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Poultry Eco-Controls: Performance and Accounting

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Abstract: This study aims to evaluate environmental performance indicators and eco-controls in the poultry production chain in Goiás, with a focus on forest management, waste generation, water resources, energy use, emissions, and environmental accounting. A mixed-methods approach was used, combining qualitative and quantitative data from 13 agro-industrial companies, 230 farms, and 816 broiler houses. The results highlight the role of environmental management accounting (EMA) in monitoring and improving environmental practices, supporting continuous performance assessment. Econometric analysis revealed a positive link between sustainability practices and economic growth, as measured by GDP per capita. However, productive capacity and energy efficiency showed no significant impact at the 5% level. The study limitations include the focus on a single region and industry, which may limit the generalizability of the findings. Future research should expand to other chains and regions to assess broader applicability and explore the public policy impacts on environmental sustainability, as well as the impact of public policies on environmental sustainability within the sector.

Keywords: agrifood value chain; sustainability; agribusiness; sustainable development; principal component analysis

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1. Introduction

Chicken meat production plays a crucial role in Brazil's economy, with the country being the largest exporter and the third-largest producer worldwide, behind the U.S. and China. Between 2000 and 2022, Brazil's production rose by over 280%, from 4.6 to 12.9 million tons, while export revenues increased from USD 828.3 million to USD 9.5 billion [1–3]. The sector employs around 3.6 million people and contributes about 1.5% of Brazil's GDP [4], driven by technological improvements that have boosted productivity [5].

However, sustainable development in the poultry industry remains a significant challenge. Addressing this requires further research on genetics, nutrition, environmental management, and resource optimization. This aligns with the growing emphasis on ESG (Environmental, Social, and Governance) disclosures across Latin America [6]. Strong governance structures are key to advancing sustainability [7]. The main research challenge this paper addresses is the lack of validated indicators and eco-controls to measure and promote sustainability in the poultry chain in Goiás.

This study aims to validate environmental performance indicators and eco-controls in the poultry production chain, highlighting their importance for competitiveness and sustainable growth. Previous research [8,9] has stressed the need for such indicators to ensure compliance with legislation and manage externalities. Ref. [10] further underscores the role of environmental management accounting (EMA) in integrating sustainability into corporate performance.

1.1. Poultry Farming and the Environmental Challenge

As highlighted by the United Nations, the agricultural sector is the largest global consumer of water resources, responsible for 70% of water usage worldwide. Despite Brazil's abundant water reserves, challenges like inefficiencies, decreased rainfall, growing populations, and heightened demand have led to localized water shortages [11,12]. The ISO 14001 standard [13] defines environmental impact as any positive or negative alteration caused by organizational activities [14,15].

Brazilian regulations, including Water Law No. 9433/1997, provide guidelines for effluent reuse, especially in fertigation, but do not comprehensively prevent environmental degradation. Performance evaluations in environmental management serve as strategic tools for planning, though further research is still needed on the impact of poultry farming on soil and water resources. This study aims to validate key indicators and eco-controls to enhance sustainability in poultry production [16,17].

Environmental management accounting (EMA) provides a structured approach to monitoring and enhancing an organization's environmental interactions, thereby supporting continuous improvement and audit processes [18]. According to [19], combining Industry 4.0 technologies with circular economy principles can lead to more sustainable poultry farming practices by maximizing resource efficiency and reducing waste. Effective evaluations depend on customized indicators and management's commitment to fostering environmental accountability [20–22]. This research contributes to the field by examining indicators and eco-controls within the poultry sector to support sustainable development.

1.2. Environmental Management Accounting and Environmental Performance

Environmental management accounting (EMA) is a critical tool for documenting and analyzing how organizations engage with the environment, tracking resources such as material flows, energy consumption, and emissions [18]. It is essential to integrate knowledge management with organizational processes to transition from eco-innovation to circular economic practices, thereby driving improvements in sustainability performance [23].

EMA enables firms to pinpoint areas requiring enhancement, collecting routine data to support environmental audits. While it facilitates informed decision-making regarding environmental impact, it does not directly resolve ecological challenges [18]. Environmental accounting facilitates sustainability tracking by utilizing performance indicators that evaluate both economic and environmental factors. However, current frameworks, such as the GRI and CDP, have limitations in fully capturing these impacts [24].

This study highlights the need to differentiate between managerial and environmental indicators to better assess operational efficiency and ecological impact [10]. EMA tools, such as impact assessments and eco-controls, support this distinction [25]. Strong organizational performance indicators and eco-control techniques are crucial for strategic management [20,22]. Ref. [7] noted that leadership diversity, including women in top positions, is associated with stronger sustainability commitments and transparency.

The success of environmental performance assessments depends on management's dedication and the application of suitable metrics, which enhance organizational efficiency and communication [20–22]. Indicators should address material usage, emissions, and compliance with regulations [26]. Studies have shown that transparency in eco-efficiency, achieved by linking financial and environmental performance, promotes sustainable resource use [26–28]. This research contributes to the field by applying these principles within the poultry production chain, underscoring their importance for sustainable development.

This study employs both qualitative and quantitative methods to examine eco-controls and environmental indicators throughout the poultry value chain, focusing on waste, water, energy, and emissions. Building on the contributions of [25,29], this research examines how integrated environmental management can promote socio-economic development and sustainability within the poultry sector.

The econometric analysis validates the relationship between environmental performance indicators and municipal economic growth. This study aligns [30]'s perspective on integrating environmental metrics into governance frameworks, contributing to the expanding body of literature on environmental accounting in agriculture.

2. Materials and Methods

2.1. Research Design

This study employs a mixed-methods approach, combining both qualitative and quantitative research methods. The case study methodology was selected for its ability to explore complex real-world phenomena within the poultry production chain [31]. This research employs a descriptive design to map and analyze environmental management practices. Documental research and questionnaires were used for data collection, while content analysis and econometric models facilitated the analysis. This methodological framework ensures depth and contextual understanding, allowing for a detailed investigation of performance indicators and eco-controls in environmental management.

The case study method was chosen for its suitability in exploring contemporary environmental management challenges, particularly in sustainability within industrial production [31]. Given the intricate nature of the poultry chain, this approach facilitates an in-depth analysis of organizational processes, management practices, and operational outcomes.

2.2. Data Collection

Data were gathered from both primary and secondary sources. Primary data were obtained through closed-end questionnaires administered to representatives of key units in the poultry production chain, including integrators, integrated farms, and others. In contrast, secondary data was extracted from financial reports and public documents. The primary data collected in 2021 focused on environmental practices, including waste management and energy use. The secondary data included the GDP per capita of municipalities, providing a macroeconomic backdrop for the environmental performance indicators analyzed.

The closed-ended questionnaire was designed to capture specific, quantifiable data related to environmental practices and operational metrics across different segments of the poultry chain (Table 1) [32]. The questions were structured based on the literature review, incorporating criteria from [17,33]. This structure ensures the collected data aligns with established academic and regulatory frameworks (e.g., ISO 14001 and NBC T 15) (Table 2). The reliability of the questionnaire was pre-tested on a small sample before full deployment, ensuring clarity and consistency.

Table 1. Characteristics of the study sample.

Number of Studied Units	Activity	Sector	Products	Productive Capacity
2	Breeder houses	Agroindustry	Hens	12.6 million fertile eggs/month
1	Hatchery	Agroindustry	One day chicks	11.4 million eggs/month

Table 1. *Cont.*

Number of Studied Units	Activity	Sector	Products	Productive Capacity
1	Warehouses	Storage and distribution	Grains for feed	110 thousand t (4 months of strategic stock)
2	Flour and oil factory	Industry	Meals and oils for pet food	51 thousand t/year
2	Chemical effluent treatment station (ETE)	Industry	Fatty oil and solid sludge	3 thousand t/year
2	Feed factory	Industry	Feed for hens, chicks and broilers	674,646 thousand t/year
2	Slaughterhouse	Industry	Whole chicken and cuts	121.4 million chickens/year
1	Chicken meat processing plant	Industry	Sausages, nuggets	3 thousand t/year
230	Integrated farms	Farming	Chicken	121.4 million chickens/year
816	Broiler houses	Chicken production	Poultry for slaughter	121.4 million chickens/year

Source: Adapted from [28].

Table 2. Legal and technical regulations regarding the researched actions.

Practices	Legal or Technical Regulations
Forest management	- Federal Law No. 12,727 of 17 October 2012, also known as the Forestry Code [34]. - Goiás State Law No. 18,104 of 18 July 2013, addressing regional forest conservation requirements [35].
Solid waste management	- Federal Law No. 12,305 of 2 August 2010, establishes the National Solid Waste Policy [36]. - Federal Decree No. 10,936 of 12 January 2022, providing regulations for Law No. 12,305/2010 [37]. - Goiás State Law No. 14,248 of 29 July 2002, creating the State Policy on Solid Waste [38]. - Goiás State Law No. 20,725 of 15 January 2020, enhancing state-level waste management policies [39]. - Goiás State Law No. 21,393 of 13 May 2022, strengthening the legal framework against unauthorized waste disposal [40].
Liquid waste management (effluents)	- CONAMA Resolution No. 430 of 13 May 2011, detailing conditions for effluent discharge [41]. - CONAMA Resolution No. 503 of 14 December 2021, updating effluent management standards [42].
Water management	- CONAMA Resolution No. 430 of 13 May 2011, addressing environmental guidelines for water management [41]. - CONAMA Resolution No. 503 of 14 December 2021, further stipulates water use conditions [40,42–44].
Energy and emissions	- CONAMA Resolution No. 491 of 19 November 2018, setting air quality standards related to emissions [45]. - Federal Law No. 14,300 of 6 January 2022, establishing the legal framework for distributed energy generation and compensation [46].
Environmental management	- ISO 14001 outlines standards for environmental management systems (EMS), enabling organizations to create frameworks for sustainable operations [13].

Table 2. *Cont.*

Practices	Legal or Technical Regulations
Environmental accounting	- NBC T 15, issued by the Federal Accounting Council, establishes guidelines for environmental and social information reporting [47].
	- CTG 9, defining Integrated Reporting protocols aligned with global sustainability standards [11,48].

Source: [49].

2.3. Sample Selection

The study population consists of 13 enterprises within the poultry value chain and 230 integrated farms. The sample represents a comprehensive cross-section of the production process, covering industrial sectors such as hen houses, hatcheries, chemical effluent treatment plants, and slaughterhouses. The selection of these units was purposive, focusing on those most representative of the sector's environmental impacts.

The sample size (n = 243) is robust for the analysis, ensuring statistical power in the study's qualitative and quantitative components [50]. Including diverse actors across the chain strengthens the generalizability of the findings. At the same time, the proportional representation of key production units (e.g., integrated farms) aligns with recommendations by [51] for analyzing environmental performance at the industry level.

2.4. Data Analysis

The study employs both qualitative and quantitative techniques. Content analysis was used for qualitative data from company reports, and econometric models, including Principal Component Analysis (PCA) and multiple regression, were applied to the quantitative data [52]. These methods ensure the extraction of meaningful patterns and relationships between variables, providing insights into the environmental performance indicators and eco-controls within the poultry chain.

The variables were grouped via PCA into three factors: production capacity and size; sustainability and environmental management practices; and energy efficiency and alternative sources. The logic of this choice is based on the normative and empirical relevance of these measures in assessing the environmental impact and its relationship with the municipal GDP per capita.

The use of PCA addresses the multicollinearity issues inherent in the dataset due to the presence of highly correlated indicators [53]. By reducing the dimensionality of the data, PCA enables the identification of key components that explain the variance in environmental management practices without a significant loss of information. Variables selected for PCA include the productive capacity, energy consumption, and waste management. The Kaiser–Meyer–Olkin (KMO) test indicated a value of 0.666, confirming the adequacy of the sample for factor analysis [54]. Factors with eigenvalues greater than 1 were retained, accounting for approximately 57% of the variance in the data (Tables 3–8).

Equation (1): Data matrix

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1p} \\ x_{21} & x_{22} & \dots & x_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \dots & x_{np} \end{bmatrix} \quad (1)$$

Equation (2): Multiple regression

$$\ln(Y) = \beta_0 + \beta_1 CA + \beta_2 SU + \beta_3 EF + \epsilon \tag{2}$$

where

- $\ln(Y)$ is the natural logarithm of GDP per capita of the municipality;
- β_0 is the constant;
- β_1, β_2, and β_3 are the parameters associated with the variables productive capacity and facility size (CA), sustainability and environmental management (SU), and energy efficiency and use of alternative sources (EF);
- ϵ is the error term.

The multiple regression model was employed to estimate the impact of environmental management practices on economic development, measured by GDP per capita. The regression model incorporates three independent variables derived from PCA: (i) productive capacity, (ii) sustainability practices, and (iii) energy efficiency. This model enables the precise analysis of how eco-controls and environmental indicators impact economic outcomes.

Table 3. Sample adequacy tests.

Variables	Kaiser-Meyer-Olkin (KMO) Test
Productive capacity	0.800
Number of employees	0.649
Number of broiler houses	0.638
Hectares of planted forests	0.608
Own biomass production (firewood)	0.617
Destination of recyclable waste on the farms	0.623
Gas consumption to burn feathers	0.692
Amount of diesel consumed	0.769
Use of photovoltaic energy on the farm	0.695
General KMO	**0.666**
Determinant of the correlation matrix	**0.154**
Bartlett's Sphericity Test	
χ^2	355.88
Degrees of freedom	36
***p*-value**	**0.0000**

Source: Research results.

Table 4. Eigenvalues and cumulative proportion of generated factors.

Factors	Eigenvalue	Difference	Proportion	Accumulated
1	**2.654**	**1.262**	**0.295**	**0.295**
2	**1.392**	**0.306**	**0.155**	**0.450**
3	**1.087**	**0.136**	**0.121**	**0.570**
4	0.951	0.118	0.106	0.676
5	0.833	0.127	0.093	0.769
6	0.706	0.101	0.079	0.847
7	0.605	0.030	0.067	0.914
8	0.575	0.378	0.064	0.978
9	0.197	-	0.022	1.000

Source: Research results.

Table 5. Factor loadings and singularity after rotation.

Variables	Factor 1	Factor 2	Factor 3	Singularity
Productive capacity	0.597	0.003	−0.191	0.607
Number of employees	0.838	0.216	0.120	0.236
Number of broiler houses	0.860	0.128	0.122	0.230
Hectares of planted forests	0.109	0.788	0.168	0.339
Own biomass production (firewood)	0.170	0.802	−0.019	0.327
Destination of recyclable waste on the farms	−0.103	0.169	0.391	0.808
Gas consumption to burn feathers	0.469	−0.168	−0.574	0.422
Amount of diesel consumed	0.562	0.091	−0.090	0.667
Use of photovoltaic energy on the farm	0.371	−0.207	0.767	0.231
Has a water supply permit	0.597	0.003	−0.191	0.607

Source: Research results.

Table 6. Factor variance after rotation.

Factors	Variance	Difference	Proportion	Accumulated
1	2.523	1.087	0.280	0.280
2	1.436	0.262	0.160	0.440
3	1.174	-	0.131	0.570

Source: Research results.

Table 7. Proposal for environmental eco-controls for the production chain.

Environmental Management Practices	Indicator	Indicator Description	Unit of Measure
Forest Diagnosis	Reforestation up to 5 ha	Areas designated for reforestation are up to 5 hectares in size.	Hectares (ha)
	Reforestation from 5 to 10 ha	Reforestation activities carried out on land between 5.1 and 10 hectares.	Hectares (ha)
	Reforestation from 10 to 50 ha	Designated reforestation lands ranging from 10.1 to 50 hectares.	Hectares (ha)
	Reforestation over 50 ha	Larger reforestation initiatives on land exceeding 50 hectares.	Hectares (ha)
	Investment	Funds allocated to support reforestation practices, including tree planting and forest preservation.	Brazilian Real (BRL)
	Cost	Total expenses related to essential operational activities, such as maintaining water sources and APP.	Brazilian Real (BRL)
Water Resources	Number of water sources	A count of water sources found on farms, including springs and surface flows.	Units
	APP + legal reserve	Areas under permanent preservation and legally required reserves that protect biodiversity.	Hectares (ha)
Waste Management	Organic waste generated	The amount of organic waste produced throughout the production chain.	Tons
	Organic waste for own use	Organic waste, such as compost, is repurposed and utilized within the facilities.	Tons
	Organic waste sold	Organic waste is sold to external buyers for agricultural and other uses.	Tons
	Investments in waste management	Financial resources are devoted to the development of waste management systems.	Brazilian Real (BRL)
	Cost in waste management	Costs incurred for managing waste, including recycling, transportation, and disposal.	Brazilian Real (BRL)

Table 7. *Cont.*

Environmental Management Practices	Indicator	Indicator Description	Unit of Measure
Other Waste	Amount of other waste	Volume of additional waste streams such as plastics, cardboard, and industrial debris.	Kg or Tons
	Waste collected by the city	Quantity of waste managed by municipal services.	Kg or Tons
	Waste for incineration	The amount of waste processed through incineration facilities.	Kg or Tons
	Waste sent to landfill	Total waste directed to landfills for disposal.	Kg or Tons
Water Resources Management	Groundwater extraction	Volume of water drawn from underground sources, typically via wells.	Cubic Meters (m^3)
	Surface water withdrawal	The amount of water obtained from surface bodies like rivers, lakes, or reservoirs.	Cubic Meters (m^3)
	Rainwater harvesting	The quantity of rainwater collected for use in production processes.	Cubic Meters (m^3)
	Investment in water resources	Funds allocated to water resource management, including conservation and sustainable use.	Brazilian Real (BRL)
	Cost of water resources capture	Expenditures related to the collection and treatment of water resources.	Brazilian Real (BRL)
Effluent Generation	Effluent destination	Description of effluent management, including septic tanks and soil infiltration.	Unit/Capacity
	Pond or ground disposal	Use of ponds or direct soil treatment for effluent processing.	Capacity
	Investment in effluent management	Financial investment in developing systems for efficient effluent treatment.	Brazilian Real (BRL)
	Cost of effluent management	Costs related to the handling, treatment, and disposal of effluents.	Brazilian Real (BRL)
Energy and Emissions	Energy consumption	The energy used within the production unit is measured in kilowatt-hours or megawatt-hours.	kWh or MWh
	Own energy generation	Energy generated on-site for self-use, partially or fully offsetting external energy needs.	Brazilian Real (BRL)
	SIN purchase	Energy is purchased from the National Interconnected System (SIN).	kWh or MWh
	Fossil fuel consumption	Quantity of fossil fuels (e.g., diesel, LPG, and gasoline) consumed monthly.	Liters or Cubic Meters
	Firewood consumption	The volume of firewood used, measured in cubic meters, sourced from own production or purchased.	Own Production (m^3)/Purchased (m^3)
Environmental Management Accounting	Water grants	Government-issued authorizations for the use of water resources from natural bodies.	Validity
	Land use certificates	Certificates that verify permissible activities and land subdivision for industrial or agricultural use.	Units
	Precautionary practices	Count and financial allocation for preventive measures that protect the environment.	Number/BRL
	Certifications	The company's environmental certifications ensure compliance with sustainable practices.	Units
	Budget forecast	Forecast of revenue and expenditure in alignment with environmental objectives.	Brazilian Real (BRL)
	Incentive system	Investments and costs related to incentive programs promoting eco-friendly practices.	Brazilian Real (BRL)

Notes: BRL refers to Brazilian Real. Source: [28].

Table 8. Analysis of environmental management practices and the municipalities' GDP.

Dependent Variable: GDP Per Capita of the Municipality	
Regressors	Model (1)
Production capacity and size of facilities	−0.012
	(0.016)
Sustainability and environmental management	0.033 **
	(0.016)
Energy efficiency and the use of alternative sources	−0.015
	(0.017)
ICMS collection (control variable)	0.087 *
	(0.047)
Constant	3.299
	(0.019)
F (4, 185)	2.43
Prob. > F	0.0491
R^2	0.0593
R^2 adjusted	0.0390
Number of observations	190

Standard deviations are in parentheses. *p*-values: **: $p \leq 0.05$; *: $p \leq 0.10$. Source: Research results.

2.5. Reliability and Validity

Several steps were taken to ensure the reliability of the data, such as pre-testing the questionnaire and using standardized measures in the analysis. Content validity was achieved by aligning the questionnaire and indicators with existing legal frameworks (e.g., the Forestry Code and the Solid Waste Management Law) and the academic literature. The triangulation of data from multiple sources, including primary surveys and secondary reports, further strengthens the validity of the findings [55].

All participants in the study were informed about the research objectives, and their consent was obtained before data collection. Data was anonymized to protect the confidentiality of participants and the organizations involved.

In summary, the eco-controls were prepared based on data collected through a closed questionnaire and documents. They are derived from systematic surveys and observations, with statistical validation through Principal Component Analysis and regressions.

3. Results

This section outlines the indicators and eco-controls created and implemented across all aspects of the poultry farming value chain, including forest management practices, waste generation, water resources, energy and emissions, and environmental management accounting. The section then delves into analyzing the econometric model applied to data gathered from the integrated farms.

3.1. Analysis of Data from the Integrating Company and Integrated Farms

This section presents the analysis of 28 indicators and 13 eco-controls (Table 3), beginning with insights into forest management practices, current scenarios, and suggested approaches. Five indicators—three focusing directly on performance and two eco-controls related to investment and costs—were developed and applied to evaluate forest management.

The integrator's actions included self-producing firewood and investing in permanent protection areas and legal reserves. In the Cerrado biome, legal requirements stipulate that 30% of farm areas, plus designated permanent preservation areas (APPs), must be allocated. In 2021, the integrator supported the natural recovery of 28 hectares and planted

30 hectares of eucalyptus, along with 4000 native plant seedlings across integrated company properties. These initiatives align with [56], which describes energy crops as essential for producing biomass fuel, a strategy reflected in the use of eucalyptus plantations as sanitary barriers in 90% of all installed poultry farms.

Regarding the reforestation potential of integrated farms, it was found that 174 out of the 230 surveyed properties had areas smaller than five hectares, rendering reforestation impractical. Only 42 farms had up to 5 hectares, 13 were between 5.1 and 10 hectares, and one ranged from 10.1 to 50; none exceeded 50 hectares. This categorization reflects the predominance of small- and medium-sized farms, with only 11% of respondents reporting investments in forest management in 2021. Recognizing energy forests and environmental assets on balance sheets or emissions inventories could benefit integrators and integrated farms, as suggested by [56].

The analysis of waste management was organized into subcategories: organic waste disposal, use for self-consumption, and solid waste. The integrator ensured that 100% of organic waste (23,000 tons in 2021) was directed to composting, reflecting the growing adoption of circular economy practices among organizations, as noted by [57]. During the integration process, it was also observed that organic waste was primarily utilized for self-consumption, with 201 integrated farms selling poultry litter as fertilizer for regional crops.

Other waste management practices were categorized into municipal collection, incineration, and collection by the integrator. The integrator allocated 628.72 tons of waste to landfills, incinerated 122.10 kg, and sold 1200 tons of scrap metal. However, only 15 farms relied on municipal services for waste collection, while 201 depended on the integrator's services, indicating widespread adoption of effective waste disposal measures.

Ref. [58] highlighted the opportunity for energy generation through biogas production from livestock waste, a renewable and low-cost alternative that benefits rural producers. This process reduces greenhouse gas emissions and produces biofertilizers for agricultural use. Water management was analyzed by examining groundwater extraction, surface water collection, and rainwater harvesting practices. The integrator gathered 3036 megaliters (MLs) from surface sources and 611.2 ML from underground wells. Of the 230 integrated farms surveyed, 223 utilized groundwater, while only seven sourced surface water. These findings underscore the need for programs that encourage rainwater use and improve water management at integrated farms, consistent with [59], which noted that environmental degradation has exacerbated regional climate change.

Effluent management was evaluated using ponds, soil applications, and stream discharge. The integrator employed two primary effluent treatment strategies, pond systems and a chemical effluent treatment plant (ETP), which processed 83% of the 3017.9 ML of effluent generated. All integrated farm respondents reported using septic tanks, with no instances of improper effluent discharge observed. These practices align with the anaerobic bio-digestion methods described by [60].

Energy and emissions management was analyzed based on the source of energy—whether self-produced, purchased, or a combination. The integrator reported 6518.346 tons of CO_2 (tCO_2) from direct Scope 2 emissions in 2021, and 13,023.023 tCO_2 from indirect Scope 1 emissions, primarily from electricity and fuel consumption. However, due to geographical and data limitations, emissions from integrated farms were not estimated.

The integrating company has implemented environmental management accounting (EMA), though it has yet to be adopted by integrated farms. As noted by [18,25], EMA provides significant benefits by guiding project development, strategy formulation, and minimizing environmental impacts. The authors of [8,9,28,61–64] also confirm EMA's potential to support sustainable development goals across the poultry production chain.

3.2. Analysis of the Econometric Model

The econometric model from Equation (1) is estimated, and the following parameters are presented in Table 4.

The model revealed that only the factor "sustainability and environmental management" has a positive and statistically significant relationship with GDP per capita (coefficient 0.033; $p < 0.05$—Table 8). Productive capacity and energy efficiency were not significant. Tables 4–7 show the extracted factors and proposed eco-controls. Table 7, for example, details the indicators applied to forest, waste, and water management.

4. Discussion

The research results reveal that sustainability and environmental management are the most significant factors affecting economic development, as evidenced by the positive relationship between these variables and GDP per capita at the municipal level. This finding supports the growing body of literature highlighting the importance of sustainable practices in driving economic growth. Studies such as [21] emphasize that eco-efficiency, which aims to meet the needs of businesses and communities while minimizing environmental impact, is crucial for enhancing competitiveness and promoting sustainable development. In the case of the poultry sector, this connection is robust, as organizations that prioritize sustainability are more likely to see improvements in efficiency, cost reduction, and access to new markets.

The insignificance of productive capacity, facility size, and energy efficiency at the 5% significance level suggests that traditional metrics of economic output, such as production scale, may no longer be as impactful as previously thought. The shift towards sustainability as a driving force is echoed in studies like [18], which argue that environmental management accounting (EMA) enables organizations to assess their processes better, providing transparency and identifying areas for improvement. The results align with those of [10,65], who highlight that EMA facilitates more accurate environmental impact assessments and enhances competitive advantage through improved transparency and accountability.

One key explanation for the positive impact of sustainability on economic development is the ability of companies to implement eco-control measures to reduce costs and increase efficiency. As [18] emphasizes, EMA can help identify inefficiencies and potential cost savings by encouraging companies to adopt practices that reduce their environmental footprint, such as waste reduction and energy conservation. These cost savings can translate into improved competitiveness, allowing municipalities with environmentally conscious poultry farmers to experience higher economic growth.

Moreover, sustainable practices not only improve a company's reputation but also enhance market access. Domestic and international consumers are increasingly concerned with the environmental and social responsibility of the products they consume. Companies that embrace sustainability can leverage this demand to access new markets and increase revenues, contributing more to local income. This supports the view of [66], who argue that environmental management contributes to economic growth by opening new opportunities in sustainable markets.

Another contributing factor to the positive relationship between sustainability and economic development is the influence of stakeholders. As noted by [21,49], suppliers, regulators, and environmental groups are increasingly crucial in shaping corporate behavior. These groups often demand greater transparency, accountability, and resource efficiency, pushing companies to adopt more sustainable practices. The pressure to conform to these expectations can lead to greater market competitiveness and, as the results suggest, local economic growth.

These dynamics overlook the importance of stakeholder influence in driving sustainable practices, which have a significant impact on local economies. As supported by the study [67], companies can respond more effectively to stakeholder demands by adopting EMA and integrating sustainability into their core operations. These actions enhance the corporate reputation and improve the company's ability to attract investment and customers, thereby promoting economic development.

One critical area where sustainability practices have a direct economic impact is the preservation of water resources, which are essential for the poultry sector. Water is vital for maintaining hygiene in poultry farms, cleaning equipment, and producing feed. The research highlights the need for integrated farms to adopt water management practices, such as rainwater harvesting and efficient water use, in line with [59], who emphasize that environmental degradation has accelerated the depletion of water resources.

The preservation of natural resources, including water, also creates positive externalities for the local economy, such as maintaining a stable water supply, supporting tourism and recreational areas, and protecting industries that depend on these resources. This contributes to improvements in public health and enhances local quality of life. As [68] argues, environmental conservation efforts can result in widespread benefits that extend beyond individual organizations to the broader community, reinforcing the idea that sustainability is a crucial driver of local economic development [9].

In summary, this study provides strong evidence that sustainability and environmental management are significant contributors to economic development in municipalities with poultry farming. The adoption of eco-control measures not only promotes efficiency and cost savings but also enhances market access and competitiveness. By aligning with stakeholder pressures and responding to environmental demands, companies in the poultry sector can build stronger reputations and attract more investment, contributing to local economic growth.

Furthermore, preserving natural resources, particularly water, and generating positive externalities for the community demonstrate how sustainable practices benefit businesses and society. As [33,67] emphasize, organizations that incorporate sustainability into their operations are better positioned to thrive in a competitive market while simultaneously driving local development. Therefore, this study's findings highlight the crucial role that environmental management and sustainability play in promoting economic growth in the poultry sector, laying the groundwork for future research into the broader implications of these practices across other industries.

5. Conclusions

This research examined the application of environmental performance indicators and eco-controls within the poultry production chain in Goiás, focusing on aspects such as forest management, waste generation, water resource utilization, energy consumption, emissions, and environmental accounting. The study involved data from 13 agro-industrial companies, 230 farms, and 816 broiler houses.

The findings suggest that well-implemented environmental accounting systems can provide crucial insights for evaluating and managing environmental practices, enabling continuous monitoring and clear objective setting. Environmental management accounting (EMA) has emerged as a strategic tool that not only improves environmental performance but also enhances operational efficiency and drives cost savings, as noted by [18,65].

Econometric analysis demonstrated the importance of sustainability indicators and controls, revealing their contribution to economic development. A positive association was identified between sustainable practices and GDP per capita, suggesting that municipalities with poultry farmers committed to sustainability tend to experience higher economic growth. This aligns with the conclusions of [21] regarding the role of eco-efficiency in enhancing business competitiveness and local development.

Companies adopting eco-controls reduce environmental impacts, drive efficiency, achieve cost savings, and enhance market competitiveness. Sustainable enterprises also gain improved market access and attract investment, bolstering their reputation, as highlighted by [49,67].

Furthermore, public institutions could support EMA adoption in different ways, through a possible set of strategies like (a) encouraging the adoption of environmental management accounting (EMA) on integrated farms; (b) promoting the use of rainwater and reuse of effluents; (c) implementing Payment for Environmental Services (PES) for conservation and reforestation; (d) offering tax incentives for renewable energy sources, such as photovoltaics and biogas; (e) creating regional technical training programs on eco-controls; and (f) integrating the study's environmental indicators into licensing and certification criteria.

This study makes a significant contribution to environmental management accounting by presenting models that integrate sustainability indicators, thereby promoting greater transparency and accountability. Effectively managing these indicators benefits businesses and local communities, preserving resources and fostering sustainable development.

Future research should investigate the application of these indicators across various production chains and regions to enhance the understanding of how sustainability impacts economic growth, thereby reinforcing the role of environmental accounting in supporting sustainable development in the agro-industrial sector.

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Abbreviations

The following abbreviations are used in this manuscript:

BRL	Brazilian Real
EMA	Environmental management accounting
ETP	Effluent treatment plant
GDP	Gross Domestic Product

References

1. CEPEA. PIB do Agronegócio Brasileiro. 2022. Available online: https://www.cepea.org.br/br/pib-do-agronegocio-brasileiro.aspx (accessed on 21 April 2025).
2. IBGE. Pesquisa Trimestral do Abate de Animais. 2023. Available online: https://sidra.ibge.gov.br/Tabela/9395 (accessed on 14 April 2023).
3. MAPA. Estatísticas de Comércio Exterior do Agronegócio Brasileiro-AgroStat. 2023. Available online: https://sistemasweb.agricultura.gov.br/pages/AGROSTAT.html (accessed on 25 February 2023).
4. ABPA. Brazilian Chicken: Nossa História. 2023. Available online: https://brazilianchicken.com.br/industria-avicola/nossa-historia/ (accessed on 15 April 2023).
5. Embrapa. Estatísticas | Mundo | Frangos de Corte. 2022. Available online: https://www.embrapa.br/suinos-e-aves/cias/estatisticas-frangos (accessed on 11 July 2022).
6. Husted, B.W.; Sousa Filho, J.M. Board structure and environmental, social, and governance disclosure in Latin America. *J. Bus. Res.* **2019**, *102*, 220–227. [CrossRef]
7. Furlotti, K.; Mazza, T.; Tibiletti, V.; Triani, S. Women in top positions on boards of directors: Gender policies disclosed in Italian sustainability reporting. *CSREM* **2019**, *26*, 57–70. [CrossRef]
8. Mokhtar, N.; Jusoh, R.; Zulkifli, N. Corporate characteristics and environmental management accounting (EMA) implementation: Evidence from Malaysian public listed companies (PLCs). *J. Clean. Prod.* **2016**, *136*, 111–122. [CrossRef]
9. Wang, S.; Wang, H.; Wang, J. Exploring the effects of institutional pressures on the implementation of environmental management accounting: Do top management support and perceived benefit work? *BSE* **2019**, *28*, 233–243. [CrossRef]
10. Gunarathne, N.; Lee, K.H. Corporate cleaner production strategy development and environmental management accounting: A contingency theory perspective. *J. Clean. Prod.* **2021**, *308*, 127402. [CrossRef]
11. UN. Integrating the SDGs into Corporate Reporting: A practical Guide. 2018. Available online: https://sdgs.un.org/documents/griun-global-compact-integrating-sdgs-corporate-reporting-practical-guide-34073 (accessed on 22 February 2019).
12. UN. Agência da ONU lista "sete segredos" das florestas do mundo. 2019. Available online: https://news.un.org/pt/story/2019/12/1698871 (accessed on 26 December 2019).
13. *ISO 14001*; Outlining Standards for Environmental Management Systems (EMS), Enables Organizations to Create Sustainable Operations Frameworks. ISO: Geneva, Switzerland, 2015.
14. *ABNT NBR ISO 14001*; Environmental Management Systems-Requirements with Guidelines for Use. ABNT: São Paulo, Brazil, 2015; 41p.
15. Brazil. *CONAMA Resolution No. 001, of January 23, 1986*; Establishes procedures and criteria for Environmental Assessment with the environmental impact study (EIA) and its respective report (RIMA); Conama: Brasilia, Brazil, 1986.
16. Pacheco Neto, G.; Bus, T.O.D.L.; Aguiar, J.T.D.; Schneider, C.R.; Kanieski, M.R.; Almeida, A.N.D. Avaliação dos impactos ambientais de atividade avicultora em Pinhal da Serra, Rio Grande do Sul, Brasil. *Rev. Bras. Gest. Ambient. Sustentabilidade* **2017**, *5*, 41–48. [CrossRef]
17. Costantini, M.; Ferrante, V.; Guarino, M.; Bacenetti, J. Environmental sustainability assessment of poultry productions through life cycle approaches: A critical review. *Trends Food Sci. Technol.* **2021**, *110*, 201–212. [CrossRef]
18. Burritt, R.L.; Herzig, C.; Schaltegger, S.; Viere, T. Diffusion of environmental management accounting for cleaner production: Evidence from some case studies. *J. Clean. Prod.* **2019**, *224*, 479–491. [CrossRef]
19. Rajput, S.; Singh, S.P. Industry 4.0 and circular economy: A literature review and recommendations for future research. *Bus. Strategy Environ.* **2021**, *30*, 1931–1947. [CrossRef]
20. Henri, J.F.; Journeault, M.; Brousseau, C. Eco-control change and environmental performance: A longitudinal perspective. *J. Account. Organ. Change* **2017**, *13*, 188–215. [CrossRef]
21. Phan, T.N.; Baird, K.; Su, S. Environmental activity management: Its use and impact on environmental performance. *Account. Audit. Account. J.* **2018**, *31*, 651–673. [CrossRef]
22. Sisdyani, E.A.; Subroto, B.; Saraswati, E.; Baridwan, Z. Levers of Eco-Control and Green Behavior in Medical Waste Management. *Int. J. Energy Econ. Policy* **2020**, *10*, 194–204. Available online: https://econjournals.org.tr/index.php/ijeep/article/view/9342 (accessed on 22 April 2025). [CrossRef]
23. Jabbour, A.B.L.S.; Ndubisi, N.O.; Seles, B.M.R.P. Integrating knowledge management and orientation dynamics for organization transition from eco-innovation to circular economy. *J. Know. Manag.* **2022**, *26*, 1221–1240. [CrossRef]
24. de Menezes, B.S.; Arruda, A.T.F.F.P.; de Aquino Cabral, A.C.; dos Santos, S.M.; Pessoa, M.N.M. Evidenciação de Passivos Ambientais: Um estudo com empresas integrantes do ISE. *Rev. Unemat Contab.* **2018**, *6*, 92–110. Available online: https://periodicos.unemat.br/index.php/ruc/article/view/2129/2265 (accessed on 22 April 2025). [CrossRef]
25. Christ, K.L.; Burritt, R.L. Water management accounting: A framework for corporate practice. *J. Clean. Prod.* **2017**, *152*, 379–386. [CrossRef]

26. Sudha, S. Corporate environmental performance–financial performance relationship in India using eco-efficiency metrics. *Manag. Environ. Qual.* **2020**, *31*, 1497–1514. [CrossRef]
27. Hafez, H.M.; Attia, Y.A. Challenges to the poultry industry: Current perspectives and strategic future after the COVID-19 outbreak. *Front. Vet. Sci.* **2020**, *7*, 516. [CrossRef]
28. Rodrigues, V.D.V.; Wander, A.E.; da Silva Rosa, F. Indicators to analyze environmental performance and eco-controls for a poultry production chain: A methodological proposal based on the EMA system. *Environ. Syst. Decis.* **2024**, *44*, 145–160. [CrossRef]
29. Rodrigues, V.D.V. Environmental Accounting of an Agroindustry in Goiás: Analysis of Equity and Profitability. Master's Thesis, Federal University of Goiás, Goiania, Brazil, 2020.
30. Solovida, G.T.; Latan, H. Achieving triple bottom line performance: Highlighting the role of social capabilities and environmental management accounting. *Manag. Environ. Qual.* **2021**, *32*, 596–611. [CrossRef]
31. Yin, R.K. *Case Study Research: Design and Methods*, 5th ed.; SAGE Publications: Thousand Oaks, CA, USA, 2014.
32. Brazil. *Law No. 13,288, of May 16, 2016*, Provides for Integration Contracts, Obligations and Responsibilities in Contractual Relations Between Integrated Producers and Integrators, and other Measures; Brasília, Brazil, 2016.
33. Rodrigues, V.D.V.; Wander, A.E.; da Silva Rosa, F. Contabilidade de Gestão Ambiental: Revisão Sistemática da Literatura. *Rev. Soc. e Ambiente* **2023**, *4*, 18–40. Available online: https://revistasociedadeeambiente.com/index.php/dt/article/view/75/67 (accessed on 22 April 2025).
34. Brazil. *Law No. 12,727, of October 17, 2012*, Amends Law No. 12,651, of May 25, 2012, Which Protects Native Vegetation; Amends Laws No. 6,938, of August 31, 1981, 9,393, of December 19, 1996, and 11,428 of December 22, 2006; and Revokes Laws No. 4,771, of September 15, 1,965 and 7,754, of April 14, 1989, Provisional Measure No. 2,166-2,167, of August 24, 2001, Item 22 of Item II of Art. 167 of Law No. 6,015, of December 31, 1973, and § 2 of Art. 4 of Law No. 12,651, of May 25, 2012; Brasília, Brazil, 2012.
35. Goias. *Law No. 18,104, of July 18, 2013*, Provides for the Protection of Native Vegetation, Institutes the New Forest Policy of the State of Goiás, and Other Measures; Goiânia, Brazil, 2013.
36. Brazil. *Law No. 12,305, of August 2, 2010*, Establishes the National Solid Waste Policy; Amends Law No. 9605 of February 12, 1998; and Takes Other Measures; Brasília, Brazil, 2010.
37. Brazil. *Decree No. 10,936, of January 12, 2022*, Regulates Law No. 12,305, August 2, 2010, Establishes the National Solid Waste Policy; Brasília, Brazil, 2022.
38. Goias. *Law No. 14,248, of July 29, 2002*, Provides for the State Policy on Solid Waste and Other Provisions; Goiânia, Brazil, 2002.
39. Goias. *Law No. 20,725, of January 15, 2020*, Establishes the State Credit Policy for Cooperatives and Associations Specialized in Recycling Materials Obtained from Garbage or Selective Collection Programs; Goiânia, Brazil, 2020.
40. Goias. *Law No. 21,393, of May 13, 2022*, Prohibits, in the State of Goiás, for Environmental Preservation, the Clandestine Release of Solid and Liquid Waste and Pollutants in Water Sources, Rivers, Lakes, and Streams; Goiânia, Brazil, 2022.
41. CONAMA. *Resolution No. 430, of May 13, 2011*, Provides for the Conditions and Standards for the Release of Effluents, Complements and Amends Resolution No. 357, of March 17, 2005, of the National Council for the Environment-CONAMA; Brasília, Brazil, 2011.
42. CONAMA. *Resolution No. 503, of December 14, 2021*, Defines Criteria and Procedures for the Reuse in Fertirrigation Systems of Effluents from the Food, Beverage, Dairy, Slaugh-terhouse and Grease Industries. 236. ed; Brasilia, Brazil, 2021; Section 1, p. 203.
43. *ABNT NBR ISO 14046*; Environmental Management-Water Footprint-Principles, Requirements, and Guidelines. ABNT: São Paulo, Brazil, 2017; 39p.
44. Brazil. *Law No. 9,433, of January 8, 1997*, Establishes the National Water Resources Policy, Creates the National Water Resources Management System, Regulates Item XIX of Art. 21 of the Federal Constitution, and Amends Art. 1 of Law No. 8001 of March 13, 1990, Which Modified Law No. 7990 of December 28, 1989; Brasília, Brazil, 1997.
45. CONAMA. *Resolution No. 491, of November 19, 2018*, Provides for air quality standards; Brasilia, Brazil, 2018; p. 155.
46. Brazil. *Law No. 14,300, of January 6, 2022*, Establishes the Legal Framework for Distributed Microgeneration and Minigeneration, the Electric Energy Compensation System (SCEE), and the Social Renewable Energy Program (PERS); Amends Laws No. 10,848, March 15, 2004, and 9,427, of December 26, 1996; and Takes Other Measures; Brasilia, Brazil, 2022.
47. *NBC T 15*; CFC Resolution No. 1,003/04-Approves NBC T 15-Social and Environmental Information. CFC: Brasília, Brazil, 2004; 8p.
48. CBC. *Brazilian Accounting Standard, CTG 09, of November 26, 2020*, Approves CTG 09, Which Deals with the Correlation to the Basic Conceptual Structure of the Integrated Report; Brasília, Brazil, 2020.
49. Rodrigues, V.D.V.; Wander, A.E.; da Silva Rosa, F. Diagnosis of the Sustainability of a Poultry Value Chain from the Perspective of Environmental Management Accounting. *Rev. Gest. Soc. Ambient.* **2023**, *17*, e03174. [CrossRef]
50. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*, 2nd ed.; Routledge: London, UK, 1988.
51. Hair, J.F. *Multivariate Data Analysis*; Bookman: Chicago, IL, USA, 2009.
52. Araujo, W.O.; Coelho, C.J. *Análise de Componentes Principais*; University Center of Anápolis: Anápolis, Brazil, 2009.
53. Varella, C.A.A. *Análise de Componentes Principais*; Universidade Federal Rural do Rio de Janeiro: Seropédica, Brazil, 2008.

54. Williams, B.; Onsman, A.; Brown, T. Exploratory Factor Analysis: A Five-Step Guide for Novices. *Australas. J. Paramed.* **2010**, *8*, 1–13. [CrossRef]
55. Creswell, J.W. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 4th ed.; SAGE Publications: Thousand Oaks, CA, USA, 2014.
56. Caballero, J.L.; Ghilardi, A.; Arroyo, J.M.; Salinas, M.Á.; Tauro, R.J. Evaluación del potencial energético de los recursos biomásicos en Honduras. In *Sede Subregional de la CEPAL en México (Estudios e Investigaciones) 47650, Naciones Unidas Comisión Económica para América Latina y el Caribe (CEPAL)*; ECLAC: Santiago, Chile, 2021. Available online: https://ideas.repec.org/p/ecr/col094/47650.html (accessed on 22 April 2025).
57. Aranda-Usón, A.; Portillo-Tarragona, P.; Scarpellini, S.; Llena-Macarulla, F. The progressive adoption of a circular economy by businesses for cleaner production: An approach from a regional study in Spain. *J. Clean. Prod.* **2020**, *247*, 119648. [CrossRef]
58. de Lira, E.B.; Dantas, M.C.; Pereira, D.A.; da Costa Sassi, C.F.; Lopes, R.M.B.P.; Pina, L.C.C.; de Souza Neto, J.J. Biodigestor anaeróbico: Produção de biogás e biofertilizante a partir de resíduos pecuários, purificação do biogás e implantação de cultivos de microalgas. *Res. Soc. Dev.* **2023**, *12*, e18312139557. [CrossRef]
59. de Medeiros, R.M.; de Araújo, W.R.; Cunha Filho, M.; de Holanda, R.M.; Saboya, L.M.F.; de França, M.V.; Coutinho Junior, J.C.M. Balanço hídrico anual relacionado à crise hídrica na avicultura de São Bento do Una-PE, Brasil. *Recima21* **2021**, *2*, e211873. [CrossRef]
60. da Costa, L.V.C. Aproveitamento de resíduos da suinocultura e avicultura: Potenciais para produção de biogás e biofertilizante. *Pubvet* **2021**, *3*, Art-0533. Available online: https://ojs.pubvet.com.br/index.php/revista/article/view/2702 (accessed on 20 July 2024).
61. Solovida, G.T.; Latan, H. Linking environmental strategy to environmental performance: Mediation role of environmental management accounting. *Sustain. Account. Manag. Policy J.* **2017**, *8*, 595–619. [CrossRef]
62. Huseno, T. The environmental management accounting (EMA) perspective calculation of environmental management environment in Riau. *J. Appl. Manag.* **2018**, *16*, 714–721. Available online: http://eprints.ipdn.ac.id/2498/1/THE%20ENVIRONMENTAL%20MANAGEMENT%20ACCOUNTING%20%20PERSPECTIVE%20CALCULATION%20OF%20ENVIRONMENTAL%20MANAGEMENT%20ENVIRONMENT%20IN%20RIAU.pdf (accessed on 22 April 2025). [CrossRef]
63. Gunarathne, A.N.; Lee, K.; Hitigala Kaluarachchilage, P.K. Institutional pressures, environmental management strategy, and organizational performance: The role of environmental management accounting. *BSE* **2021**, *30*, 825–839. [CrossRef]
64. Nishitani, K.; Kokubu, K.; Wu, Q.; Kitada, H.; Guenther, E.; Guenther, T. Material flow cost accounting (MFCA) for the circular economy: An empirical study of the triadic relationship between MFCA, environmental performance, and the economic performance of Japanese companies. *J. Environ. Manag.* **2022**, *303*, 114219. [CrossRef]
65. Christensen, B.; Himme, A. Improving environmental management accounting: How to use statistics to better determine energy consumption. *J. Manag. Control* **2017**, *28*, 227–243. [CrossRef]
66. de Morais, A.R.V.B.; Cohim, E.H.B. Análise energética na cadeia produtiva do frango de corte em Feira de Santana-BA. *Rev. Eletrônica Gest. Tecnol. Ambient.* **2022**, *10*, 120–134. Available online: https://periodicos.ufba.br/index.php/gesta/article/view/46884 (accessed on 22 April 2025).
67. Nyakuwanika, M.; van der Poll, H.M.; van der Poll, J.A. A Conceptual Framework for Greener Goldmining through Environmental Management Accounting Practices (EMAPs): The Case of Zimbabwe. *Sustainability* **2021**, *13*, 10466. [CrossRef]
68. da Rosa, F.S.; Costa, G.D.; de Oliveira Silva, L.P.; Lunkes, R.J.; da Silva Gomes, S.M.; Rodrigues, V.D.V.; Ribeiro, V.P. Poultry Production Nexus-Few: A Study About the Effect of Public and Private Investments on the Efficient Use of Water. *Rev. Gest. Soc. Ambient.* **2023**, *17*, e03352. [CrossRef]