase up to 18.6% in permanent management and 30.9% in rotational management, compared to natural vegetation.

In agrosilvopastoral management, carbon is removed when harvesting corn or beans planted in the area, but this removal is compensated by the addition of animal manure and remains of cultivated plants, in addition to permanent vegetation and litter (layer of dry leaves, branches, remains of fruits, flowers and dead animals that are on the surface of the soil).

[8] CAMPELLO, 2005.

In silvopastoral, soil carbon increases due to the deposition of plant materials (tree and leaf remains, animal manure) in the soil. The thinning of 60% of the trees in the system increases luminosity and favors the development of vegetation closer to the ground and greater accumulation of litter, which helps to increase the amount of carbon.

The results of this research are of direct use to farmers who work in the semi-arid region, as they demonstrate that the decision for a sustainable form of land use can guarantee the continuity of their management practices, without the need for constant displacement for agricultural plantations or raising livestock. It should be noted that another advantage for farmers in the region, who already adopted agroforestry systems, is that their land will not need long periods of rest. In other words, those who already adopt them can be more confident about what will happen in the future, in terms of the care that their land needs to continue producing, in addition to contributing to reducing the effects of heat on the planet.

4.3 REGENERATION OF DEGRADED PASTURES

The ABC+ Plan aims to recover 30 million hectares of degraded pasture by 2030. Recovering these pastures that have been degraded by poor land use is equivalent to reducing the 3.4 million tons of carbon dioxide emitted into the atmosphere per year. But it is necessary to advance in sustainable solutions for the recovery of degraded pastures considering the characteristics of biomes and family farming.

The recovery of pastures increases the carbon stock in the soil, generates greater infiltration and storage of water due to the increase in the quantity, proportional distribution, depth and decomposition of roots, in addition to reducing erosion and increasing the adaptive capacity to prolonged droughts.

A pasture is considered degraded when the soil loses the ability to produce enough food for its livestock. Degradation can be seen when it is not possible to raise the same number of animals on the same plot, when cattle lose weight or stop producing milk.

According to Embrapa, there are two types of degradation:

- Due to an excess of weeds that start to compete with forage crops (species of plants aimed at animal feed), which makes it difficult for animals to choose the correct vegetation for their food;
- Soil deterioration, when there is an increase in the area of bare soil, which facilitates erosion and the loss of soil nutrients.

In Brazil, the main causes of degradation are lack of care for the soil and lack of nutrient replacement; inadequate animal management, such as pasture overcrowding; the planting of a forage species in a soil for which it is not adapted; fires, pests and diseases.

According to a booklet published by Embrapa, there are three ways to recover a pasture:

- **Direct recovery:** it is the simplest and relatively least expensive way to recover a pasture. It usually consists of controlling weeds and adjusting fertility through fertilization. There may be a need to replant forages, but only in areas of bare soil, without the need for prior preparation. In direct recovery, it may not be necessary to remove the animals from the pasture, but when this is necessary, the period is relatively short, around 30 days. This type of intervention is recommended for pastures with levels one and two of degradation;
- **Renewal:** consists of the formation of a new pasture, with the correction of soil fertility and the replanting of the forage, with or without a change of the species, with the need for prior soil preparation. Depending on the situation, the renewal can have a cost, on average, up to three times higher than that of direct recovery. The use of the area has to be interrupted for about 90 days, the time needed to form the new pasture. This type of intervention is recommended for pastures at levels three and four of degradation;
- **Indirect recovery/renewal:** occurs when pasture is integrated with crops or forest to recover soil fertility, generate short-term income, or diversify income generation. This option requires higher initial investments, but it usually offers a higher return on invested capital and allows you to add other activities and sources of income in the same area. It is important to choose the appropriate agricultural crop or forest species and evaluate the market before opting for this alternative, which involves mechanization, soil preparation, nutrient correction, and greater technical qualification and labor. Despite being more expensive than the direct recovery of pasture, costs can vary according to the region and the economic situation. It is generally used in pastures with degradation levels three and four.

Family farming has been incorporating pasture recovery practices, such as soil liming (application of limestone) and the use of other pH correctives (soil acidity levels). The use is more extensive in the South and Southeast regions of the country. In a study with cratilian and gliricidia alleys, in the central region of MG (Cerrado), the original pH changed from 5.6 in 2015 to 6.3 and 6.5, respectively, due to the phytomass contribution of these perennial legumes.

4.4 PASTURE MANAGEMENT

Pasture recovery strategies for family producers are presented with the implementation of agrosilvopastoral systems. This system can promote environmental preservation, since it aims at the proper management of the use of biomass and the recovery of degraded areas, in addition to working with different species of successional stages[10]. Integrated production systems generate economic benefits, and provide greater productivity and greater diversification of products and income.[11].

These systems also promote yield diversification and improve long-term animal productivity and performance[12]. However, in the planning of integrated production areas, especially those managed by family farmers, it is necessary to have a holistic view of the rural property, to identify its real production aptitude[13].

For this, spatial and temporal designs promote numerous ecological and economic interactions, which must be analyzed in the planning, implementation, and management of the system[14]. These spatial and temporal designs must be studied so that technologies, such as the integration of animal and plant production, the use of alternative inputs, and tree and shrub species, contribute to rural development sustainably.

Organic pasture management has also been an alternative in the recovery of degraded pastures. Grass pastures can be intercropped with nitrogen-fixing forage legumes, which are a low-cost option for producers, also providing an increase in the N content (amount of nitrogen) and organic matter to the soils[15] and can decisively interfere with the productivity and quality of pastures. The use of these legumes improves the quality of the pasture litter and can provide large amounts of N to the soil-plant system.[16].

The N fixed by the legume is recycled in the system, being an extra source of N for the grass. This extra source makes it possible to increase the carrying capacity of the pasture and its productive capacity[17]. In addition, the N fixed by the legume can improve the quality of the diet and increase animal production[18], due to the lower seasonal variation in nutritive value, compared to non-intercropped grasses[19].

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[10] NAIR, 1987
[11] SÁNCHEZ-ROMERO et al., 2021
[12] SEKARAN et al., 2021
[13] SEGHESE, 2006
[14] OLIVEIRA NETO et al., 2010
[15] FYN et al., 2013
[16] LÜSCHER et al., 2014.
[17] AZEVEDO JÚNIOR et al., 2012
[18] LÜSCHER et al., 2014, PIRHOFER-WALZL, 2012
[19] AZEVEDO JÚNIOR et al., 2012; STURLUDÓTTIR et al., 2013

Another advantage of legumes is their use as green manures that contribute to the incorporation of organic matter and nitrogen into the soil. Green manure consists of adding large amounts of phytomass to the soil, allowing the increase in organic matter content[20]. According to Pirhofer-Walzl[21], the use of legumes in rotation systems increased the cation exchange capacity (CEC) of the soil, which reduces nutrient losses by leaching. The cultivation of herbaceous legumes also allows the supply of nitrogen to the soil, making this nutrient available to other crops, due to the symbiosis of these species with N-fixing bacteria.

Soares *et al*[22]. have shown in recent studies that soil remineralizers promote long-term effects on soil phosphorus and potassium stability and on the growth of intercropped pastures. They also identified that the incorporation of green manure with *Crotalaria juncea* before the implementation of pasture increases productivity, especially when used in an organic system, and that this system increases the proportion of forage legumes in pastures compared to conventional management.

[20] ALCANTARA et al., 2000
[21] Pirhofer-Walzl, 2012
[22] Information about the Vista Alegre Project is available at: https://www.vivavistaalegre.com.br/; https://www.instagram.com/projetovistaalegre. Accessed on: 19 Nov. 2024.

5.1 REGIONAL CHARACTERISTICS AND OUTSTANDING PRODUCTS

Socio-bioeconomy is a development model that seeks to reconcile biodiversity conservation with social and economic development and has proven to be a fundamental tool for maintaining forests. The diversity of sociobiodiversity products is vast and varies according to the region and ecosystems.

It is worth highlighting Amazonian fruits such as açaí, nuts and seeds such as Brazil nuts from the Amazon,[1] baru and pequi in the Cerrado[2] and pine nuts in the South, a wide variety of teas, such as yerba mate, but also resins such as latex and artisanal fishing itself.[3]

These chains have significant economic importance, value traditional knowledge, promote the participation of local communities, and create sustainable value chains that contribute significantly to the conservation of forest ecosystems and the improvement of the quality of life of traditional peoples and communities. But, due to the great diversity, in addition to the geographical and resource challenges for data surveys in the territories, these activities suffer from a certain economic invisibility.

Although with little diversity of products and based on a data collection model designed for conventional agriculture, the IBGE's annual report on the Production of Plant Extraction and Silviculture (PEVS) provides a brief overview of the importance of some of these chains.[4]

The PEVS 2023[5] reveals that the sum of the value of the production of Non-Timber Forest Products was R$ 2.2 billion. The açaí chain represents 46% of the market, but yerba mate also stands out, with a market of almost R$ 600 million.

[1] FGV. **Amazônia brasileira: produtos nativos para a sustentabilidade do desenvolvimento regional.** 2023. Available at: https://agro.fgv.br/publicacao/ocbio-amazonia-brasileira-produtos-nativos-para-sustentabilidade-do-desenvolvimento. Accessed on: 19 nov. 2024.

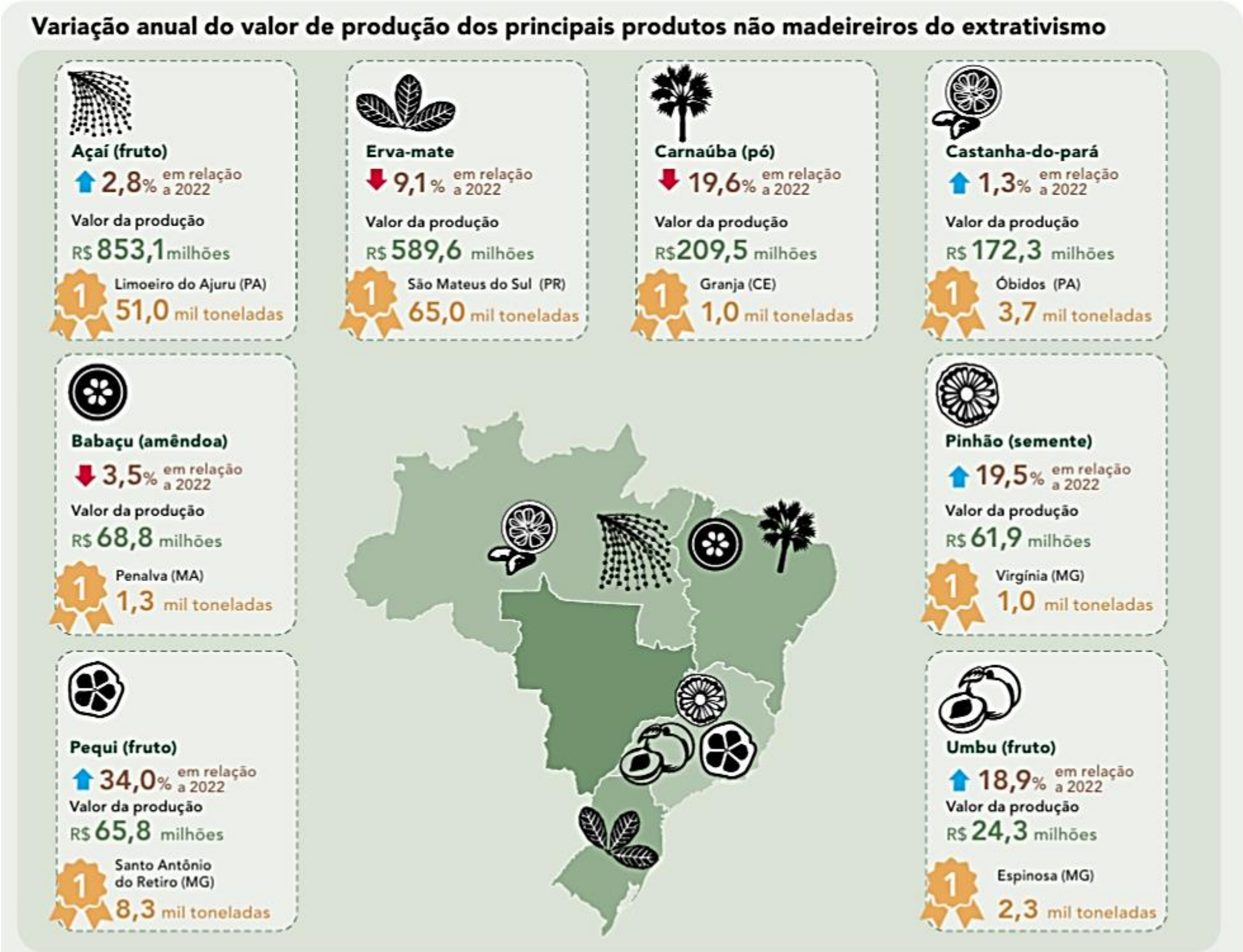
[2] FGV. **Produtos de extrativismo do cerrado: preservando a caixa d'água do Brasil.** 2023. Available at: https://agro.fgv.br/publicacao/ocbio-produtos-de-extrativismo-do-cerrado-preservando-caixa-dagua-do-brasil. Accessed on: 19 nov. 2024.

[3] FGV. **Caatinga: O Bioma Exclusivamente Brasileiro.** 2024. Available at: https://agro.fgv.br/publicacao/ocbio-caatinga-o-bioma-exclusivamente-brasileiro. Accessed on: 19 Nov. 2024.

[4] IBGE, 2024. **PEVS - Produção da Extração Vegetal e da Silvicultura.** Available at: https://www.ibge.gov.br/estatisticas/economicas/agricultura-e-pecuaria/9105-producao-da-extracao-vegetal-e-da-silvicultura.html. Accessed on: 19 nov. 2024.

[5] IBGE, 2024. Produção da Extração Vegetal e da Silvicultura (PEVS). Available at: /https://biblioteca.ibge.gov.br/visualizacao/periodicos/74/pevs_2023_v38_informativo.pdf. Accessed on: Feb. 25.

Figure 4 - Annual variation in the value of production of the main non-timber products of extractive.



Source: IBGE.

5.2 TIMBER AND NON-TIMBER PRODUCTS

The concept of Non-Timber Forest Products (NTFP) covers all goods of biological origin, except wood, extracted from natural ecosystems, such as forests, fields, and savannahs, as well as managed or planted areas in the different biomes of the country. These products include various uses such as food, medicine, bio inputs, structural materials, fuel, and handicrafts, among others, contributing significantly to the maintenance of the livelihoods of local communities, promoting food security, income generation, cultural preservation, and conservation of biodiversity and ecosystem services.[6].

NFNM are marketed, consumed, industrialized, and exported, in addition to having a remarkable presence in the country's history and the national and international economy. In Brazil, according to the Plant Extraction and Silviculture Production - PEVS 2023 report[7], extractive activity

[6] FAO, 1999; HOMMA, 2012
[7] IBGE, 2024. Produção da Extração Vegetal e da Silvicultura (PEVS). Available at: /https://biblioteca.ibge.gov.br/visualizacao/periodicos/74/pevs_2023_v38_informativo.pdf. Accessed on: Feb. 25.

totaled a value of 2.2 billion reais. The product of greatest economic relevance was açaí, which represented 46% of this value, however there is an extensive range of socio-biodiversity products, such as yerba mate, nuts, fruits, among others, of great economic and social relevance, especially for traditional communities.

However, NTFPs can still be considered an invisible economy due to the lack of reliable data regarding their production and commercialization. The collection and analysis of relevant statistics of the NTFP are carried out by the IBGE in eight categories, including latex, gums, waxes, fibers, tanning, oilseeds, food, and aromatics. The IBGE monitors less than a dozen PFNM permanently. These data fall short of the 300 PFNM that are already recognized for having commercial potential only in the Brazilian Amazon.[8].

NTFPs are also essential for mitigating deforestation and land degradation. They align with Brazil's efforts to improve biodiversity conservation and the sustainable use of natural resources, as well as with the goals of the UN 2030 Agenda, promoting biodiversity as an economic source, empowering women, combating climate change, and curbing deforestation.[9].

Brazil, a country of megadiversity, dedicates about 18% of its territory to conservation units (UCs), which add up to approximately 1.6 million km2. However, only 6% of the area in UCs are in full protection units, that is, those that only allow the indirect use of natural resources and activities such as education, scientific research and tourism. This number is insufficient to maintain all our megadiversity and the functionality of ecosystems.

Thus, it is necessary to incorporate the functionality of the environmentally conserved territories of rural properties into the PAs, through, for example, the promotion of activities related to NTFPs. These products can be a viable alternative from an economic, social and environmental point of view to agribusiness enterprises. The cultural and organizational dimensions present in the territories under the domain of traditional peoples and communities and family farming can contribute to this process.

Thus, the evolution of a regulatory framework for NTFP deserves attention, due to the potential for greater integration of these products into the daily routine of national activities, in addition to their inclusion in public actions and policies such as the Food Acquisition Program (PAA) and the national school lunch program (PNAE). Natural goods and ecosystem services are of great importance for the resilience of the most varied economic sectors. Despite the recognition of the importance of biodiversity and healthy ecosystems for the country's economic and social development, this is still not fully reflected in the construction and implementation of policies and

[8] BALZON et al., 2004
[9] MMA, 2021; UE, 2020

business decisions. There are few practical examples of implementation and structured dialogue between the various institutions and levels of government on their integration into public policies and the business sector.

The consolidation of more in-depth knowledge about NTFP in Brazil is a crucial step to safeguarding biodiversity, maintaining traditional populations, and supporting family farming. Since the establishment of the Paris Agreement, targets for reducing greenhouse gas emissions have been recognized, requiring most countries to report emissions from agriculture, forestry, and other land uses.

The insertion and continuity of NTFP in the national economy and in the lives of thousands of inhabitants in all regions of the country, and the maintenance of their positive effects on the conservation of ecosystem services and biodiversity, depends on several factors. The updating of information and accumulated knowledge on plant biodiversity and the production of ecosystem services is a priority.

Other important issues include the potential use of NFPs in innovation processes, and linking biodiversity with cutting-edge technologies for sustainable solutions. The prospection of information and the understanding of these links are urgent and necessary to make their roles visible to society and the well-being of the population. It is essential to demonstrate to society and decision-makers the relationships of dependence and impact between natural capital and the economy, reflecting on planning processes and the elaboration of public and business policies. Only with a solid base of knowledge about biodiversity and sustainable use, it is possible to benefit the formulation of public policies and decisions in science and technology, contributing to the conservation of Brazilian ecosystems and the mitigation of the impacts of climate change.

6.1 INVESTMENTS IN RESEARCH

> The expansion of agricultural R&D capacity does not consist only in expanding investments in the sector. It also involves increasingly including lines of research specifically aimed at the development of technological solutions for the productive reality of family farming. Historically, even in those countries where the success of agricultural research is notorious (such as Brazil), efforts have been concentrated around the development of techniques and technologies eminently oriented to the model of the Green Revolution and particularly appropriate for monoculture production systems carried out in extensive mechanized areas.[1]

Knowledge about complex production systems, such as agroforestry systems, where many species make up the arrangement, has been generated within the scope of academia and the commercial agroforestry systems under construction. Studies with more simplified arrangements, such as in systems with alleys using a perennial legume species, can contribute to the transition to more complex agroforestry systems.

The central region of Minas Gerais has an intense environmental liability related to soils exhausted by the export of nutrients and pastures degraded by excessive grazing. An important technique to change this situation is the use of green manures, using leguminous plants. In the regional context, it was identified by Matrangolo *et al.* (2010), during dialogues with corn producers in the central region of Minas Gerais (48 properties in 19 municipalities), that only one producer used green manure (in succession to silage corn), as a winter crop of forage radish (Raphanus sativus L.), of the Brassicaceae family.

This regional reality needs to be updated, but there has likely been no significant change in this picture. During the rainy season, the productive area is usually occupied by brachiaria, cassava, corn, beans, pumpkin, and vegetables. Among the factors that hinder the use of green manures in the central region of Minas Gerais would be the lack of rainfall (recurrent in the Cerrado, between April and October), the high cost, and the reduced supply of green manure seeds.

The reduced planting window in the central region of Minas Gerais minimizes the possibility of using short-cycle legumes in cultivation areas, especially where there is no possibility of irrigation. In this context, the productive arrangement in a system of alleys with perennial legumes presents itself as an option to improve the quality of the soil in the region.

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[1] CASTRO, César Nunes de. **Agricultura familiar no Brasil, na América Latina e no Caribe: institucionalidade, características e desafios.** IPEA, 2024. Available at: https://repositorio.ipea.gov.br/bitstream/11058/14052/9/Agricultura_familiar_no_Brasil_na_America_Latina_e_Caribe.PDF. Accessed on: 13 nov. 2024.

The accumulated estimate in just over 10 years of dry phytomass input/ha was 69.4 tons for cratily (average annual input of 6.94 t.ha-1) and 67.8 for gliricidia (average annual input of 6.78 t.ha-1). Among the phytomass-producing plants studied by Silva *et al.* (2005), the black velvet bean was the most productive legume, with 6.51 t.ha-1 of dry matter per cycle.

It is noteworthy that, despite the sharp reduction in rainfall in 2014 (551 mm), there was no stoppage in the phytomass production of the two legumes, and cratilia showed an increase in production greater than gliricidia. Because it comes from the Cerrado biome, cratiliana is more adapted to water stress, compared to gliricidia, which is natural to the region with a rainier tropical climate. In 2014, the rainfall of 551 mm was below the average for the period from 2013 to 2022 (10 full years), which was 1,357 mm. Considering extreme events, with unpredictable and prolonged periods of drought, and increasingly frequent climatic occurrences that negatively impact plant production, the use of perennial legumes becomes increasingly relevant.

Reis (2021) recorded an average production of 3.45 g of dry matter (DM)/pl of cratilia cut at 10 cm from the ground, 31.4 g DM/pl cut at 30 cm, and 63.39 g DM/pl cut at 50 cm.

The use of perennial legumes in alley systems is suitable for nutrient cycling and consequent improvement of soil quality. Compared to short-cycle legumes, green manure from the productive arrangement in alleys brings the benefit of amortization, over the years of production, of the initial investment (acquisition of seedlings or labor for the production of seedlings) as a result of the longevity of the system. Short-cycle legumes require constant investments for the production or acquisition of seeds and sowing, steps that are not repeated, in the short term, in the system in alleys.

6.2 INVESTMENTS IN TECHNICAL ASSISTANCE AND RURAL EXTENSION (ATER)

In addition to financing policies and credit lines, family farmers can count on the Technical Assistance and Rural Extension (Ater) policy, aimed at both the most vulnerable producers and those who are already in advanced economic development. Its main objective is to improve the income and quality of life of rural families, through the improvement of production systems, and mechanisms for access to resources, services, and income, in a sustainable way.

Currently, Ater is promoted by the federal, state, and municipal governments, as well as cooperatives, integrating input companies, private companies, and Non-Governmental Organizations (NGOs). However, almost 80% of the planned resources are allocated to the payroll of technicians and other professionals, leaving very little for the cost and investment of the service itself.

CONTAG defends new goals and pillars for Ater to be reformulated, such as:

- strengthen the current supply capacity in states and municipalities based on budget stability and funding resources; training for extension workers; agronomic residency; planning and technical support tools; and integration between research and extension;
- expand the coverage of Ater services, with greater participation of city halls; and
- Monitoring and evaluation of results, with greater availability of tools to collect data and information and the gradual structuring of a robust database on Brazilian agriculture.

According to the 2017 Agricultural Census, less than 20% of family farming establishments have some type of technical assistance. In addition to this low rate, access is also unequal, with a concentration in some Brazilian regions. The North and Northeast regions, with the largest number of family farming properties, were the ones that received the least after services.

According to the maps of organization in cooperatives and access to rural credit, in the regions where there is a greater presence of family farming, only 39% of the establishments are affiliated with associations and 11% are cooperative, while only 15% used financing via rural credit. To overcome these challenges, Ater must be able to serve all groups of family farmers, from the most structured to the most vulnerable.

6.3 INVESTMENTS IN RURAL EDUCATION

In the last two decades, we have had important achievements in rural education, such as:

- CNE/CEB Resolution nº 01/2002 - approval of the Operational Guidelines for Basic Education in Rural Schools;
- Creation of the Secretariat of Continuing Education, Youth and Adult Literacy, Diversity, and Inclusion – SECADI, in 2004;
- CNE Resolution nº. 2/2008 - approval of the Complementary Guidelines for Rural Education;
- Decree nº 7,352/2010 - approval of the Rural Education Policy and the National Program for Education in Agrarian Reform;
- Ordinance nº 86/2013 - the creation of the National Program for Rural Education (PRONACAMPO); and
- CNE Resolution nº. 2/2023 - creation of the Curricular Guidelines for the Pedagogy of Alternation in Basic Education and Higher Education.

Despite the achievements, we still need to expand and strengthen rural education actions. According to data from the INEP/2023 School Census,[2] Brazil has 45,199 Public Schools in the Countryside and 112 Rural Community Schools of the Family Center for Alternation Training Network – Cefas Network.

In rural schools, the biggest challenge is to curb closures, since, between 2013 and 2023, 19,941 schools were closed, an average of 1,994 per year.[3]. The closure of schools gives rise to the hiring of poor quality school transport, with long hours of commuting, removing students from their territories to urban schools, and disrespecting the traditions, cultures, knowledge, and ways of life of these populations.

The schools of the Cefas Network, as they are considered community schools, are unable to access resources directly from the Ministry of Education. Therefore, for this network, it is necessary to advance an agenda that can guarantee the allocation of public budget for hiring teachers, physical structure and technical staff, in addition to support for activities developed in alternation time, enabling full-time teaching.

In Scientific and Technological Professional Education, the Federal Network of Federal Institutes stands out. In 2024, there are already 685 units, including *campuses*, Federal Institutes, Federal Centers for Technological Education (Cefets), Federal Technological University of Paraná (UTFPR), and technical schools linked to Federal Universities and Colégio Pedro II. In this modality, it is important to highlight the creation of the Working Group on Agroecology and Professional and Technological Education of Rural Peoples, of Water and Forests. The WG was created in February 2024, within the scope of the National Commission for Rural Education (Conec) of the Ministry of Education, and aims to contribute to the formulation of actions and public policies aimed at technical and technological training, having as a theoretical and methodological reference the agroecology in alternation of the peoples of the countryside, the waters and the forests.

[2] MEC, 2024. **MEC e Inep divulgam resultados do Censo Escolar 2023.** Available at: https://www.gov.br/inep/pt-br/assuntos/noticias/censo-escolar/mec-e-inep-divulgam-resultados-do-censo-escolar-2023. Accessed on: 13 nov. 2024.

[3] CONTAG. **Anuário Estatístico da Agricultura Familiar - 2023 / Ano 2.** Brasília: 2023. Available at: https://ww2.contag.org.br/documentos/pdf/17916-696048-anua%CC%81rio-agricultura-2023-web-revisado.pdf. Accessed on: 13 nov. 2024.

Family farming faces several challenges aggravated by climate change. It is essential to invest in public policies that strengthen the sector, considering its diversity, and ensuring environmental sustainability and food security in the country. As previously mentioned, access to knowledge and the development of advanced scientific methods is urgent to qualify and quantify the role of different ecosystems and agrifood systems in mitigating GHG emissions and adapting to climate change.

This data is fundamental to confronting conventional agribusiness production systems and their sustainability narratives. They are important to guide decisions on charging for the effects of the negative externalities produced by these systems – such as excessive water consumption, silting of rivers, contamination of soils, water, and people and elimination of pollinators by the indiscriminate use of pesticides, among other factors – since these losses are socialized with the State and society, while profits are private.

Among the main points, it should be noted that:

- family farming is fundamental for food and nutritional security in Brazil;
- climate change poses a serious threat to agricultural production and the livelihoods of family farming;
- it is urgent to implement public policies that strengthen family farming and promote adaptation to climate change;
- family farming is part of the solution to the climate crisis; and
- Through sustainable and low-carbon practices, it must lead the transition of agriculture.

Brazil can and should develop economically from its biodiversity, encouraging research, innovation, and development of technologies, products, and processes focused on conservation and sustainable use. The sustainable use of land for food production plays a vital role in the balance of national ecosystems, maintains a collection of genetic, chemical, and biochemical information of industrial interest, and is central to the food and livelihoods of local communities, complementing the consumption of agricultural, fisheries and livestock goods.

However, in the face of climate and sustainable development challenges, family farming and traditional peoples and communities should not enter this equation only as a source of inputs and cheap labor, but as effective agents of transformative processes with the promotion of concrete opportunities for insertion in socio-bioeconomic circuits, territorial recognition, access to technologies, markets, credit, public policies and training for the development of local capacities with a view to personal and professional fulfillment and promotion of quality of life in their territories.