Smallholders in the Caatinga and the Cerrado: A Baseline Analysis for a Rural Just Transition in Brazil

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CLIMATE POLICY INITIATIVE

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ABOUT CLIMATE POLICY INITIATIVE

Climate Policy Initiative (CPI) is an analysis and advisory organization with deep expertise in finance and policy. Our mission is to help governments, businesses, and financial institutions drive economic growth while addressing climate change. CPI has six offices around the world in Brazil, India, Indonesia, Kenya, the United Kingdom, and the United States. In Brazil, CPI partners with the Pontifical Catholic University of Rio de Janeiro (PUC-Rio).

KEYWORDS
Smallholders, Caatinga, Cerrado, Rural Just Transition

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CPI/PUC-Rio	Climate Policy Initiative/Pontifical Catholic University of Rio de Janeiro (*Climate Policy Initiative/Pontifícia Universidade Católica do Rio de Janeiro*)
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IBGE	Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*)
IFAD	International Fund for Agricultural Development
INCRA	National Institute for Colonization and Land Reform (*Instituto Nacional de Colonização e Reforma Agrária*)
SEEG	Greenhouse Gas Emission and Removal Estimating System (*Sistema de Estimativa de Emissão de Gases*)

CONTENTS

Due to the increasingly high global carbon emissions, the world is reaching a tipping point and is set to pass the 1.5°C threshold by 2040. Agriculture, food, and land use are responsible for a third of global emissions (Pinfield 2021).

In Brazil, agriculture in 2021 was directly responsible for 24.8% and indirectly responsible, through land use and land coverage, for 49% of the country's emissions (SEEG 2022). At the same time, the agricultural sector in Brazil is a pillar of Brazil's economy, responsible for 25% of the country's GDP (We Forest 2019).

As the fourth largest food producer in the world and the number one global crop producer (We Forest 2019), Brazil's agricultural production plays a vital role in meeting growing food demands as the world's global population is expected to reach almost 10 billion people by 2050 (Viglione 2021).

Brazil has made strides in improving its environmental performance and becoming more competitive in a commodity market that increasingly demands more responsible production. However, on the brink of climate change, the country also faces considerable challenges to ensure greater production, sustainability, and resilience. For Brazil, rising global temperatures will bring increased and prolonged droughts, more intense and frequent extreme precipitation and flooding, and increased risks of fire weather. Responding to this challenge will require a substantial change in the way food is produced, processed, and consumed. This not only implies changes to reduce the climate impact of the highly industrialized agricultural sector, but also requires special attention to ensure that the livelihoods of agricultural workers are not ignored.

A rural just transition to carbon neutral and sustainable agricultural production systems in Brazil is necessary to reduce emissions, while protecting farms, farmers, and their communities, and maximizing the social and economic opportunities of climate action (Viglione 2021). The impact of climate change on groups and individuals depends on both who they are and where they are located. For areas that already face persistent poverty and poor socioeconomic conditions, in addition to restricted access to resources, climate change increases vulnerability and risk. **Effectively promoting a rural just transition that addresses their potential outcomes on those who will be most affected requires developing regional and sector-specific strategies, giving communities actionable paths to reduce emissions, and increasing resilience without exacerbating inequalities and inequities.**

Understanding the profile of Brazil's smallholders[1] — those who must be at the center of policy reform and targeted efforts for a rural just transition — is a critical first step in making agricultural workers and their livelihoods a central part of the discussion. Researchers from Climate Policy Initiative/Pontifical Catholic University of Rio de Janeiro (CPI/PUC-Rio) recognize the overall lack of empirical work on just transition policies, particularly in Brazil where the concept is still emerging and has yet to be mainstreamed into policy discussions.

1 This report identifies smallholders as family producers who practice activities in rural areas, simultaneously meeting the following requirements: do not hold, in any capacity, an area larger than four fiscal modules; predominantly use the family's own labor for economic activities; and have a minimum percentage of family income originated from farm activities.

This report aims to provide a profile of smallholders, who need to be at the center of reform, since they are in the position of bearing the largest burden and reaping the fewest benefits. This analysis provides an overview of the situation of smallholders based in two of Brazil's most critical biomes, the Cerrado and the Caatinga.

Results show considerable differences between smallholders across both biomes in terms of productivity and methods of production. Smallholders in the Caatinga present lower levels of productivity and access to technical assistance. More importantly, a large group of smallholders is inserted in subsistence farming and live in places with high levels of poverty. This puts them at an even higher climate risk exposure, due to restricted access to mitigation mechanisms — such as insurance or climate resilient inputs.

CPI/PUC-Rio's analysis highlights that a rural just transition in Brazil will require a tailored approach and a nuanced understanding of smallholders' realities. While technological solutions will be required, integrating the social dimension of producers will be a key component in designing agricultural policies that aim to tackle climate change alongside food security challenges.

JUST TRANSITION IN BRAZIL'S AGRICULTURE

Agricultural land in Brazil is heavily concentrated. Brazil's 2017 Agricultural Census indicates that approximately 4% of the farms comprise 63% of the farmland. By contrast, 65% of rural establishments account for 9% of farmland with areas corresponding to less than one fiscal module (Souza, Herschmann, and Assunção 2020), which is the minimum area where agricultural activity can provide subsistence and social and economic progress to families who invest all their workforce in it – as defined by the National Institute of Colonization and Land Reform (*Instituto Nacional de Colonização e Reforma Agrária* – INCRA). This distribution of agricultural land illustrates a strong duality in Brazilian agriculture: less productive subsistence farms coexisting primarily in the North and Northeast regions of the country in parallel to a thriving, commercially oriented, and capitalized agricultural industry across the South, Southeast and Midwest regions, which is reaching export markets with increasing success.

This sharp contrast in the agricultural sector is fundamental in thinking about what a rural just transition means for Brazil and is a key consideration for addressing the social and economic effects of a transition to a carbon neutral, nature positive society, that centers around the regions, industries, workers, and citizens who will face the greatest challenges (Baldock and Buckwell 2021).

While, on one hand, agriculture is one of the main sources responsible for greenhouse gas (GHG) emissions in Brazil, on the other hand, the sector presents a unique ability to positively contribute to the global carbon budget as its fundamental input of productivity since plant growth through photosynthesis removes CO_2 from the atmosphere. As both food security and climate change become more pressing issues, it is important to converge the dual role that agriculture presents by identifying and disseminating technologies that increase production and productivity, enhance resilience to climate change, and reduce GHG emissions.

Converging agriculture's dual role requires considerable investments to advance sustainable practices. For instance, increases in agricultural productivity have historically slowed farmland expansion, thereby reducing deforestation and related land use change emissions (Stevenson et al. 2013; Gollin, Hansen, and Wingender 2021). Moreover, technologies already used at scale, that simultaneously increase productivity and reduce emissions, such as double-cropping, provide pathways for advancing a climate transition in Brazil's agriculture.

Nevertheless, this transition requires innovation to better adapt production to specific biomes and geographical conditions, human capital investment on new practices, financial resources to make the necessary investments, and financial instruments to deal with eventual new risks. This is particularly challenging for smallholders. The strategic expansion of both resources and technologies to this group of farmers provides an opportunity to shift agriculture in the country from an extractive to a more sustainable and regenerative model.

SMALLHOLDERS IN THE CAATINGA AND THE CERRADO

With 3.9 million establishments,[2] smallholders represent 76.8% of all establishments in Brazil. At the same time, they occupy 23% of cropland. They are the most vulnerable group to climate change, as the majority have more limited access to resources to expand their production using climate-smart technologies. For instance, while evidence has shown that rural credit for smallholders has the greatest conservation benefits by allowing them to do more with their existing land instead of extending their production over forested areas, most of the public resources are still directed to medium and large producers (Souza, Herschmann, and Assunção 2020).

Almost half of Brazilian smallholders (1.9 million establishments) are located on the Caatinga and the Cerrado biomes, that together make up around 30% of the Brazil's total area and represent 53% of its cropland. Both biomes are susceptible to droughts with advancing desertification and farmers in these areas are increasingly exposed to climate-related risks. However, besides the challenge due to climate risk of their production, the Caatinga presents one of the highest poverty indicators in the country, with a poverty rate of 22.8, compared to a national level of 6.6 (IBGE 2010).

The Cerrado and the Caatinga biomes are distinctly different and understanding the profile of smallholders in each biome provides insight into how policies and programs can meet the needs of these farmers.

The Caatinga region is heavily dependent on agriculture. Over a quarter (26%) of the population work in the agricultural sector in this biome, compared to national level of around 6%. The Caatinga contains 32% of the country's farms, while also accounting for 18% of the country's poorer rural population (FBDS nd). In the Caatinga, 1.4 million smallholders make up 36.8% of all producers in the biome.

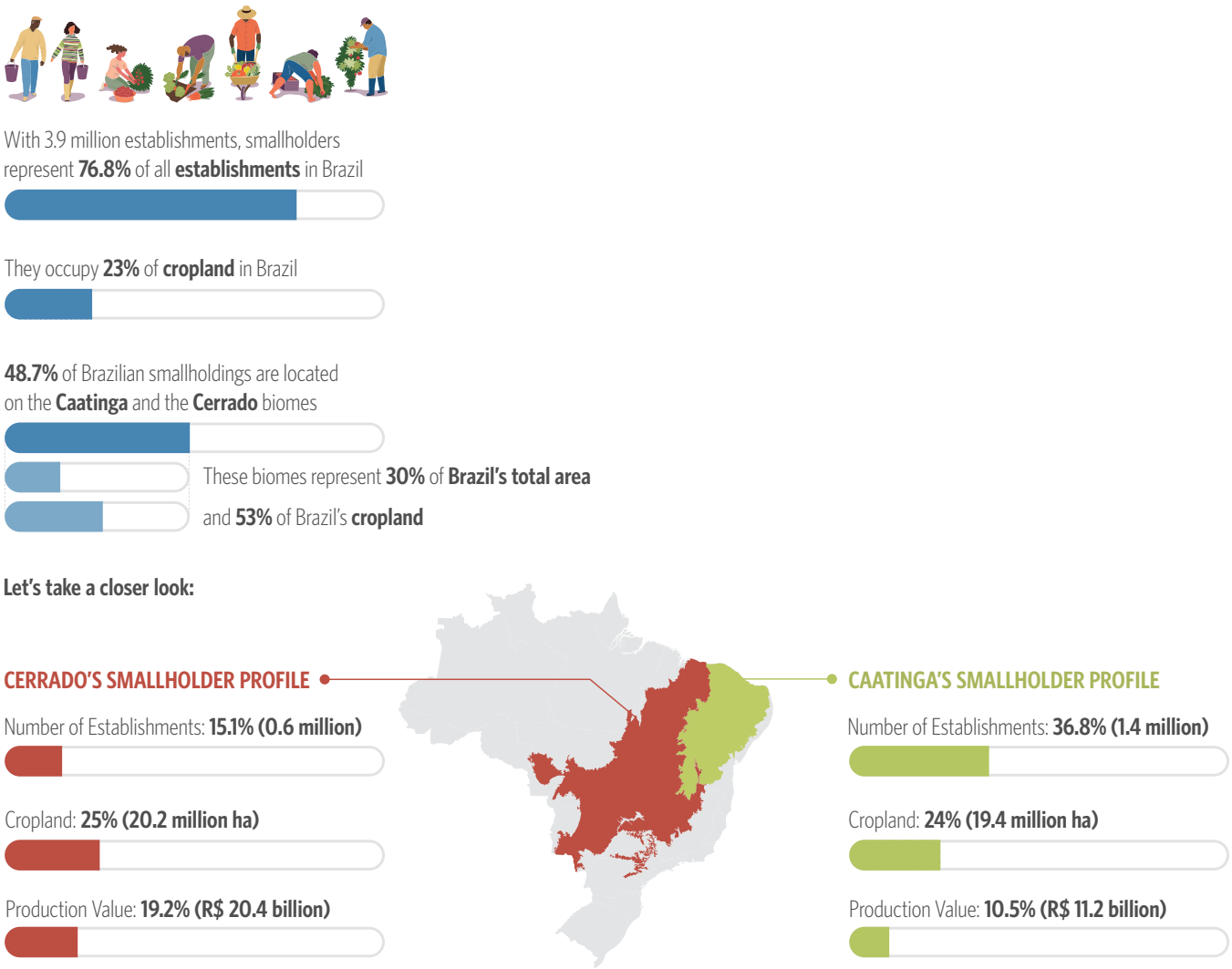
On the other hand, the Cerrado region plays a central economic role in Brazil, accounting for half of the country's soy production (Souza et al. 2021). Due to its geographical location, it also holds a unique position in maintaining water resources for the continent (Filho and Costa 2016). In the Cerrado, smallholders comprise 15% of the producers in the biome.

Despite the differences in number of smallholders between the biomes, they occupy nearly the same amount of land: 19.4 million hectares in the Caatinga and 20.2 million hectares in the Cerrado (Figure 1). This implies that smallholders in the Cerrado have bigger farms: their farms average 36.2 hectares, compared to 14.3 hectares in the Caatinga. In terms of the value produced, another stark contrast appears. While the Caatinga has a greater number of producers, the total value of their production is lower than those in the Cerrado, which implies significant differences in productivity between biomes. Despite the prevalence of

2 According to the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* – IBGE), an agricultural establishment is any production/exploitation unit dedicated, totally or partially, to agricultural, forestry and aquicultural activities, regardless of its size, legal form (whether it belongs to a producer, to several producers, to a company, to a set of companies etc.), or its location (urban or rural area), with the objective of production, whether for sale (commercialization of production) or for subsistence (support of the producer or his family).

smallholdings in the Caatinga, its total value of agricultural production is less than in the Cerrado: the Cerrado stands out with larger overall production yields, producing almost twice as much as in the Caatinga.

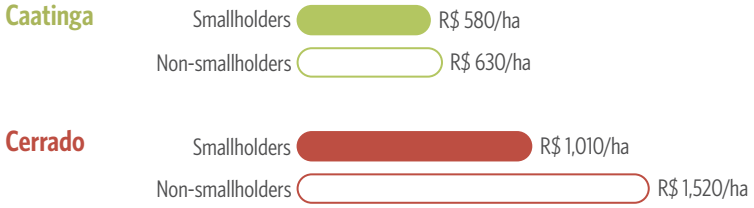
Figure 1. Production Value of Smallholders in the Cerrado and the Caatinga



Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

Disparities in production yields also exist within the biomes between smallholders and larger scale producers. However, this difference is much greater in the Cerrado: while non-smallholders in the Caatinga are 9% more productive than smallholders, in the Cerrado they are 50% more productive. More surprisingly, smallholders in the Cerrado are more productive than medium and large-scale producers in the Caatinga (Figure 2).

Figure 2. Productivity of Smallholders in the Cerrado and the Caatinga



Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

These productivity differences between the biomes, however, are not driven by specialization in terms of agricultural activity. The biomes have similar production profiles, with cattle ranching being the main activity among smallholders, followed by temporary crops, and only a few smallholders dedicated to permanent crops or horticulture. Nevertheless, the previous pattern remains, where the Caatinga has lower productivity in all activities (Figure 3).

Figure 3. Economic Activity of Smallholders in the Cerrado and the Caatinga

Figure 3a. Productivity by Economic Activity

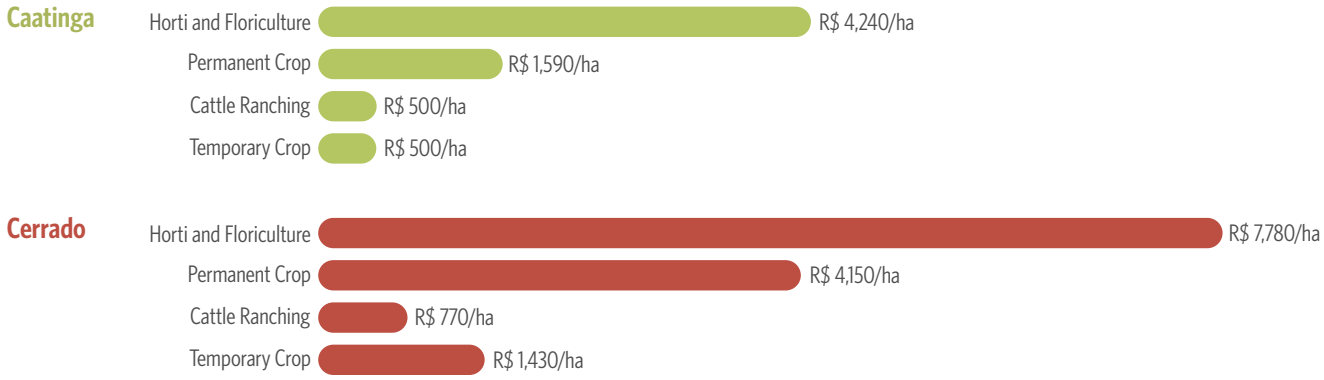


Figure 3b. Smallholdings by Economic Activity

Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

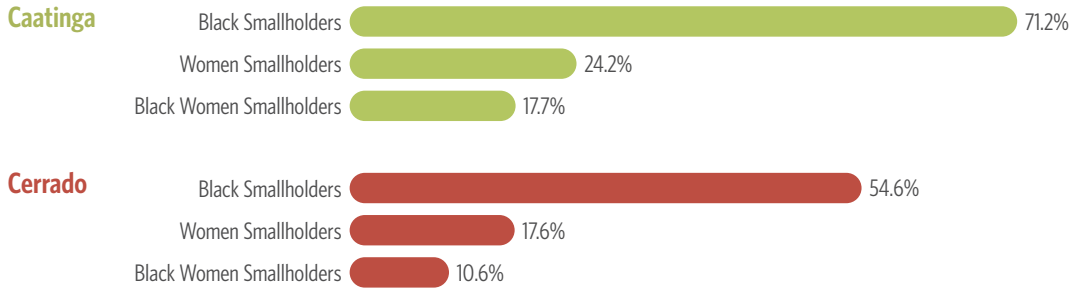
Ultimately, these results reveal a greater number of smallholders in the Caatinga than in the Cerrado who produce on smaller farms with lower yields, primarily focused on cattle and temporary crops.

Differences also exist along the lines of gender and race between and within biomes.

Women are more likely to be the head of farm for smallholders than they are for commercial farms. In the Caatinga biome, women's participation exceeds the average for Brazil. Female producers are responsible for 24% and 17% of smallholdings in the Caatinga and the Cerrado, respectively. However, women-led smallholdings do not directly reflect the share of area they occupy: 15% and 12% of the area in the Caatinga and the Cerrado, respectively, is occupied by female-led farms, which implies they have smaller farms than their male counterparts (Figure 4).

In terms of race, black smallholders run 71% and 54% of smallholdings in the Caatinga and the Cerrado, respectively. Nevertheless, they are more likely to have smaller farms — black smallholders represent 60% and 46% of smallholders' area in the Caatinga and the Cerrado, respectively. In the intersection of gender and race, we see that on average the Caatinga has a higher share of black women (17.7%) as head of the farms than the Cerrado (10.6%).

Figure 4. Percentage of Smallholdings by Gender and Race

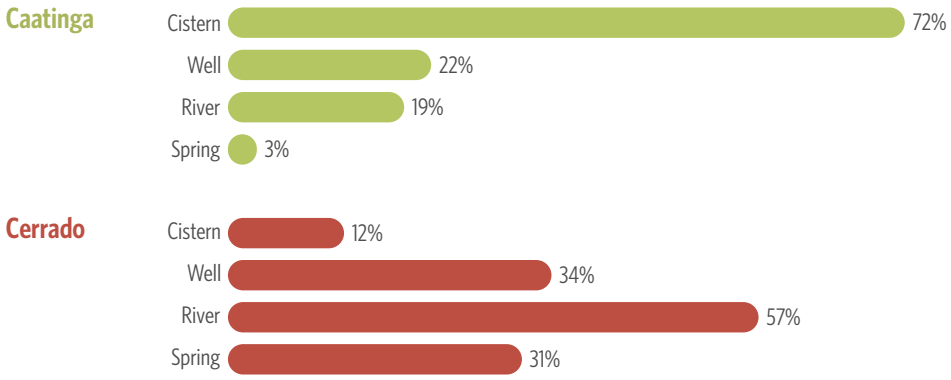


Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

PRODUCTION METHODS

The Cerrado and the Caatinga have distinct climate profiles that have implications for what and how farmers produce. While the Caatinga is characterized by long periods of drought, the Cerrado, called the "water tank" of Brazil, houses nine springs out of the 12 Brazilian hydrographic basins. While both biomes present a similar number of rainy days as Brazil (approximately 31 days), the precipitation levels are lower: 141.5 mm in the Cerrado and the Caatinga in 2018 compared to 152.7 mm in the rest of the country. The Caatinga and the Cerrado are also warmer areas, with one degree Celsius above national average. In the Caatinga, where producers face higher water scarcity, most producers (72%) use cisterns, which is the main source of water in the biome. Less than 20% of the smallholders have access to a river and approximately 22% have access to a well. In the Cerrado only 12% of smallholders use cisterns, and have greater access to rivers, springs, or wells (Figure 5). Smallholders from both biomes present low levels of irrigation for farming. In the Caatinga the irrigation ratio (10.7%) is even higher than in the Cerrado (7.9%), likely because drought periods are shorter in the Cerrado than in the Caatinga, allowing producers to keep higher productivity in a more stable rainfed system (Figure 6).

Figure 5. Percentage of Water Source Use by Smallholders



Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

Figure 6. Percentage of Irrigation Use by Smallholders

Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

Commercial agriculture in Brazil uses a variety of inputs to enhance the quality of soil, increase nutrients for crops, and control weeds, insect infestation and diseases. The use of these kinds of inputs for smallholders in both biomes is low. Around 25% of smallholders use pesticides. Very few producers practice liming to improve the soil quality in the Caatinga, and while this percentage increases in the Cerrado, it still seems to be very low (Figure 7a).

Less than one third of smallholders use any fertilizer. Smallholders in the Caatinga predominantly use organic fertilizers, while in the Cerrado chemical fertilizers (or a mixture of chemical and organic fertilizers) are used by almost three quarters of smallholders (Figure 7b). The Cerrado presents higher use of organic agriculture than the national average, however it is still very low, with less than 2% of establishments report using it. The Caatinga presents the lowest ratio, with only 0.7% of farmers report doing organic farming (Figure 7c).

Figure 7. Fertilizer Use by Smallholders

Figure 7a. Pesticides, Liming, and Fertilizer Use by Smallholders

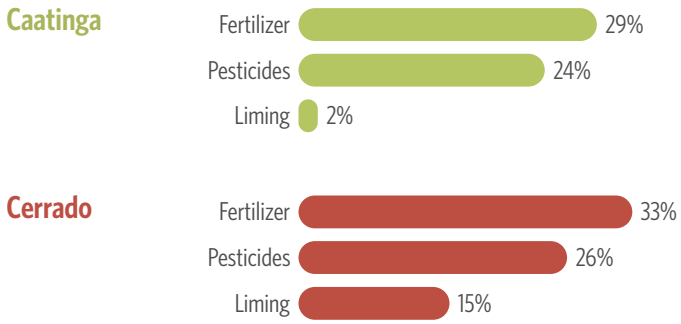


Figure 7b. Chemical and Organic Fertilizer Use by Smallholders

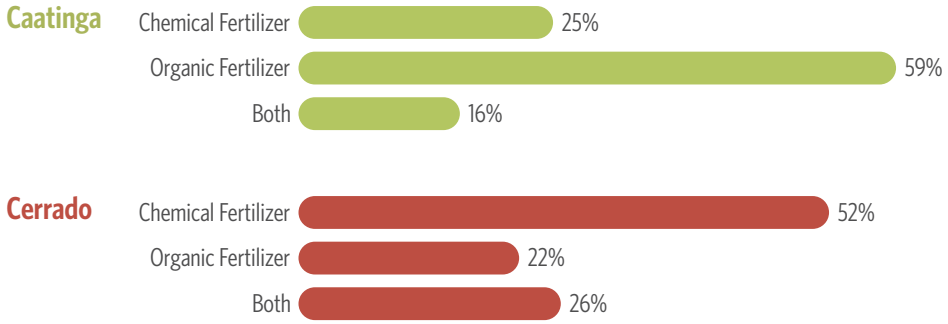


Figure 7c. Percentage of Organic Agriculture by Smallholdings

Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

Considering that 24% of smallholders in the Caatinga report using herbicides, there seems to be an opportunity to include the remaining 76% into practice organic agriculture.

In summary, in the Caatinga, smallholders face more extreme weather and are dependent on cisterns as their main source of water. In the Cerrado, smallholders have access to more perennial sources of water, and despite having some access to chemical fertilizers, the percentage is still very low. The Caatinga presents higher use of organic fertilizers, which might be related to limited access to chemical fertilizers.

In terms of what crops they cultivate, Figure 9 presents the main crops cultivated by smallholders for subsistence farming across biomes. Beans and corn are at the core of their production, raised by 68% farmers in the Caatinga and 44% in the Cerrado. Manioc appears as the third most common crop in both biomes but is more prevalent with producers in the Cerrado (Figure 8a).

Analyzing crops by area for both biomes provides different insights. In the Caatinga most of the area is occupied by the two most common crops – beans and corn. However, in the Cerrado, soy, which is cultivated by less than 3% of smallholders, occupies 29% of total area cultivated by smallholders, followed by corn. Beans, the second most farmed crop in the Cerrado, only occupy 5% of the area (Figure 8b).

Figure 8. Main Crop Production in Smallholdings

Figure 8a. Percentage of Crops in Smallholdings

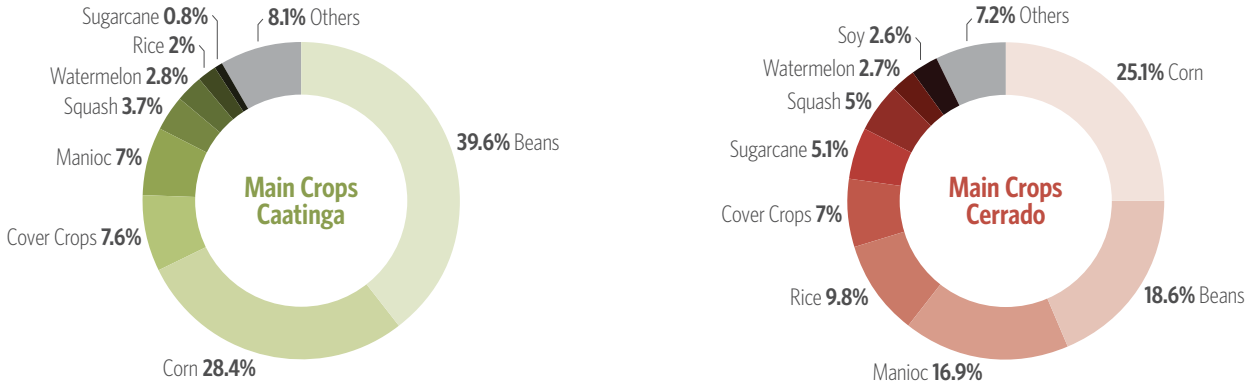
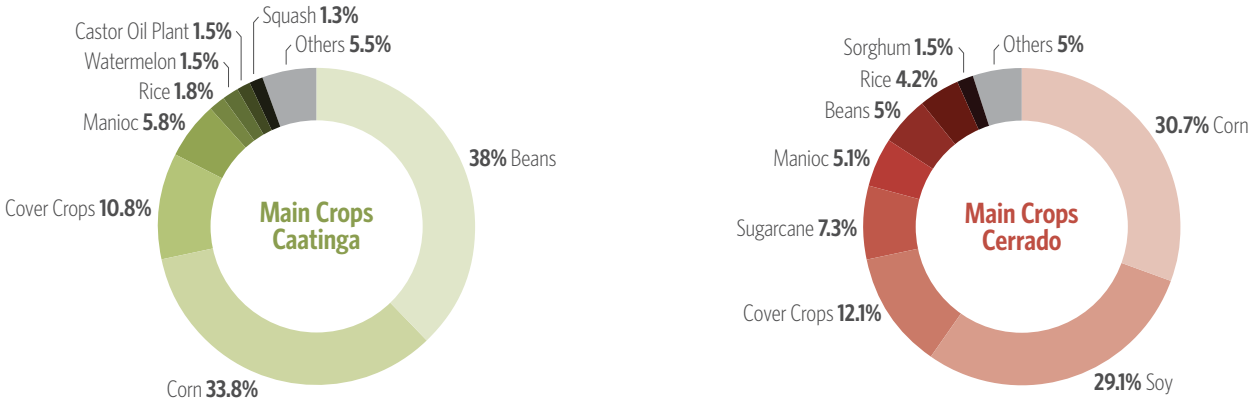


Figure 8b. Percentage of Crops by Area

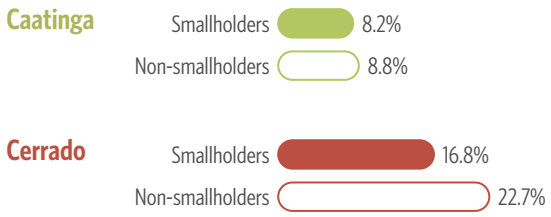


Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

CHALLENGES FOR THE ADOPTION OF NEW PRODUCTION METHODS

Ensuring a rural just transition requires the adoption of more sustainable practices that allow smallholders to mitigate and adapt to the impacts of climate change. Access to technical assistance plays an important role in preparing producers to change what and how they produce. Analysis shows that technical assistance is deficient in both biomes, especially in the Caatinga where only 8% of smallholders receive technical assistance. While this number is greater in the Cerrado (16.8%), it is still low and reflects a challenge for disseminating more sustainable practices (Figure 9).

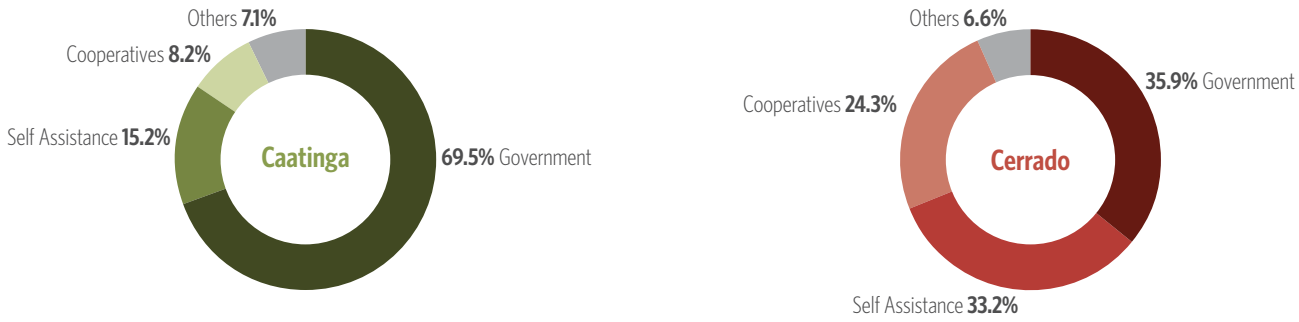
Figure 9. Percentage of Technical Assistance Received by Smallholders



Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

Many of these efforts seem to be government dependent. In fact, around 70% and 36% of the technical assistance to smallholders in the Caatinga and the Cerrado, respectively, are funded by the government. However, in the Cerrado, smallholders show a greater ability to access technical assistance by either paying for it themselves or through cooperatives (Figure 10).

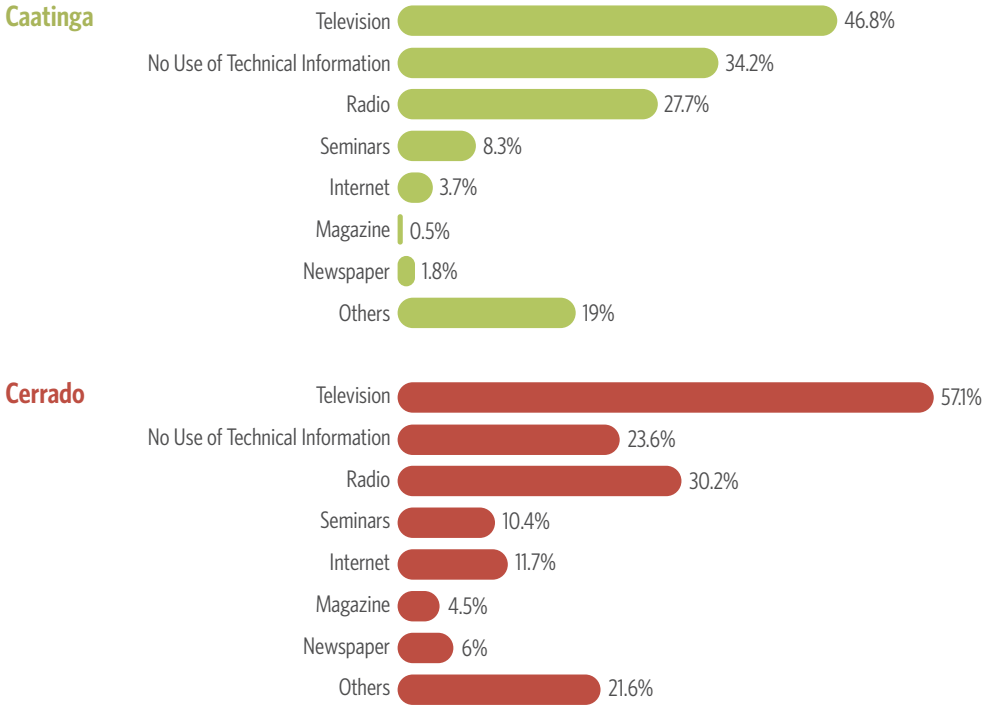
Figure 10. Percentage of Technical Assistance Origin Received by Smallholders



Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

In addition to technical assistance, limited access to technical information also seems to be a bottleneck for the dissemination and adoption of better agricultural practices. Smallholders primarily look to television and radio as the two main sources of technical information. Few individuals access information from the internet, magazines, or newspapers, especially in the Caatinga (Figure 11).

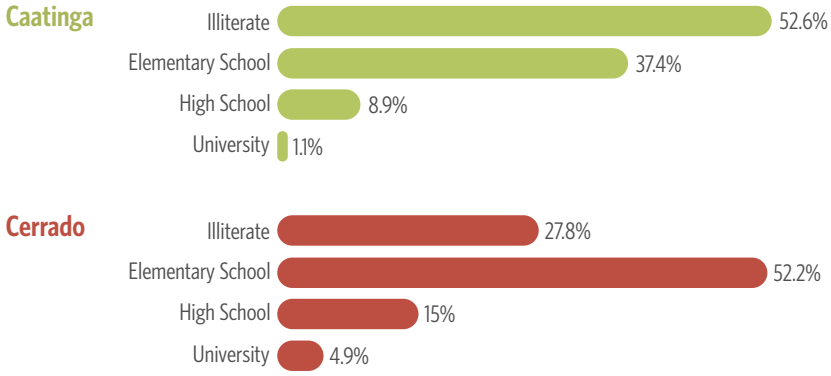
Figure 11. Source of Technical Information Used by Smallholders



Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

Designing programs aimed to increase the capacity of small-scale producers must consider the educational background of these individuals. Overall, smallholders have low levels of education. More than 50% of smallholders in the Caatinga are illiterate. And just over 10% completed high school. In the Cerrado, smallholders show slightly higher, but still limited, levels of education — 28% are illiterate and 52% have only completed basic education (Figure 12).

Figure 12. Education Levels of Smallholders



Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

Low education levels, inadequate technical assistance, and restricted access to technical information, primarily through TV or radio, leave smallholders with limited options for increasing their capacity and altering their production methods in a meaningful way.

POVERTY, SUBSISTENCE AND INSURANCE

Besides the methods of production, the main destination of the production (own consumption or commercialization) is a key aspect that also differentiates smallholders across both biomes. Although many smallholders across both biomes produce for their own consumption, this rate is higher in the Caatinga (68.3%) than in the Cerrado (43.5%) (Figure 13).

Figure 13. Main Destination of Smallholders' Production

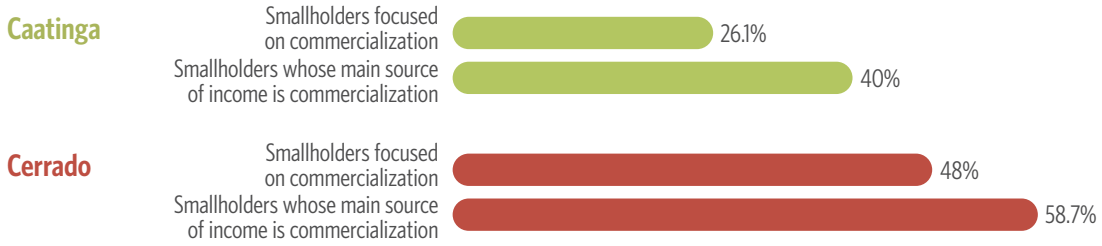
Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

In terms of the economic relevance of agriculture activity for these smallholders, in the Cerrado, 48% of smallholders have commercialization as their main source of income. However, the Caatinga presents almost half of this share, with only 26% of smallholders reporting commercialization of their production as their main source of income (Figure 14).

Differing levels of commercialization may be the result of different scenarios. On the one hand, smallholders may have a main source of income in markets other than agriculture and have their rural property as a secondary activity. This would be a scenario in which other sources of income compensate for their lack of specialization as agricultural producers (e.g., having agriculture as a kind of insurance for unstable jobs or as a means to reduce household food expenses). On the other hand, another possibility may be that the production of smallholders is so low that they do not have any surplus for commercialization, and most of their income comes from government transfers, which would be the most critical scenario from a social point of view.

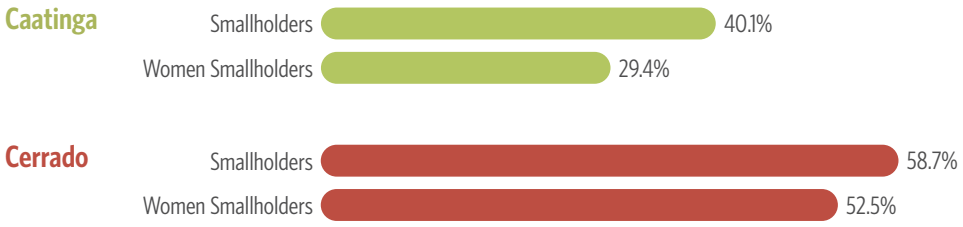
This creates three potential groups of smallholders. The first group of producers is inserted in a broader context of poverty, producing in subsistence agriculture for lack of means to commercialize it. Second, is a group of producers who are not interested in having agriculture as their main source of income, keeping farmland as insurance for other income generating activities. The third group appears with those farmers interested in commercializing their production. Figure 14 shows that among smallholders focused on commercialization (from Figure 13 above, 32% in the Caatinga and 57% in the Cerrado), only 40% of them have commercialization as the main source of income in the Caatinga. This represents an opportunity for policy design targeted at this group who is interested in commercializing their production but still does not have it as a primary income generating activity.

Figure 14. Percentage of Commercialization Smallholdings



Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

Figure 15. Percentage of Commercialization Smallholdings whose Main Source of Income Is Agricultural Production

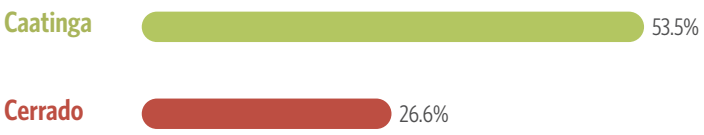


Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

Figure 15 shows the proportion of establishments for which agriculture serves as the main source of income among those farms focused on commercialization. Results indicate a gender disparity. The proportion of establishments that have production as the main source of income drops considerably when looking only at establishments run by women. This drop is especially greater in the Caatinga biome. This presents a situation of income vulnerability for female producers in the Caatinga, where most of the production for smallholders is for subsistence. Additionally, in the Caatinga, female run establishments where the focus is commercialization and not self-consumption, show that primary sources of income come from sources other than the commercialization of products.

Additional analysis is needed to better understand the context of poverty and production for these farms, considering that even producers who are focused on commercialization require additional sources of income. For instance, Figure 16 shows the number of households that receive government transfers through one of Brazil's conditional cash transfer program (*Bolsa Família* - PBF). Over 4.2 million beneficiaries live in the Caatinga, representing 29.2% of the total number of beneficiaries all over Brazil.

Figure 16. Number of Households Benefited by PBF



Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

Over half of the population lives with less than half a minimum wage[3] in the Caatinga (53.5%) (Figure 17). This number drops to just over a quarter of the population (26.6%) in the Cerrado. Taken together, these numbers make up a broader scenario of rural poverty, which is possibly correlated with the high numbers of subsistence farming in the Caatinga.

Figure 17. Percentage of Population Living with Less than Half a Minimum Wage

Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

All these numbers can be summed up in maps that present the hotspot of more productive farmers *versus* regions where smallholders produce for self-consumption and are in regions with high levels of poverty (Figure 18). Figure 18a shows that, in most municipalities in the Caatinga, the share of smallholders is higher than 80% of the number of total producers. In the Cerrado, especially in the state of Mato Grosso and Goiás, major hubs of grain production, most smallholders are commercial farmers. Figure 18b shows that the places where these commercial farmers are located are those with higher productivity levels. Figure 18c correlates that with the fact that most producers in the Caatinga produce for their own consumption. Finally, Figure 18d shows that the subsistence systems are also located in places with high levels of poverty.

3 Brazil's current minimum wage in February, 2023, is R$ 1,302 (US$ 260.52). bit.ly/3YmrvFD.

Figure 18. Socioeconomic Profile of Smallholders in the Cerrado and the Caatinga

Figure 18a. Percentage of Smallholdings

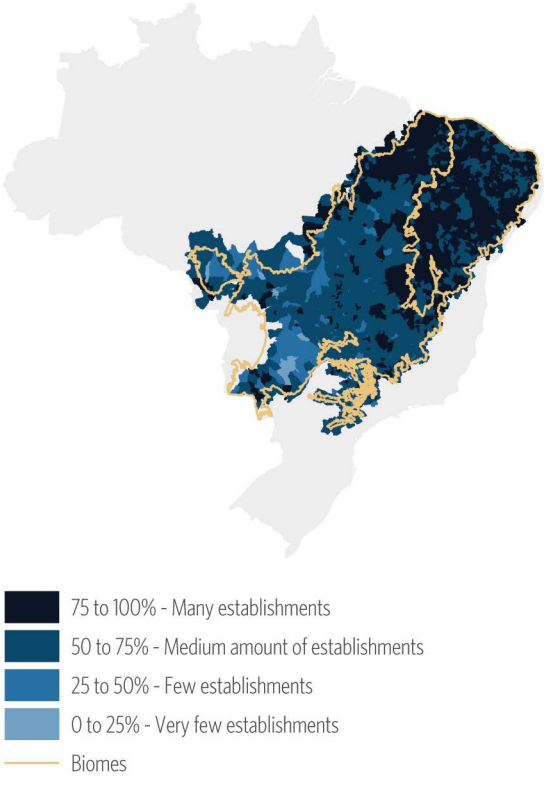


Figure 18b. Productivity of Smallholders

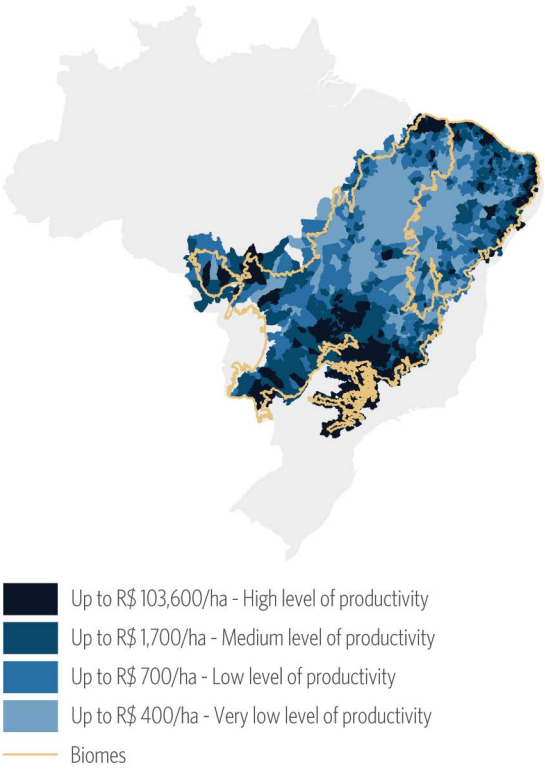


Figure 18c. Percentage of Smallholdings that Focus on Self-consumption

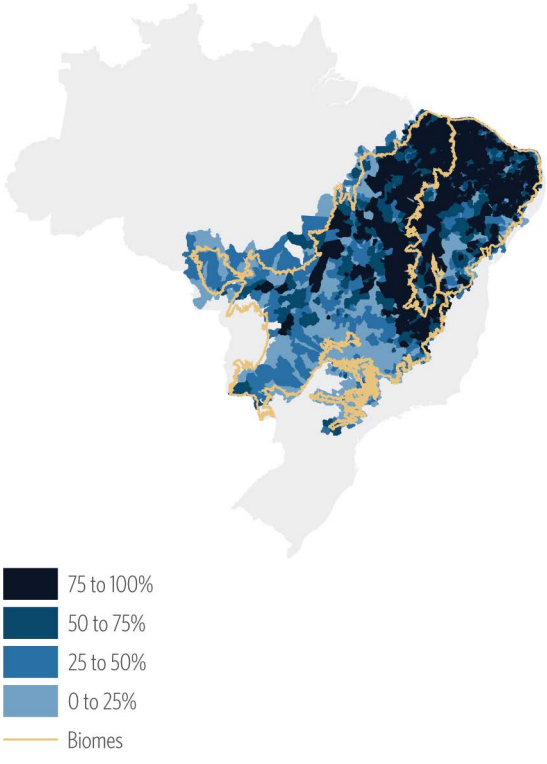
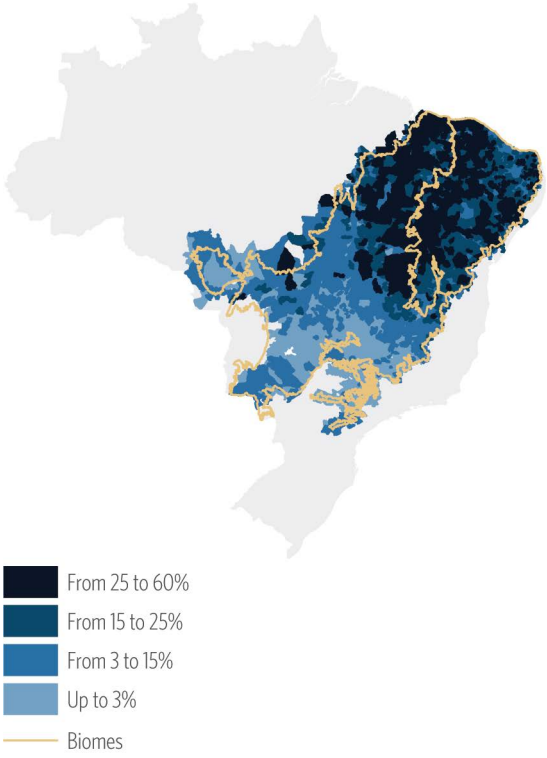


Figure 18d. Percentage of Smallholders Living in Extreme Poverty[4]



Source: *CPI/PUC-Rio with data from 2017 Census of Agriculture (IBGE), 2023*

4 According to the 2010 Demographic Census (IBGE) extreme poverty is defined as "individuals whose monthly income is equal to or lower than R$ 70 (approximately US$ 14)".

CONCLUSION

The promotion of a rural just transition that effectively supports climate mitigation efforts and improves the livelihood of rural communities in Brazil requires a detailed understanding of the realities and needs of smallholders. This baseline analysis of smallholders in the Caatinga and the Cerrado biomes highlights three important considerations for transitioning the agricultural sector to a more inclusive, sustainable, and regenerative model.

1. **The production of smallholders varies considerably and must be at the center of policymaking**. Smallholders are not a unified group — they present different characteristics across and within biomes. Across both biomes, smallholders show considerable differences in terms of productivity and methods of production. While smallholders in the Caatinga present lower levels of productivity and access to technical assistance, they also have a lower use of chemical fertilizers.

2. **A large group of smallholders engaged in subsistence farming face social challenges that need broader support outside usual agricultural policies (e.g., access to credit or technical assistance)**. For these farmers, social policies that focus on improvements on education and health indicators are key to addressing their actual needs and ensuring that the impacts of climate change do not leave them in a more vulnerable condition. Additionally, female producers present higher levels of socioeconomic vulnerability, especially in the Caatinga.

3. **A subset of smallholders demonstrates interest in commercialization and has a greater capacity to increase their production.** Harnessing the potential of these farmers, given that they have a comparative advantage in terms of labor intensity, provides a unique opportunity for Brazil to advance a just transition across the sector. According to the International Fund for Agricultural Development (IFAD), when accessing the same inputs and conditions, small farms tend to be more productive than larger ones given the quality and monitoring capacity of family labor, when compared to bigger farms. Furthermore, smallholders are more invested in protecting the fertility of the soil and contributing to agro-biodiversity (Houngbo 2020), which increases their potential as key players in reducing impact of agriculture on the environment.

These distinct profiles require different solutions to adapt and meet the needs of smallholders.

As Brazil attempts to promote a more inclusive and sustainable agriculture sector, it must put smallholders at the center of these discussions. For example, for those interested in commercializing and improving their production, a set of policies that focuses in inserting these producers in markets of products that are more labor intensive, such as organic horticulture and extractive agriculture, could be effective in scaling down the adoption of conventional agriculture methods. Promoting a leapfrog strategy that allows smallholders to increase production without turning to intense use of pesticides, for instance, represents an opportunity for the just rural transition agenda in Brazil.

Nevertheless, Brazil's current public policies do not prioritize these producers or this transition, presenting a window of opportunity to design effective policies for this group of smallholders. This will require a transfer of both technological and financial solutions. Given that technological transitions generate systemic changes that might affect producers in different ways, policies focused in promoting the diffusion of low-carbon technologies among smallholders should be complemented by policies focused on smoothing the shocks producers might face during the transition process.

Pursuing and ensuring a rural just transition requires adapting policies and engaging food producers to transform food and land-use systems to address and adapt to climate change by placing justice, equity, and rural livelihoods in the center of these efforts and recognizing that certain producers face greater barriers in tackling these transitions. This creates a significant challenge — one that requires systemic changes in which institutions redirect policies and strategies to allow agriculture to provide a common good while being accountable and inspired by grassroots movements.

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