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Translating climate-smart agriculture into practice: the role of national research systems and the Brazilian ABC Plan

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1 Introduction

During the 20th century, the proliferation of agricultural innovations and research led to significant increases in yield, improvements in food security and human health, poverty reduction, and a raise in economic outputs (Rosegrant et al., 2023; Nin-Pratt and Stads, 2023). Rosegrant et al. (2023) propose that agricultural research is "one of the interventions with the highest return in all of agriculture and global development" (p. 182). They argue that investment in agricultural research is a cost-beneficial strategy to reduce poverty and hunger as well as address climate change.

Aimed at aiding public policy-making, agricultural research is mainly conducted by two types of stakeholders (Rosegrant et al., 2023). On the one hand, international research organizations, like the Consortium of International Agricultural Research Centers (CGIAR), have a crucial role in conducting research that shapes global policy-making agendas and in sharing scientific knowledge between countries. On the other hand, national agricultural research systems' mostly conduct nationally relevant research and have an important role to adapt innovations to local contexts.

Global agricultural spending grew by 50% between 2000 and 2016 (Nin-Pratt and Stads, 2023). In particular, funding for research on the Global South's agrifood sector was around $60 billion US dollars per year during the period of 2010-2019 (Prasad et al., 2023). From that total, less than 7% focuses explicitly on delivering environmental outcomes, and less than 5% on social outcomes. About two-thirds of this funding originates from national governments, which allocated 10–13% of their yearly agricultural budgets to research.

This expansion was driven largely by middle-income countries after the 2008 global food price spike (Rosegrant et al., 2023), while investment stagnated in high-income countries and declined in low-income countries (Nin-Pratt and Stads, 2023). China, India and Brazil alone accounted for nearly 40% of total innovation funding (Prasad et al., 2023). Private corporations and equity investors contribute 15–25% and 2–3% of the total funding, respectively (Prasad et al., 2023), with global private spending on agricultural research tripling between 1990 and 2014 (Nin-Pratt and Stads, 2023). Development partners, including philanthropic and multilateral agencies, provide around 8% of total funding but have increasingly shifted support from innovation generation toward scaling and local adaptation, which is an area where national agricultural research systems remain indispensable (Prasad et al., 2023).

In this paper, we discuss the macro-level dynamics between international research organizations and national research systems. It argues for the importance of national research systems to adapt and support implementation of international concepts in local contexts. The rise of the climate-smart agriculture (CSA) concept in the global research agenda led by international organizations and the implementation of the ABC Plan in Brazil supported by Embrapa, the Brazilian Agricultural Research Corporation, will be set as a case study to demonstrate such dynamics. Finally, it concludes with a call for investments in national agricultural research systems.

2 The rise of CSA to the global policy-making agenda

As one of the several frameworks that emerged to push for more sustainable and productive agriculture, climate-smart agriculture (CSA) was first formally launched by the United Nations Food and Agriculture Organization (FAO) at the Hague Conference of Food Security, Agriculture and Climate Change (Food Agriculture Organization of the United Nations, 2010). The term was then defined as “an approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change” (Food Agriculture Organization of the United Nations, 2013, p. 9).

CSA’s goal can be defined as threefold: (i) sustainably increase agricultural productivity and food security, (ii) adapt and build resilience to climate change, and (iii) reduce/remove atmospheric greenhouse gas (GHG) emissions where possible (Lipper et al., 2014). Also referred to as the “triple win” of productivity, adaptation, and mitigation. Unlike prescriptive approaches based on technological packages, CSA was conceived as a guiding framework capable of integrating agricultural, environmental, climate, and rural development policies. The literature highlights that this formulation was an explicit response to the limitations of conventional intensification policies, which sought productivity gains without measuring climate risks or impacts on ecosystems (Lipper et al., 2014; Thornton et al., 2018).

At a time where the international community was increasingly acknowledging the interactions between climate change and agriculture, such as during the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP)15 and COP16, the concept was quickly adopted and promoted by a variety of global-level stakeholders (Newell, 2017). Research to assess which agricultural practices deliver on the “triple win” quickly popularized, providing evidence on trade-offs between practices and rapidly increasing awareness of context sensitivity for implementation (Smith et al., 2020). International research organizations and international non-governmental organizations (INGOs) contributed to evidence generation and capacity-building. For example, FAO’s Climate-Smart Agriculture Sourcebook (2013) provided guidance for countries on CSA policy-making and implementation. The CGIAR, particularly the Climate Change, Agriculture and Food Security (CCAFS) program, promoted the idea through country profiles, toolkits, and research-policy engagement.

Multilateral institutions then translated this evidence into policy recommendations, aligning it with financing mechanisms, and establishing measurement, reporting and verification (MRV) systems (Freed et al., 2023). Multilateral development banks, such as the World Bank, mainstreamed CSA through lending instruments and climate finance mechanisms. Bilateral donors, including the United States Agency for International Development (USAID) and the European Union (EU), funded pilot programs and capacity-building initiatives that further embedded CSA into national policy frameworks.

The concept came to influence national public policies and international agreements. Elements of CSA increasingly appeared in National Adaptation Plans (NAPs) and multilateral funding programs (Campbell et al., 2016). Global South countries, such as Brazil, India, Kenya, and Ethiopia, incorporated its principles into national sustainable agriculture programs. The result is that CSA ceased to be a technical FAO agenda and became a reference for low-carbon and climate-resilient agricultural policy-making.

Despite its broad adoption, CSA has also been subject to critical scrutiny. The flexibility that makes CSA attractive as a policy framework has been criticized for allowing heterogeneous interpretations, uneven ambition levels, and, in some cases, limited accountability regarding mitigation outcomes (Newell, 2017; Totin et al., 2018). These critiques highlight that CSA is not a prescriptive solution, but rather a governance framework whose effectiveness depends on institutional design, monitoring capacity, and alignment with farmers’ economic incentives.

3 The Brazilian ABC Plan: the scientific-institutional translation of CSA into national policy

The ABC Plan (Plano Setorial de Mitigação e de Adaptação às Mudanças Climáticas para a Consolidação de uma Economia de Baixa Emissão de Carbono na Agricultura, or “Low-Carbon Agriculture Plan”) is an example of how Global South countries can translate and implement international climate narratives into public policies rooted in local contexts. Although formulated before the consolidation of the CSA concept, the ABC Plan already reflected the central pillars of the climate-smart agriculture framework: sustainable productivity increases, enhanced adaptation and resilience, and reduction of greenhouse gas emissions (Lipper et al., 2014). What makes the Brazilian experience particularly relevant is the centrality of tropical scientific knowledge accumulated over decades, combined with sustained public investment, institutional coordination, and credit-based policy instruments. Without these conditions, similar outcomes would be unlikely to emerge in other contexts. As demonstrated in various economic analyses, the Plan not only responded to international agendas but anticipated them by transforming scientific evidence into financing, credit, and governance

TABLE 1 Results achieved during the first phase, 2010–2020, of the ABC Plan (Brazilian Ministry of Agriculture and Livestock, 2023).

Technology	Target (million ha/m^3/animals)	Result (million ha/m^3/animals)	Achievement (%)	Target (million $MgCO_2$ eq)	Result (million $MgCO_2$ eq)	Achievement (%)
Recovery of degraded pastures	15.0 ha	26.8 ha	179%	104.0	36.01	35%
Crop-livestock-forest integration	4.0 ha	10.76 ha	269%	18.22	40.78	185%
No-till system	8.0 ha	14.59 ha	182%	20.0	26.7	133%
Biological nitrogen fixation	5.5 ha	11.78 ha	214%	10.0	21.56	216%
Planted forests	3.0 ha	1.88 ha	63%	–	8.82	–
Animal waste treatment	4.4 million m^3	38.34 million m^3	871%	6.9	59.81	867%
Total	35.5	54.03	152%	133–163	193.67	119%

instruments (Paixão and Bacha, 2015; da Silva and Vieira Filho, 2020).

Between 2010 and 2020, the ABC Plan enabled the adoption of sustainable agricultural technologies on 54.02 million hectares, mitigating the equivalent of 193.67 million tons of CO_2eq (Brazilian Ministry of Agriculture and Livestock, 2023). In integrated crop-livestock-forestry systems alone, there was an expansion of 10.76 million hectares, while an additional 26.8 million hectares of degraded pastures were recovered (Table 1). Furthermore, such practices contribute to the overall increase in livestock productivity, leading to a reduction in emission intensity per unit of product, while simultaneously slowing the expansion of pasturelands, which curbs CO_2 emissions associated with deforestation and preserves biodiversity (Paarlberg, 2025). The policy is currently in its second phase, called ABC+ Plan, which covers the period from 2021 to 2030 and sets a goal of expanding sustainable practices to an additional 72.68 million hectares, potentially resulting in mitigation of over 1 Gt of CO_2eq (Brazilian Ministry of Agriculture and Livestock, 2021).

The design of the ABC Plan differs significantly from approaches focused exclusively on mitigation, typical of high-income countries. The Plan was deliberately structured around the productive priorities of Brazilian farmers: productivity gains, reduction of operational costs, stability in the face of climate variability, and restoration of soil fertility (Brazilian Ministry of Agriculture and Livestock, 2021). Climate benefits, such as carbon sequestration, methane reduction, and improved water infiltration, were conceived as co-benefits, not as the main driver for adoption. This logic aligns with the scientific literature on CSA in low- and middle-income countries, which demonstrates that climate policies only become scalable when linked to direct and measurable economic returns (Totin et al., 2018; Harvey et al., 2014). By placing income and resilience at the center, the ABC Plan avoided the common mistake of "carbon-first" policies, often unable to gain traction among producers.

The ABC Plan adopts a governance strategy based on State Management Committees (CGE/SMCs) that enables its scaled implementation. These committees bring together federal and state governments, research and technical assistance institutions, as well as organized civil society (Brazilian Ministry of Agriculture and Livestock, 2023). Their role is to mobilize producers through technology transfer that promote the adoption of the ABC's sustainable practices (Bragança et al., 2022; Vinholis et al., 2021). The CGEs also allow for adapting implementation to local operational conditions, resource availability, and long-term development dynamics in each Brazilian state (Brazilian Ministry of Agriculture and Livestock, 2023; Vinholis et al., 2021).

Despite the advances, the Brazilian experience also highlights structural limitations in implementing climate-smart policies in the Global South. Persistent challenges include barriers to credit access, regional disparities in technical capacity, concentration of resources in the Center-South, and institutional weaknesses that limit uptake in the North and Northeast parts of the country (Lovato et al., 2020; Gianetti and Ferreira Filho, 2021). These findings underscore the need for climate-smart policies to have national-level coherence combined with tailored implementation strategies for different regional contexts, robust monitoring systems, qualified technical assistance, and alignment between banks, research, and territorial governance. Technology alone is not sufficient: institutions, coordination, and state capacity matter as much as the suggested technical package (Conceição, 2022).

This article does not aim to provide a causal impact evaluation of the ABC Plan. Instead, it offers an institutional and policy analysis of how national research systems contribute to translating global climate frameworks into scalable public policies. Importantly, the Brazilian experience should not be interpreted as a readily transferable model. Its outcomes reflect specific historical, institutional, and scientific trajectories, reinforcing the argument that CSA implementation pathways must be nationally grounded rather than globally standardized.

4 Conclusion

International development organizations were crucial in shaping the policy-making agenda, financing mechanisms, and monitoring frameworks of CSA. International frameworks such as CSA and regenerative agriculture tend to circulate globally in an asymmetric manner, reflecting the scientific, economic, and normative interests of the Global North (Sabourin et al., 2021). The ABC Plan operates as a counterpoint to this dynamic. Far from being a mere recipient of external models, Brazil hybridized the principles of CSA with its tropical scientific base, its productive realities, and its development objectives. In doing so, it not only translated global concepts into applicable policies but contributed to reconfiguring them.

Brazil's experience shows that national agricultural research systems have an important role in generating innovations, monitoring implementation, and scaling for maximizing impact across the CSA pillars. There needs to be greater recognition of the role of national systems in advancing the food systems transition and their capacity to generate context-specific innovations and scale climate-smart solutions across different regions. The Brazilian trajectory also demonstrates that successful climate-smart transitions in the Global South emerge from the combination of local science, institutional innovation, and policies designed based on farmers' priorities.

We therefore call for a Global South-led agricultural research agenda, supported by increased investment from national governments and international development funders, to ensure that global standards and priorities reflect the ecological and socio-productive realities of the region's most central to the future of global food systems. However, investments in agricultural research systems alone will not efficiently transform food systems (Nin-Pratt and Stads, 2023). System-level funding and knowledge exchange between countries are essential to unlock human capacity and research systems, enabling their success in producing, implementing, and scaling innovation.

Author contributions

MC: Writing – original draft, Writing – review & editing, Conceptualization, Resources, Data curation, Formal analysis, Project administration, Validation, Visualization. LR: Visualization, Resources, Formal analysis, Funding acquisition, Writing – original draft, Conceptualization, Project administration, Investigation, Data curation, Validation, Methodology, Supervision, Writing – review & editing, Software. BB: Data curation, Resources, Validation, Project administration, Formal analysis, Methodology, Visualization, Conceptualization, Writing – review & editing, Funding acquisition, Investigation, Supervision, Writing – original draft, Software. MM: Conceptualization, Project administration, Validation, Investigation, Writing – review & editing, Methodology, Supervision, Visualization, Writing – original draft, Software, Formal analysis, Funding acquisition, Data curation, Resources. DD: Supervision, Writing – original draft, Funding acquisition, Software, Formal analysis, Writing – review & editing, Methodology, Resources, Investigation, Project administration, Data curation, Visualization, Validation, Conceptualization.

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