

Socio-Economic and Environmental Effects of Poultry Production in Maputo Region, Mozambique

Research Article

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Abstract

The poultry sector is growing in the Maputo region and its importance is increasing. The sector's contribution is recognized in the employment creation, especially for women and youth, income generation (diversification), and improved food security. However, waste management and greenhouse gas emissions are the challenges to be considered for the sector in Mozambique. The present study analyzed the social and economic benefits and their environmental effects. The AMBITEC-AGRO tool which integrates qualitative and quantitative approaches was applied to determine the levels of effects. Surveys, interviews, focus group discussions, and secondary data were applied for additional and complementary data collection. The results demonstrated that the poultry production in Maputo has high perceived environmental risks which are related to inadequate waste management and lack of investment in the infrastructure, lack implementation of biosecurity measures despite its contribution to the economic growth as indicated above. To overcome the challenges, the study suggests the adoption of sustainable practices and required policies to balance sector growth with the social and environmental means.

Keywords: Poultry Production, AMBITEC-AGRO, Socio-Environmental Impacts, Sustainable Development.

Introduction

Agriculture is the cornerstone of Mozambique's economy, contributing significantly to the Gross Domestic Product (GDP) and serving as the primary source of livelihood for approximately 70% of the population [1]. Within the agriculture sector the livestock contribution, especially the poultry farming emerged as a vital component, due to its substantial economic, social, and nutritional potential. The government of Mozambique prioritizes poultry production within its agricultural strategy due to its role in enhancing food and nutrition security, generating employment, and alleviating poverty [2].

In recent years, Mozambique's poultry industry has experienced significant growth, particularly in the Maputo region, where production density has intensified markedly (Figure 1). This expansion is driven by increasing domestic and regional demand for poultry products

[3,4]. The development of the poultry sector aligns with broader national agricultural strategies focused on enhancing productivity and sustainability across the value chain [2]. Economic benefits, including income generation and job creation, have been substantial, particularly for marginalized groups such as women with limited formal education [4-6]. The industry's growth has also contributed to poverty reduction by providing accessible livelihood opportunities across various population segments such as youth and women [6-8].

The poultry sector has witnessed rapid growth in the region as a result of increasing demand hence placing a clear intensification of production in the region bringing in several challenges such as workforce specialization for the sector and environmental risks. These challenges have increased the demand for advanced managerial and technical training, reflecting the growing complexity of poultry production



systems [6-9]. Grahan et al [10], indicate that livestock and poultry farming is the largest source of natural greenhouse gas emissions in most African countries. Therefore, the appropriate management of waste items such as poultry litter, manure, and dead chicks is crucial due to their potentially significant impact on the environment and health [11]. Studies conducted in other countries highlight the po-

tential negative environmental impacts of intensive poultry farming, including waste management issues, greenhouse gas emissions, water, soil, and air pollution, health harmful odors [10-14]. These findings suggest studies to understand the levels of effects on the different sustainable dimensions such as social, economic, and perceived environmental effects as the sector continues growing in the region.



Figure 1: The production density of Mozambique poultry production.

For the analysis of the effects, the Ambitec-Agro system, which is initially developed by Rodrigues et al. [15], offers a valuable framework for assessing the socio-environmental effects of agricultural production systems. The AMBITEC AGRO, which includes indicators related to technological efficiency, environmental conservation, and recovery potential was considered relevant to evaluate the effects of the poultry sector in this study.

Materials and Methods

The social and environmental assessment of the poultry value chain was carried out based on a literature review, a field survey with the application of questionnaires, and the use of a socio-environmental impact assessment tool, Ambitec-Agro (Environmental Impact Assessment System of Agricultural Technological Innovations initially developed by Rodrigues et al [15]. The Ambitec-Agro system is focused on evaluating changes in the socio-environmental performance of rural establishments because of the adoption of a certain practice or technology, verifying negative and positive changes, and pointing out recommendations for environmental management according to these impacts [16].

The Ambitec-Agro System considers seven (7) aspects related to the

sustainable development of agricultural activity:

- i. use of inputs and resources;
- ii. environmental quality;
- iii. respect for the consumer;
- iv. work or employment;
- v. income;
- vi. health; and
- vii. management and administration.

In addition, two (2) dimensions are considered: (i) ecological performance and (ii) socio-environmental, integrating 24 criteria

As highlighted in Figure 2, each dimension is composed of automated weighting matrices (where the impact index is generated), in which the indicators are valued with coefficients of change according to the knowledge of the actors involved in the livestock activity. Component alteration coefficients are the digit that indicates the intensity of the effect of the change observed in the production unit or rural establishment due to practice or technology.

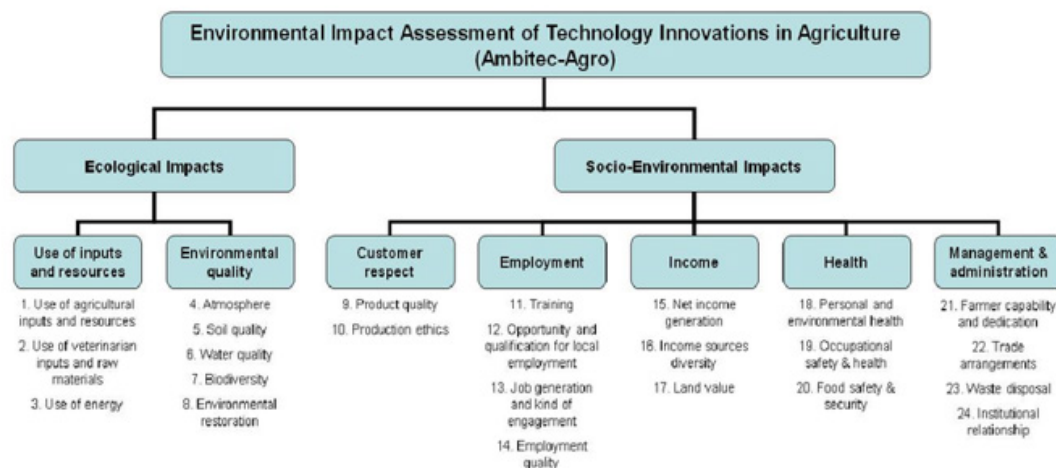


Figure 2: Structure of the impacts, dimensions, and criteria of the rural eco-cert system. Source: Rodrigues et al. [15].



Source of Data

The FGD (Focus group discussions) were carried out with the farmers and other key actors in the sector, key informant interviews were conducted with experts, and questionnaires were administered to collect qualitative data from producers. Focus group discussion was carried out to fill up the indicator matrix according to the Ambitec-Agro methodology, as proposed by Rodrigues et al., [15]. The method is based on social and environmentally established indicators and by conducting an FGD and questionnaires where actors expressed their perceptions on the impacts and consequences.

The social domain can be analyzed through many layers of people's lives and livelihoods. The chosen framework attempts to elaborate an image of the main outcomes of the value chain activities: Working conditions, land and water rights, gender and social inclusion, food and nutrition, social capital, infrastructure, health, education, and training.

Methods of data collection

A focus group discussion was organized to fill in the matrixes. The workshop was held on June 12, 2020, at the Directorate of Animal Sciences of Mozambique Agricultural Research Institute (IIAM). The workshop brought together 20 participants, key players in poultry production, representing the main organizational structures of the chain in the region, ADAM (Association of Poultry Farmers in Maputo) and AMIA (Association of Mozambique Poultry Industry), as well as the different segments of the chain where small, medium, and large producers were represented by their representative organizations. The exercise aimed at filling the matrixes to obtain the coefficients of alteration of the components, for each socioenvironmental impact on the poultry production in the Maputo region.

The 20 participants filled in the weighting matrices for the Ambitec-Agro and participated in the recognition of the main socio-

Table 1: The impact of poultry activities and the changes of coefficients to be inserted in the evaluation matrices.

Source: Rodrigues et al., [15].

Impacts of Activities	Changes of Coefficients
Great increase on the component > 25%	3
Moderate increase in the component < 25%	1
Unchanged increase	0
Moderate decrease in component <25%	-1
Great decrease in component > 25%	-3

The geographic scale of the occurrence expresses the location in which the change in the components of the indicator takes place, according to the specific situation observed in the activity, which can be:

- a) Punctual: when the impact of the activity is restricted to the area or production unit (1).
- b) Local: when the impact is felt outside the area but confined to the limits of the productive unit (2).
- c) Surroundings: when the impact covers the limits of the productive unit (5).

Hence the matrixes were filled out, the coefficients were input into a Microsoft Excel spreadsheet, which resulted in the automatic expression of the socio-environmental impact coefficient. The matrix calculates the impact coefficient, weighted by the factors due to the scale of occurrence of the change, and the values for the importance of the indicators. The impact coefficients are added to result in the overall performance index of the activity (an example of a sequential-

economic and environmental impacts of the poultry production activity. The filling-in-matrixes exercise was divided into three phases:

First Phase

Delimitation of the activity, that is, the definition of the scope of the impacts, the importance of the components and indicators according to the characteristics of the activity, and the scale of occurrence in the poultry unit. For this purpose, 14 indicators were selected (Product quality, production ethics, training, qualified local employment opportunity, job offer, income generation, income diversity, environmental and personal health, food security, marketing condition, use of veterinary supplies and raw material, destination of residues, atmosphere, and institutional relations). In the weighting matrices, there is an exclusive line in which the evaluator marks X if the component does not apply to the study.

Second Phase

The printed matrixes were distributed to the poultry actors, asking them to actively participate with their historical knowledge of the activity, indicating the direction of the impact (increase, decrease, or maintenance). The change coefficients vary from -3 to +3, depending on the intensity of the effect observed on the activity or the management conditions of the poultry production unit. The geographic scale of the occurrence was also registered for the analysis.

Third Phase

The analysis and interpretation of these indices were made and presented graphically on a standardized scale ranging from -15 to +15 (see Table 14). These results highlight the management practices with the greatest effects on the sustainability dimensions, enabling thus, decision-makers, managers, and organizations to define the policies and instruments that improve the performance of poultry activity, by minimizing negative effects.

ly filled-in weight matrix is presented in the appendix). The weight values of the components were changed by the user to better reflect the situations of the study region if the sum of the total weight of the components of a given indicator is equal to +/- 1 unit. To complement the matrixes, questionnaires or individual interviews were applied to producers.

Data Analysis

Identification of the Main Social and Environmental Impacts

For the analysis of the main social and environmental impacts, the IBM SPSS Software (Statistical Package for the Social Sciences) Version 25 was applied, doing only frequency analysis for better perception of the distribution of events and application of the Ambitec-Agro system tool by inserting the coefficients of change in the weighting matrixes in the Microsoft Excel 2003 spreadsheet. To analyze the matrixes, a graphic comparison where the average scores of socio-environmental effects for each selected criterion were applied. The dispersion of indices among the actors was also analyzed.



Table 2: The weighting factor of the scale of the impact on the performance component of the activity.

Source: Rodrigues et al. [15].

Occurrence Scale	Weighting Factor
Punctual	1
Local	2
Surroundings	5

Analysis of the Consequences of Social and Environmental Impacts

The implications of the socio-environmental effects were analyzed using the Ambitec-Agro system, sequentially inserting the change coefficients into the Microsoft Excel 2003 spreadsheet to verify the direction of the impacts and how they jeopardize the quality of life of the populations and the environment.

Results

Socio-Economic Impacts of Poultry Production

The population of Maputo region tends to increase, and poultry product consumption is also growing in the region, being thus one of

the most important for the daily diet, contributing thus to the dietary diversification of many low-income families and hence affecting positively the lives of the provision of food security and beyond. The poultry impact on income generation, employment creation, and entrepreneurial opportunities for women and youth especially is confirmed for the region and hence, it has a special role in these socio-economic dimensions. The poultry sector also has demonstrated to have an inclusive side to the type of employment generated which mostly includes both specialized and unskilled labor. Poultry production in the region has also been demonstrated to facilitate income generation and diversification promotion, mainly for women and youth involved in the sector as employees or entrepreneurs. Many other social impacts can be described.

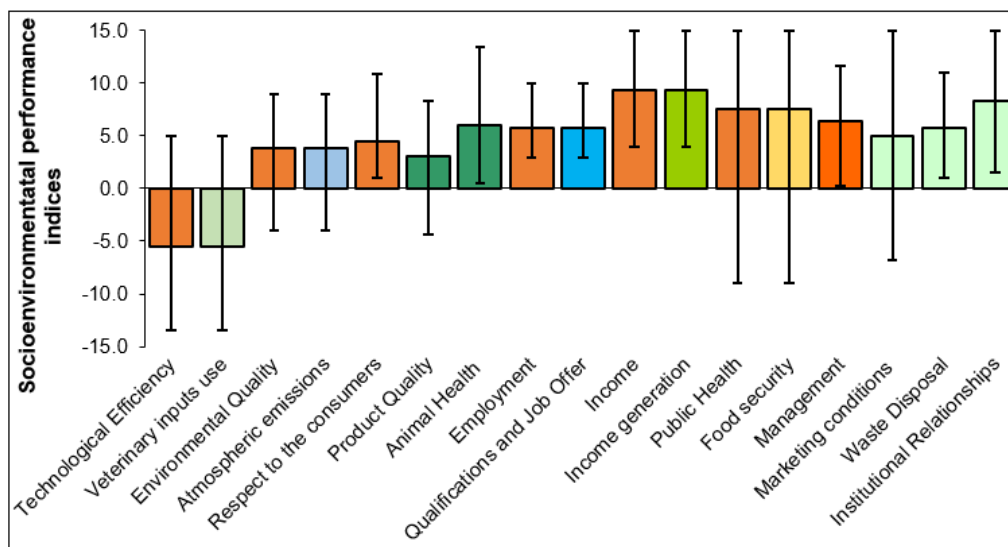


Figure 3: Average of the socio-environmental impact criteria of the Ambitec-agro system applied to 25 poultry farmers.

Source: Computed by the author (2022).

Employment creation: Poultry production offers opportunities for different levels of skills to secure employment in the region. The industry demands medium to high-skilled personnel, including farm managers, nutritionists, and engineers, who are integral to optimizing production efficiency [17,18]. Additionally, the sector relies heavily on specialized roles such as veterinarians and animal health experts, essential for managing disease outbreaks and ensuring biosecurity [19]. However, employment in this sector often lacks formal contracts, leading to precarious job conditions characterized by seasonal or temporary arrangements and informal family labor due to financial constraints [6]. The matrices on employment criteria demonstrate that most poultry farms are likely to engage low-skilled labor permanently, suggesting a dependence on readily available, low-cost workers. The coefficients for manual labor and average technical staff showed maximum positive variation, resulting in an integrated index up to +10, indicating a moderate positive impact on employment generation within the poultry sector [5,20].

Income generation and diversification: Poultry production promotes income generation and economic diversification and is thus impactful for the population of Maputo. The study shows positive changes in income generation coefficients, which means, improvements in security and distribution metrics, though with a slight decrease in stability indicators due to reduced income seasonality and variability. Farmers' perceptions of income security are mixed; some view poultry income as unstable due to factors such as suboptimal feed quality, high costs of key inputs (such as day-old chicks and feed), and adverse climatic conditions like extreme temperatures that negatively affect productivity [6,21]. Despite these challenges of the sector, the income generation criteria have scored the highest index of up to +15, which reinforces that poultry has significant effects on income generation and diversification in the region. Studies have demonstrated that poultry farming improves the socioeconomic status of rural communities by providing a steady income that supports household needs, such as education expenses while enhancing economic resilience through income diversification [22].



Food security: The impact of poultry production on food security is clear. The study has demonstrated that results from different indicators related to production reliability and food availability have experienced moderate declines due to irregular poultry meat supplies, particularly during periods of high demand, such as festive seasons [20]. According to Silva (2006), food security is defined as stable access to sufficient, safe, and nutritious food, a criterion met by poultry production through the provision of affordable animal protein [5]. Although inconsistencies in supply persist, the food security criterion showed a positive impact index of up to +15. Research further substantiates that poultry production is instrumental in enhancing food security by improving access to high-quality protein sources for both urban and rural populations, thereby reducing hunger and malnutrition rates in Mozambique [20,17].

Product Quality: The quality of the product is key for the consumer behaviour which has direct relation with the competitiveness of the poultry value chain in Maputo. The study indicates that most of the indicators of product quality have a maximum impact index of +8 which is well below the +15 as demanded. Issues such as excessive antibiotic and vitamin use raise concerns about chemical residues in poultry products (Correa et al., 2003). While some studies argue for the necessity of antibiotics to maintain health and productivity in intensive poultry systems [23,20], their overuse poses significant public health risks [24]. Moreover, risks associated with biological contaminants, stemming from suboptimal farm management practices, necessitate stricter adherence to food safety standards and quality control measures [25].

Marketing condition: Marketing conditions for poultry products are generally unfavorable, particularly for independent producers. Indicators such as advanced sales, proprietary transport, and promotional activities have shown moderate declines, reflecting market access challenges and visibility constraints [24,20]. Independent producers face heightened market uncertainty, compounded by logistical difficulties and limited access to reliable transportation as often they sell the produce at municipal markets which are a reasonable distance from their production units. The cost of transport will then increase the overall cost of production and hence reduce the profitability of the activity in Maputo [5]. Additionally, high processing fees at slaughterhouses and inadequate storage facilities further strain financial viability [26]. The marketing indicators presented a maximum score of +15, suggesting that integrated production models, which benefit from established supply chains, offer some protection against market fluctuations.

Institutional relationship: Poultry production is still demanding a better structure and organization in Maputo. Despite the demonstrated arrangements challenges, the sector in Maputo has showing encouraging institutional relationships which are well established among the stakeholders. These positive relationships with an impact index reaching +15 are expected to have a good impact in near future of the poultry sector in the region. This progress reflects the effectiveness of producer organizations such as the Associação para o Desenvolvimento da Avicultura em Moçambique (ADAM) in securing better terms for their members, such as discounted input supplies [20]. Nevertheless, administrative inefficiencies within these associations remain a concern among some members [22]. These institutions play a vital role in advocating for poultry farmers' interests, fostering public-private dialogue, and addressing common sectoral challenges [24]. The positive relationships should be considered to a future development of the sector in Maputo as Nicolau (2008) argue that robust institutional frameworks can enhance sector performance by promoting collaboration and ensuring equitable benefit distribution across the value chain.

Environmental Impacts of Poultry in Maputo

Poultry production has potential environmental risks, particularly in waste management and greenhouse gas emissions due to its nature and arrangements. While practices for managing poultry litter and carcasses

are diverse, the reuse of manure as fertilizer is an advantageous approach, provided it is applied correctly to mitigate environmental risks such as soil and water contamination [27,28]. The possible challenges as perceived by the actor require improved management practices, including enhanced ventilation systems and regular facility maintenance to minimize waste accumulation and its associated impacts [12,29]

Waste disposal: The potential perceived negative impacts are basically due the litter and carcasses of dead birds management practices. These practices have shown to have a positive to the environment as they are described as acceptable according to the standards of practices in regards to their management, and therefore, scored +11. The destination or treatment indicator was unchanged, according to the poultry specialists, the destination of the manure is up to the farmers as they can decide whether to reuse it or not. And for the reuse indicator, there was a large increase in the coefficients of change meaning that most of the farmers are currently reusing the manure, especially selling it to the horticulture farmers. These criteria presented an integrated index of +11 which indicates that the producers are really satisfied and their perception of the impact of the manure on the socio-environment effects. The producers usually reuse it bringing then, an additional income to the producers which makes it positive in their perception.

It is estimated that on average about 2 kg of litter is produced per broiler aged between 42 and 46 days in every six batches. The quantity is variable depending on number of birds, feed composition, quantity of water consumed and bedding composition [30]. In the province of Maputo in 2018, the estimate is the generation of approximately 123,6162 tons of litter [31]. Poultry farmers in Maputo province have used sawdust for the composition of the birds, due to the ease of access to this material, available from several carpenters that supply these wood particles. However, currently, there is a shortage of sawdust and consequently high costs for that material. For Fiorentin [25], to minimize this cost, poultry farmers can reuse the bedding for up to 6 cycles, if sanitary problems that could compromise the health of the next batch are not detected.

In contrast, in the Maputo region, the sale of manure is an important factor in aggregating income for poultry farmers since this by-product is valued in the market for soil fertilization. As shown in Table 15, the application of manure in fertilization is the destination for this by-product and almost 70% of farmers are selling the manure to the farmers for soil fertilization.

It must be emphasized that the simple application of manure without previous treatment (e.g., fermentation) and applied in appropriate quantities, can pose risks to human health, damage to the environment, pollute the soil and water bodies due to the presence of nitrogen, phosphorus, and microorganisms such as *Salmonella* and *Escherichia coli*. The objective is not the ban on the use of chicken manure, but its proper application.

Dead bird carcasses: It was also clear that the management of dead birds' carcasses is another perceived environmental risk of the poultry production in the region. Incineration is the most common method in the region, yet it has drawbacks, including high fuel costs and even possible greenhouse gas emissions as suggested by different studies [32]. Composting offers a more sustainable alternative that does not pollute air or water and results in organic fertilizer that can be used for agricultural purposes [33]. To minimize environmental impacts, the adoption of composting over burial or incineration is recommended (Rodón, 2008).

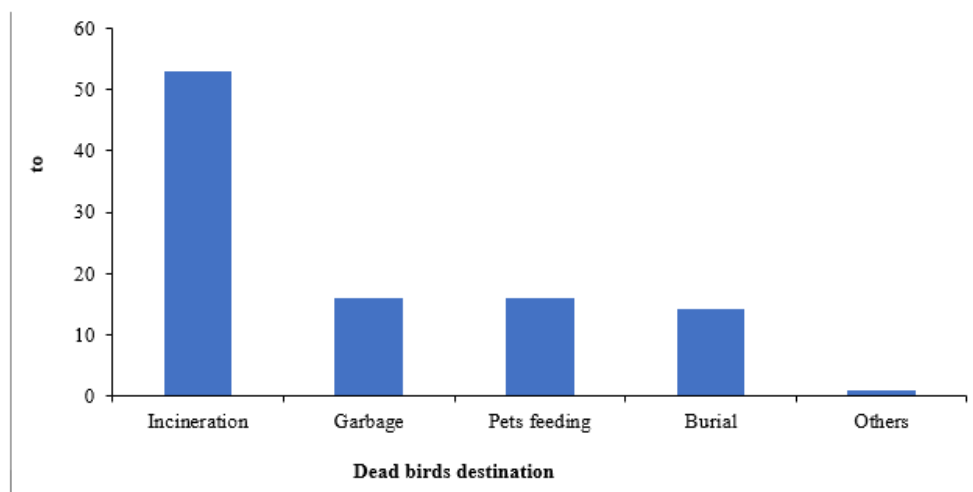
Animal welfare and animal health: The criteria for animal welfare and health display mixed outcomes. Although positive impacts arise from safety precautions and preventive health measures, overcrowding, and inadequate facilities compromise animal welfare [34]. Insufficient thermal comfort, exacerbated by poor-quality roofing materials, such as zinc sheets, contributes to heat stress and increased mortality, particularly in hot seasons. Improved farm management practices are necessary to ensure better living conditions and productivity [24].



Table 3: Destination of manure.

Source: Survey data, author computation (2022).

Destination	Number of farmers	Percentage (%)
Sell	17	68
Reuse	0	0
Throw out	1	4
Others	7	28
Total	25	100

**Figure 3:** Dead birds' destination.

Source: Computed from farm's survey (2019).

Atmospheric emissions and noise: There is a general perception among the different stakeholders that exist a serious environmental regarding the production practices on the odours and dust which may contribute to the greenhouse gases emissions (FAO, 2013). According to Ávila (2007) and FAO [24], odours and dust from poultry farms pose health risks to both humans and birds, necessitating the implementation of proper ventilation systems and routine facility maintenance. Effective environmental management practices are required to mitigate these emissions and their associated impacts [5].

Greenhouse gas emissions: There was difficulty in indicating the direction of the coefficients of change, with discrepancies between the actors, some considering that the activity has an impact on the environment and others not. These impacts go unnoticed by producers, but they exist and are acting negatively on the environment [10,35]. For development countries the challenge with possible greenhouse gases emissions is high as there is a lack of awareness and poor sustainable management practices to properly handle the activities which are related to emissions [36].

Odors and dust: The indicators of odors and dust, due to the sanitary management used, showed a moderate increase, and are considered natural by the poultry farmers. However, some production units have characteristic odors due to the production of gases from bird feces such as ammonia, carbon monoxide, and dioxide. During fieldwork, poor production management was observed in some areas, such as the presence of dead bird carcasses and wet litter caused by the high density of animals, thus causing odors in the production unit. To minimize these emissions, the ventilation system in the facilities must be better and the facilities must be clean, without accumulation of waste [12,13,29].

Trends of Socio-environmental Impacts in the Poultry Value Chain

In Maputo region, poultry production brought negative effects on ecological performance, a common consequence of livestock activities as mostly related to the use of inputs, such as veterinary drugs and poor feed quality. Also in the ecological performance, the criteria of emissions to the atmosphere with an index equal to 3.84 was evaluated positively, although this criterion has shown greater divergences of opinion among poultry farmers about the greenhouse gases impact. Some farmers justify the smaller scale of production and practices management employed on their premises to reduce the negative impact. states that gas emissions can cause health risks to workers and the birds themselves. Poultry workers may lose olfactory sensitivity and develop eye ulceration after long and repeated exposures to these odors [37]. The emission of gases interferes with the quality of air in the surrounding areas of poultry facilities [38].

The socio-economic performance of poultry production in a region is clearly positive. The sector has demonstrated significant contributions to the following socio-economic indicators: Income generation and diversification, Employment creation, Food security, and Institutional relationships [39-42]. Among the criteria evaluated, income generation, with an average index equal to 9.3 (the highest average in all criteria as shown in Figure 8, is no doubt the most important. Other indicators showing positive effects were those related to food security and institutional relationships. The criteria of product quality index is equal to 3.09 and have a smaller amplitude, and with negative indicators in these criteria, discrepancies were also observed among the poultry farmers. Despite the diversity of opinions, the positive impacts of the animal welfare criterion (index equal to 5.99) due to safety



precautions and preventive sanitary management, had a marginal influence [43-48]. For the qualification and job offer criterion, it was observed that workers with low qualifications were hired in the permanent regime along with some temporary ones to assist in the sanitary and feeding management of the chickens. It was also observed that the professional technicians were mostly hired on a temporary regime.

The marketing criteria have a positive effect (index 5.01) although there are discrepancies among the poultry farmers, some pointing out negative values for this criterion due to the difficulties they have faced with the sale of their product. The waste disposal criteria (index 5.73) showed variations among ADAM members due to the selective use of waste programs. The activity demands quantities of droppings, dead bird carcasses, and dust and odors [49-53].

Some of the actions that can be taken to adapt to these negative impacts include:

- a. The reduction of ammonia concentration (bedding moisture control and improving ventilation in the premises).
- b. Planning and zoning of poultry facilities (own space for the practice of poultry production).
- c. Use of chicken manure in soil fertilization, balancing nutrients, and soil capacity.
- d. Reuse of litter if sanitary problems are not detected, especially in regions where this resource is not used as soil fertilizer.
- e. Use of biosecurity practices

Conclusions and Recommendations

Conclusions

In conclusion, the study indicates that there is a positive socio-economics effects in income generation and diversification, employment creation, and food security while identifying possible environmental risks associated to the production practices such as the use of veterinary inputs and waste disposal. The income generation and diversification, employment creation and entrepreneurship are the most significant socio-economics effects of the sector in the region. This indicate that poultry can be considered as a sector facilitating the development of the local economy and empowering the disadvantaged groups such as youth and women. However, the intensification of the poultry activity has rising environmental concerns among stakeholders and brought perceived risks with the intensive use of veterinary inputs, with a negative average impact score of -5.55 and waste disposal management practices. This suggests that there is lack of knowledge on good production standards and poor management of the production process which affects the technical efficiency of poultry production in the region.

Recommendations

Considering the results of the present study, the poultry production needs to adopt good productions practices following technological sustainable production standards to minimize the perceived environmental risks while maximizing the demonstrated possible positive effects in the socio-economic dimension. Therefore, a setting of strategies to promote good production practices and proper management of production through a clear awareness of the production requirements, management practices which may include planning, budgeting and the establishment of partnerships.

Supplementary Materials

The following supporting information can be downloaded at: www.mdpi.com/xxx/s1, Figure S1: title; Table S1: title; Video S1: title.

Author Contributions

Conceptualization, João Chunga.; Formal analysis, João Chunga; Investigation, João Chunga; Methodology, João Chunga, L. Mira da Silva & F. Soares; Supervision, L. Mira da Silva & F. Soares; Visualization,

João Chunga; Writing—original draft, João Chunga; Writing—review & editing, João Chunga, L. Mira da Silva & F. Soares. All authors have read and agreed to the published version of the manuscript.

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References

1. INE (2019) Anuário Estatístico (Statistical yearbook).
2. Mader (2022) Plano Estratégico para o Desenvolvimento do Sector Agrário. Ministry of Agriculture and Rural Development (PEDSA II 2020-2030).
3. Mader (2022) Plano Nacional do Investimento do sector Agrário. Ministry of Agriculture and Rural Development (PNISA II 2022-2026).
4. INE (2022) Anuário Estatístico (Statistical yearbook).
5. Oppewal Jorrit, Alberto Cruz, Vasco Nhabinde (2016) Estudo Sectorial: Cadeia de Valor de Frango em Moçambique. Maputo: Ministério de Economia e Finanças.
6. Bah E, O Gajigo (2019) Improving the Poultry Value Chain in Mozambique. Working Paper Series N° 309, African Development Bank, Abidjan, Côte d'Ivoire.
7. FAO (2021) Africa Sustainable Livestock 2050: Women and biosecurity practices in urban and periurban poultry value chains-Evidence from Kenya and Uganda. Rome.
8. Nicolau Q, Borges A, de Souza J (2011) Cadeia produtiva avícola de corte de Moçambique: Caracterização e Competitividade. Revista de Ciências Agrárias 183-198.
9. Chunga João, Luis Mira Silva, Fernando Brito Soares (2023) Poultry Value Chain Performance Measurement Using Stochastic Frontier Analysis in Mozambique, Maputo Region. Economies 11(8): 214.
10. Graham MW, Butterbach Bahl K, du Doit CJL, Korir D, Leitner S, et al. (2022) Research Progress on Greenhouse Gas Emissions From Livestock in Sub-Saharan Africa Falls Short of National Inventory Ambitions. Front Soil Sci 2: 927452.
11. Himu Homaira Afroz, Asif Raihan (2023) A Review of the Effects of Intensive Poultry Production on the Environment and Human Health. Journal of Veterinary Science and Animal Husbandry 11: 2.
12. Nowak, Adriana, Katarzyna Matusiak, Sebastian Borowski, Tadeusz Bakula (2016) Cytotoxicity of Odorous Compounds from Poultry Manure. Int J Environ Res Public Health 13(11): 1046.
13. Kumar Atul, Anil Patyal (2020) Impacts of intensive poultry farming on 'one health' in developing countries: challenges and remedies. Explor Anim Med Res 10(2) (2020):100-111. Exploratory Animal and Medical Research 10(2) 2020.
14. Liang Y, H Xin, A Tanaka, SH Lee, H Li, et.al. (2003) Ammonia emissions from U.S. poultry houses: part II-layer houses. Research Triangle Park NC October p. 12-15.
15. Rodrigues G, Buschinelli C, Rodrigues I, Monteiro R, Viglizzo E (2006) Sistema de base para avaliação e Eco certificação de actividades rural.
16. Rodrigues G (2015) Avaliação de impactos sócioambientais da tecnologia na Embrapa. Jaguarina, Embrapa meio ambiente
17. FAO (2022) Africa Sustainable Livestock 2050: Biosecurity and public health practices along the poultry value chain in Kenya. Evidence from Kiambu and Nairobi City Counties, Rome.
18. GARCES A, MARTINS I (2006) Texto de apoio de avicultura. Faculdade de Veterinária, Universidade Eduardo Mondlane.
19. Lana G (2000) Avicultura Recife: UFRPE.



20. Nicolau, Q (2008) Análise das transformações técnicas produtivas da avicultura de corte em Moçambique: Do estado estruturante ao liberalismo económico, Jaboticabal-SP.
21. Silva C, Saes M (2005) Estruturas e características da cadeia de valor a partir do tipo de governação: avaliação preliminar da avicultura paranaense. Informe GEPOC Toledo 9(1).
22. GUSSELE M (2018) Avaliação do comportamento térmico de pavilhões de produção de frangos em Moçambique.
23. CORREA GS, GOMES AVC, SALES AS (2003) Utilização de antibióticos e probióticos como promotores de crescimento na alimentação de frangos.
24. FAO (2019) Food production and trade database.
25. FIORENTIN L (2005) Reutilização da cama de frangos e as implicações de ordem bacteriológica na saúde humana animal.
26. GARCES A, MARTINS I (2006) Texto de apoio de avicultura. Faculdade de Veterinária, Universidade Eduardo Mondlane.
27. Dili Ramces M, Ruthra Mae B Kalaw, Anne Dominique L Miguel, Gloria M Ting (2022) Analysis of Environmental Impact and Waste Management of Egg Poultry Industry in the Philippines: A Case of San Jose, Batangas. *Journal of Sustainability and Environmental Management (JOSEM)* 1(2): 188-196.
28. Oliveira MD, Sousa FC, Saraz JO, Calderano AA, Tinôco IFF (2021) Ammonia Emission in Poultry Facilities: A Review for Tropical Climate Areas. *Atmosphere* 12(9): 1091.
29. Viegas S, VM Faísca, H Dias, A Clérigo, E Carolino, C Viegas (2013) Occupational exposure to poultry dust and effects on the respiratory system in workers. *Journal of Toxicology and Environmental Health* 76(4-5): 230-239.
30. PALHARES J (2005) Novo desafio para avicultura: a inserção das questões ambientais nos modelos produtivos brasileiros.
31. Masa (2019) Relatório anual da produção pecuária de Moçambique. Apresentado em conselho coordenador do ministério Maputo.
32. Rondón E (2008) Tecnologias para mitigar o impacto ambiental da produção de frango de corte. *Revista Brasileira Zootécnica*.
33. Medeiros P (2008) Produção Avícola: subsídios na busca de alimentação saudáveis económicos e de menor impacto ambiental. Universidade Federal de Santa Catarina (2008) *Desertion de Mestrado em Agroecosystems*.
34. Gbotosho Oluwabukola, Peter JA Burt (2013) Environmental and health impacts of poultry manure disposal methods: a case study of Lagelu and Egbeda local government areas in Oyo State, Nigeria. *International Journal of Agricultural Sustainability* 11(1): 38-51.
35. Brouček Jan, Bohuslav Čermák (2015) Emission of harmful gases from poultry farms and possibilities of their reduction. *Ekológia (Bratislava)* 34(1): 89-100.
36. MacLeod, M, P, Gerber, A Mottet, G Tempio, A Faluccci, et.al. (2013) Greenhouse gas emissions from pig and chicken supply chains-A global life cycle assessment. Food and Agriculture Organization of the United Nations (FAO) Rome.
37. PALHARES, J (2011) Impacto ambiental da produção de frangos de corte - Revisão do cenário brasileiro. Documento 149 Embrapa.
38. Martin Hilmi, Frands Dolberg, Robyn Alders (2004) *Diversification booklet number 3* Second edition Martin Hilmi, Frands. Dolberg and Robyn Alders Rural Infrastructure and Agro-Industries Division Food and Agriculture Organization of the United Nations Rome (2011) *Products and profit from poultry*.
39. CORREA J, MIELE M (2011) A cama de aves e aspectos agrónómicos, ambientais e económicos.
40. da Conceição Nicolau Quintília, Ana Claudia Giannini Borges, José Gilberto de Souza (2011) Cadeia produtiva avícola de corte de Moçambique: Caracterização e Competitividade. *Revista de Ciência Agrária* 34: 183-98.
41. Drozd Danuta, Katarzyna Wystalska, Krystyna Malinska, Anna Grosser, Anna Grobelak, et al. (2020) Management of poultry manure in Poland-Current state and future perspectives. *Journal of Environmental Management* 264: 110327.
42. FAO (2013) Poultry Sector Mozambique. FAO Animal Production and Health Livestock Country Reviews No 5, Rome.
43. Gbotosho Oluwabukola, Peter JA Burt (2013) Environmental and health impacts of poultry manure disposal methods: a case study of Lagelu and Egbeda local government areas in Oyo State, Nigeria. *International Journal of Agricultural Sustainability* 11(1): 38-51.
44. GUEYE EF (2002) Employment and income generation through family poultry in low-income food-deficit countries. *World's Poultry Science Association 2002 World's Poultry Science Journal* 58(4): 541-557.
45. Karnani A, K McKague (2014) Job creation in the Mozambican Poultry Industry.
46. MINAG (2016) Plano Operacional para o Desenvolvimento Agrário. Ministry of Agriculture (PODA 2015-2016).
47. MINAG (2012) Trabalho de Inquérito Agrícola. Ministério da Agricultura e Desenvolvimento Rural Maputo: Mozambique.
48. OPPEWE J, DA CRUZ e, NHABINDE (2016) Estudo sectorial: cadeia de valor de frango em Moçambique. Ministério de Economia e Finanças Maputo.
49. Rodrigues G, Buschineli C, Avilaa (2017) An impact assessment system for Agricultural Research and Development. *Institutional Learning Experience at Embrapa. Journal of Technology management and innovation* 5(4).
50. Rodrigues G, Martins C, Barros I (2020) Assessment of Economic and environmental performance in citrus-based intercropping system. *Revista Brasileira de Fruticultura*.
51. Rodrigues G, Buschinelli C, Rodrigues I (2007) Environmental impact of biodiesel production in Brazil.
52. Silva PL (2006) Segurança alimentar e legislação na produção. In simpósio Brasil Sul de Avicultura Concórdia.
53. Vernooij, Adriaan, Mena dos Anjos, Joep van Mierlo (2016) *Livestock Development in the Zambezi Valley Mozambique: Poultry, Dairy and Beef Production*. Wageningen UR (University and Research). Centre for Development Innovation. Report CDI-16-027. Wageningen.

