ARTICLES

THE NORTHEAST CONSTITUTIONAL FUND (FNE) FOR FINANCING THE NATIONAL PROGRAM FOR STRENGTHENING FAMILY FARMING (PRONAF): A SPATIAL ANALYSIS OF THE FUND'S PERFORMANCE IN THE TRAJECTORY AND GEOGRAPHIC DISTRIBUTION OF RESOURCES

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Abstract

The Northeast Constitutional Fund (FNE) is the primary source of financing for the National Program for Strengthening Family Farming (PRONAF). This study has aimed to assess the effective scope of FNE-PRONAF actions, with a particular focus on the spatial distribution of its financial volume. The methodology combines an exploratory study, a literature review, and descriptive data analysis, employing spatial analysis and geoprocessing techniques. The findings have indicated that between 2002 and 2023, the participation of FNE-PRONAF in the total number of contracts remained stable, thereby reflecting significant municipal reach. In terms of values, participation increased until 2017, particularly in the semi-arid region, before declining after 2018. This period was marked by the an expansion into this region from the western and coastal areas. Furthermore, the bivariate spatial analysis identified that this expansion presented two patterns of association for the location of the FNE-PRONAF and the FNE financial volume.

Keywords

Public Policy Analysis; Financing of Regional Policies; Regional Development; Spatial Analysis; FNE; PRONAF; Rural Credit.

ARTIGOS

O FUNDO CONSTITUCIONAL DO NORDESTE (FNE) NO FINANCIAMENTO DO PROGRAMA NACIONAL DE FORTALECIMENTO DA AGRICULTURA FAMILIAR (PRONAF): UMA ANÁLISE ESPACIAL DA ATUAÇÃO DO FUNDO NA TRAJETÓRIA E NA DISTRIBUIÇÃO GEOGRÁFICA DOS RECURSOS

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Resumo

O Fundo Constitucional do Nordeste (FNE) representa a principal fonte de recursos para o financiamento do Programa Nacional de Fortalecimento da Agricultura Familiar (Pronaf). Nesse sentido, o presente estudo buscou identificar a dimensão efetiva da atuação do FNE-Pronaf, principalmente pela distribuição espacial da massa monetária. A metodologia fundamenta-se em um estudo exploratório com revisão bibliográfica e análise descritiva de dados, mediante técnicas de análise espacial e geoprocessamento. Os resultados indicam que, entre 2002 e 2023, a participação do FNE-Pronaf na quantidade de contratações manteve percentuais estáveis e relevante capilaridade municipal. Em termos de valores, até 2017, ocorreu expansão dessa participação, sobretudo no Semiárido, e, após 2018, registrou-se redução, caracterizada pelo avanço em direção a essa área (das faixas oeste e litorânea). Adicionalmente, a análise espacial bivariada revelou que tal avanço apresenta dois padrões de associação para a localização do FNE-Pronaf e a massa monetária do FNE.

Palavras-chave

Análise das políticas públicas; Financiamento de políticas regionais; Desenvolvimento Regional; Análise Espacial; FNE; Pronaf; Crédito Rural.

THE NORTHEAST CONSTITUTIONAL FUND (FNE) FOR FINANCING THE NATIONAL PROGRAM FOR STRENGTHENING FAMILY FARMING (PRONAF): A SPATIAL ANALYSIS OF THE FUND'S PERFORMANCE IN THE TRAJECTORY AND GEOGRAPHIC DISTRIBUTION OF RESOURCES[1]

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Introduction

The Constitutional Financing Funds (FCFs), established in 1988, have become a cornerstone of regional policy, fostering productive investments in the North, Northeast, and Central-West regions through subsidized credit. With the institutionalization of the National Policy for Regional Development (PNDR) under Decree No. 6,047 (Brasil, 2007a), these funds expanded their territorial governance, strengthening the role of spatial guidelines in resource allocation in order to mitigate regional inequalities.

In the Northeast, the operational management of the Northeast Constitutional Fund (FNE) is taken on by the Banco do Nordeste (BNB), a public institution that also functions as a multiple-service bank, combining commercial banking activities with the mission of promoting regional development. Monteiro Neto, Macedo, and Silva (2022) emphasized that the bank has facilitated a significant distribution of credit to areas with low population and economic density, operating extensively throughout the region.

The line of credit from the National Program for Strengthening Family Farming (referred to hereafter by its Portuguese acronym – PRONAF) has been a vital tool in extending the territorial reach of the FNE. Created in 1995, PRONAF acknowledged the need for targeted policies aimed at a large, numerically significant segment of producers who had previously been unable to obtain access to rural credit, primarily due to the high costs involved for smaller, undercapitalized production units (Guanziroli, 2007; Grisa, Wesz Junior, Buchweitz, 2014; Valadares, 2021).

1. JEL Classification: O18, Q58, R12.

The Northeast region accounts for 47.2% of family farming establishments in Brazil, with 35% located in the semi-arid region, and represents 46.5% of the workforce employed in family farming (Brazilian Institute for Geography and Statistics – IBGE, 2017). The majority of family farmers in the region (89%) fall under PRONAF Group B, meaning that they belong to the lowest family gross income bracket (Aquino, 2023).

Family farming in the Northeast region accounts for 79.2% of agricultural establishments, thereby surpassing the national average of 76.8%. Of this total, 74.2% of family establishments are located within the full expanse of the Northeast semi-arid region, where they carry out their productive activities. The figures become even more striking when examining the workforce in family farming: 4.7 million farmers are engaged in this activity in the Northeast, accounting for 73.8% of the total rural labor force. In the semi-arid region, this percentage is even higher, reaching 75.7% (IBGE, 2017). According to Castro and Freitas (2021), Northeast family farming makes a particularly significant contribution to the production of staple items such as rice, bananas, beans, and cassava, with production rates exceeding 60%. The Rural Credit Data Matrix (Banco Central, 2024) indicates that, on average, from 2013 to 2022, the Northeast accounted for approximately half (50.5%) of all PRONAF contracts nationwide. However, over this same period, the region represented just 13.7% of the total value of contracts. This disparity between the high number of contracts and the low total value indicates that contracts negotiated in the Northeast are of a significantly lower value.

Since its creation, PRONAF has been funded by resources from FNE. Both of these public policy instruments aim to reduce sectoral and regional inequalities, while fostering national economic development. However, it is essential to recognize that socioeconomic transformations within the territory and the allocation of financial resources through public credit are shaped by the conjunctural and structural dynamics of economic and political cycles, which can be amplified or balanced depending on institutional choices and the design of incentives within public policies and their instruments (Secchi, 2011; Lascoumes; Le Galès, 2013). Therefore, the aim of this article is to assess the effective scope of the FNE-PRONAF operations, primarily through the spatial distribution of financial volume between 2002 and 2023. This period encompasses institutional, political, and economic changes that significantly impacted the implementation of public actions across the territory.

The theoretical framework is based on the recognition of an asymmetric effect of the banking structure on the regional economy. This asymmetry primarily affects micro and small-scale productive activities in peripheral regions, where

the main characteristic is a high reliance on bank credit (Cavalcante *et al.*, 2018; Crocco; Figueiredo; Santos, 2010; Martin; Pollard, 2017). The proposed investigation is further anchored in the need to understand the "[...] plurality of the diverse and heterogeneous fractions of capital across various scales, sectors, regions, and urban and rural spaces in Brazil" (Brandão, 2004, p. 51). In this context, it is understood that institutions and territories, within an environment of structural heterogeneities, consistently contribute to development processes – both equal and unequal. Therefore, to broaden analytical understanding, first it is essential to identify and comprehend the spatial expressions of banking relations in territories historically excluded from the banking and financial circuits, such as the Northeast region of Brazil (Crocco; Santos; Figueiredo, 2013).

This exploratory study has aimed to establish connections between credit policy instruments and perceptions that could enhance their effectiveness, particularly regarding their territorial impact. The study focuses on the municipalities within the area of operation of the Superintendency for the Development of the Northeast (SUDENE), examining in detail the spatiotemporal changes in FNE resources within the framework of PRONAF. To achieve this, spatial analysis and geoprocessing techniques have been employed, specifically studying areas through the use of geographic information systems (GIS), with QGIS software (QGIS, 2022), on a selected data set. The investigation has included an analysis on the behavior of FNE operations via PRONAF both from a univariate and a bivariate perspective, with the latter involving the mapping of spatial association patterns (Tyner, 2010).

The structure of the article, in addition to the introduction and final considerations, includes a second section that contextualizes PRONAF policy in the region, outlining its funding sources, with particular emphasis on the role of FNE in credit allocation. The third section presents the data and methods used for the spatial analysis, which is detailed in the fourth section, and which examines the spatiotemporal distribution of FNE-PRONAF contracts and values at the municipal level, as well as the distribution of the fund's financial volume in relation to the total amount of resources allocated by FNE.

1. PRONAF, FNE and financing family farming in the Northeast

Despite the significant role of family farming in the Northeast as a source of income, food security, and rural development, Aquino (2023) highlighted that producers in the region continue to face numerous challenges. These include precarious access to land, limited availability of formal education in rural areas, a lack of technical assistance, low mechanization, and restricted access to credit.

In terms of credit, PRONAF stands out as one of the most significant mechanisms for supporting rural producers by bridging public credit with the financial needs of agricultural workers (Guanziroli, 2007). Since its inception, the program – alongside other initiatives targeting family farmers – has played a key role in shaping State policies for this sector. Its implementation has yielded positive outcomes in production, employment, and overall quality of life in rural areas (Guanziroli; Buainain; Di Sabbato, 2012; Grisa; Wesz Junior; Buchweitz, 2014; Rodrigues, 2019; Valadares, 2021).

Notwithstanding these advancements, the literature underscores the need for improvements, particularly in addressing distributive inequalities in credit access within the highly heterogeneous rural landscape of Brazil. These inequalities are evident both in production, where a larger share of resources is allocated to commodities, and across regions, with more capitalized producers, especially in the South, receiving a major part of the funds (Grisa; Wesz Junior; Buchweitz, 2014; Souza *et al.*, 2019; Valadares, 2021; Fossá; Matte; Mattei, 2022).

Elias and Pequeno (2007) emphasized that, within this context of technological dominance and financial resource concentration among oligopolized enterprises, the expansion of global agribusiness in the Brazilian Northeast – particularly in tropical fruit and soybean production – has led to several negative impacts. These include the weakening of family farming, the expansion of monocultures and subsequent loss of biodiversity, the privatization of water resources, and rising land prices. The authors further highlighted that the semi-arid regions and the northeastern Cerrado have become increasingly attractive for agribusiness expansion, especially in humid valleys for fruit cultivation (São Francisco, Açu, and Jaguaribe), and in the Cerrado for soybean production (southern Maranhão, southern Piauí, and western Bahia). This incorporation process has unfolded by "disrupting the preexisting socio-spatial structures and introducing new territorial, political, and sociocultural dynamics to the surrounding areas" (ibid., p. 30).

According to Aquino and Schneider (2015), addressing this issue requires a comprehensive analysis of public policies and a reassessment of the model for promoting agricultural activities through public funds. Wesz Junior (2021) highlighted that between 2014 and 2018, the PRONAF financing rules underwent significant changes. One key modification involved a shift in how interest rates were determined. Previously calculated based on contract values, they began to be set according to the type of activity financed, with lower rates for food crops and agroecological or transitioning production systems. Additionally, financing limits were raised, particularly for PRONAF working capital, alongside increased

thresholds for family income eligibility and insurable net income limits (Sead, 2017). Despite these changes, Wesz Junior (ibid.) reported that PRONAF's overall funding was reduced, thereby disproportionately affecting differentiated activities and the least capitalized producers in the Northeast, Southeast, and North regions.

According to the 2017 Agricultural Census (IBGE, 2017), 50% of family farmers in the Northeast hold a PRONAF Aptitude Declaration (DAP) and are eligible to receive resources from the program. This percentage surpasses the national average of 42.7%, and is the highest among all regions in Brazil, suggesting that the Northeast is relatively better positioned to access these funds. However, Aquino (2023) points out that, the majority of family farmers in the same region (89%) fall under the PRONAF Group B[2]. These farmers experience extremely low average productivity and rely heavily on external income sources for survival, particularly rural social security benefits and the Bolsa Família Program (PBF)[3]. Notably, Batista and Neder (2014) demonstrated that loans granted through PRONAF (Groups A, B, and A/C) between 2001 and 2009 played a significant role in increasing per capita household income and reducing income inequality, as measured by the Gini Index.

Figure 1 illustrates the amount of PRONAF resources by source, highlighting that the FNE significantly surpasses the others in financial volume. During the analyzed period, PRONAF raised an average of R$[4] 4.75 billion per year, with the Fund financing an average of R$ 3.33 billion. In comparison, *Poupança Rural* [Rural Savings], the second-largest source, contributed an average of R$ 1.07 billion, while *Recursos Obrigatórios* [Mandatory Resources] (MCR 6.2), the third main source, contributed an average of R$ 207.3 million. Furthermore, the FNE and Mandatory Resources are the only sources that showed annual growth in PRONAF financing. The program's resource volume grew by 2.0% per year, with the FNE contributing to this dynamism with an annual growth rate of 1.6%. Therefore, in addition to being the primary source of resources in terms of financial volume, the Fund has demonstrated continuous growth, which is essential for supporting family farming in the region.

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2. According to the Rural Credit Manual (Chapter 10, Section 2), PRONAF Group B beneficiaries are producers whose annual gross family income does not exceed R$ 23,000.00 (twenty-three thousand BRL) and who do not hire permanent salaried labor (Central Bank, 2024). BANCO CENTRAL DO BRASIL. *Manual de Crédito Rural*. Updated until January 10, 2024. Brasília, DF: Bacen. Available at: https://www3.bcb.gov.br/mcr. Accessed on: March 15, 2024.

3. Bolsa Família is a social welfare program aimed at reducing poverty and inequality. It provides direct financial assistance to low-income families, with the goal of ensuring access to basic needs such as food, education, and healthcare, particularly for children and pregnant women.

4. Brazilian Real – BRL, represented as R$.

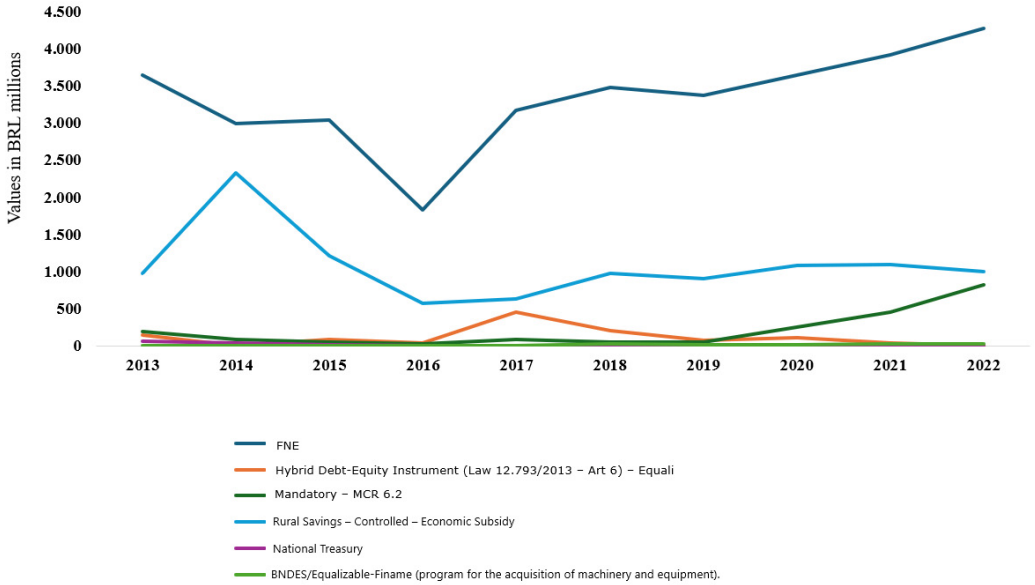

Figure 1. Availability (in millions of BRL) of PRONAF resources by source in the Northeast
Source: The Rural Credit Data Matrix (Banco Central, 2024). Values updated by the IPCA of December 2022.

According to Lopes (2023), the FNE has been a key driver of regional dynamism in the Northeast during the twenty-first century, owing to the volume and financial availability of credit aimed at stimulating the region, making it a crucial instrument for regional development. The impacts of the FNE – and of the FCFs as a whole – vary across territories, and the assessment of variables extends beyond traditional outcome indicators used in econometric models (e.g., GDP and employment), as noted by Pires, Quaglio, and Vasconcelos (2022). Silva and Monteiro Neto (2022) further emphasized that PRONAF contracts, by targeting smaller municipalities within the areas covered by the FCFs, help to reduce regional disparities. They stressed that, while the amounts involved are not substantial, they nonetheless play a significant role in strengthening the economic and social resilience of municipalities by ensuring financial resources for new local enterprises, stimulating demand for food and other local products, and generating multiplier effects in the economy. Therefore, even though PRONAF and the FCFs operate independently, they complement one another in advancing the State's objectives of promoting the development of family farming and reducing regional inequalities.

Two aspects merit attention in the management of FNE resources. The first concerns the spatial prioritization of enterprises located in the semi-arid regions and in microregions classified by the PNDR in the Annual Programs as medium-income with low or medium dynamism. According to the 2023 FNE Management Report (Banco do Nordeste, 2023, p. 78), "of the total volume of FNE resources,

R$ 13.5 billion were allocated to PRONAF operations as of December 31, 2023 (R$ 11.3 billion as of December 31, 2022). On the other hand, R$ 78.7 billion are allocated to the semi-arid region (65.1% of total allocations)". Silva *et al.* (2020) highlighted that the Brazilian semi-arid region is home to 1.83 million agricultural establishments, accounting for 36.2% of the country's total. Of these, 78.8% (1.44 million) belong to family farming, representing 37.1% of this segment in Brazil. These figures underscore a significant demand for rural credit in the region.

The second aspect concerns the FNE management conducted through the Banco do Nordeste, a credit institution that operates as a multi-purpose bank, blending commercial activities with its role as a bank for regional development. Monteiro Neto, Macedo, and Silva (2022) observed that, since the 1990s, BNB operations have facilitated significant dispersion or deconcentration in areas with low population and economic density, demonstrating the institution's ability to operate across a broad territorial expanse. They also emphasized that, in response to shifts in the capitalist system, especially after the 2007-2008 crisis, public banks have taken on an increasingly important role in financing productive systems, through transforming the productive structure and promoting innovation strategies.

In this regard, the financial institution is committed to sustaining regional financing, with the PRONAF line demonstrating extensive reach across the territory, as will become evident in the spatiotemporal analysis of the program's disbursements. Table 1 below illustrates the participation of PRONAF in FNE disbursements, in terms of contracted value and number of operations between 2002 and 2023. The analysis was divided into periods to better capture and assess the temporal changes in disbursements, as discussed below.

In the first period, from 2002 to 2010, FNE disbursements saw a notable increase, with significant growth in both total FNE and PRONAF. The FNE-PRONAF experienced higher growth in the number of contracts (45.6%), but outpaced the growth rate in the contract value (24.4%), and although substantial, it was still below that of the total FNE. During this period, there is an outstanding trend of decline in the average contract value[5]. The second period, from 2011 to 2017, was marked by national macroeconomic instability, which affected productive sectors, particularly those oriented toward the domestic market (Oreiro, 2017). FNE contracts showed the lowest growth rate among the periods analyzed (4.1%) and a negative result for the contracted values (-0.5%). In contrast, PRONAF showed positive growth, including in contract values, although this growth was insufficient to influence the overall credit trajectory in total FNE.

5. Average contract value is the total contracted value in the period divided by the number of contracts made during that period.

The third period, from 2018 to 2023, encompasses the most recent developments in the policy, including the impact of the COVID-19 pandemic, which notably reduced the level of economic activity, especially in 2020. Additionally, this period saw changes, such as adjustments to the interest rates[6] of the Constitutional Funds and modifications to the Gross Family Income limits for accessing PRONAF credit. This period, therefore, reflects a combination of recent socioeconomic and managerial shifts. It may be observed that the total FNE witnessed an increase in contracts (10.0%), which was not accompanied by a significant increase in disbursed value (0.3%). In the case of PRONAF however, the reverse occurred, with a recorded growth in the contracted value (8.3%), but a more modest increase in the number of contracts (2.1%), leading to a slight rise in the average contract value.

Period	Total FNE		FNE-PRONAF[1]		Participation of PRONAF-FNE (%)		Average contract value – PRONAF-FNE (c/d)
	Operations (b)	Value (a)	Operations (d)	Value (c)	Operations (d/b)	Value (c/a)	
2002-2010	36.0%	43.2%	45.6%	24.4%	85.8	19.2	11,377.2
2011-2017	4.1%	−0.5%	4.3%	5.3%	92.5	17.7	8,028.8
2018-2023	10.0%	0.3%	2.1%	8.3%	84.6	13.2	8,642.0
2002-2023	18.3%	19.2%	19.3%	14.6%	87.6	17.1	9,565.8

Table 1. Growth rate (% p.a.) for contracted value, number of FNE-Total and PRONAF operations, PRONAF participation, and average contract value (subperiods)

Source: Portal Brasileiro de Dados Abertos [Brazilian Open Data Portal] (Brasil, 2023).

Note: [1]Value updated by the IPCA as of December 2023. N.B.: The PRONAF values include all subprograms linked to it.

Between 2002 and 2023, PRONAF contracts mirrored the growth of total FNE disbursements, becoming dominant in the number of operations within FNE, with an average of 87.6% of the contracts directed toward family farming. However, this preponderance is not reflected in the total amount disbursed by the Fund, where the average participation of PRONAF was just 17.1%. This would suggest that

6. Central Bank Resolution No. 4,673, of June 26, 2018; Central Bank Resolution No. 4,674, of June 26, 2018; Central Bank Resolution No. 4,728, of June 27, 2019. CENTRAL BANK OF BRAZIL. Resolution No. 4,673, of June 26, 2018. This establishes the methodology for calculating interest rates applicable to rural credit operations using resources from the Constitutional Financing Funds. *Diário Oficial da União* [Official Federal Gazette]: Brasília, DF, June 28, 2018. BANCO CENTRAL DO BRASIL. Resolution No. 4,674, of June 26, 2018, defines financial charges and the payment compliance bonus for rural operations carried out with resources from the Constitutional Financing Funds for the period from July 1, 2018, to June 30, 2019. *Diário Oficial da União* [Official Federal Gazette]: Brasília, DF, June 28, 2018. CENTRAL BANK OF BRAZIL. Resolution No. 4,728, of June 27, 2019. Defines financial charges and the payment compliance bonus for rural operations carried out with resources from the Constitutional Financing Funds for the period from July 1, 2019, to June 30, 2020. *Diário Oficial da União* [Official Federal Gazette]: Brasília, DF, July 1, 2019.

many contracts are of a relatively low value, underscoring the demand from more vulnerable and lower-income family farmers. Lastly, it is vital to note the drastic reduction in PRONAF's share of operations within the FNE in 2023, falling from levels of nearly 90% to 59%. The FNE Management Report (Banco do Nordeste, 2023) provided no justification for this reduction. On the contrary, it emphasized the achievement of performance targets set for values (123.1%) and for serving active PRONAF clients (100.6%), the latter being an indicator of social inclusion.

In light of the above, analyses that lack a spatial perspective fail to capture the full scope of FNE's role through PRONAF, especially considering its function as a regional policy instrument. As demonstrated, on average, FNE accounted for more than 70% of PRONAF operations, while experiencing lower growth in contracted volumes in the Northeast compared to PRONAF at a national level. Furthermore, when recalculating the average rates, excluding the year 2023 and separating PRONAF from FNE, it becomes clear that the FNE (excluding PRONAF) grew by 9.3% in the number of operations and 20.5% in values. The reverse occurred however, in PRONAF via FNE, with growth rates of 20.4% and 13.8%, respectively. This disparity calls for a more detailed spatial analysis of the role of FNE-PRONAF in the distribution of financial volume, which will be explored in the following sections.

2. Data and methods

The study in question focuses on the municipalities within the operational area of SUDENE, specifically examining the spatiotemporal changes in FNE resources under PRONAF. This area was initially defined by Complementary Law No. 125, of January 3, 2007 (Brasil, 2007b). Following the inclusion of 85 municipalities through Complementary Law No. 185, of October 6, 2021 (Brasil, 2021), the territorial scope now encompasses all 1,794 municipalities in the Northeast region, 249 municipalities in Minas Gerais, and 31 municipalities in Espírito Santo. Of the 2,074 eligible municipalities, the database used includes 2,070 municipalities, i.e., approximately 99.8% of the operational area.[7]

In addition to the geographic delimitation, the study also defines a temporal scope of investigation covering the period from 2002 to 2023. This timeframe is justified by the significant increase in credit provided by the FCFs and to capture the main institutional changes in the management of these resources. The subperiods 2002-2010, 2011-2017, and 2018-2023 were selected to reflect consistent intervals in the spatial distributions of the variables. To examine the role of the FNE in operations

7. The eligible municipalities, as of 2021, that recorded no operations during the study period are all located in Minas Gerais. They are: Goiabeira, Itanhomi, Santa Rita de Minas, and São Félix de Minas.

via PRONAF, historical data on FNE contracts[8] (Brasil, 2023) from 2002 to 2023 were used. In order to map the territorial performance of the FNE in credit operations through PRONAF, spatial analysis of areas using geographic information systems (GIS) was employed.

Given the descriptive nature of this study, the exploratory analysis focused on the spatial distribution of the phenomena. To achieve this, univariate and bivariate choropleth maps were used, following the guidelines of authors such as Câmara *et al.*, 2004; Carvalho *et al.*, 2004; Dent, Torguson, Hodler, 2009; Tyner, 2010. According to the specialized literature, constructing an appropriate choropleth map should be based on variables independent of the polygon sizes (Carvalho *et al.*, 2004; Tyner, 2010). Thus, the following variables were chosen: (i) FNE-PRONAF[9], calculated as participation percentages in total local values and in the total local number of FNE contracts; and (ii) FNE, calculated per capita and, subsequently, expressed as its local per capita proportion relative to the overall per capita FNE. The per capita values[10] correspond to the local average in each subperiod analyzed.

3. Results

Analyzing FNE disbursements without considering the spatial perspective at the municipal level is a limiting factor for understanding the role of FNE-PRONAF as a regional policy instrument. To address this, the municipal spatial performance of the FNE operating the PRONAF program, in terms of contract values, is illustrated in Figure 2. A comparison of the 2002-2010, 2011-2017, and 2018-2023 subperiods reveals that the FNE contribution to directing resources within the scope of PRONAF has undergone a continuous transformation process across the territory covered by SUDENE, as noted by Elias and Pequeno (2007). Between 2002 and 2010, the accumulated FNE-PRONAF values, totaling approximately R$ 17.5 billion, show that participation percentages in 1,441 municipalities were predominantly above 25% and below 75%. These values were distributed across the territory but were concentrated in the semi-arid polygon. Additionally, there were isolated occurrences with percentages that exceeded 75%, most of which were located within the semi-arid region, and others below 25%, predominantly along the border with the states of Tocantins, Goiás, and Minas Gerais.

8. Values updated by the IPCA of December 2023.

9. The term FNE-PRONAF does not correspond to any specific financing line from BNB; it is merely a generic designation to represent all the Fund's contracts within the scope of PRONAF.

10. For population data, the Demographic Censuses and population estimates from IBGE were used.

In the following subperiod, 2011-2017, with approximately R$ 26.8 billion, there was a notable increase in the number of municipalities where FNE-PRONAF participation percentages exceeded 50%, rising to 1,268 municipalities (previously, there had been 1,105). During this subperiod, the FNE played a more prominent role in PRONAF, particularly in the states of Piauí, Paraíba, Pernambuco, and Bahia. Key intermediate regions include Picos (PI), Teresina (PI), Campina Grande (PB), Petrolina (PE), Caruaru (PE), Paulo Afonso (BA), and Vitória da Conquista (BA), all located in the semi-arid polygon, saw significant improvement. Moreover, there was a substantial increase in the participation of FNE-PRONAF in a greater number of municipalities. The number of municipalities with FNE-PRONAF participation percentages above 75% increased from 239 municipalities in the previous subperiod to 611, a growth of 155.6%. This expansion was particularly concentrated in the states of Piauí, Paraíba, and Bahia.

Between 2018 and 2023, despite a total accumulation of nearly R$ 30 billion, there was a decline in the participation of FNE-PRONAF in the total contracted amounts, as reflected in the spatial distribution. While in the previous subperiods, only around 18% of municipalities presented FNE-PRONAF percentages below 25%, in this last subperiod, this percentage rose to about a quarter of municipalities. The states most affected by this reversal were Maranhão and Ceará, as well as the entire surrounding area of the semi-arid region, both in the western and coastal zones. In contrast, the states of Piauí and Bahia maintained at least half of the municipalities with FNE-PRONAF participations above 75%, particularly in the intermediate regions of Teresina and Picos in Piauí, as well as the immediate regions of Guanambi and Brumado in Bahia. However, the number of municipalities with FNE-PRONAF participations above 75% fell by about 27% compared to the immediately previous subperiod.

With regard to Figure 2, it should be emphasized that the reduction in FNE-PRONAF participation is spatially characterized by its shift toward the semi-arid region. The highest participation percentages, in each subperiod, are increasingly concentrated in specific regions within the priority area, such as in the southeast of Piauí and in the south of Bahia. Furthermore, there is a noticeable decline in participation in municipalities outside the semi-arid region, especially along the coastal strip and in the municipalities bordering this area. This shift is exemplified by the intermediate regions of Corrente – Bom Jesus (PI), Presidente Dutra (MA), Barreiras (BA), Maceió (AL), and Mossoró (RN).

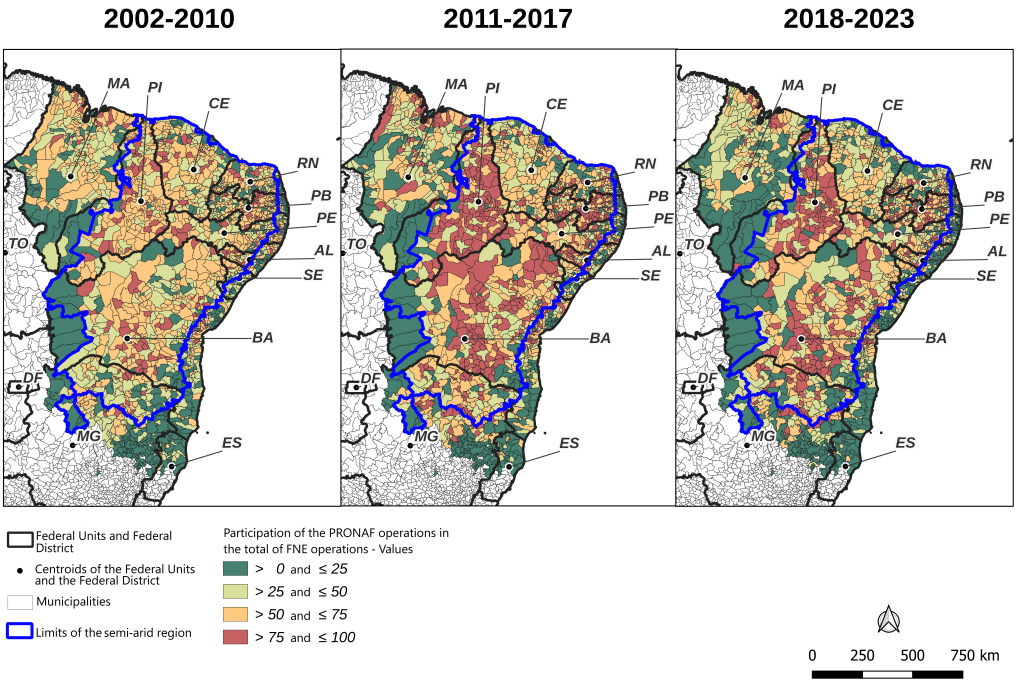

Figure 2. Univariate choropleth map – participation (%) of FNE-PRONAF operations – in terms of contracted values (subperiods 2002-2010, 2011-2017, and 2018-2023)

Source: Own elaboration.

In relation to the distribution based on the number of operations, the changes in the FNE-PRONAF performance are less pronounced, as demonstrated in Figure 3. The increase in the number of operations across the three subperiods – 2.6 million, 3.3 million, and 3.4 million, respectively – indicates broader municipal coverage. Even in the last subperiod, from 2018 to 2023, where the reduction in the spatial distribution of values was more evident, the number of operations continued to maintain participation above 75% in the majority of municipalities. However, a noticeable decline in these participations may be observed, particularly along the coastal strip, such as in the intermediate regions of Salvador, Maceió, and Recife. Nevertheless, from the perspective of spatial coverage, the data reveals that FNE-PRONAF retained the capacity to operate in a decentralized manner across the territory, thereby confirming its viability as a tool for regional policy, as supported by the literature.

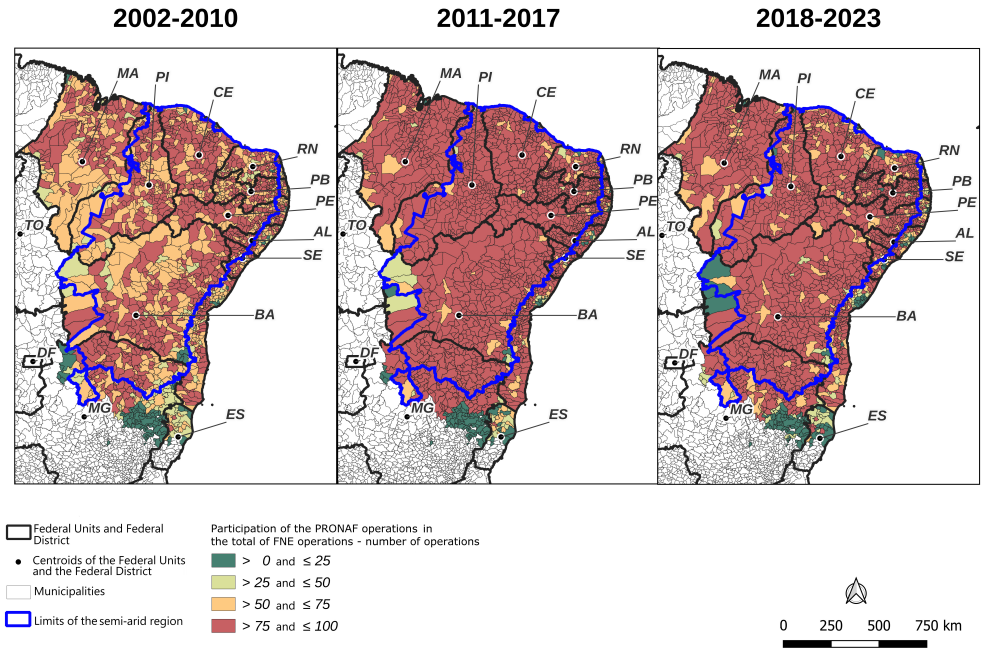

Figure 3. Univariate choropleth map – participation (%) of FNE–Pronaf operations – in terms of number of contracts (selected subperiods)

Source: Own elaboration.

To broaden the investigation into the distribution of the financial volume of resources allocated by FNE through PRONAF, Figure 4 presents an analysis of the spatial relationship between the proportion (%) of per capita FNE in each municipality relative to the overall[11] average per capita FNE versus the participation (%) of FNE-PRONAF in the total FNE of the municipality. In this case, the aim is to visually explore how these two variables relate spatially. Nine possible bivariate groupings have been identified:2 “LL”, “LM”, “LH”, “ML”, “MM”, “MH”, “HL”, “HM”, and “HH”. The letters “L”, “M”, and “H” correspond to the value-axis categories L (low), M (medium), and H (high), considered within the measurement scale of each variable. The bivariate spatial overlap of the variables enables the following question to be addressed: Do municipalities with a higher percentage FNE-PRONAF participation in the total value of their contracts also exhibit a higher proportion of the average per capita FNE?

11. The term “overall” refers to the entire operational area of SUDENE. Respectively, the values for each subperiod of the average per capita FNE in the SUDENE area were: R$ 1,938.57, R$ 2,442.28, and R$ 3,614.85. Thus, for example, from 2011 to 2017, the municipality of Petrolina (PE) recorded an average per capita FNE of R$ 3,346.49, which represents a proportion of 137%, while the municipality of Cruz das Almas (BA) recorded an average per capita FNE of R$ 1,302.58, resulting in a proportion of 53%.

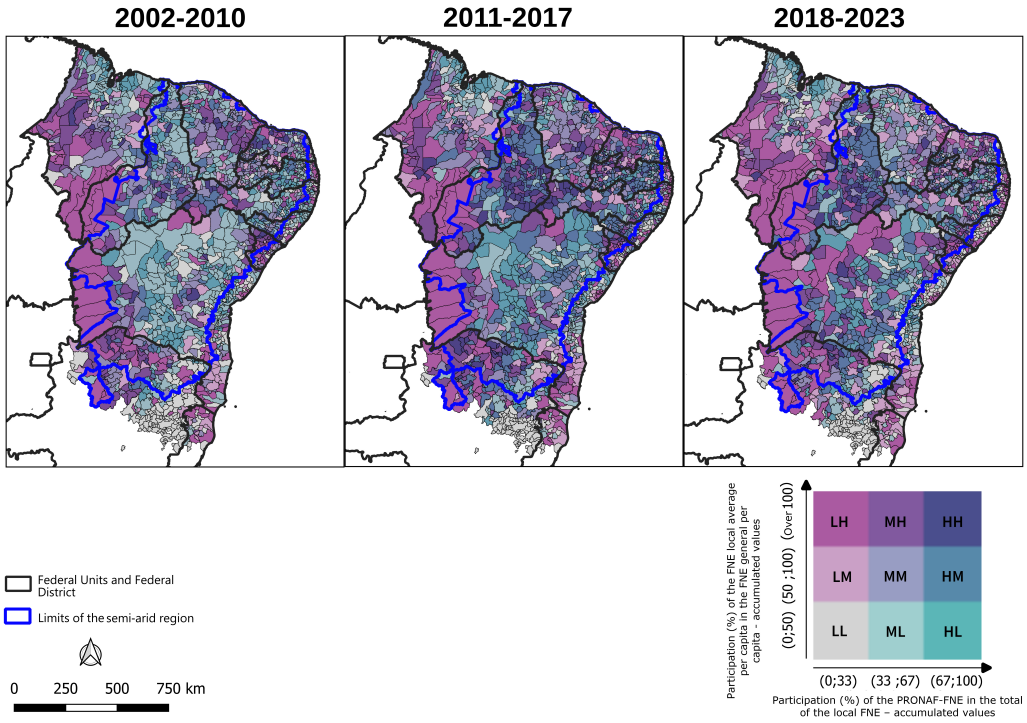

Figure 4. Bivariate choropleth map – local/overall (%) proportion of average per capita FNE versus local (%) participation of FNE-PRONAF (selected subperiods)

Source: Own elaboration.

In the first subperiod, from 2002 to 2010, a clear distinction may be observed among municipalities within the spatial association color scale. Outside the limits of the semi-arid region, there is a higher occurrence of municipalities classified as LH, particularly in the western section of the area covered by SUDENE. In these areas, municipalities exhibit a pattern of low FNE-PRONAF participation and a high average per capita FNE, signifying that they hold a larger share of the financial volume of granted resources, although with low allocation through PRONAF. Examples include the immediate regions of Balsas (MA) and Uruçuí (PI) and the municipalities of Luís Eduardo Magalhães, São Desidério, and Correntina in Bahia.

In the same subperiod, specifically within the limits of the semi-arid region, the ML association prevails, indicating municipalities with a medium level of FNE-PRONAF participation and a low proportion of the average per capita FNE. These municipalities tend to have a smaller share in the total financial volume of contracted resources, despite FNE-PRONAF accounting for the second tercile of operations. In the states of Pernambuco and Bahia, there is also a higher occurrence of municipalities exhibiting an HL association pattern, characterized by a low proportion of the average per capita FNE alongside high FNE-PRONAF participation.

Notable examples include: (i) the municipality of Presidente Jânio Quadros and its surroundings in southern Bahia; (ii) the municipalities of Barra de Santana, Boqueirão, and São João do Cariri in Pernambuco; and (iii) municipalities in southeastern Piauí, such as Dirceu Arcoverde and Várzea Branca.

Municipalities exhibiting MH, HH, or HM associations, which denote medium-high participation in FNE-PRONAF and a medium-high proportion of per capita FNE, are distributed throughout the territory. Examples include the immediate regions of Santa Inês and Açailândia, in Maranhão; Paulistana, Simplício Mendes, and São João do Piauí, in Piauí; Quixadá, Russas, and Limoeiro do Norte, in Ceará; Mossoró and Açu, in Rio Grande do Norte; Patos, in Paraíba; Araripina and Petrolina, in Pernambuco; Nossa Senhora da Glória, in Sergipe; and, in Bahia, the regions of Jeremoabo, Itaberaba, and Barreiras.

In analyzing the subsequent subperiod, from 2011 to 2017, a clear shift toward more localized patterns emerges, with higher percentages of FNE-PRONAF participation corresponding to greater per capita FNE proportions, particularly within the limits of the semi-arid region. In the state of Piauí, the HH and HM association patterns predominated, as observed in the immediate regions of Campo Maior, Picos, and São João do Piauí. In the states of Ceará and Rio Grande do Norte, this pattern extended to the southernmost immediate regions, such as Iguatu (CE) and Caicó (RN).

In the state of Paraíba, the changes in this pattern were more pronounced in municipalities located in the central-eastern part of the state, such as in the immediate regions of Campina Grande, Sumé, and Cuité-Nova Floresta. In Pernambuco, municipalities near the Petrolina and Juazeiro hub maintained this association, with similar patterns observed further east in the immediate region of Garanhuns, as well as in the northwest, in Araripina. In Alagoas, changes were concentrated in the immediate western regions, including Pão de Açúcar, Olhos d'Água das Flores, Batalha, Santana do Ipanema, and Delmiro Gouveia. Additionally, it should be noted that, between the borders of Piauí and Pernambuco, there is a notable concentration of municipalities with a strong association between FNE-PRONAF and per capita FNE, both medium-high and high, during this subperiod.

In contrast, in the state of Bahia, the HL association pattern predominated, characterized by high percentages of FNE-PRONAF participation coupled with low proportions of per capita FNE. Therefore, this indicates that the financial volume is not primarily concentrated in municipalities with higher FNE-PRONAF participation. Exceptions to this pattern are more localized and occur only in municipalities exhibiting MH and HM patterns, with the latter being more prevalent. Municipalities with the MH pattern include Manoel Vitorino, Barra da Estiva, Mucugê, and Brumado. In the more common pattern, HM, several municipalities

are found in the southern part of the state, around Brumado, such as Presidente Jânio Quadros and Aracatu, as well as others in the central-eastern part of Bahia, concentrated in the immediate region of Feira de Santana. Outside the semi-arid region, the LH and LM patterns are predominant. However, along the coastal strip extending from Bahia to Pernambuco, the LL and ML patterns are more frequent.

In the final subperiod, from 2018 to 2023, the association patterns underwent notable changes, principally when compared to the immediately preceding subperiod. The most significant changes are discussed below. In the state of Ceará, the ML pattern predominated, especially in the immediate regions of Russas, Limoeiro do Norte, and Iguatu, which consistently exhibited medium FNE-PRONAF participation and a medium-high per capita FNE proportion across all three subperiods. In Rio Grande do Norte, a similar situation can be observed in the immediate region of Pau dos Ferros. Additionally, in this state, it is noteworthy that the immediate region of Mossoró reversed its pattern: previously characterized by HH occurrences, it shifted in the last subperiod to a more heterogeneous mix with a prevalence of MM patterns.

In Paraíba, a reversal was observed in the immediate regions of Campina Grande and Cuité-Nova Floresta, where the association patterns shifted to ML and HLs. In Pernambuco, the immediate regions of Araripina and Garanhuns continued to present a higher prevalence of MH, HH, and HM patterns, a trend also seen in the immediate region of Nossa Senhora da Glória, in Sergipe. Conversely, the immediate region of Petrolina (PE) became more heterogeneous, with municipalities exhibiting a wider variety of patterns, indicating different dynamics addressed by the FNE. In the state of Alagoas, the immediate regions to the west, such as Pão de Açúcar, Olhos d'Água das Flores, Batalha, Santana do Ipanema, and Delmiro Gouveia, with a higher occurrence of HM, now also include ML and HL municipalities. This shift reflects a reversal, where spatial associations with medium and high FNE-PRONAF participation are now linked to a low per capita FNE proportion.

Lastly, in the state of Bahia, the notable shift in spatial association patterns occurred during the last subperiod. The first key development refers to the advancement of the LH classification, i.e., the occurrence of municipalities with low FNE-PRONAF participation and high FNE per capita proportion. This shift moved from the outer areas inward within the semi-arid region, following a trajectory that begins in municipalities identified as agribusiness cities by Elias and Pequeno (2007), such as São Desidério and Luís Eduardo Magalhães, moving up to Barreiras, Riachão das Neves, Cotegipe, Barra, Sento Sé, Sobradinho, Casa Nova, and finally reaching Juazeiro.

Final considerations

By perceiving that FNE-PRONAF represents a financial instrument supporting the reduction of regional inequalities, this study has investigated its spatial distribution and identified association patterns. This is because while it is understood that general indicators and performance goals are necessary, they are insufficient to encompass the complexity of the socio-spatial issues of the region.

Based on the spatial analysis, it was found that between the years of 2002 and 2023, the FNE contribution to direct resources within the scope of PRONAF underwent a continuous transformation across the territory covered by SUDENE. The main results of the univariate analysis for the contracted values include: (i) in the subperiod of 2002-2010, resource distribution was more dispersed across the territory, with the PRONAF participation predominating ranging between 25% and 75%; (ii) in the subperiod of 2011-2017, there was an increase in the percentage of FNE-PRONAF participation, especially in the states of Piauí, Paraíba, and Bahia; (iii) in the subperiod of 2018-2023, FNE-PRONAF participation declined, with a spatial shift toward the semi-arid region, advancing from both the western border and the coastal strip.

The spatial analysis of the number of contracts revealed that changes in the performance of FNE-PRONAF were less pronounced. The increase in the number of operations across the three subperiods was accompanied by broader municipal coverage, particularly with participation percentages exceeding 75%. However, it is crucial to monitor the behavior of this indicator closely, since specific reductions were observed during the last subperiod, particularly in relation to the year 2023. Despite this, the overall trend in the FNE-PRONAF participation suggests that the FNE has demonstrated substantial territorial coverage as a regional policy instrument. Notably, all municipalities within the SUDENE coverage area were served by FNE-PRONAF, maintaining participation percentages consistently above 50% throughout the entire studied period.

Building on the relative difference observed in the spatial distribution of participation for both the contracted values and the number of contracts, this study has aimed to provide a broader understanding of the actual impact of FNE-PRONAF in terms of the financial volume spatially distributed by the FNE. Thus, among the key findings, the most significant is that, across the three subperiods of analysis, the predominant spatial association pattern outside the semi-arid region – low FNE-PRONAF participation and high per-capita FNE (LH) – began to encroach upon this region, with increasing intensity in the last subperiod. Additionally, certain regions have gradually emerged as areas where municipalities exhibited the MH, HH, and HM patterns, indicating medium-high FNE-PRONAF participation alongside a medium-high proportion of per capita FNE.

A more in-depth analysis of the spatial distribution of credit and its interaction with agricultural production and the environment is essential to understand the structural changes of production related to the demand for credit. In this context, three research directions are proposed as next steps: (i) select and conduct a detailed investigation into cases with divergent spatial association patterns in municipalities and/or immediate regions; (ii) analyze the financing lines and the crops financed to identify productive transformations within the territory that may be targeted for improvements in public policies; and (iii) examine the role of the Banco do Nordeste and the institutional rules, especially in the semi-arid region, which establish a set of norms and incentives designed to potentialize FNE-PRONAF as an effective regional policy instrument.

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