

Impact of public policies and research and development on Brazilian agriculture*

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ABSTRACT

The objective of this work was to analyze impact evaluations in the field of agriculture, based on academic studies registered in master theses and doctoral dissertations defended in Brazil. As the methodological procedure, bibliometric techniques and data analysis were used to investigate nine indicators related to the main themes, methodologies, study territories, universities, and types of impact explored. The results show that the environmental dimension was predominant in the investigations, mainly in the Northeastern, Southern, and Southeastern regions. The most common themes are the protection of natural resources, organic and agroecological production, and carbon stock. Regarding methodological procedures, the non-experimental approach is the most common, and, among projects, programs, and public policies, the program for strengthening family agriculture, Programa Nacional de Fortalecimento da Agricultura Familiar (PRONAF), is the most evaluated in the context of Brazilian agriculture.

Index terms: bibliometrics, Brazil, data analysis, impact evaluation in agriculture, theses and dissertations.

Impactos das políticas públicas e da pesquisa e do desenvolvimento na agricultura brasileira

RESUMO

O objetivo deste trabalho foi analisar as avaliações de impacto no campo da agricultura, a partir de estudos acadêmicos, registrados em dissertações e teses defendidas no Brasil. Como procedimento metodológico, empregaram-se técnicas bibliométricas e de análise de dados para investigar nove indicadores relacionados aos principais temas, às metodologias, aos territórios de estudo, às universidades e aos tipos de impacto explorados. Os resultados mostram que a dimensão ambiental foi predominante nas investigações, principalmente nas regiões Nordeste, Sul e Sudeste. Os temas mais comuns são a proteção de recursos naturais, a produção orgânica e agroecológica, e o estoque de carbono. Quanto aos procedimentos metodológicos, a abordagem não experimental é a mais comum, e, dentre os projetos, programas e políticas públicas, o Programa Nacional de Fortalecimento da Agricultura Familiar (Pronaf) é o mais avaliado no contexto da agricultura brasileira.

Termos para indexação: bibliometria, Brasil, análise de dados, avaliações de impacto na agricultura, dissertações e teses.

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Ideias centrais

- Institutional interventions and research and development actions in food production and competitiveness in the international market.
- Bibliometric analysis and other data analysis techniques on impact assessments in the agricultural sector.
- Representative overview of scientific production in the field of impact evaluation of Brazilian agriculture.
- Regional analysis of investigated impacts reveals a common approach across various geographic and socio-economic contexts.
- Need to develop more integrated and holistic impact assessments in agriculture.

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INTRODUCTION

Agriculture is considered as the oldest and most relevant economic activity, playing a strategic role in food security and social development in different nations (Paggiossi, 2019). According to the Food and Agriculture Organization (FAO, 2022), the growth of the agricultural sector is one of the most effective ways to reduce poverty in emerging countries such as Brazil. In addition, since agriculture has a strong relationship with the natural resource base, it is important to adopt practices and services to improve sustainability, including pollination, soil nutrient cycling, and water quality (FAO, 2022). Under this perspective, the agricultural activity is strongly related to environmental dynamics and the socioeconomic performance of societies.

In Brazil, according to Centro de Estudos Avançados em Economia Aplicada and Confederação Nacional de Agricultura (CEPEA & CNA, 2022), the sector accounts for about 25% of the gross domestic product from activities undertaken by more than 5 million agricultural establishments in the country (IBGE, 2017). As an important economic segment, Brazilian agriculture has been driven by institutional interventions through public policies and actions in research and development and rural extension, seeking to support and expand the relevance of food production, both within and outside the country. Souza Filho et al. (2011) concluded that much of agriculture is subsidized by public resources, aiming to make the production and supply of the domestic market viable and, at the same time, allow of a greater competitiveness in relation to the international market. In this regard, monitoring and evaluating the interventions carried out by the state become essential, especially to ensure that the expected transformations occur and the necessary adjustments are made.

In the identification of the scope of interventions, whether beforehand or afterward, impact evaluations are considered instruments to carry out periodic and objective analyses of a planned, ongoing, or completed action, answering specific questions related to the its implementation and outcomes (Horton, 1998; Mackay & Horton, 2003; IEG, 2011; Almeida et al., 2016; Casa Civil et al., 2018; Casa Civil & Ipea, 2018; Fabiani et al., 2018; Gertler et al., 2018; Lassance, 2021). This explains the recent increase in impact evaluations in agriculture, as observed by the Independent Evaluation Group (IEG, 2011) of World Bank, Cameron et al. (2016), and Merigó et al. (2018).

In the context of Brazilian agriculture, impact evaluations have been used to support the structuring of public policy designs and to measure and identify the reach of the results of agricultural research, as well as the effectiveness of agricultural policies and of the implemented research (Castro et al., 2014; Meneses & Pinto, 2021). In the country, the impacts of the implemented agricultural public policies are investigated by organizations such as Instituto de Pesquisa Econômica Aplicada, the institute for applied economic research, and Conselho de Monitoramento e Avaliação de Políticas Públicas, the council for monitoring and evaluation of public policies. In the field of agricultural research, the Brazilian Agricultural Research Corporation has evaluated the impacts arising from the technological solutions developed and made available by the company itself, as reported in Araújo et al. (2019), Ávila et al. (2008), Irias et al. (2004), Pinto et al. (2020), Pinto et al. (2021), Rodrigues (2015), Rodrigues et al. (2003), and Vedovoto et al. (2022).

The impacts of agriculture and livestock have also been identified in academic works, as master theses and doctoral dissertations, which can help to understand the most prominent themes for the scientific community, as well as the most researched regions and commonly used methods, among other important indicators in the field of impact evaluation in Brazilian agriculture. The applied bibliometric techniques are particularly useful in helping to understand specific areas of science, enabling the visualization of the intrinsic characteristics of large document sets, allowing of the development of a comprehensive and representative view of the scientific production of a knowledge area through reliable indicators that can influence decision-making (Mejia et al., 2018, 2021). Therefore, the objective of this work was to analyze impact evaluations in the field of agriculture, based on academic studies registered in master thesis and doctoral dissertations defended in Brazil.

Impact evaluation in agriculture

According to Furtado et al. (2008), impact studies have become essential for measuring and assessing the effect of certain actions on an environment or community, guiding decision-making before and after the implementation of an action. In this sense, impact evaluations can be classified in two ways, as: *ex ante*, referring to anticipatory studies of an intervention, aimed at identifying, in advance, the potential risks and benefits of a certain action; and *ex post*, aiming to identify the effect caused by the carried out intervention (Gertler et al., 2018).

Characterized by Scriven (1994) as a transdisciplinary field, evaluation studies, in this case, impact studies, formally began in the 1970s when the Office of Technology Assessment was established in the United States, promoting the opening of similar offices in several other countries, especially in Europe (Cruz-Castro & Sanz-Menéndez, 2005; Cruz-Castro & Sanz-Menéndez, 2006). In Brazil, according to Trevisan & Van Bellen, (2008), these studies are recent, occurring from the 1980s when they were intensely carried out within the scope of public policies, particularly related to science and technology (S&T).

The use of impact evaluations in the agricultural sector has its roots in the broader field of development economics, which has been concerned with evaluating the effectiveness of interventions over several decades (Evenson, 2001). Many studies have focused on identifying the economic impacts resulting from technological transformations, such as those caused by the Green Revolution, a set of research, development, and technology transfer initiatives aimed at increasing agricultural productivity in developing countries in the mid-20th century (Alene & Coulibaly, 2009; ACIAR, 2022; Campagnolla & Macêdo, 2022).

In general, impact evaluations in agriculture seek to measure, primarily, the effect of actions, programs, public policies, and technologies on the environment, economy, and society (IEG, 2011; Cameron et al., 2016). Through outcome indicators, these evaluations are intended to detect changes that can be attributed to a specific action carried out by a public or private institution, be it the state, a research institution, or a company. Norton & Alwang (2016) added that the impact of actions related to agriculture is assessed through a combination of observational and experimental methods, such as controlled trials, field trials, and qualitative research. These authors explained that more recent advances in impact evaluation methodologies, such as randomized controlled trials (RCTs), have allowed of more rigorous evaluations of the impact of agricultural interventions and, therefore, have become widely used in the agricultural sector in the last two decades.

The main methods of impact evaluation in agriculture, according to Evenson (2001), are: RCTs, an experimental approach in which interventions are randomly assigned to participants; quasi-experimental designs, i.e., non-randomized studies in which a comparison group is selected non-randomly, but still aiming to control confounding variables; difference in difference, a method that compares the change in outcomes between a treatment group and a control group, controlling any underlying trends in the data; propensity score matching, a method that matches individuals in the treatment and control groups based on their probability of being treated; regression discontinuity design, a methodology that uses a threshold for treatment eligibility to create two comparison groups; and instrumental variables, a method that uses a third variable as an instrument to identify the impact of a treatment.

However, a study of the World Bank team (IEG, 2011) on the state of the art of impact evaluations in the technical-scientific literature indicated that experimental investigations, such as RCTs, are rarely used, unlike the quasi-experimental and non-experimental approach, which represent a large part of the impact studies analyzed. Therefore, each approach has its own strengths and weaknesses, and the choice of a method depends on the research question and data availability, among other factors.

The research conducted by the World Bank (IEG, 2011) also showed that most impact studies in agriculture were designed after the start of an intervention or the completion of the implementation (*ex post*) of an action, project, program, or policy. Moreover, in terms of the object to be evaluated,

most studies covered interventions related to agrarian reform or rural extension, which were grouped into the following eight categories proposed by IEG (2011):

- Land leasing and titling: aims to facilitate access to agricultural credit and promote land markets. Most of the impact evaluations analyzed in this category reflected an institutional change, related to legislation on property rights. Includes titling, leasing law, and inheritance law.
- Extension services: seeks to expand the farmer's knowledge in the use of new technologies and agricultural practices. It is related to rural schools, technical assistance services, and access to information.
- Irrigation: aims to improve the productivity and income of rural producers through water accessibility and availability. Includes access to water infrastructure, water management systems, and dams.
- Natural resource management: seeks to raise awareness among rural producers about the use of the environment and natural resources through the adoption of new technologies and conservation techniques. Includes soil and water conservation, crop management systems, and aquaculture-agriculture integration.
- Technology: focuses on the development and adoption of improved crop varieties, improved seed technology, and innovative fertilizer application techniques. Improved seeds and fertilizers are highlighted.
- Marketing arrangements: seeks to promote links between buyers and sellers. Covers contracts, credit agreements, cooperatives, and social learning.
- Microfinance: aims to provide small-scale financial services (from cash grants to credit counseling) to producers in order to increase access to credit and consumption. Includes access to financial services and non-rural credit or insurance.
- Others: seeks to improve the economic well-being of the farmer and, in some cases, agricultural performance. Varied, but includes mainly rural roads or infrastructure, community development, and safety net programs.

According to Kerr & Kolavalli (1999), although different types of technologies are evaluated in agricultural impact studies, depending on the objectives of the research and the specific context of the evaluated agricultural sector, the most common include: seeds and planting materials, specifically the effect of improved seed varieties and planting materials on crop yield and quality; irrigation systems, mainly the impact of improved irrigation systems, such as drip irrigation or center pivot systems, on crop yield and water use efficiency; agricultural inputs, particularly the effect of improved agricultural inputs, such as fertilizers, pesticides, or other chemicals, on crop yield and soil health; machinery and equipment, especially the impact of improved machinery and equipment, such as tractors or harvest machines, on labor efficiency and crop yield; information and communication technologies, such as mobile apps or remote sensing technologies, primarily the effect on the access of farmers to information, decision-making, and crop yield; and agricultural practices, specifically the impact of improved agricultural practices, such as conservation agriculture or agroforestry systems, on crop yield, soil health, and environmental sustainability.

First known impact studies in the context of agriculture

It is difficult to determine the first published study on impact evaluation in agriculture due to the different definitions and uses of the concept at the time of publication. However, agricultural research and development have been a topic of study for many years, with the first known examples of impact evaluations in agriculture being reported in the 19th century (Evenson et al., 1979). The field of impact evaluation in agriculture has evolved and expanded over time, including the development of new

methods and approaches to study the effects of technological innovations in agriculture on various aspects of society. The investigation of impacts in agriculture carried out by research institutions or government agencies, but not yet by the academia, dates back to the early 1950s and has long been concerned with the economic impacts of a given innovation (Colinet et al., 2014; Colinet, 2021).

Most commonly used indicators in agricultural impact evaluation studies

Indicators are synthetic instruments used to measure the quality, efficiency, and effectiveness of a specific management/activity and of other related and relevant aspects. Traditional S&T indicators are known as input (innovation expenses and team statistics) and output (scientific or technical publications) according to Organisation for Economic Co-operation and Development and Eurostat (OECD & Eurostat, 2018). In the research conducted by the World Bank team (IEG, 2011), the most common indicators measured in impact studies are related to: yield, defined as production or work per total area of cultivated land; income, considered as the earnings from all activities; production, defined as the amount of cultivated and harvested agricultural output; and profit, considered as the marginal gains or net benefits (sales minus costs) reported by farmers.

Bibliometric studies

Bibliometrics is the study of the mathematical and statistical properties of scientific literature, including the use of bibliographic databases and citation analysis. Its goal is to understand how research is produced, distributed, and consumed, focusing on analyses of technical-scientific production to evaluate the progress and development of a knowledge area (Santos et al., 2010). Although it is difficult to pinpoint the origin of the bibliometric activity (Alvorado, 2007), records, such as those of Cole & Eales (1917), two scientists linked to statistics, show that, at the beginning of the 20th century, statistical analysis techniques applied to scientific production were used to understand the advances and state of the art in the field of Anatomy. However, bibliometrics, as it is known today, only began in the late 1960s when Pritchard (1969) popularized the term, which replaced the nomenclature “statistical bibliography” commonly adopted since 1922 (Vanti, 2002). In addition to consolidating the term, Pritchard (1969) also established standards and mathematical and statistical models for measuring information processes, which served as a tool for various organizations (Macias-Chapula, 1998).

In the 1960s, when S&T began to be discussed from the perspective of managing their investments and results, OECD (OECD, 1963), through the Frascati Manual, presented bibliometric indicators that would serve as a basis for evaluating the performance of a scientific activity. Despite the criticisms related to the quantifying model imposed by bibliometrics, the area expanded and was established as a discipline.

As a field of study, the empirical laws of the discipline were structured by and named after the authors Samuel Clement Bradford (Bradford, 1934), Alfred Lotka (Lotka, 1926), and George Kingsley Zipf (Zipf, 1949). According to Bradford’s law, the distribution of the articles published in scientific journals is highly skewed, and a small number of highly productive journals account for a disproportionate share of the total output of publications in a given field. Zipf’s law states that the frequency of a word in a text is inversely proportional to its rank in the frequency table, meaning that the most frequent word in a text will occur about twice as often as the second most frequent, thrice as often as the third most frequent, and so on. In addition, according to Lotka’s law, the number of articles published by an author is proportional to the square of the number of authors with a similar publication record, i.e., a small number of highly productive authors are responsible for a large proportion of the total output of publications in a certain field.

Considering the wide range of applications and the importance for understanding and managing S&T, bibliometrics is used in several contexts. In the scenario of Brazilian agriculture, the analysis of the scientific production of the academia related to impact evaluation will allow of understanding the evolution of research over the years.

METHODOLOGY

The used methodology consisted of an exploratory study, with a qualitative-quantitative approach according to Cervo et al. (2006), which aimed to understand and map the technical-scientific production on the topic “impact evaluation in Brazilian agriculture”. The data source was the database Biblioteca Digital Brasileira de Teses e Dissertações (BDTD), containing doctoral dissertations and master theses developed and maintained, since 2002, by Instituto Brasileiro de Informação em Ciência e Tecnologia, the Brazilian information science and technology institute. The BDTD database integrates and disseminates, through an online catalog, the full texts of the master theses and doctoral dissertations defended in 133 Brazilian institutions of education and research (BDTD, 2023).

The used methodological procedures were structured through the five following activities:

- 1) Definition of a search string for metadata collection in BDTD, which was “impact* evaluat* OR impact* AND agr* NOT agreg*”.
- 2) Structuring of a database containing the works retrieved from BDTD.
- 3) Processing, cleaning, and analysis of the retrieved textual data to check for duplicates and inconsistencies related to the study topic, which was done through manual analysis, using: the R software, version 4.1.2 (R Core Team, 2021); the RStudio software, version 2021.09.0 Build 351 (RStudio Team, 2020); and the dplyr, readxl, and strngr packages.
- 4) Establishment of the investigated indicators shown in Table 1:

Table 1. Investigated indicators.

Indicator	Investigated variable	Observation
Investigation topics	Title, abstract, and subjects	Aimed to identify the most recurring topics by frequency.
Used methodologies	Abstract	Aimed to identify the most common methodological procedures.
Indicators	Abstract	Aimed to identify the most common indicators, based on IEG (2011).
Categories	Title, abstract, and subjects	Aimed to identify the most common categories, based on IEG (2011).
Studied regions (most studied territories)	Abstract	Aimed to identify the most studied Brazilian municipalities.
Most productive universities	Institutions and programs	Aimed to identify the most productive institution and postgraduate programs on the topic.
Type of works	Types	Identification of the types of monographs: master thesis or doctoral dissertation.
Impact	Abstract	Classification of the works according to the dimensions of the investigation.
Study period	Publication dates	Period of scientific production.

- 5) Application of data analysis techniques, using: the Iramuteq Software (Ratinaud, 2009); R software, version 4.1.2 (R Core Team, 2021); the RStudio software, version 2021.09.0 Build 351 (RStudio Team, 2020); and packages bibliometrix, textplot, XML, readxl, topicmodels, caret, tidyr, ggplot2, quanteda, pdftools, stringr, NLP, curl, tidytext, wordcloud, dplyr, SnowballC, stopwords, tm, and RColorBrewer.

RESULTS

A total of 351 academic papers were retrieved using the search string. The data were processed, cleaned, and analyzed by identifying title duplications, verifying if the “Abstract and/or Resumo” field was filled in for the thematic analysis, and evaluating the relevance of the papers on the researched topic using natural language programming and manual verification. A total of 53 duplicated titles and 316 titles without the “Abstract and/or Resumo” field filled in were identified, representing about 90% of the total base. In the analysis of relevance to the researched topic, the “Title” field was used first, giving preference to joint occurrences of the terms “evaluation”, “impact”, and “agriculture”, which resulted in 220 works, reduced to 127 after their abstract was read and analyzed. Therefore, a total of 127 works were analyzed, comprising 28 doctoral dissertations and 99 master theses. The abstracts of 92 works were filled in through scraping and manual search. Then ten following new variables were created: “category_WB”, “indicator_WB”, “methodology”, “methodology_type”, “impact”, “municipality”, “state”, “region”, “policy”, and “observation”. The analyses were, then, performed according to the indicators established in Table 1.

Publication period

Regarding the publication period of the evaluated works, 1992 appeared as the first year when an impact evaluation was recorded in the BDTD database (Figure 1). The master thesis entitled “*Um projeto alternativo para a pequena produção algodoeira no agreste paraibano: uma análise ex-ante dos impactos econômico-sociais*” (an alternative project for small cotton production in the Paraiban agreste: an ex-ante analysis of economic and social impacts), defended by Ivaldo Mário Cavalcanti Brandão in the Economics postgraduate program of Universidade Federal de Campina Grande, in the state of Paraíba, stood out. It was the only work under analysis that sought to assess the ex-ante impacts of a project called Projeto de Ação Concentrada, Subprojeto Algodão: Região Agreste (concentrated action project, cotton subproject: agreste region), verifying its viability and effects on the cotton activity in the studied region.

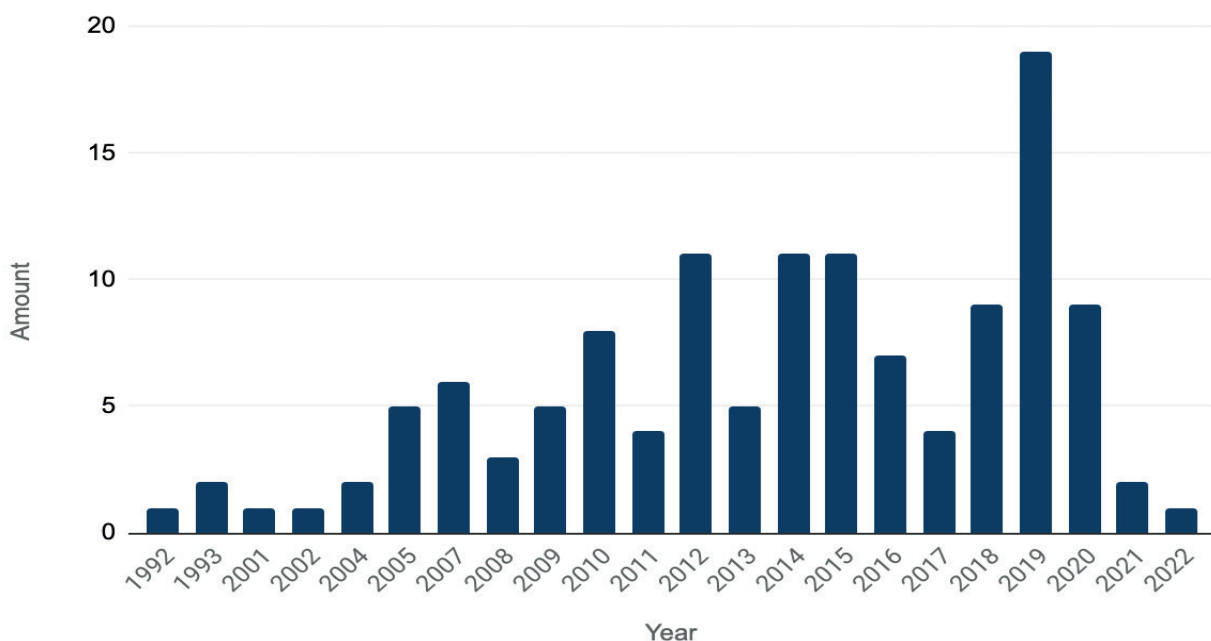


Figure 1. Period of the analyzed scientific production (master theses and doctoral dissertations) on agricultural impact evaluation.

On average, 5.7 works were produced per year, with 2019 showing the highest number of defenses, which was 19, followed by 2012, 2014, and 2015, with 11 defenses each.

There was a sharp decline in publications during 2020 and 2021, a phenomenon that can be attributed to a confluence of factors, many rooted in the emergence of the COVID-19 pandemic. Firstly, the pandemic led to unprecedented restrictions on movement and to the closure of academic institutions, likely interrupting ongoing research. Furthermore, fieldwork, essential for the development of impact evaluations related to agriculture, faced obstacles due to social distancing measures and lockdowns. No less significant was the potential reorientation of research funding since financial resources, often scarce during the crises, may have been redirected to combat the health emergency, leaving areas, such as education, with less support. The mechanics of academic publishing itself may also have been affected, with peer review and editorial processes facing delays due to the adjustment to remote work and other logistical complications.

A shift in research priorities can also be considered since academics turned their attention to issues directly related to COVID-19. Such a shift in focus is understandable in light of the urgency imposed by the pandemic, but it has the side effect of slowing down academic production in other areas. Another important factor is the personal impact of the pandemic on researchers, many of who faced challenges such as caring for loved ones, dealing with their own health and well-being, or adapting to new work dynamics. Moreover, budget cuts may have led to the loss of research staff and a more stressful and challenging work environment. Although these explanations provide a comprehensive framework for the possible reasons behind the drop in academic production, a more in-depth analysis is essential to fully understand the nuances of this decline. It would be useful, for example, to compare these data with academic production in other areas to discern whether this trend was isolated or reflects a broader pattern that affected academic research during the pandemic.

Themes of investigation

Regarding the explored themes, natural resources, such as water and soils, stood out, being mainly associated with the environmental dimension. The word cloud in Figure 2 shows the terms that occur at the highest (larger size) and lowest (smaller size) frequencies.



Figure 2. Word cloud of the analyzed master theses and doctoral dissertations.

For the 127 works analyzed, four thematic groups can be highlighted (Figure 3): data collection for the studies, mainly through questionnaires and interviews; programs, projects, and public policies; organic and agroecological production and carbon stock; and natural resources, with studies associated with the environmental impacts of pesticide contamination in the Mogi-Guaçu and Pardo River basins, in the Ribeira de Iguape River in the state of São Paulo, in the Mogi-Guaçu River in the state of Minas Gerais, in the municipality of Natuba in Pernambuco, and in the sub-basins of the municipality of Tailândia in the state of Pará.

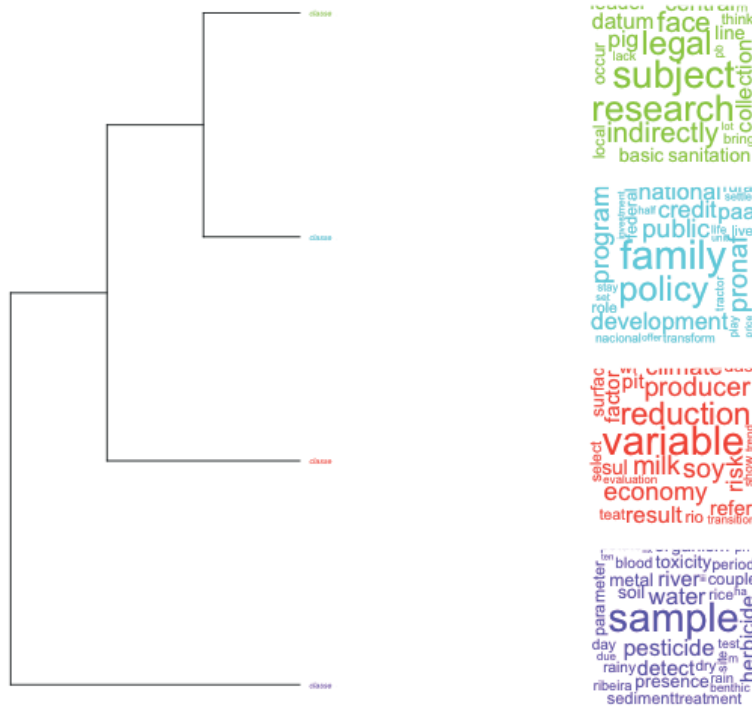


Figure 3. Thematic groups representative of the studied set of analyzed master theses and doctoral dissertations.

In terms of the farming segment, family farming is the most frequent, having been studied in 40 master theses and 8 doctoral dissertations, which corresponds to 38% of the entire evaluated set. Research related to chemical pesticides and their effects on the environment and human health was the focus of 36 works, whereas organic production appeared in 17 studies. Regarding crops, palm oil, corn, soybean, bean, and rice stood out.

Categories and indicators

Based on the analysis of the abstract, each of the 127 works analyzed was classified according to the categories and indicators identified by the World Bank team (Table 1). All eight proposed categories were identified, with “Natural resource management” standing out (Table 2), mainly associated with environmental impact studies that aimed to evaluate, for example, sugarcane agro-industrialization, an agricultural recycling program of sewage sludge, and water quality in areas of surface capture in hydrographic basins, among others. The second most common category was “Other”, which, according to IEG (2011), varies greatly, but aims at the economic well-being of the farmer and, in some cases, agricultural performance. In this category, there are works related to the impact evaluation of public programs and policies that aimed to improve the social and economic condition of rural products.

The categories “Irrigation” and “Technology” both had five occurrences each, with studies on effluent disposal, irrigation water quality, pesticide use in irrigated rice cultivation, and irrigation agriculture in the Northeastern region (Table 2). The “Technology” category was associated with studies on the use of new techniques to improve agricultural production, whether from inside or outside the farm. The categories “Land leasing and titling” and “Extension services”, with two occurrences each, represented works associated with land reform settlements, the evaluation of rural extension regarding the empowerment of rural populations through information sharing, and the use of the internet and rural extension by farmers. “Marketing arrangements” had only one occurrence, being related to the evaluation of the operation of a sugarcane agro-industry located in the municipality of Mamanguape, in the state of Paraíba. In general, it was possible to categorize 97% of the works, i.e., 123 of them.

Table 2. Categories and indicators of the analyzed master theses and doctoral dissertations.

Category	Frequency	Indicator	Frequency
Natural resource management	56	3. Production	50
Others	40	2. Income	46
Microfinance	12	1. Not identified	30
Irrigation	5	4. Profit	1
Technology	5		
Not identified	4		
Land leasing and titling	2		
Extension services	2		
Marketing arrangements	1		

In relation to the indicators, 23.6% (30) of the works could not be classified. The indicators “Production” and “Income” show with the highest occurrence, which is related, for example, to the increase in soybean yield and in the income of family farmers in Northeastern Brazil. The indicator “Profit” was associated with the work defended by Neivaldo Ramos Pontes at Universidade Federal do Rio Grande do Sul, in 2004, entitled “*Avaliação dos impactos e transformações do programa MODERFROTA na indústria de máquinas agrícolas: caso AGCO*” (evaluation of the impacts and transformations of the MODERFROTA program in the agricultural machinery industry: AGCO case), which aimed to improve the production of industries, focusing on their economic impact.

Used methodologies

Based on Evenson (2001), the following three methodological approaches were identified in the analyzed works: non-experimental, experimental, and quasi-experimental (Figure 4).

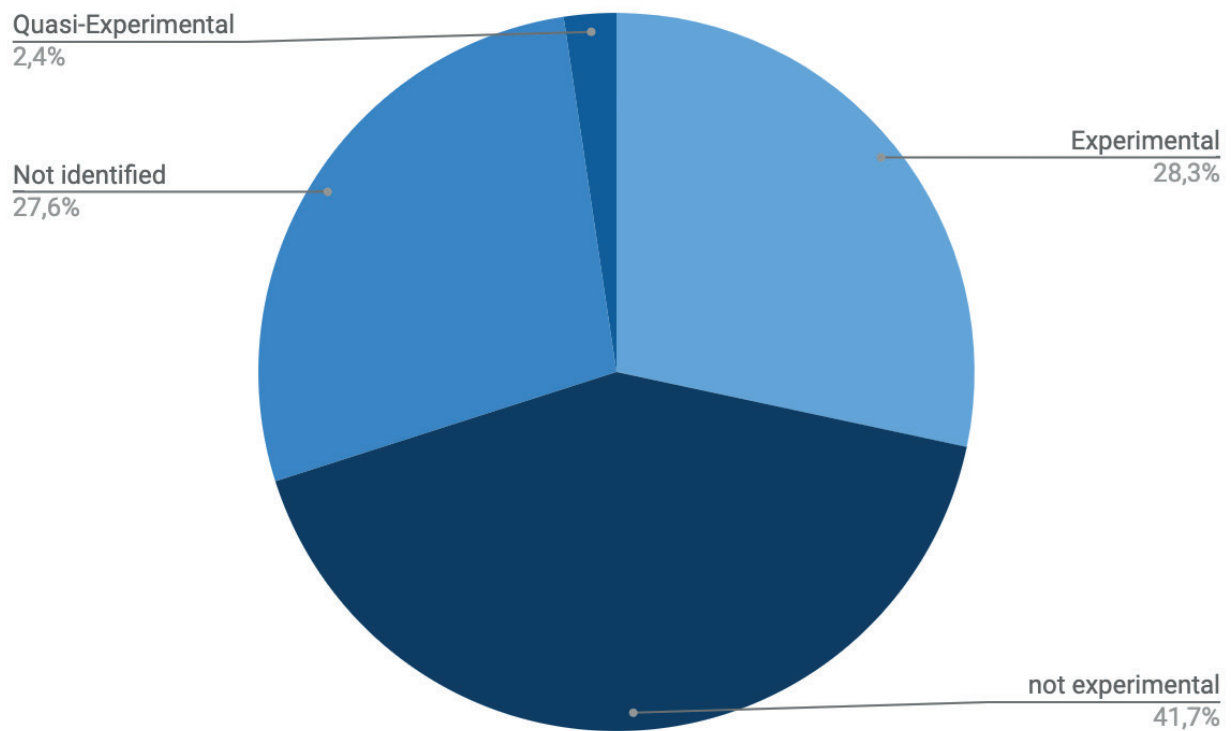


Figure 4. Identified methodologies used in the analyzed master theses and doctoral dissertations.

The non-experimental approach stood out with 53 occurrences. In terms of the tools used in this approach, the exploratory-descriptive analysis, the investigation through questionnaires and interviews, case studies, and the analysis of secondary data are highlighted. Multicriteria tools were also identified, such as the Ambitec-Agro case by Bin et al. (2003) and the method of Carniel (2013), as well as the development of specific methodologies for different researches.

The experimental approach came in second with 36 occurrences, and its main tools and instruments were the structuring of control groups, the use of geotechnologies, the Carnegie-Ames-Stanford approach method, logistic regression, the input-output matrix, and the panel vector autoregression.

The quasi-experimental approach was used in three studies, in which propensity score matching predominated.

Impact

In the analyzed works, the following six impact dimensions were identified: environmental, economic, social, political, technological, and socioterritorial (Figure 5).

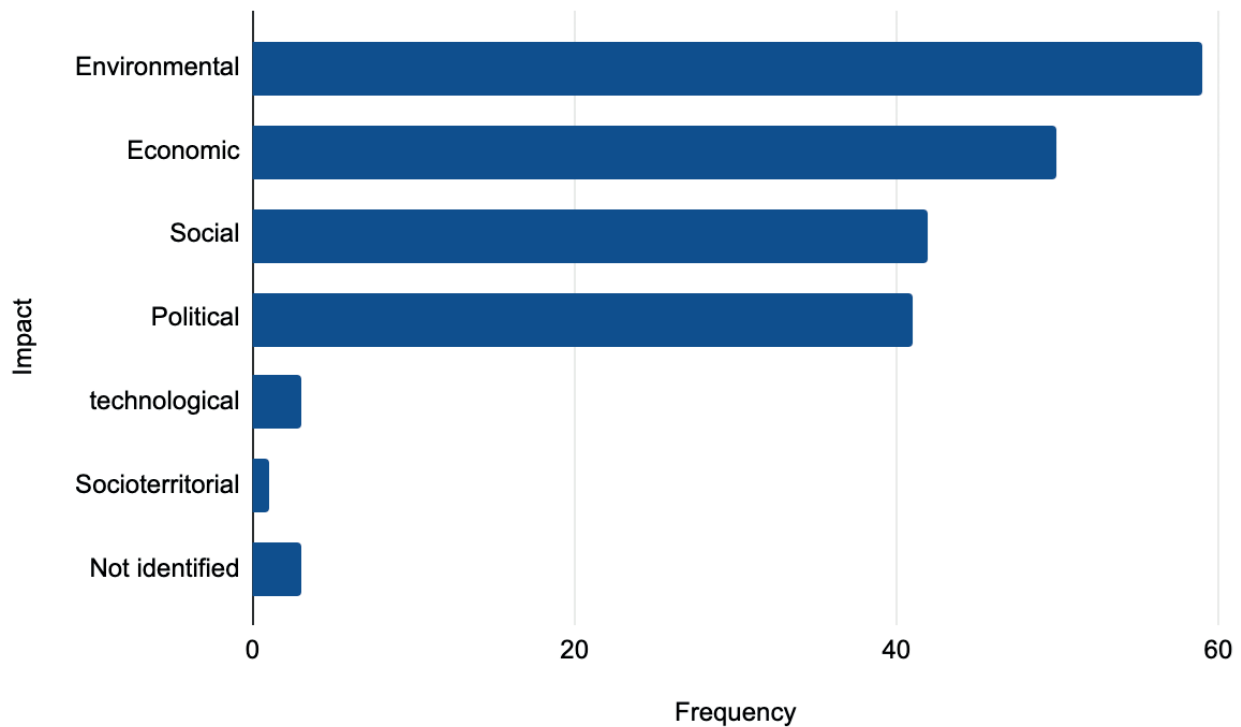


Figure 5. Dimensions investigated by the analyzed master theses and doctoral dissertations.

The evaluation of the impacts of agricultural activities on the environment stood out in 59 studies, which analyzed different regions of Brazil, especially the Northeast, with emphasis on the state of Pernambuco, and the South, with emphasis on the state of Rio Grande do Sul.

A total of 50 studies investigated the economic dimension by analyzing, for example, the impact of technological solutions on the income of producers of crops such as soybean and sugarcane, as well as of a legal reserve on different types of agribusiness production units, specifically in the following regions (in order of occurrence): Northeast (states of Paraíba and Rio Grande do Norte), Southeast (states of Rio de Janeiro and São Paulo), Midwest (state of Goiás), and North (states of Amazonas, Acre, Pará, and Tocantins).

Social impacts were the subject of 42 studies, which focused on identifying the transformations that occurred, for instance, as a result of governmental actions, such as sanitary legislation, and of the sugarcane agribusiness in a fishing community, particularly in the five following regions (in order of occurrence): Northeast (states of Paraíba and Pernambuco), Southeast (states of São Paulo and Rio de Janeiro), Midwest (state of Goiás), South (state of Santa Catarina), and North (state of Amazonas).

Political impacts, characterized as the impact of public policies, were the object of 42 studies, 36 master theses, and 6 doctoral dissertations, which evaluated the programs, projects, and policies identified and presented in Table 3.

Table 3. List of programs, projects, and policies evaluated by the analyzed master theses and doctoral dissertations.

Program/Project/Policy	Number
Programa Nacional de Fortalecimento da Agricultura Familiar (PRONAF)	14
Programa de Aquisição de Alimentos (PAA)	8
Programa Nacional de Alimentação Escolar (PNAE)	5
Programa Nacional de Produção e Uso do Biodiesel (PNPB)	5
Plano Nacional de Agroecologia e Produção Orgânica (Planapo)	2
Programa de Garantia da Atividade Agropecuária (Proagro)	2
Plano ABC	1
Produção Integrada de Sistemas Agropecuários (PISA)	1
Programa Bolsa Família (PBF)	1
Programa de Ação Concentrada (PAC)	1
Programa de Análise de Resíduos de Agrotóxicos em Alimentos (PARA)	1
Programa de Aquisição de Alimentos in the Compra Institucional modality (PAA-CI)	1
Programa de Reciclagem	1
Programa MODERFROTA	1
Programa Nacional de Reforma Agrária (PNRA)	1
Programa Um Milhão de Cisternas Rurais (P1MC)	1
Projeto Hora de Plantar	1
Sistema Água Viva no Projeto de Assentamento Monte Alegre I – Upanema-RN	1

The program Programa Nacional de Fortalecimento da Agricultura Familiar had the highest number of occurrences, being investigated as to its effects on: the quality of life of young family farmers in Paraíba; family agriculture in municipalities in the states of Pernambuco, Minas Gerais, and Paraná; and the restriction of rural credit. In general, the studies that sought to evaluate policies focused on the following regions (in order of occurrence): Northeast (states of Ceará and Paraíba), Southeast (state of São Paulo), South (state of Santa Catarina), and North (states of Acre and Pará).

Regarding technological impacts, three studies aimed to evaluate, respectively: 1. social technologies for water management on the sustainability of small farmers in the semi-arid region of Ceará, 2. the impact of implementing good milking practices in the agreste region of Pernambuco, and 3. how the results of the Hora de Plantar project affected the sustainability of family farmers in the Cariri microregion.

Finally, there was one occurrence of a new impact dimension, identified as “Socioterritorial”, in the master thesis “*A territorialização do agronegócio canavieiro e seus impactos socioterritoriais no assentamento Betel e na comunidade camponesa Estrelinha em Glória de Dourados – MS*” (the territorialization of the sugarcane agribusiness and its socioterritorial impacts in the Betel settlement and Estrelinha peasant community in Glória de Dourados – MS), defended by Cleivaldo Siqueira Pereira, in 2019, at Universidade Federal de Grande Dourados. It should be noted that the analyzed works were classified according to the investigated impacts and that a same study could measure more than one dimension, which was the case of a total of 50 studies that investigated at least two and at the most four dimensions.

Most studied regions

Regarding the identification of the most commonly studied regions, it is important to mention that 42 studies did not provide information on the territory of interest. This is often due to the scope of the study, as observed for the master thesis “*A Codificação Florestal Brasileira (Leis n.º 4.771/65 e 12.651/12) e seus impactos na agricultura familiar*” [the Brazilian forest code (Laws No. 4,771/65 and 12,651/12) and its impacts on family agriculture] defended by Ricelho Fernandes de Andrade,

in 2019, at Universidade Federal de Campina Grande. In the 85 studies that provided information on the location of the study, 63 municipalities from 17 states and five Brazilian regions were identified (Table 4).

Table 4. Territories identified in the analyzed master theses and doctoral dissertations.

Region	Municipality	State	Number of municipalities
Northeast	Cabo de Santo; Baixa Grande do Ribeiro; Baía Formosa; Mamanguape; Rio do Peixe; Ibimirim; Boqueirão; Cariri; Bonito; Uruçuí; Irecê; Lagoa Seca; Ribeiro Gonçalves; Conde; Cajazeiras; Ceará-Mirim; Araçagi; Areia; Esperança; Itatuba; Lagoa Seca; Baturité; Iguatu; Quixadá; Serra do Mel; Dormentes; Lagoa	PB; PE; CE; PI; BA; RN; MA	27
Southeast	Toledo; Presidente Prudente; Mogi-Guaçu; Bom Repouso; Iguape; Bom Repouso; Limeira; Médio Paraíba Fluminense; Ourinhos; São Carlos; Japeri; Campos dos Goytacazes	RJ; MG; SP	13
South	Paranacity; Curitiba; Garruchos; Guarani das Missões; Cantuquiriguaçu; Guarani; Santo Ângelo; Santo Antônio das Missões; São Paulo das Missões; Pirapó; São Nicolau	PR; RS	11
Midwest	Glória de Dourados; Terezópolis; Gameleira de Goiás; Silvânia; Corumbá; Goianápolis; Jaraguá ; Itaberaí; Brasília	MS; DF; GO	9
North	Rio Branco; Eva; Tailândia	AM; TO; AC; PA	3

The region with the highest number of occurrences was the Northeast (40), followed by the Southeast and South (each with 15), the Midwest (10), and the North (9). The environmental impact prevailed in all regions, except in the North, where the social and economic impacts were the most frequent, followed by the environmental and political ones.

In the Northeast, besides the investigation of environmental impacts, a large part of the studies focused on programs/policies aimed at family farming. In the Southeast, several works evaluated the environmental impact of pesticides on water resources and the economic impact of agricultural credit, among others. In the Midwest, studies analyzed the environmental impact of productive activities and climate variables on the production of the region. In the South, of the 15 occurrences, 11 referred mainly to the environmental impacts of agrochemical use in agricultural production.

Universities

A total of 38 higher education institutions (HEIs) (Table 5) registered defenses related to impact evaluations in agriculture, which corresponds to an average of 3.3 works per university. Of the HEIs, 87% are public, and only five are from private capital, namely: Ânima, Pontifícia Universidade Católica de São Paulo, and Universidade Nove de Julho, from the state of São Paulo; Pontifícia Universidade Católica do Rio de Janeiro, from the state of Rio de Janeiro; and Universidade Salvador, from the state of Bahia. A total of 35 postgraduate programs were mapped, with Universidade Federal Rural do Rio de Janeiro standing out, with 12 (34%) distinct postgraduate programs, where master theses and doctoral dissertations related to the topic were defended.

Table 5. Higher education institutions and postgraduate programs.

University ⁽¹⁾	Program	Number
USP	Programa de Pós-Graduação em Tecnologias Computacionais para o Agronegócio	13
UFCG	Programa de Pós-Graduação em Sistemas Agroindustriais; Programa de Pós-Graduação em Engenharia Agrícola; Pós-Graduação em Recursos Naturais	12
UFC	Programa de Doutorado em Desenvolvimento e Meio Ambiente; Programa de Pós-Graduação em Farmacologia	11
UNICAMP	Pós-Graduação em Saneamento e Ambiente; Pós-Graduação em Economia	8
UFRRJ	Programa de Pós-Graduação em Ciências Ambientais e Florestais; Programa de Pós-Graduação em Agronomia – Ciência do Solo; Programa de Pós-Graduação em Agricultura Orgânica; Programa de Pós-Graduação em Fitotecnia; Programa de Pós-Graduação em Desenvolvimento Territorial e Políticas Públicas; Programa de Pós-Graduação em Educação Agrícola; Programa de Pós-Graduação em Medicina Veterinária (Patologia e Ciências Clínicas); Programa de Pós-Graduação em Ciências Veterinárias; Programa de Pós-Graduação em Fitotecnia; Programa de Pós-Graduação em Práticas em Desenvolvimento Sustentável	7
UFRPE	Programa de Pós-Graduação em Engenharia Ambiental; Programa de Pós-Graduação em Administração e Desenvolvimento Rural	6
UNB	Programa de Pós-Graduação em Agronegócio	6
UFG	Not identified	5
UFRGS	Programa de Pós-Graduação em Administração; Programa de Pós-Graduação em Sensoriamento Remoto	5
UFSCAR	Programa de Pós-Graduação em Agroecologia e Desenvolvimento Rural; Programa de Pós-Graduação em Biotecnologia	5
UFPB	Programa de Pós-Graduação em Psicologia Social	4
UFPE	Not identified	4
UFPR	Programa de Pós-Graduação em Agronomia: Ciência do Solo; Pós-Graduação em Geologia Ambiental	4
UFSM	Not identified	4
UFV	Not identified	4
FIOCRUZ	Programa de Pós-Graduação em Ciências	2
IPEN	Área de Tecnologia Nuclear	2
UFERSA	Not identified	2
UFRN	Programa de Pós-Graduação em Gestão Pública	2
UFT	Programa de Pós-Graduação em Biodiversidade e Biotecnologia da Amazônia Legal	2
UNESP	Not identified	2
Ânima	Programa de Pós-Graduação em Ciências Ambientais	1
FJP	Not identified	1
PUC-RIO	Not identified	1
PUC-SP	Not identified	1
UEG	Not identified	1
UEL	Not identified	1
UFAM	Not identified	1
UFES	Not identified	1
UFFS	Not identified	1
UFGD	Not identified	1
UFPA	Not identified	1
UFPEL	Not identified	1
UFS	Not identified	1
UFSC	Not identified	1
UNIFACS	Programa de Pós-Graduação em Regulação da Indústria de Energia	1
UNINOVE	Not identified	1
UTFPR	Programa de Pós-Graduação em Tecnologias Computacionais para o Agronegócio	1

⁽¹⁾USP, Universidade de São Paulo; UFCG, Universidade Federal de Campina Grande; UFC, Universidade Federal do Ceará; UNICAMP, Universidade Estadual de Campinas; UFRRJ, Universidade Federal Rural do Rio de Janeiro; UFRPE, Universidade Federal Rural de Pernambuco; UnB, Universidade de Brasília; UFG, Universidade Federal de Goiás; UFRGS, Universidade Federal do Rio Grande do Sul; UFSCAR, Universidade Federal de São Carlos; UFPB, Universidade Federal da Paraíba; UFPE, Universidade Federal de Pernambuco; UFPR, Universidade Federal do Paraná; UFSM, Universidade Federal de Santa Maria; UFV, Universidade Federal de Viçosa; FIOCRUZ, Fundação Oswaldo Cruz; IPEN, Instituto de Pesquisas Energéticas e Nucleares; UFERSA, Universidade Federal Rural do Semi-Árido; UFRN, Universidade Federal do Rio Grande do Norte; UFT, Universidade Federal do Tocantins; UNESP, Universidade Estadual Paulista; FJP, Fundação João Pinheiro; PUC-RIO, Pontifícia Universidade Católica do Rio de Janeiro; PUC-SP, Pontifícia Universidade Católica de São Paulo; UEG, Universidade Estadual de Goiás; UEL, Universidade Estadual de Londrina; UFAM, Universidade Federal do Amazonas; UFES, Universidade Federal do Espírito Santo; UFFS, Universidade Federal da Fronteira Sul; UFGD, Universidade Federal da Grande Dourados; UFPA, Universidade Federal do Pará; UFPEL, Universidade Federal de Pelotas; UFS, Universidade Federal de Sergipe; UFSC, Universidade Federal de Santa Catarina; UNIFACS, Universidade Salvador; UNINOVE, Universidade Nove de Julho; and UTFPR, Universidade Tecnológica Federal do Paraná.

Observing the location of the universities, 36.8% (14) are found in the Southeastern region, 23.7% (9) in the Northeastern region, 21% (8) in the Southern region, 10.5% (4) in the Midwestern region, and 8% (3) in the Northern region.

Considering the list of universities, even though the Northeast was the region with the highest number of studies, it came in second after the Southeast, with the highest number of identified graduate programs.

CONCLUSIONS

The several tools and methods used for impact evaluation in Brazilian agriculture can help to elucidate different technologies and public policies, as well as their implications for transforming the country's rural environment. Although the scope of this type of study can be unidimensional or even multidimensional, in both cases, it is generally possible to detect changes and even their negative effects on people's lives and the environment.

Brazil's agriculture, which is export-oriented and brings foreign exchange to the country, is highly productive and has been growing annually, demanding a greater attention to natural resources such as soil and water. This requires the adoption of sustainable production techniques and practices, whose positive or negative effects can be investigated through impact evaluations. With investigations focused on the environmental dimension, it is possible to identify the positive and negative factors of a particular intervention, whether originating from organized actions through public policies or research programs.

The results obtained in the present work are relevant for understanding the research trends and priorities regarding impact evaluations in Brazilian agriculture. The predominance of the evaluated impacts on the environmental dimension suggests a growing concern with the effects of agricultural activities on the environment, which may reflect both public awareness and demands for public policies focused on sustainability and the conservation of natural resources. The regional analysis showed that the analyzed works address different regions of the country, with emphasis on the Northeast, South, and Southeast, indicating that impact evaluations in agriculture are a common concern in different geographical and socioeconomic contexts.

Therefore, the present work points to the need of a better understanding of the different dimensions of the impacts observed in agriculture and of developing more integrated and holistic approaches for this evaluation. Future research can explore the interaction between the identified dimensions and investigate the determinants and consequences of agricultural policies and practices in terms of social, economic, and environmental impacts. Additionally, comparative studies between regions and countries can enrich the knowledge base on impact evaluations in agriculture and contribute to the formulation of more effective and sustainable public policies and strategies for agricultural development. Finally, it should be noted that this research was anchored in a sample of academic works recovered in the BDTD database and could be complemented by other studies that are adherent to the researched theme, originating from other sources and types of document. Therefore, there is an opportunity for the expansion of such research, exploring the theme through other databases and broader research indicators.

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