



# NATIONAL SCHOOL FEEDING PROGRAM

## Systems Approach and Efficiency in Family Farming

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## ABSTRACT

This study analyzes the National School Feeding Program (Programa Nacional de Alimentação Escolar – PNAE), a public policy that requires at least 30% of program funds to be allocated to the direct procurement of products from family farming for school meals. The study aims to identify the variables that determine efficiency in the transfer of these food products to school feeding programs in the state of Santa Catarina between 2011 and 2022. The analysis is based on the program's reference model and adopts a systems approach to policy implementation, with the goal of fostering more sustained and integrated social development. To this end, qualitative documentary research was conducted using secondary data provided by the National Fund for the Development of Education (FNDE) on family farming procurement in the state. The analysis focused on the volume of resources invested and the degree of compliance with targets set by municipalities, allowing for an understanding of the policy's trajectory over time and the identification of opportunities for improvement. The findings indicate that, despite ongoing constraints to the program's full effectiveness, there has been steady growth in resource allocation, near-universal municipal participation, and evidence of opportunities for improvement, including the identification of local bottlenecks, the dissemination of best practices, and the use of monitoring tools to strengthen program planning and transparency.

**Keywords:** public policies; National School Feeding Program; family farming; sustainable development; system; subsystems.

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## 1 INTRODUCTION

The National School Feeding Program (Programa Nacional de Alimentação Escolar – PNAE) is a public policy designed to promote the growth, biopsychosocial development, learning, and improvement of the dietary and nutritional conditions of children and adolescents. According to Bellé *et al.* (2014), cited by Souza, Souza, and Santos (2023), it is the oldest federal government assistance initiative and, when compared with other food-related policies, the largest in operation worldwide. Also known as the school meals program, the PNAE is administered by the National Fund for the Development of Education (FNDE), which provides supplementary financial transfers to states and municipalities to meet the nutritional needs of students in basic education, including those enrolled in Indigenous and Quilombola schools (Brazil, 2009).

States and municipalities receive federal transfers directly, based on the previous year's school census. Under Law No. 11,947 of June 16, 2009, a central pillar of this policy is the requirement that 30% of PNAE funds be invested in the direct procurement of products from family farming. This measure seeks to stimulate local economies and promote sustainable development within communities (Brazil, 2009).



The concept of family farming encompasses aspects that go beyond food production, as it reflects a more intelligent, sustainable, and inclusive development model. The PNAE is directly and indirectly linked to several Sustainable Development Goals (SDGs), such as poverty eradication (SDG 1), zero hunger and sustainable agriculture (SDG 2), and the reduction of inequalities (SDG 10). At the same time, the program is premised on strengthening family farming, which, according to Ramos and Patrício (2014, p. 322. Our translation), “should constitute a genuine instrument of social and territorial cohesion, combating inequality and poverty [...], while mobilizing regional resources and specificities”. Sen (2000) further emphasizes the importance of social policy in expanding people’s capacity to participate freely in the productive process. In this sense, the program represents an alternative for addressing social inequality and poverty in rural areas, while also seeking to provide high-quality food to students in the public school system.

Given the extensive territorial reach of the PNAE—which serves all 5,507 Brazilian municipalities and benefits more than 40 million students (Silva, 2019)—the efficiency of resource allocation is a matter of considerable interest. Municipalities show particular concern regarding compliance with the requirement that at least 30% of resources be directed to family farmers, a key indicator in evaluating program management. Although there are qualitative studies on this topic, such as those by Elias, Belik, Cunha, and Guilhoto (2019); Vieira, Teo, Lutinski, and Taglietti (2023); Gabriel, Goulart, and Calvo (2015); and Gabriel *et al.* (2014), these analyses, while valuable, focus on outcomes and perceptions of isolated segments of the process. By contrast, the systems approach offers the advantage of revealing the underlying structure that generates observed outcomes. Rather than emphasizing linear causality, it allows for mapping the complex network of interactions and feedback loops among the multiple actors involved in the PNAE, explaining how unintended consequences and systemic delays may perpetuate challenges, such as failure to meet the 30% allocation requirement.

Accordingly, a research gap remains regarding the representation and mapping of the subsystems involved in resource distribution and their convergence toward family farming. There is a lack of systemic analysis capable of identifying existing constraints and indicating ways to improve the financial execution of the policy, from the perspective of interactions among the agents involved.

Thus, considering the importance of policies supporting family farming for society in the state of Santa Catarina, the present study aims to analyze the current operational model of the PNAE in order to identify the variables and relationships that determine the allocation of resources for the procurement of family farming products for school meals.

To achieve this objective, the following guiding questions were defined:

- What is the performance of municipalities in Santa Catarina in the use of PNAE resources?
- Have municipal governments allocated at least 30% of the funds received to the acquisition of products from family farming?



- Which variables can be identified in the program's implementation process, particularly with regard to the origin and allocation of resource

## 2 LITERATURE REVIEW

This section discusses key concepts related to systems modeling and the National School Feeding Program, a public policy understood as a complex system composed of subsystems whose interconnections influence multiple other components.

### 2.1 Systems modeling

According to Bastos (2003), the application of systems thinking in organizational contexts seeks to identify more effective ways of conducting operations. From a learning perspective, this approach does not primarily aim to faithfully reproduce system behavior, but rather to improve individuals' mental models. Gomes Galindo and Façanha Câmara (2012), while acknowledging the limitations of this perspective in representing reality, regard it as a relevant practice for supporting learning processes, especially when combined with modeling techniques.

This analytical approach, which focuses on interactions rather than isolated elements, can be applied to the study of public policies which, due to their complex and dynamic nature, constitute systems composed of subsystems in which multiple agents interact and generate often unpredictable behaviors.

Maani and Cavana (2000) emphasize the distinction between hard and soft modeling, concepts that are also associated with quantitative and qualitative approaches, respectively. Hard modeling focuses on formalized techniques aimed at measurement, analytical precision, and the solution of well-structured problems. Soft modeling, in contrast, refers to conceptual methods that seek greater realism, pluralism, and more holistic forms of intervention.

Both hard and soft modeling share similarities with the field of project management, which defines these approaches as paradigms. According to Pollack (2007), hard approaches—rooted in positivist, reductionist, and realist philosophies—emphasize the pursuit of objective knowledge, whereas soft approaches—grounded in constructivist and interpretive schools of thought—emphasize the intersubjective creation of knowledge.

Public policies can also be approached as scientific fields (Andrade; Seleme; Rodrigues; Souto, 2006), in which, from a hard perspective, model construction seeks to expand the human mind's capacity to deal with numerous variables by comparing model outputs with observed reality. From a soft perspective, however, it is possible not only to expand this capacity but also to enhance the understanding of problems and situations by taking into account the subjectivity inherent in human nature, thereby contributing to the learning process.

For Schindwein (2005), the cyclical learning process arises from systemic thinking and practices applied to complex real-world situations. Berticelli Nunes and Schindwein (2009) highlight that



scientific developments were instrumental in the emergence of both hard and soft systems approaches. The authors note that the hard approach is based on the premise that an objective system exists, endowed with its own structure, whose performance can be optimized through the identification of its essential characteristics. By contrast, the soft approach acknowledges the observer's involvement and responsibility in defining the system as part of a problem situation for which improvement paths are sought. In this regard, the authors align with Schön (1982), emphasizing that the soft approach goes beyond the mere search for solutions, constituting a structured process of reflection on reality as perceived by individuals—perception understood as a social or psychological construct.

When addressing situations that require intervention, Fernandes (2001) argues that it is necessary to test the different types of behavior that a real system may exhibit, enabling the identification and evaluation of potential improvements through the adoption of one or more intervention points. System optimizations—whether in the form of intended improvements or problem-solving efforts—involve complex observation and action within systemic scenarios in which actors are not static and systems are not self-contained; rather, they merge into a tangled web of relationships. Thus, system perception as a whole and the representation of reality depend on the adopted approach, whether hard or soft, expanding or restricting the observable variables and the scope of action.

## 2.2 National School Feeding Program

In public policies, the objective is often to change or maintain the behavior of large groups of individuals in order to achieve socially desirable outcomes (Rand, 2015). The author highlights, however, the inherent challenge of this process—namely, the complexity of policy evaluation—since individuals do not respond uniformly to new incentives, and overall outcomes emerge from interacting and self-reinforcing reactions rather than from the mere aggregation of individual responses.

The notion of interdependence is central to understanding the implementation of any public policy, as outcomes arise from multiple individual decisions and depend on how these choices interact with one another and with the policy itself. Thus, different government actions are interconnected across multiple dimensions that, much like a system, sustain continuous interactions. In this sense, Silveira (2002) argues that, in complex environments, it is necessary to characterize the interfaces that define the role of each interacting system based on specific indicators. Ignoring this complexity can be detrimental. Indeed, much of the failure of public policies in Brazil and elsewhere stems from reductionist approaches that attempt to address complex phenomena using tools suitable only for simple problems (Mueller, 2015).

Faced with complex realities, it is assumed that simplified models can be used to support the understanding of phenomena. Rossoni (2007) argues that, once a problem has been defined, it is not necessary to know all aspects of reality in order to reach a solution, provided that the model is valid and corresponds adequately to reality. In the context of policy formulation and evaluation, mental models and simulations complement traditional planning tools, contributing to the interpretation of change and the anticipation of possible scenarios. Nevertheless,



predictive capacity has limits. Mueller (2015) acknowledges that complex domains may exhibit relatively stable dynamics, but are also subject to abrupt phase transitions marked by chaotic dynamics and emergent phenomena capable of unexpectedly altering outcomes.

Policies such as the PNAE are situated precisely within these diverse and complex scenarios, whose connective dynamics affect multiple other components. Given this interdependence, the search for different analytical models is essential for identifying failures, inefficiencies, and critical points. This search aligns with the trajectory of public policies themselves, which, by analogy with systems, have a life cycle. According to Peres (2007), this cycle comprises the phases of formulation, implementation, monitoring, and evaluation, within an environment of interaction among multiple social actors.

Prior to the implementation of the PNAE, the organization of institutional markets underwent significant transformation. Until the early 1990s, self-regulated markets and long supply chains predominated. A critical shift occurred in 1994 with Law No. 8,913 of July 12, 1994 (Brazil, 1994), which decentralized resources and directed them to municipalities and states. In 1998, Provisional Measure No. 1,784 of December 14, 1998 (Brazil, 1998), made these transfers automatic, eliminating the need for formal agreements and enhancing access to locally sourced food. Currently, the implementation of the PNAE encompasses all stages of basic education, including federal schools.

A cornerstone of this new configuration is the legal requirement that executing entities acquire at least 30% of program resources through the purchase of products from family farming (Brazil, 2009). As noted by Marques and Ponzilacqua (2022), institutional market initiatives like the PNAE are structuring actions for sustainable development that create opportunities yielding benefits for society as a whole, such as stimulating local economies and promoting food security. In this arrangement, the State plays a central role because, as the sole buyer, it defines the program's institutional design, induces negotiation processes, and establishes legal mechanisms that condition transactions to the realities of farmers and local governments (Freitas; Freitas, 2020).

However, local contexts and their actors may generate new rules and procedures and produce varying impacts on expected behaviors (Rocha, 2004). While Marques and Ponzilacqua (2022) describe the PNAE as involving “symbiotic actions” with win-win relationships, Costa (2013) acknowledges that the program requires planning and management that could be strengthened through capacity-building initiatives, as many actors remain unfamiliar with existing regulations. As Grisa (2012) and Abreu (2014) point out, successful sales require farmers to comply with standards, ensure delivery regularity, and—critically—engage in networked interaction to build a viable supply chain.

This operational challenge across different contexts manifests in contrasting ways. In some scenarios, program reach is limited and few producers gain access (Belik, 2017). In others, producer engagement is so extensive that transfer amounts become relatively small, making it easier to meet the 30% requirement (Gregolin *et al.*, 2017). The authors also highlight two factors that affect the PNAE: the use of municipalities' own resources and the possibility of increasing FNDE transfers, since many managers do not recognize that federal funding is intended to be complementary.



Within this context, numerous studies have sought to understand and strengthen relationships within the PNAE cycle in the state of Santa Catarina. Qualitative analyses such as those by Elias, Belik, Cunha, and Guilhoto (2019); Vieira *et al.* (2023); Gabriel, Goulart, and Calvo (2015); and Gabriel *et al.* (2015) illustrate interest in the program's technical and operational dimensions, emphasizing the need for cooperation among multiple actors. The present study differs by adopting a political-organizational approach that recognizes the need for cooperation among actors and focuses on budget decentralization and the role of the executing entity, including its willingness to provide additional financial support to the PNAE. The analysis is conducted through the representation and mapping of the subsystems involved in the program's resource distribution.

### 3 METHODOLOGY

For the execution of the research and the development of the analysis, four complementary stages were defined. These stages are interconnected, ranging from the research design to the formulation of proposed improvements.

The first stage—Definition of scope and data sources—consisted of defining the situation of interest and the guiding research questions. The study adopted a documentary and bibliographic approach and relied on publicly available secondary data from the National Fund for the Development of Education (FNDE), extracted from the Accounts Management System (SigPC) through the platforms Family Farming Data and Family Farming Procurement under the PNAE – 2011 to 2022. The analysis was geographically delimited to the state of Santa Catarina and encompassed procurements carried out by municipal education departments and the state education department.

It is essential, however, to acknowledge the limitations inherent in this approach. First, the scope of the study does not include purchases made by federal institutions located in the state, due to the absence of consolidated data for this level made available by the FNDE. Accordingly, the analysis focuses exclusively on purchases executed by state and municipal entities. Second, the use of secondary data implies that the research is subject to the biases and accuracy of the original records. As the information originates from the SigPC and is entered by public managers themselves for accountability purposes, the veracity and reliability of these records are assumed.

The second stage—System mapping and identification of variables—presented the PNAE operational model using a soft systems approach. This process involved identifying the actors and causal relationships among them, representing the system of interactions, and characterizing its feedback loops. The subsystems were mapped along with their functions, endogenous and exogenous variables, and respective performance indicators, in order to understand how the system is structured.

The third stage—Analysis of the program's financial execution—focused on the empirical analysis of the data, examining the volume of resources allocated to family farming and the degree of compliance of municipalities in Santa Catarina with the statutory 30% requirement.



The objective was to measure the program’s evolution and performance over the analyzed period.

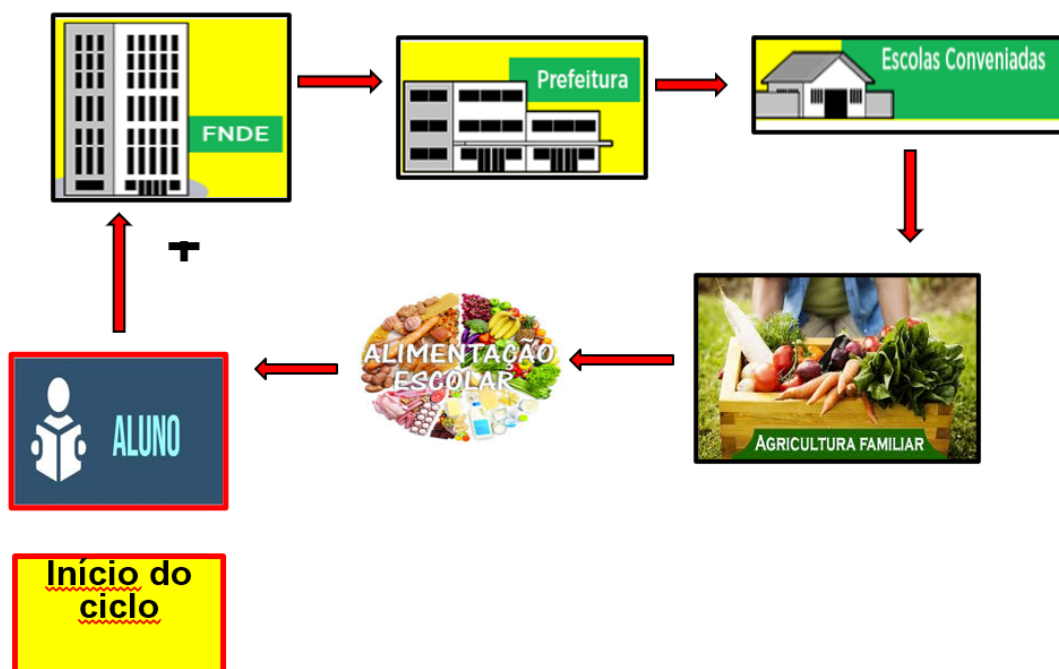
The findings from this analysis informed the fourth and final stage—Diagnosis and proposal of systemic improvements—which consisted of formulating intervention proposals. Based on the system diagnosis, sufficient information was gathered to suggest optimizations in program execution, with a view to improving effectiveness and enhancing the allocation of resources to family farming.

### 3.1 Presentation of the current model

The analysis of the PNAE began with the development of a conceptual model using causal loop diagrams. This qualitative technique is particularly useful for illustrating how the system is structured and how its actors interact, enabling an understanding of the system’s likely behavior through a simplified representation of elements and interactions.

Figure 1 presents the PNAE operating model, highlighting the dynamic relationships among actors, the system’s inputs and outputs, and how these elements interact to form the policy’s operational cycle.

**Figure 1 – Decentralization of resources under the National School Feeding Program**



Source: Prepared by the authors, based on FNDE data (Brazil, 2024).

To maintain system stability, the resource allocation cycle relies on a feedback mechanism based on the number of students enrolled in the education system. In principle, this



information guides the actions of other agents and, consequently, the availability of financial resources provided by the FNDE. As a control mechanism for budget allocation calculations, official data from the School Census of the year preceding service delivery are used (Brazil, 2009). The calculation considers 200 school days and per capita amounts defined in Resolution No. 2 of March 10, 2023 (Brazil, 2023b), which amended Resolution No. 6 of May 8, 2020 (Brazil, 2020b).

Despite its structure, the system has vulnerabilities. Student entry and exit without prior notice complicate governance, and budget allocations may be affected by factors such as school dropout rates. In addition, per capita amounts have historically lagged behind, having been adjusted only twice in the previous decade (2013 and 2017). Following the update carried out in 2023, per capita values now range from BRL 0.41 to BRL 2.56 (Brazil, 2023b). Transfers are made in up to eight annual installments between February and September, as established by FNDE/CD Resolution No. 7 of May 2, 2024 (Brazil, 2024).

After decentralization, procurement processes should preferably be directed toward family farming. Policy implementation is overseen by a robust control framework that includes civil society—through the School Feeding Councils (CAEs)—as well as institutions such as the National Fund for the Development of Education (FNDE), the Brazilian Federal Court of Accounts (TCU), the Office of the Comptroller General (CGU), and the Public Prosecutor's Office (Brazil, 2009). The obligation to render accounts, as provided for in Article 70 of the Federal Constitution (Brazil, 1988), is the cornerstone of this oversight. The institutional framework also promotes family farming by prioritizing agrarian reform settlements and Indigenous and Quilombola communities (Brazil, 2009), allowing price premiums for organic products (Brazil, 2013), and recognizing women's groups as priority beneficiaries (Brazil, 2023a).

Given the heterogeneity of the PNAE's components, the system was organized into five subsystems, each defined according to actor relationships, functional roles, and contributions to program operation.

**Table 1 – Subsystems of the National School Feeding Program System**

Order	Subsystem	Function	Contributions
1	Student/FNDE	Technical	Calculation of values and budget allocation
2	FNDE/Government entities	Technical	Decentralization of resources
3	Government entities/Schools	Operational	Sustainable procurement processes
4	Schools/Family farming	Execution	Provision of healthy food/development and income Generation for Family farming cooperatives/sustainable development



Order	Subsystem	Function	Contributions
5	School feeding/ Student	Execution	Nutrition/food security/environmental education

Source: Prepared by the authors, based on FNDE data (Brazil, 2024).

Among these subsystems, the third—Governmental entities/Schools—plays a crucial operational role, as it is at this level that participation rules and procurement procedures are defined, enabling farmer engagement. It is also at this stage that situational behavior and bounded rationality among managers may lead to operational shortcomings or distortions, resulting in underutilization of resources allocated to family farming.

The analysis of variable behavior over time constitutes the primary tool of system dynamics for supporting decision-making (Souza *et al.*, 2007, cited in Souza, 2011). Accordingly, the main variables involved in the process were identified.

**Table 2 – Variables related to the procurement of Family farming products**

Variable type	Topic	Indicator	Possible causal relationships
<b>Exogenous</b>	Students	Number of enrollments recorded in the previous year's school census	Student x FNDE Student x Municipality Students x Schools Students x Family farming Student x School feeding
	Institutional framework	Existing legal instruments governing program implementation	Student x FNDE Student x Municipality Students x Schools Students x Family farming Student x School feeding
<b>Endogenous</b>	Program resources – financial amounts transferred by the Federal Government to municipalities in Santa Catarina for the operation of the PNAE	Annual PNAE budget allocation	FNDE x Municipalities Municipalities x Schools
	Procurement of food from family farming – federal financial resources operationalized by municipalities in Santa Catarina for the purchase of products from family farming	Percentage of purchases allocated to family farming	Schools x Family farming Family farming x School feeding School feeding x Student

Source: Prepared by the authors, based on FNDE data (Brazil, 2024).



The table presents two exogenous variables: the number of students—which acts as a demand aggregator, feeding back into the system—and the institutional framework, which guides individual behavior. The latter, although regulatory in nature, does not ensure full compliance, since actors’ rationality and discretionary power affect adherence.

The endogenous variables—program resources and family farming procurement—are activity-generating, driving the dynamism of relationships and propelling the procurement cycle. They reflect the effects of the policy and support a complexity perspective, as the PNAE integrates educational, environmental, nutritional, social, and rural development actions.

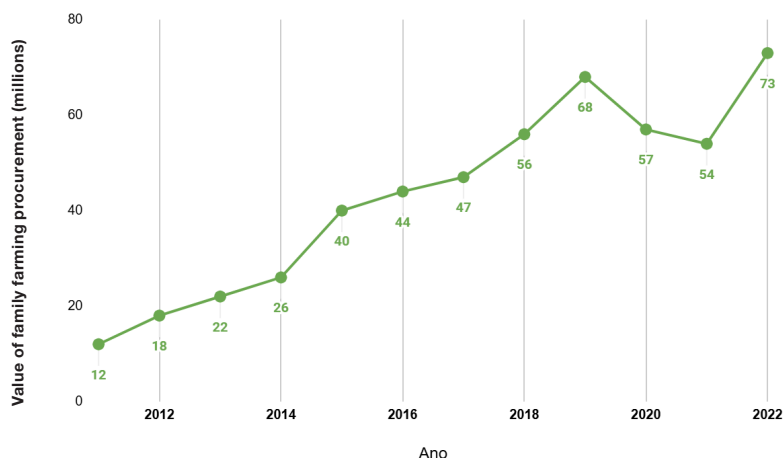
## 4 RESULTS AND DISCUSSION

This section presents the results of the study regarding the resources allocated to the purchase of food from family farming and discusses the improvement of the conceptual model of the PNAE subsystems.

### 4.1 Resources allocated to the procurement of food from family farming

The analysis of data from Santa Catarina, between 2011 and 2022, made it possible to assess the behavior of endogenous variables, highlighting the evolution of the allocation of resources intended for the procurement of food from family farming. Graph 1 shows the trend in the amount of financial resources applied to these purchases by municipalities in Santa Catarina.

**Figure 1 – Value of family farming procurement in Santa Catarina (2011–2022)**



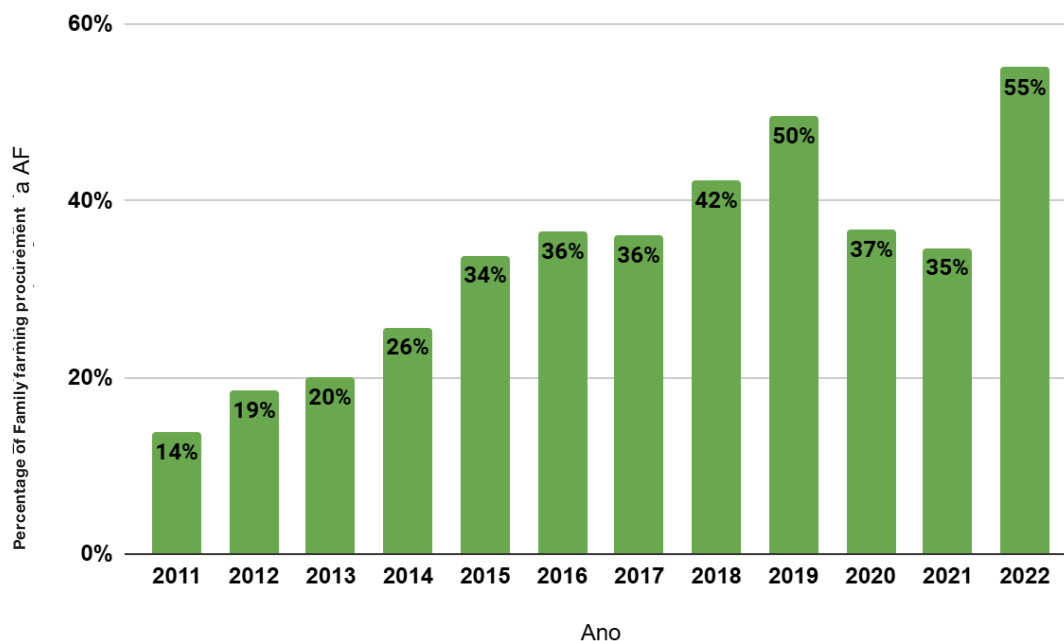
Source: FNDE data panel (Brazil, n.d.).

The figure reveals a continuously upward execution trend between 2011 and 2019, characterizing system stability and growth. Despite the evident decline observed in 2020 and



2021, a strong rebound is observed in 2022, with a growth trend exceeding that of previous years. Figure 2 highlights the progressive trend in resource allocation in percentage terms, revealing the program's “evolutionary memory”.

**Figure 2 – Percentage of family farming procurement in Santa Catarina (2011–2022)**



Source: FNDE data panel (Brazil, n.d.).

Analysis of these percentages shows that the state, overall, reached the minimum 30% target starting in 2015. Another positive aspect is that in subsequent years this percentage was maintained or continued to increase. The year 2022 represents a milestone, reaching 55.10%, indicating that more than half of federal resources were allocated to the procurement of family farming products. The variation observed between 2020 and 2021, although significant, did not alter the long-term upward trend.

Table 1 provides a granular view of municipal performance by distributing municipalities across ranges of resource allocation over the years. A percentage of 100% or more indicates that, in the year analyzed, the executing entity used all federal resources transferred by the FNDE for the procurement of food from family farming.

**Table 1 – Percentage of family farming resource allocation by year**

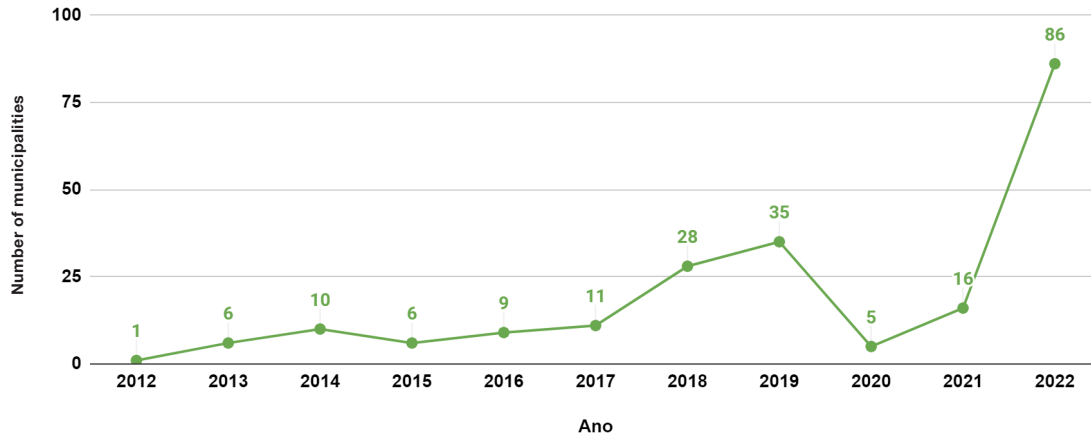
Year	0 to 10%	10 to 20%	20 to 30%	30 to 40%	40 to 50%	50 to 60%	60 to 70%	70 to 80%	80 to 90 %	90 to 100%	Greater than or equal to 100%
2011	76	21	26	89	42	17	11	6	3	2	
2012	57	20	40	91	27	24	16	5	8	3	1
2013	34	26	36	84	46	24	16	14	4	3	6
2014	41	17	24	60	50	41	19	19	9	6	10
2015	26	15	31	72	53	44	22	13	7	7	6
2016	11	15	42	57	51	46	25	12	16	5	9
2017	16	7	22	67	46	41	36	27	12	7	11
2018		6	12	39	38	49	36	35	30	15	28
2019	2	6	11	38	37	35	39	23	33	34	35
2020	34	25	60	63	42	26	15	14	5	3	5
2021	60	35	26	37	33	29	23	17	10	7	16
2022	5	2	10	21	19	27	41	23	31	23	86

Source: FNDE data panel (Brazil, n.d.).

Analysis of the table shows a clear evolution in resource allocation. In 2011, 123 municipalities were concentrated in the three lowest ranges, below 30%. Eleven years later, in 2022, there was a marked concentration of municipalities in the highest category, with 86 municipalities allocating 100% or more of resources to family farming, indicating supplementation with their own funds. The situation in 2011, when no municipality reached 100%, contrasts sharply with the 2022 scenario. Figure 3 illustrates the growth in the number of municipalities with exemplary performance ( $\geq 100\%$ ), with a significant regression only during 2020–2021.



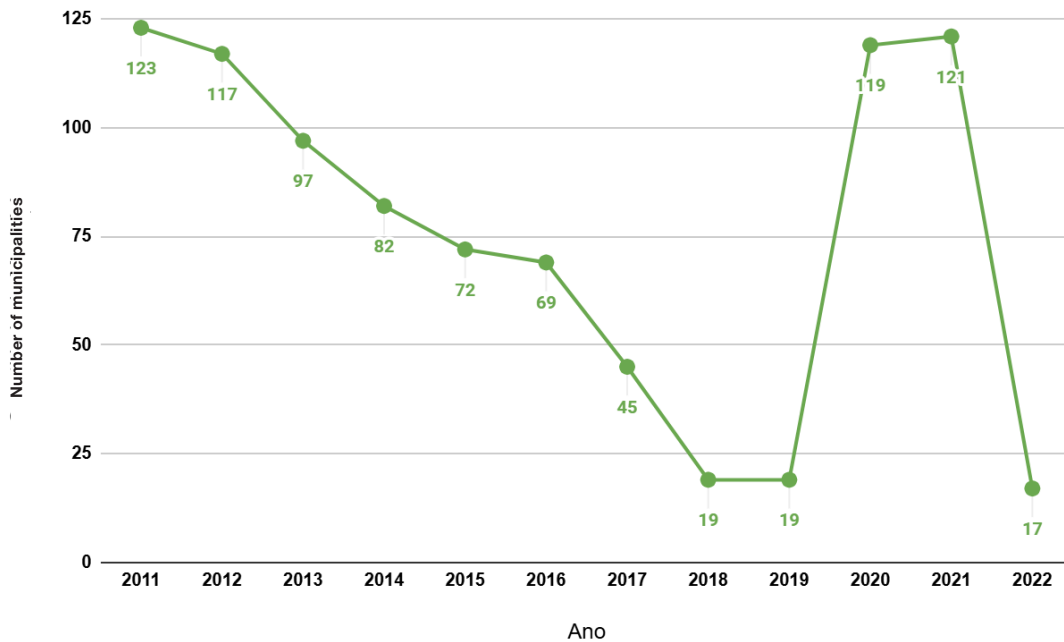
**Figure 3 – Number of municipalities that met or exceeded 100% of the family farming procurement target**



Source: FNDE data panel (Brazil, n.d.).

Figure 4, in turn, shows a declining trend in the number of municipalities that failed to meet the 30% target, although a significant increase is observed precisely during the pandemic period.

**Figure 4 – Number of municipalities that did not reach 30% of the family farming procurement target**

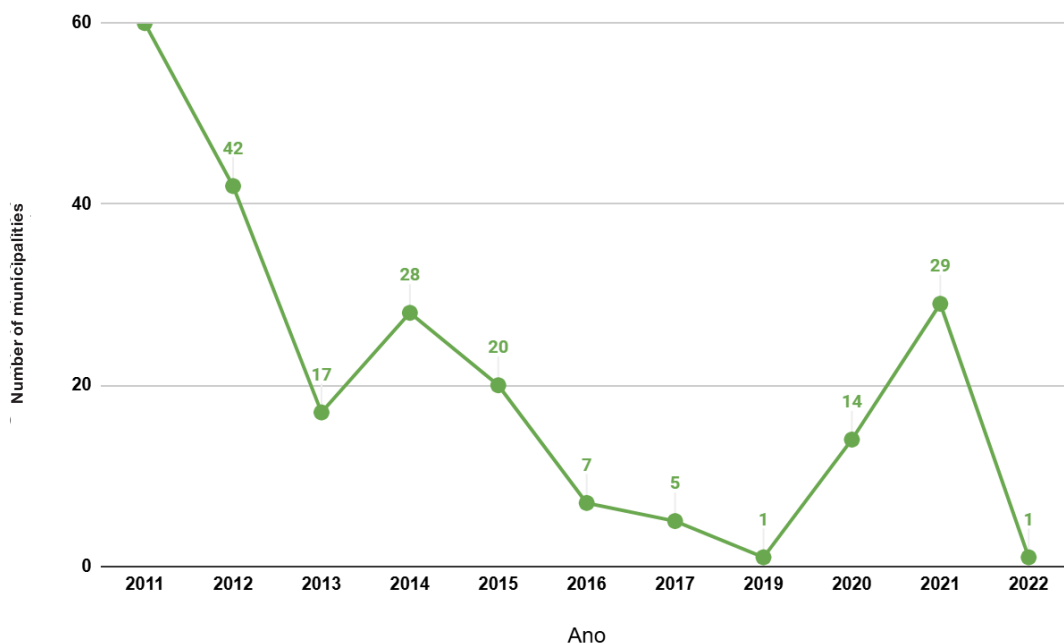


Fuente: Panel de datos del FNDE (Brasil, sin fecha).



Finally, Figure 5 shows that the number of municipalities that virtually did not procure family farming products (<1%) continued to decline, reaching only one municipality in 2022, following the imbalance observed in 2020–2021.

**Figure 5 – Number of municipalities that achieved less than 1% of the family farming procurement target**



Source: FNDE data panel (Brazil, n.d.).

Following the presentation of variable behavior, it is important to note that the destabilization of the transfer subsystem observed between 2020 and 2021 was largely due to the COVID-19 pandemic. This public health emergency represented an exogenous, unforeseeable shock, with wide-ranging effects on the PNAE. In response, the institutional framework demonstrated adaptive capacity by implementing an action plan (Brazil, 2020a) that, among other measures, enabled the transfer of additional installments. This response illustrates the system’s resilience in the face of crises that may culminate in economic instability and food insecurity. Indeed, from 2022 onward, the system showed a strong recovery, resuming the growth trend observed up to 2019.

#### 4.2 Intervention points and potential improvement of the representation of resource distribution subsystems

Given that monitoring outcomes in public policies is a complex task permeated by methodological and operational challenges, potential intervention points within the PNAE subsystems and their connections to system-wide feedback mechanisms are identified below. Subsequently, hypotheses are presented for improving these conceptual models, with an



emphasis on enhancing resource distribution and strengthening family farming procurement, thereby guiding future improvements in the program's operating dynamics.

#### 4.2.1 Intervention in endogenous variables: resources and procurement

The analysis begins with the behavior of endogenous variables. The first—an increase in per-student funding—can be influenced by political decisions; however, the mere injection of additional resources does not guarantee that the policy's intended outcomes will be achieved.

The second—procurement directed to family farming—is primarily shaped by municipal and state management and requires proactive implementation behavior. Efforts to provide healthy, locally sourced food face operational challenges, including barriers that still hinder the entry of local family farmers into the public policy framework.

#### 4.2.2 Self-regulation through the exogenous variable: the role of students

Next, the exogenous variable related to the number of students is examined. Under scenarios of stable or increasing enrollment, the system itself generates demand in the form of financial resources to be executed, thereby fostering the continuity of activities. In this sense, intervention within the subsystem occurs through self-regulation: policy outcomes are achieved as a function of students (ensuring food provision) and are conditioned by them (maintenance of enrollments).

#### 4.2.3 Complexity of adherence: human and behavioral factors

System effectiveness, however, extends beyond financial variables and depends on actor adherence. Student acceptance of meals, for example, is a social construct. It is not sufficient merely to direct efforts toward the procurement of family farming products. Alignment between nutritionists and educators is required to promote awareness of healthy and locally sourced food, while also considering students' socioeconomic conditions, which may shape their preferences.

Similarly, adherence by government managers is not instantaneous. The mere enactment of legislation and sanctions does not appear sufficient to ensure engagement. Managers depend on optimized menus developed by nutritionists, well-structured procurement processes, and the existence of local cooperatives capable of supplying. The diversity of circumstances may alter expected effects, and the most effective outcomes tend to arise from consensual choices resulting from interaction among students, nutritionists, managers, and farmers, even though collaborative behavior is not a natural characteristic of complex systems.



#### 4.2.4 Hypotheses for improving the conceptual model

Based on the diagnosis, several lines of action emerge that may contribute to improving the conceptual model of the PNAE subsystems. The first involves an in-depth analysis of local contexts in municipalities in Santa Catarina that, in 2022, had not yet reached the minimum 30% family farming procurement threshold. In such cases, it is essential to identify productive and logistical bottlenecks, assess local productive arrangements, and stimulate regional production in line with each territory's specific potential, as well as to provide prioritized technical assistance and audits to address persistent difficulties.

Conversely, the positive performance of the 86 municipalities that, in 2022, achieved or exceeded 100% execution reveals a set of practices that merit systematic study. The identification and dissemination of these best practices may inform replicable strategies in other contexts, serving as references to strengthen the effectiveness of public policy at the state level.

Another avenue for improvement lies in the development of public municipal monitoring dashboards, featuring real-time indicators on budget execution, the percentage of family farming procurement, and school attendance. In addition to enhancing transparency, such tools would enable more qualified monitoring by the various actors involved and function as predictive guides capable of identifying seasonal patterns and supporting procurement planning under conditions of uncertainty. In this way, dashboards emerge as strategic instruments for continuous learning and improvement in program management.

## 5 FINAL CONSIDERATIONS

The analysis of the PNAE subsystems in Santa Catarina shows that hard and soft systems modeling approaches are not mutually exclusive, but rather complementary in understanding public policies. The hard perspective provided the “what”—the objective measurement of system performance, growth, and anomalies—confirming that the PNAE operates as a complex and goal-oriented system, endowed with clear objectives and feedback mechanisms. In turn, the soft perspective offered the “why”—an understanding of underlying causes, relational complexity, and the system's remarkable capacity for learning and adaptation in the face of crises, such as the COVID-19 pandemic.

This study aimed to analyze this subsystem and, through the collection of quantitative data and the identification of variables that structure the system, to suggest potential improvements. The results confirm that the PNAE is a public policy whose outcomes depend on the integrated action of different agents and on specific social demands, reinforcing its complex and interdependent nature. In this context, basic education students emerge as the most significant agents, as they constitute the central demand-generating element of the system.

The analysis of the current model, by highlighting leverage points and structural bottlenecks, revealed that the most significant positive impacts stemmed from the system's upward



trajectory throughout most of the analyzed period. This finding demonstrates both the adaptability of the agents involved and the collective effort toward continuous improvement in indicators related to the allocation of resources to family farming.

Despite this performance, the analysis also revealed structural vulnerabilities. The exogenous variable related to enrollment levels proves difficult to control, since student inflows and outflows are linked to the challenge of school dropout—a phenomenon that depends on the interconnection of multiple policies and on the adoption of multifaceted approaches to consolidate governance aimed at student retention. Similarly, the program's legal and institutional framework, although exerting strong influence on agents' strategies, is not sufficient on its own to ensure the expected behavior. Policy implementation remains partially unpredictable, shaped by agents' rationality and the discretionary power inherent in established rules.

Even in the face of these complexities, the study highlights the consistent efforts of municipalities in Santa Catarina to increase efficiency in resource allocation, with substantial progress over the analyzed period. Nevertheless, the persistence of municipalities that have not yet reached the minimum 30% allocation to family farming, combined with the lag in per capita values—which prevents more than half of municipalities from providing the necessary supplementation—reveals constraints that hinder the program's full implementation.

In addition, the findings point to concrete avenues for improving the subsystem, particularly through the identification of productive and logistical bottlenecks in low-performing municipalities; the systematization and dissemination of best practices observed among municipalities that achieved 100% or more of execution; and the development of public monitoring dashboards to support municipal oversight, enhance transparency, and improve procurement planning under conditions of uncertainty.

These conclusions lead to practical implications and objective recommendations. For municipal and state public managers, proactive action based on open data is recommended, including the creation of working groups focused on low-performing municipalities to map and overcome logistical, productive, and bureaucratic bottlenecks. Management should act as a development agent, fostering local productive arrangements and disseminating best practices from the 86 municipalities that already exceed 100% execution.

For the federal government, a revision of the per capita adjustment policy is recommended, with the introduction of an automatic annual update mechanism. In addition, strengthening coordination between the Ministry of Education (MEC) and the Ministry of Development and Social Assistance (MDS) is essential to ensure that school retention policies operate in a coordinated and complementary manner.

Although this study provides a comprehensive overview of the state of Santa Catarina, it is acknowledged that the macro-level approach does not allow for an in-depth exploration of the specificities of each municipality. Accordingly, further refinement of the model requires future research, including comparative case studies between high-performing municipalities and those facing persistent challenges, to generate more precise insights. The incorporation



of complementary data collection methods, such as interviews with managers and family farmers, is also recommended to enrich the quantitative analysis and deepen understanding of the observed phenomena.

Finally, an investigation into the territorial reach of the PNAE and its potential contribution to a broader sustainability agenda represents a promising field for future research, particularly given the multidisciplinary and multicentric nature of this public policy, whose strategic relevance to sustainable development and food security is widely recognized.

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