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BRAZILIAN JOURNAL OF PUBLIC ADMINISTRATION

Article

Public policy instruments, institutional innovation, and agricultural adaptation to climate change in Brazil

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Despite the development of numerous policies and programs to adapt agriculture to climate change in recent years, their implementation remains deficient. This phenomenon can partly be explained by failures in climate governance, which require innovation and institutional transformation to accelerate policy implementation and build long-term impacts. This article has two main objectives: from a theoretical-methodological perspective, to introduce agricultural adaptation to climate change and innovation in climate governance through procedural instruments; and from an empirical perspective, to trace the agricultural climate adaptation instruments within Brazil's federal government, categorized as either procedural or substantive. As a result, 21 policies and programs related to agricultural climate adaptation were identified, comprising 136 instruments, of which 58 were procedural. The article discusses these findings in light of the literature and highlights research developments that contribute to filling the gap in the literature on procedural instruments.

Keywords: procedural instruments; adaptation of agriculture to climate change, public policies, climate governance, institutional innovation.

DOI: https://doi.org/10.1590/0034-761220240473x ISSN: 1982-3134

Submitted on December 10, 2024, and accepted for publication on February 11, 2026.

[Translated version] Note: All English quotes were translated by this article's translator.

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The peer review report is available at https://periodicos.fgv.br/rap/article/view/97853/90852

Instrumentos de políticas públicas, inovação institucional e adaptação da agricultura às mudanças climáticas no Brasil

Apesar de muitos programas e políticas de adaptação da agricultura às mudanças climáticas terem sido desenvolvidos nos últimos anos, sua implementação é deficiente. Parte do fenômeno pode ser explicado por falhas da governança climática, que requer inovação e transformação institucional para acelerar a implementação de políticas e construir impactos de longo prazo. O presente artigo possui dois objetivos: do ponto de vista teórico-metodológico, abordar a adaptação da agricultura às mudanças climáticas e a inovação na governança climática por meio de instrumentos procedimentais; e, do ponto de vista empírico, rastrear os instrumentos de adaptação climática da agricultura no governo federal brasileiro, organizados entre procedimentais e substantivos. Como resultado, foram identificados 21 programas e políticas relacionados à adaptação climática da agricultura, com 136 instrumentos, dos quais 58 procedimentais. O artigo discute o resultado do levantamento à luz da literatura e aponta desdobramentos de pesquisa que contribuirão para preencher a lacuna na literatura de instrumentos procedimentais.
Palavras-chave: instrumentos procedimentais, adaptação da agricultura às mudanças climáticas, políticas públicas, governança climática, inovação institucional.

Instrumentos de políticas públicas, innovación institucional y adaptación de la agricultura al cambio climático en Brasil

Aunque en los últimos años se han desarrollado muchos programas y políticas para adaptar la agricultura al cambio climático, su implementación es deficiente. Parte del fenómeno puede explicarse por las fallas en la gobernanza climática, que requiere innovación y transformación institucional para acelerar la implementación de políticas y generar impactos a largo plazo. El presente artículo tiene dos objetivos: desde el punto de vista teórico-metodológico, abordar la adaptación de la agricultura al cambio climático y la innovación en la gobernanza climática mediante instrumentos procedimentales; y, desde el punto de vista empírico, rastrear los instrumentos de adaptación climática de la agricultura en el Gobierno federal brasileño, organizados entre procedimentales y sustantivos. Como resultado, se identificaron 21 programas y políticas relacionados con la adaptación climática de la agricultura, con 136 instrumentos, de los cuales 58 son procedimentales. El artículo discute el resultado del estudio a la luz de la literatura y señala desarrollos de investigación que contribuirán a llenar el vacío en la literatura sobre instrumentos procedimentales.
Palabras clave: instrumentos procedimentales, adaptación de la agricultura al cambio climático, políticas públicas, gobernanza climática, innovación institucional.

1. INTRODUCTION

This article examines public policy instruments for agricultural adaptation to climate change in Brazil at the federal level. The study is part of the research project Assessing Climate Plans and Institutional Innovation Instruments for Climate Change: Climate Governance Risks: Improving Procedural Instruments for Adaptation of Agriculture to Climate Change in the North and Global South (APIICC), which compares innovation processes in climate governance. The project provides the theoretical framework for this article.

Previous research on agricultural adaptation to climate change (AACC) has concluded that, despite the proliferation of national climate plans developed in recent years, implementation remains deficient and governance is marked by structural shortcomings. These plans often exhibit practices disconnected from AACC; their institutional design remains conservative in addressing emerging problems and challenges, continuing to operate in a sectoral and hierarchical manner; and their instruments are predominantly oriented toward very short-term responses to immediate vulnerabilities and climate variability, rather than the long-term impacts of climate change (Biabiani et al., 2022; Massardier, 2022; Massardier et al., 2024; Milhorance et al., 2022).

Thus, climate policies face a "tragedy" characterized by a persistent tension between slow, incremental implementation and the urgency of the problem they aim to address. Although intended

to support a rapid transition, these policies appear myopic regarding the long-term impacts of climate change (Massardier et al., 2024).

AACC is urgent in both the short and long term to ensure food security. It requires transforming agricultural practices and production contexts to reduce vulnerabilities and enhance resilience. Climate governance is a central challenge, as climate risk is exacerbated by vulnerabilities in implementing plans and policies in this domain (Massardier et al., 2024). Therefore, institutional innovation is crucial to enable more effective climate policy implementation, which requires creating new structures and governance mechanisms. Procedural instruments, i.e., mechanisms that shape political behavior and policy processes during formulation and implementation, are key tools for such innovation, providing technical means to structure political governance (Howlett, 2000).

Recent studies examine climate change from the perspective of public policy research; however, coordination and systematization of scholarship in this field in Latin America remain limited (Oliveira & Maillet, 2026). Within the framework of the dossier "Expanding the frontiers of research on climate public policies in Latin America: issues, cases, and approaches," published in the Brazilian Journal of Public Administration, this study offers reflections, based on the Brazilian case, on the design and use of climate policy instruments. Emphasis is placed on instruments that shape climate governance, including mechanisms for implementation and coordination across levels and sectors of public action, as well as mechanisms for integrating social and economic groups.

The article is organized into five sections, in addition to this introduction. The next two sections present theoretical discussions of AACC and procedural instruments. The fourth section maps AACC instruments across programs and policies of the Brazilian federal government from 2016 to 2024. The fifth section discusses the findings in light of the literature, and the sixth section presents concluding reflections, outlining research avenues that may help address the gap in the literature on procedural instruments.

2. AGRICULTURAL ADAPTATION TO CLIMATE CHANGE

Agriculture is one of the main sources of greenhouse gas emissions in Brazil. Because agricultural activity is fundamentally shaped by meteorological and climatic conditions, the sector is among the most affected by climate change.

Increasing variability and frequency of extreme events associated with global climate change, such as temperature extremes, altered precipitation patterns, sea-level rise, humidity changes, and wind intensity, pose growing risks to agricultural activity. These dynamics are expected to substantially affect production and continually test farmers' adaptive capacity (Bednar & Henstra, 2018; Ministério do Meio Ambiente, 2016). In the short term, climate extremes can cause crop failures, leading to food shortages and heightened price volatility. In the medium and long term, declines in agricultural production and productivity due to climate impacts affect the entire agri-food chain, not only in meeting international demand (exports) but, more critically, in relation to national food and nutrition security (Banco Mundial, 2013; Távora et al., 2022).

According to Dupuis and Knoepfel (2013), three main adaptation framings have evolved over time. The first is a climate change – centered framing, aimed at adapting to the specific impacts of anthropogenic climate change. The second focuses on adaptation to climate variability. The third is a vulnerability-centered framing that seeks to reduce the structural drivers of vulnerability to climate

change impacts. Together, these framings broaden understanding of adaptation and foster greater involvement of social, political, and scientific actors in addressing climate-related challenges (Termeer et al., 2017).

To illustrate agricultural adaptation to climate change (AACC), Table 1 summarizes the main practices identified in policy guidelines, academic literature, and national and sectoral climate adaptation plans relevant to Brazilian agriculture (Assad, 2021; Banco Mundial, 2013; Empresa Brasileira de Pesquisa Agropecuária [Embrapa], 2018; Ministério da Agricultura, Pecuária e Abastecimento, 2021a, 2021b; Ministério do Meio Ambiente, 2016; Távora et al., 2022).

TABLE 1 AACC PRACTICES IN BRAZIL

AACC Practices	Description
Water conservation and irrigation	- Efficient irrigation systems - Intelligent drainage and increased water infiltration - Rainwater harvesting and storage systems (e.g., cisterns)
Soil conservation ("soil building")	- Incorporation of organic matter - Soil cover - No-till farming - Crop diversification
Pest and disease control	- Reduction in pesticide use and increased efficiency - Crop diversification and crop rotation - Use of bio-inputs and biological control - Control of exotic species
Seeds and cultivars	- Use of seeds, cultivars, and varieties better adapted to diverse climates; resistant to climatic stress (especially water scarcity); and tolerant of heat, drought, and other abiotic stresses - Improvement of integrated crop protection management against diseases, insects, and weeds - Genetic improvement and transgenics - Seed and gene banks
Protected cultivation	- Protected cultivation systems: mulching, greenhouses, low tunnels
Storage and post-harvest processing	- Increase food storage capacity - Process products to produce food with greater durability
Integrated production systems	Systems with reduced dependence on external resources: - Crop-Livestock-Forest Integration - Agroforestry systems - Adoption of agroecological systems and organic production

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AACC Practices	Description
Sustainable management of natural resources	- The recovery and conservation of permanent preservation areas and legal reserves help maintain springs, watercourses, the water cycle, milder temperatures, and ecosystems that are more resilient to pests.
Information systems/risk mitigation	- Climate zoning: information on how, what, and when to plant, based on an analysis of crops best adapted to specific territories. - Disaster monitoring, early warning, and response mechanisms; and improved technologies and standards for disaster diagnosis - Studies on pest risks as a function of climate change
Response to losses	- Rural/climate insurance - Subsidy policies and minimum prices
Income increase/sustainable development	- Practices to increase farmers' income and reduce poverty can be considered adaptation strategies under the Adaptive Capacity Framework (ACF) because they create better conditions for adopting preventive and corrective practices.

Source: Elaborated by the authors based on Assad (2021), the World Bank (Banco Mundial, 2013), Ministério da Agricultura, Pecuária e Abastecimento (2021a, 2021b), Ministério do Meio Ambiente (2016), Embrapa (2018), and Távora et al. (2022).

Climate adaptation governance refers to the patterns of governance and management that emerge from the actions of social, political, and administrative actors in the context of climate change. Governance activities encompass efforts to adapt to climate change, to establish institutions that address climate-related issues, and to align these actors' ideas with normative assumptions about how climate change adaptation should be governed, considering broader social and political belief systems (Huitema et al., 2016).

This form of governance presents a relatively new scientific challenge, encompassing issues such as policy innovation, policy diffusion, barriers to adaptation, social contracts, adaptive capacity, resilience building, legal frameworks, communication, financing, and evaluation processes (Huitema et al., 2016; Termeer et al., 2017).

Institutional innovation refers to intentional changes in governance structures that make policies more adaptive and better prepared to operate under uncertain and evolving climate futures. In the literature on climate governance innovation, there remains a notable gap in analyses of the institutions that structure and may be reshaped by such innovative activities (Patterson & Huitema, 2019). In political science and governance research more broadly, policy innovation is commonly treated not merely as a dependent variable but as one of the most consequential dimensions of policy change (Jordan & Huitema, 2014).

3. PROCEDURAL INSTRUMENTS

Public action instruments, also referred to as policy instruments, government instruments, or tools of government, can be defined as the means through which governments seek to influence behavior and achieve public policy objectives (Hood, 1986) or as the set of techniques by which public authorities exercise power to secure, sustain, promote, or prevent social change in pursuit of specific objectives (Bemelmans-Videc et al., 1998). Instruments translate policy intentions and expected outcomes; thus, their analysis provides an opportunity to revisit and reinterpret public policy decisions (Lascoumes & Le Galès, 2012).

At a basic level, instruments can be divided into two broad types based on their primary orientation. Substantive instruments aim to directly alter the substance of social and economic activities, affecting the production, consumption, and distribution of goods and services. Procedural instruments focus on shaping political and policy processes during formulation and implementation. They affect production, consumption, and distribution only indirectly by influencing decision-making procedures, actor interactions, and governance arrangements (Bali et al., 2021; Howlett, 2000).

In this sense, the procedural dimension encompasses the processes and activities required to coordinate the actors responsible for policy formulation, decision-making, and administration (Howlett, 2011). Therefore, procedural instruments are necessary for substantive instruments to operate effectively, gain legitimacy, and enhance compliance (Bali et al., 2021).

Howlett and Rayner (2007) identify three generations of research on instrument choice. The first generation focused largely on the relationship between business and government, examining the effects of regulation and proposing techniques to correct market failures. However, it tended to analyze instruments in isolation and adopt a relatively rigid, simplified view of policy instrument choice, disconnected from complex administrative practices. The second generation developed more sophisticated models that incorporated contextual factors and policy networks, thereby advancing theories of instrument choice and comparative research. The third generation moved beyond single-instrument analysis to address the design and adoption of optimal instrument mixes in complex decision-making and implementation contexts (Howlett & Rayner, 2007).

However, most of this literature has focused primarily on substantive instruments (Bali et al., 2021). As a result, early scholarship offered only a partial account of policy instruments and of the relationship between instrument choice and policy design (Howlett, 2011). By focusing predominantly on substantive instruments, scholars overlooked the foundational insight, already recognized by early policy researchers, that both the substance and the process of policymaking must be considered in instrument analysis (Howlett, 2000).

Together, substantive and procedural instruments constitute the policy toolbox from which governments select means to address public problems (Howlett, 2011). Established typologies for categorizing instruments include the carrots-sticks-sermons classification (Bemelmans-Videc et al., 1998) and Hood's (1986) NATO model (nodality, authority, treasure, and organization). These typologies are most commonly applied to substantive instruments but can also extend to procedural ones (Howlett, 2000).

In climate governance, characterized by networked and polycentric modes of governance, the use of financial instruments (the carrots or treasure category), which rely on incentives and resource allocation to shape behavior, has expanded significantly. This expansion includes the development

of financial policy networks and mechanisms for mobilizing financial resources within governance arrangements (Howlett, 2000, 2011).

Procedural instruments and their effects remain less studied and less well understood than substantive instruments, and have historically been neglected in the policy instrument literature (Bali et al., 2021). Howlett (2000) argues that the dominant focus on substantive instruments has become problematic for addressing the paradoxes of modern governance and for identifying appropriate methods to manage governance gaps. Procedural instruments have become essential components of pluralist and polycentric governance systems, particularly as mechanisms for facilitating coordination and dialogue among actors.

Procedural instruments can serve multiple functions: defining or redefining the positions of political actors; adding or excluding actors from policy networks; modifying access rules; shaping network formation; promoting self-regulation; altering governance structures in policy implementation; redefining evaluation criteria; influencing incentive and reward structures; shaping professional and policy-relevant codes of conduct; managing political and social conflicts; restructuring interaction patterns among actors; encouraging certain forms of political action while discouraging others; and modifying oversight and accountability relationships (Bali et al., 2021).

According to Massardier et al. (2024), in the field of climate governance, procedural instruments may be innovative by fostering policy integration on climate issues, enhancing flexibility in complex and uncertain polycentric contexts, and improving governance quality. By potentially accelerating program implementation and incorporating long-term considerations into decision-making, procedural instruments constitute a particularly promising locus for investigating innovation in climate governance.

The literature on procedural instruments remains fragmented and uneven, leaving several critical questions unresolved. Not only are their effects insufficiently understood, but the determinants of their selection are even less explored. This gap is especially significant given that substantive and procedural instruments typically co-occur within policy mixes (Bali et al., 2021). Translating political ambitions into practice is inherently complex. Thus, a design-oriented perspective requires broadening the analytical lens of policy formulation to include procedural instruments in the "menu of governmental choices" and to systematically examine interactions between substantive and procedural instruments within instrument mixes (Howlett, 2011, 2017).

4. MAPPING AGRICULTURAL ADAPTATION TO CLIMATE CHANGE INSTRUMENTS IN THE BRAZILIAN FEDERAL GOVERNMENT

This section presents the methodological procedures adopted and the results of the systematic mapping of policies and programs related to agricultural adaptation to climate change (AACC) and their associated instruments within the Brazilian federal government.

4.1 Methodology

The identification of policies and programs related to AACC began with an analysis of official federal government documents, specifically the ministerial Management Reports and the 2024–2027 Multi-annual Plan (*Plano Plurianual* – PPA) (Ministério do Planejamento e Orçamento, 2023), the federal

government's main medium-term budgetary planning instrument. The PPA sets the guidelines, objectives, and targets for the federal public administration, covering capital expenditures and related expenses, as well as ongoing programs. Enacted by law for a four-year period, the PPA provides an authoritative reference for assessing the extent to which AACC is incorporated into forward-looking federal planning. A keyword search for the term "adaptation" was conducted in the PPA, and programs related to agriculture were selected for further analysis.

As a second documentary source, management reports from ministries with direct or indirect responsibilities for agriculture were examined (ministries of agriculture and livestock; agrarian development and family farming; environment and climate change; mines and energy; regional development; social development; and finance). For these reports, covering the period 2016-2023 (the temporal scope of the broader research project), keyword searches were conducted using the terms "climate," "adaptation," and "agriculture."

These ministerial management reports are produced annually and serve as a key transparency and accountability instrument. They document implemented actions and include accounting, financial, budgetary, operational, and patrimonial information. The analysis of these reports helps to identify how AACC has been incorporated into past federal policy implementation.

In the second analytical stage, the relationship between identified programs and policies and AACC was assessed. Programs were classified as directly linked when adaptation was explicitly mentioned and as indirectly linked when adaptation was not explicitly referenced but related themes were addressed, such as adaptation to climate variability, vulnerability reduction, or the adoption of technologies recognized in the literature as supporting AACC.

In the third stage, policy instruments associated with each program and policy were identified through documentary analysis of official websites and relevant legislation. This stage involved analytically "deconstructing" programs into their constituent instruments, thereby identifying the concrete means of action mobilized. Instruments were preliminarily classified as procedural or substantive, and further as financial or non-financial.

Several methodological limitations should be acknowledged. First, the degree of implementation was not assessed; thus, the analysis does not evaluate the effectiveness or practical uptake of the identified programs and instruments. Second, the federal-level focus excludes state and municipal policies, which hold significant prerogatives in agricultural policy and, in many cases, are central to implementation at the farm level. Third, the identification of instruments depends on the depth of document analysis; procedural instruments are not always explicitly labeled and may therefore be under-identified. Accordingly, the inventory presented here should not be considered exhaustive. Finally, the procedural-substantive distinction requires further analytical refinement and theoretical discussion.

The strategy of systematically tracking policies through structured keyword searches in official documents aligns with recent text-as-data approaches in policy analysis, which aim to extract and systematize policy design elements from normative and programmatic texts (Sewerin et al., 2023). A similar methodological approach has been used to analyze public strategies in Brazil and Argentina on digital transformation, using procedural and substantive instruments (Lui et al., 2025).

4.2 Results

Table 2 presents the preliminary results of the mapping exercise. A total of 32 programs and policies were identified, with 9 explicitly referencing agricultural adaptation to climate change and 23 showing indirect links to AACC. Across these programs and policies, 136 instruments were identified, of which 78 were classified as substantive (S) and 58 as procedural (P).

Additionally, 44 instruments were categorized as financial (F) and 92 as non-financial (NF). Given the methodological limitations outlined above, the analysis avoids more sophisticated quantitative interpretation. Nonetheless, several qualitative findings must be emphasized. Both procedural and substantive instruments were identified across all 32 programs and policies, indicating that instrument mixes are systematically present. Financial instruments appear in 23 of the 32 cases, representing 71.8% of the identified universe.

Programs and policies were qualitatively ordered by the extent to which they were explicitly linked to AACC. Of the 32 identified initiatives, 9 explicitly reference adaptation. These include the Adaptation and Low Carbon Emission Plan in Agriculture – ABC Plan; the National Climate Change Policy (within which the Sectoral Adaptation Plan for Agriculture is situated); the Ecological Transformation Plan; and climate risk management and rural insurance mechanisms, such as ProAgro and Garantia Safra.

The remaining 23 programs and policies show indirect links to AACC. Although they do not explicitly reference adaptation, they incorporate elements widely recognized in the literature as central to agricultural adaptation, including adaptation to climate variability, vulnerability reduction, and the adoption of adaptive technologies. Examples include initiatives focused on water resource conservation, native vegetation protection, soil conservation, farmer training and capacity building, research and development, and territorial, economic, or sustainable development strategies.

TABLE 2 MAPPING OF AACC POLICIES, PROGRAMS, AND INSTRUMENTS IN THE BRAZILIAN FEDERAL GOVERNMENT

Policies and Programs	Summary	Mention to AACC	Instruments	P/S	F /NF
ABC Plan – Adaptation and Low Carbon Emission Plan in Agriculture	Mitigation and adaptation to climate change in agriculture	Direct	RenovAgro/ABC Program – Credit for Financing ABC Technologies	S	F
			Testing and Demonstration Units (UTDs) or Technological Reference Units (URTs)	S	NF
			ABC Plan Governance System (SIGABC)	P	NF
			State Management Groups (GGE)	P	NF
			State Action Plans	P	NF
			Training of farmers and technical assistance and rural extension technicians in Sustainable Production Systems, Practices, Products and Processes (SPSABC)	S	NF

(Continue)

Policies and Programs	Summary	Mention to AACC	Instruments	P/S	F /NF
National Climate Change Policy	Mitigation and adaptation to climate change	Direct	Climate Plan (2023) / Plan. National Adaptation Plan (NAP) (2016)	S	NF
			National Climate Change Fund (Climate Fund)	S	F
			Management Committee of the National Climate Change Fund	P	NF
			National Climate Authority (not created)	P	NF
			Interministerial Committee on Climate Change	P	NF
			Temporary Working Groups (TWG) Adaptation	P	NF
			Brazilian Forum on Climate Change	P	NF
Ecological Transformation Plan	Economic transformation for climate change mitigation and adaptation	Direct	Sustainable Sovereign Bonds (Green Bonds) by the National Treasury – Contribution to the Climate Fund	P	F
			Committee on Sovereign Sustainable Finance (CFSS) at the Ministry of Finance (MF)	P	NF
			Brazilian Emissions Trading System – regulation of the carbon market	P	F
			Brazilian Sustainable Taxonomy (TSB)	P	F
			Interinstitutional Committee of the Brazilian Sustainable Taxonomy (CITSB)	P	NF
			Integration between the Crop Plan and the Low Carbon Agriculture Program – CMN Resolution No. 5,102 of 8/24/2023 (National Monetary Council)	P	F
Program for Guaranteeing Agricultural Activity (PROAGRO)	Climate risk/rural insurance	Direct	Prize Subsidy Program Rural Insurance	S	F
			Special Appeals Committee	P	NF
			Rural Insurance Monitor – Recurring Meetings	P	NF
			Agricultural Zoning of Climatic Risk (ZARC)	P	NF
			ProAgro Mais – Family Farming Insurance Program	S	F
Program Crop Guarantee	Climate risk/ rural insurance	Direct	Crop Guarantee Fund	S	F
			Crop Guarantee Benefit	S	F
			Crop Guarantee Management Committee	P	NF
National Program for Agricultural Zoning of Climatic Risk (ZARC)	Climate risk/ rural insurance/ information system	Direct	Agricultural Zoning of Climatic Risk System (SISZARC)	P	NF
			Planting Right App	S	NF
AdaptaBrasil – Information and Analysis System on the Impacts of Climate Change	Information system	Direct	AdaptaBrasil Platform with “Drought” and “Rain” indicators and indices	P	NF

(Continue)

Policies and Programs	Summary	Mention to AACC	Instruments	P/S	F /NF
National Policy on Agroecology and Organic Production (PNAPO)	Production management	Direct	National Plan for Agroecology and Organic Production (PLANAPO)	S	NF
			National Commission for Agroecology and Organic Production (CNAPO)	P	NF
			Interministerial Chamber of Agroecology and Organic Production (CIAPO)	P	NF
			Public calls for technical assistance and rural extension	S	NF
			Financing schemes (National Program for Strengthening Family Farming – PRONAF) with lower interest rates for organic and agroecological production	S	F
			Government purchases	S	F
			Research, development and Innovation	S	NF
			National Registry of Organic Production (CNPO)	P	NF
			National Program for Reducing the Use of Pesticides (PRONARA)	S	NF
National Policy for Combating Desertification and Mitigating the Effects of Drought	Territorial development (Brazil's semi-arid region)	Direct	National and State Action Plans to Combat Desertification and Mitigate the Effects of Drought	S	NF
			Annual Reports	P	NF
			Units for the Recovery of Degraded Areas and Reduction of Climate Vulnerability (URAD)	S	NF
			Early Warning System for Drought and Desertification (INPE)	S	NF
			Ecological-Economic Zoning (ZEE)	S	F
			National Commission to Combat Desertification	P	NF
			Interministerial Chamber to Combat Desertification	P	NF
			Technical Cooperation Projects	S	F
National Soil Program (PRONASOLOS)	Information system	Indirect	PRONASOLOS Geoportal, with soil survey maps	S	NF
			PRONASOLOS Strategic Committee	P	NF
			PRONASOLOS Executive Committee	P	NF
National Program for Bioinputs	Production management	Indirect	Strategic Council of the National Bioinputs Program	P	NF
			Credit schemes for R&D and implementation of biofactories	S	F
			Technical assistance and rural extension	S	NF
			Application Bioinputs	S	NF
Program for Good Agricultural Practices (BPA Brasil)	Production management	Indirect	Recognition of good practices	P	NF

(Continue)

Policies and Programs	Summary	Mention to AACC	Instruments	P/S	F /NF
National Policy for Technical Assistance and Rural Extension for Family Farming and Land Reform (PNATER)	Production management	Indirect	Digital Technical Assistance and Rural Extension Program (2021) – SAF	S	NF
			Calls for proposals for technical assistance and rural extension	S	NF
			Training and capacity building of technical assistance and rural extension agents	S	NF
			Accreditation of entities executing technical assistance and rural extension	P	NF
			Promotion of the production of technologies and knowledge appropriate for family farming	S	F
National Program for Decarbonized Agricultural Supply Chains (Carbono + Verde)	Development of sustainable production chains	Indirect	Thematic Chamber of Sustainable Agrocarbon	P	NF
			Tax incentives	S	F
			Sustainable financing schemes	S	F
			Environmental certification – *Carbono + Verde* accreditation	S	NF
			Green carbon credit	S	F
National Program for the Conversion of Degraded Pastures into Sustainable Production Systems – Caminhos Verdes (PNCPD)	Development of sustainable production chains	Indirect	Interministerial Management Committee	P	NF
National Program for Urban and Peri-urban Agriculture (PNAUP)	Development of sustainable production chains	Indirect	Working Group of the National Program for Urban and Peri-urban Agriculture	P	NF
			Coordination and access to existing public policies for this segment (credit, technical assistance and rural extension, public procurement, payments for environmental services)	S	F
Política Nacional de Recuperação da Vegetação Nativa (PROVEG) [National Policy for the Recovery of Native Vegetation]	Native vegetation	Indirect	National Commission for the Recovery of Native Vegetation (CONAVEG)	P	NF
			National Plan for the Recovery of Native Vegetation (PLANAVEG)	S	NF
			Awareness-raising and promotion actions for the productive chain of recovery	S	NF
			Development of markets for revenue generation from nature recovery	S	F
			Coordination of interinstitutional action	P	NF
			Public calls for technical assistance and rural extension	S	NF

(Continue)

Policies and Programs	Summary	Mention to AACC	Instruments	P/S	F /NF
Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAM); and the Cerrado (PPC)	Native vegetation	Indirect	Permanent Interministerial Commission for the Prevention and Control of Deforestation and Burning	P	NF
			Executive subcommittees by biomes	P	NF
			Environmental monitoring and inspection	P	NF
			Technical assistance and rural extension to promote the Bioeconomy	S	NF
			Coordination and access to existing public policies for this segment (credit, technical assistance and rural extension, technologies for adaptation to agriculture, public procurement, payments for environmental services, tax incentives)	S	F
National Policy and National Program for Payment for Environmental Services (PNPSA)	Native vegetation	Indirect	Contracts for payments for environmental services	S	F
			National Registry of Payments for Environmental Services (CNPSA)	P	NF
National Irrigation Policy (PNI)	Water management	Indirect	National Irrigation Plans	S	NF
			National Irrigation Information System (SisNIR)	P	NF
			Tax incentives – Reidi Irrigation	S	F
			Incentivized debentures for irrigation	P	F
			Irrigated agriculture hubs and public irrigation projects	S	NF
Cisterns Program – National Program to Support Rainwater Harvesting and other Social Technologies for Access to Water	Water management	Indirect	Public calls for proposals for cistern implementation	S	F
			Internal Management System (SIG Cisterns)	P	NF
National Water Resources Policy	Water management	Indirect	National Water Resources Council	P	NF
			National Water Resources Plan	S	NF
			State Water Resources Plans and River Basin Plans	S	NF
			Water resources information system	P	NF
			Granting of water use rights	S	NF
			Charging for water use	S	F
Agricultural Water Program – National Program for Sustainable Soil and Water Management in Micro-Watersheds	Water management	Indirect	Technological Reference Units	S	NF
			Technological assistance and rural extension and training for the adoption of good practices	S	NF
			Monitoring of adoption and regional impacts	P	NF

(Continue)

Policies and Programs	Summary	Mention to AACC	Instruments	P/S	F /NF
Dom Helder Câmara Project	Territorial development (Brazil's semi-arid region)	Indirect	Technical assistance and rural extension to beneficiaries of the Bolsa Família program	S	NF
			Documentation drives	S	NF
National Policy for the Sustainable Development of Traditional Peoples and Communities	Territorial development (traditional peoples and communities)	Indirect	Sustainable Development Plan for Traditional Peoples and Communities	S	NF
			National Commission for Sustainable Development of Traditional Peoples and Communities	P	NF
			Regional and local forums	P	NF
National Plan for Strengthening Riverside and Extractive Communities (PLANAFE)	Territorial development (traditional peoples and communities)	Indirect	Bolsa Verde Program	S	F
			Local productive arrangements	S	NF
			Minimum Price Guarantee Policy for Socio-biodiversity Products (PGPM-Bio)	S	F
			PGPM-Bio Management Group	P	NF
			Coordination with other sectoral instruments supporting agriculture	S	NF
			Technical assistance and rural extension	S	NF
Natural Springs Project (Vertentes)	Territorial development (Brazilian Cerrado region)	Indirect	Direct actions for soil and native vegetation restoration	S	NF
			Integrated and Sustainable Management of the Productive Natural Landscape (SLM)	P	NF
			Socio-environmental Management Framework (MGSA)	P	NF
National Fund for Scientific and Technological Development (FNDCT) – Agribusiness Sector	Research and development	Indirect	Public calls for funding/subsidies in R&D in climate change mitigation and adaptation; Promotion of bioeconomy production chains	S	F
			Technical Chamber of Agriculture (CT-AGRO)	P	NF
Program Green Grant (Bolsa Verde)	Social programs/ environmental conservation	Indirect	Quarterly payments	S	F
			Technical assistance and rural extension	S	NF
			Terms of Adhesion to the Bolsa Verde Program	P	F
Program for the Promotion of Rural Productive Activities (Fomento Rural)	Social programs	Indirect	Direct transfer of non-refundable financial resources for productive projects	S	F
			Social and productive monitoring (technical assistance and rural extension)	S	NF
			Terms of Adhesion, with productive project	P	F
			Management Committee of the Rural Development Program	P	NF

(Continue)

Policies and Programs	Summary	Mention to AACC	Instruments	P/S	F /NF
National Food and Nutritional Security Policy (PNSAN)	Social programs/food and nutritional security	Indirect	Interministerial Chamber of Food and Nutritional Security (CAISAN) federal, state and municipal	P	NF
			Council for Food and Nutritional Security (Consea) federal, state and municipal	P	NF
			Cisterns Program	S	F
			Food Acquisition Program (PAA)	S	F
			National Program for Urban and Peri-urban Agriculture	S	NF
			Food distribution	S	NF
			Rural productive inclusion of traditional peoples and communities and/or traditional and specific groups and populations	S	F
			Support for the structuring of public food and nutrition facilities, such as food bank networks, popular restaurants and community kitchens	S	NF
			Actions to support food education and Nutritional, etc.	S	NF
Minimum Price Guarantee Program (PGPM)	Agricultural risk	Indirect	Federal Government Procurement (AGF)	S	F
			Financing for Agricultural Product Storage (FEE)	S	F
			Product Flow Premium (PEP)	S	F
			Equalizing Premium Paid to the Producer (PEPRO)	S	F
			Financing for Price Guarantee to the Producer (FGPP)	S	F
			Family Farming Price Guarantee Program (PGPAF)	S	F
			PGPM-Bio	S	F
			PGPM-Bio management group	P	NF

Note: P = Procedural; S = Substantive; F = Financial; NF = Non-financial.

Source: Elaborated by the authors based on PPA 2024-2027 and Management reports from Brazilian ministries related to agriculture from 2016 to 2023.

5. DISCUSSION

Ultimately, the agricultural adaptation to climate change (AACC) depends on the individual adoption of practices by autonomous farmers operating in heterogeneous production contexts (such as climate, biome, crops, and production conditions). Public policy formulation in the face of an unprecedented and highly urgent phenomenon such as climate change and its risks entails multiple layers of action, ranging from the negotiation of international agreements to the elaboration of national plans and the implementation of effective instruments capable of aligning long-standing individual production paradigms with new climate imperatives in a markedly transformed scenario.

The explicit reference to AACC in certain programs indicates that, for specific actors and policy arenas, the issue of "adaptation" has achieved greater consolidation and legitimacy. In other programs, although the proposed actions address elements directly related to AACC, the issue is not formally framed or recognized by the involved actors. A similar pattern has been observed in Brazilian municipalities regarding climate policy more broadly (mitigation and adaptation), where numerous initiatives contribute to climate objectives but are framed under other policy domains, such as mobility, urban forestry, or quality of life (Caldas & Moura, 2024).

Furthermore, many of the programs and actions identified rely on instruments not originally designed to address the climate crisis but rather on pre-existing policy tools that have been reframed within the context of climate change (Caldas & Massardier, 2020). This raises a critical analytical question: does adaptation in this context represent merely the reframing of traditional instruments that may not be fully adequate to confront climate-specific challenges, or does it reflect genuine policy innovation resulting from internal and external learning processes (Massey et al., 2014)?

Once plans and their respective instruments are established, attention must turn to the governance arrangements required to ensure effective implementation (Bednar & Henstra, 2018). Part of the adaptation literature emphasizes self-organization and autonomous or self-governed responses by social actors (Jordan & Huitema, 2014). However, such an approach is limited. Adaptation requires innovative capacities and access to private resources, both of which are unevenly distributed. Moreover, climate impacts vary across regions, cities, neighborhoods, and even households, as does the capacity to perceive and respond to emerging climate-related risks (Huitema et al., 2016).

Although numerous technical solutions and technologies for agricultural adaptation have already been developed and identified, their large-scale adoption by farmers remains limited. This suggests that adaptive processes depend not only on individual initiative but also on institutional arrangements capable of sustaining and scaling transformation. Adaptation involves collective risks and objectives and therefore requires governance (Huitema et al., 2016). Historically, public institutions have played a central role in encouraging farmers to modify production practices (Ruttan, 1989). Accordingly, the AACC depends fundamentally on the state's capacity to implement policies directed at farmers. The mapping conducted in this study offers a comprehensive overview of this policy landscape.

The results reveal a dense and diverse set of instruments mobilized in policies and programs that act, directly or indirectly, on agricultural adaptation. This instrumental density characterizes AACC as a cross-cutting field that permeates multiple domains of federal public action. The presence of procedural instruments across all identified programs and policies suggests that AACC is undergoing institutional consolidation. It also corroborates the complementarity and interactivity between procedural and substantive instruments highlighted in the literature. Procedural instruments may be understood as institutional infrastructures that condition the implementation capacity of substantive AACC instruments. The analytical distinction between procedural and substantive instruments illuminates their often implicit yet structurally significant role in policy processes.

Five main groups and purposes of procedural instruments were identified: internal governmental governance structures that integrate multiple policy sectors, including high-level decision-making arenas, aimed at expanding political priority (e.g., governance systems and steering committees); broad governance arrangements that incorporate social and private actors, thereby increasing representation

and actor integration; institutional structures that define roles and responsibilities across federative levels and among actors; registries and information systems that organize, systematize, and publicly disseminate data relevant to climate policy, enhancing transparency and coordination; and instruments that facilitate stakeholder adherence to policies.

Although this study did not assess policy implementation, it is possible to argue that the identified configuration of procedural and substantive instruments aims to enhance the effectiveness of AACC policies by establishing institutional conditions that support viability, legitimacy, and access. In this sense, these instruments assume innovative roles, as suggested by Massardier et al. (2024), by promoting policy integration in the climate domain, increasing governance flexibility in polycentric settings, and improving overall governance quality.

These functions are particularly relevant in the field of AACC, which is characterized by high uncertainty, strong dependence on territorially and climatically diverse contexts, and the need for coordination across sectors and levels of government. Procedural instruments thus serve as structuring components of AACC policy design, enabling productive, financial, and informational interventions to be implemented in a coherent and adaptive manner over time.

Identification of financial instruments in most programs aligns with trends highlighted in the literature. Their use in agricultural policy is well established historically, especially through rural credit, agricultural insurance, and market-oriented instruments (taxation mechanisms and institutional procurement). More recently, financial instruments have also been used to incentivize shifts toward sustainable practices, including certification schemes, market regulation, and payments for environmental services.

As an economic activity, agriculture encourages farmers to prioritize profitability and risk reduction. Transitioning toward climate adaptation-oriented practices often entails additional risks that many farmers are reluctant to assume, which explains the reliance on financial instruments. However, these instruments are often inaccessible to less-capitalized or structurally vulnerable farmers, limiting their distributive reach and overall effectiveness.

Inter-federative coordination strategies between states and municipalities also appear limited, raising the risk that the numerous instruments identified may be implemented in a fragmented, poorly articulated manner, with objectives disconnected from local governance dynamics and territorial contexts. Procedural instruments such as the state-level plans under the umbrella of the Adaptation and Low Carbon Emission Plan in Agriculture – ABC Plan (see Table 2), designed to territorialize implementation, constitute important exceptions, albeit with still partial and incipient execution.

Finally, procedural instruments to expand participation by social and economic actors, such as councils and committees, were identified in nearly all programs and policies. Nevertheless, their actual capacity to foster meaningful integration warrants further investigation. Procedural instruments hold significant potential in two central areas of AACC: (i) strengthening the integration of market actors within adaptation governance (market governance), and (ii) incorporating farmers more actively and directly into adaptation strategies, thereby moving beyond a predominantly state-centered governance model. Advancing in this direction will require not only reinforcing procedural instruments but also fostering a broader cultural transformation in agricultural governance practices.

6. CONCLUSIONS

Tracing procedural instruments within the Brazilian federal government shows that they are not immediately visible. They are embedded in processes and often dispersed across official documents and websites, frequently within what is conventionally referred to as "grey literature." The identification of instruments depends on the depth of analysis applied to each policy and program. This indicates that the mapping of procedural (and substantive) instruments of agricultural adaptation to climate change (AACC) at the federal level in the country is not exhaustive, as additional instruments may emerge through further investigation, particularly through interviews and qualitative fieldwork.

Overall, the survey revealed a policy framework characterized by a broad diversity of instruments mobilized across policies and programs that support AACC, directly or indirectly. These instruments are distributed across multiple domains of federal public action, reflecting efforts to mainstream the AACC agenda within the federal policy architecture.

The findings suggest that AACC-related policies in Brazil are primarily structured through normative frameworks that centralize formulation and implementation at the federal level. This configuration reflects a state-centric strategy anchored in hierarchical governance arrangements. Although state and municipal initiatives were not systematically examined, the results indicate limited vertical coordination and relatively few robust institutional mechanisms for inter-federative management.

The main limitation of this study is its exclusive reliance on documentary analysis, without incorporating interviews or stakeholder perspectives. This methodological choice limits the analysis of informal implementation dynamics, actor strategies, and the concrete territorial effects of the identified instruments.

Finally, the hypothesis that procedural instruments are vectors of innovation in climate governance remains to be systematically tested in subsequent stages of this research through a qualitative analysis of selected instruments. The literature identifies relevant analytical variables for such an inquiry, including: instrument structure; formulation and implementation dynamics; the role of innovation agents; competitive dynamics within the arenas; governance modes and configurations (Bednar & Henstra, 2018); the objectives assigned to procedural instruments (Bali et al., 2021); their impact on climate governance arrangements; and the ways in which authority is exercised.

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DATA AVAILABILITY

All data supporting the findings of this study are available within the article.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ARTIFICIAL INTELLIGENCE USAGE

No artificial intelligence tools were used.

FUNDING

This article presents partial results from the research project Assessing Climate Plans and Institutional Innovation Instruments for Climate Change – Climate Governance Risks: Improving Procedural Instruments for Adaptation of Agriculture to Climate Change in the North and Global South (APIICC), Process No. 2023/03313-1, funded by the São Paulo Research Foundation (FAPESP) under the 2023 Regular Research Grant Call, within the framework of cooperation agreements with the Agence Nationale de la Recherche (ANR). French project reference: APIICC – ANR (Montpellier, France), Project No. ANR-23-CE53-0008-01, *Évaluation des plans et instruments d'innovation institutionnelle pour lutter contre le changement climatique. Les risques de la gouvernance climatique : améliorer les instruments procéduraux d'adaptation de l'agriculture au changement climatique dans les pays du Nord et du Sud.* (https://share.google/98QgraLgQFluY178u). Project website: https://gouvernance-climatique-apiicc-projet.fr. The APIICC project is jointly funded by FAPESP and ANR.