



International Journal of Environment and Sustainable Development

ISSN online: 1478-7466 - ISSN print: 1474-6778
<https://www.inderscience.com/ijesd>

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DOI: [10.1504/IJESD.2022.10052369](https://doi.org/10.1504/IJESD.2022.10052369)

Article History:

Received:	20 October 2021
Accepted:	27 September 2022
Published online:	03 April 2023

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Abstract: Market opportunities and improved demands for sustainable production and consumption highlight the importance of engaging smallholder farmers. This study aims to understand the transition towards sustainability through the perception about the value created and appropriated of small poultry farmers who supply a company that practices Nature Farming, in a

vertical integration system. The authors adopted a system of indicators (Ambitec-Agro, assessment of the impact of technological innovations in agriculture) and used content analysis software (ATLAS.ti) to assess farmers' perceptions. The results suggest that the transition to sustainable production creates capacities to add value, mainly from social and economic perspectives. In addition, the relational value has a strong influence on this dynamic. The study contributes by proposing an application of methodology based on mixed methods to identify the perceptions of smallholder farmers about created and appropriated value in migrating from an input-intensive production to a sustainable system, offering opportunities for improvement in traditional supply chains.

Keywords: poultry production; shared value; sustainable farming; value perception; relational value; vertical integration system.

Reference to this paper should be made as follows: Demattê Filho, L.C., de Carvalho, Í.C.S., Mendes, C.M.I., Nascimento, R.A. and Vieira, L.M. (2023) 'Assessing smallholder farmers' perception of value creation and appropriation in sustainable production', *Int. J. Environment and Sustainable Development*, Vol. 22, No. 2, pp.226–253.

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1 Introduction

Governments, researchers, entrepreneurs, and social actors will have to adopt transdisciplinary approaches involving science, society, and industry to respond to the challenges of sustainability in world food production following the United Nations 2030 Agenda (Dekker et al., 2020). Smallholder farmers, however, lack the financial resources and access to information to enable their participation in sustainable agri-food chains, which in turn submits them to competitive disadvantage relative to large farms (Dicecca et al., 2016; Liang et al., 2021).

The demand and pressure for sustainable production and consumption highlight the importance of engaging smallholder farmers in sustainability. Zhu and Habisch (2020) reinforce the opportunity to accelerate smallholder farmers' engagement in improved farming practices as exemplified in a study about non-certified organic production in China.

Some alternatives towards sustainable production are comprised of public or private quality assurance and conformity mechanisms and protocols, which introduce differentials in production, governance structure, and supply chain management of those firms that are leading this trend in the agri-food sector, especially in developing nations (Henson and Humphrey, 2010; Vieira et al., 2013). Moved mainly by the demand for solutions that address the sustainability of their production systems, and often interested in the economic aspect, smallholder farmers are looking for inclusion in sustainable supply chains (Glasbergen, 2007; Schouten et al., 2012). The role of palm oil's West African smallholders in addressing sustainable practices, in contrast with large scale mono-cropping plantations mostly in East Asia, has been recognised as a good example. Led by government policy and international schemes, the sustainable approach by the first has been cited as a successful example, in a sector where sustainability is a hot topic (Begum et al., 2019).

The literature demonstrates the various benefits associated with sustainable production, especially in food industry agents that are protagonists in the decision-making process. In rural spaces, relationships beyond the exclusively commercial tend to thrive, ensuring a relational dynamic based on exchange of experiences and know-how. The expansion of new and sustainable ways of production, addressing health, environmental preservation, maintenance of rural culture and social values have stimulated the development of differentiated farming systems (Muchnik et al., 2008; Zhu and Habisch, 2020). In addition, such relationships are a source of value creation and appropriation (Vieira et al., 2013) that can empower smallholder farmers and improve their awareness of sustainability. Pronti and Coccia (2020) found that agroecological farming systems can support small local farmers to diversify income and improve environmental sustainability.

The present study illustrates the case of Brazilian smallholder farmers that are suppliers of broilers reared in certified sustainable farming systems guided by the values of Mokichi Okada (Japan, 1882–1955). This group of farmers are part of a vertical integration system characterised by:

- 1 not using antibiotics and growth promoters
- 2 not using genetically modified ingredients and animal by-products in feed
- 3 ensuring greater animal welfare
- 4 improving the environmental standards in the farms as a means to achieve better animal health and ensure compliance with environmental regulations (Demattê Filho et al., 2015).

This study aims to contribute to the understanding of the transition towards sustainable farming by proposing the application of an integrative methodology for assessing value creation and appropriation through the perception of farmers.

The choice of the poultry sector comes from its socio-economic relevance in Brazil. The country is one of the three largest producers and the leading exporter of chicken meat, with revenues of US\$6.994 billion in 2019 (Brazilian Association of Animal Protein, 2020). However, the sector faces challenges in ensuring environmental improvements and is criticised for poor animal welfare standards and the intensive use of antibiotics (Bessei, 2019).

In Section 2, we review the literature on value creation and appropriation and the importance of measuring impacts for small farmers in a sustainable supply chain. Then, we present the Ambitec-Agro indicators system (Rodrigues et al., 2010). Section 3 details our integrative methodology, and Section 4 describes the empirical results of interviews and data analysis. Finally, we conclude with practical considerations and research recommendations.

2 Literature review

2.1 Value creation and appropriation in supply chain management

The value approach is one of the most relevant aspects of corporate business strategy. The differentiation strategies of firms in the agri-food sector are an important way of creating and delivering value (Berti and Mulligan, 2016; Henson and Humphrey, 2010; Neutzling et al., 2018; Vieira et al., 2013), considering the significant diversity that exists in the value concept in different areas. The literature about value has not been completely clear in its conceptualisation in business relationships, and firms are frequently unable to define it. Importantly, there is no consensus on what constitutes a value proposition (Lindgreen and Wynstra, 2005).

Value creation is associated with a competitive advantage linked to activities structured or developed within and outside organisational boundaries. Value appropriation is related to the organisation's ability to capitalise on the competitive advantage and absorb the value created by cooperative interactions (Burkert et al., 2017; Chou and Zolkiewski, 2018). In the field of organisations, all aim to create and deliver more value than their competitors, and to do it, plan their value strategies (Lindgreen and

Wynstra, 2005). There are many topics of interest in research and in theories that support the analysis of the creation and delivery of value (Bowman and Ambrosini, 2000).

In the field of strategy and operations, finding the most valuable and appropriate suppliers represents a substantial contribution to the creation of value (Kähkönen and Lintukangas, 2012). Several studies addressed open and collaborative structures, intangible resources, and regional dynamics in the value proposition in business administration (Brito and Miguel, 2017; Lindgreen and Wynstra, 2005; Peteraf and Barney, 2003).

The suggestion that the buyer has a more collaborative relationship with farmers offers an opportunity for analysing the relational value experienced by integrated producers (Kleinaltenkamp, 2015). According to Porter's theory of value creation, differentiating the production system generates products with specificities that access niche markets and constitutes value creation (Kähkönen and Lintukangas, 2012).

According to Porter and Kramer (2011), shared value is created when companies generate profits while also delivering tangible benefits for society. Unlike fair trade, which promotes the redistribution of income to farmers, shared value seeks to improve the company's competitiveness and to identify connections between social and economic progress, thereby improving the living conditions of the community in which the firm operates (Porter and Kramer, 2011). Creating shared value is an integral part of the competitiveness and profitability of the strategy of the business and, in this sense, it surpasses corporate social responsibility.

2.2 Developing and measuring sustainable agricultural supply chains

We adopted the concept of sustainable supply chain management (SSCM), defined as the management of inputs within the company and collaboration between companies along the supply chain, while simultaneously considering all three dimensions of sustainable development required by customers and other stakeholders (Seuring and Müller, 2008). This concept may represent important changes in management, from the relationship with the supplier to the consumer, and can improve organisational performance and strengthen common purposes of shared value along the supply chain (Ahi and Searcy, 2013; Sharfman et al., 2009).

The concept of sustainability adopted in this paper derives from the triple bottom line (TBL), a perspective that includes the social, environmental, and economic dimensions, based on long-standing partnerships, sharing of knowledge and sustainable business models (Elkington, 1997). Although TBL has been the most known approach since the 1990s, it has been critically revised recently, highlighting the importance of expanding the limited accounting and economic perspective practiced in the corporate world, requiring a more cautious look at the well-being of people and the planet (Elkington, 2018). Various organisations still face the lack of a comprehensive management framework to address, balance and integrate the pillars of TBL (Jamali et al., 2006).

The transition towards environmental sustainability seems inevitable since everything indicates that we are reaching the limit of our resources and the resilience of ecological systems (Rockström et al., 2009). Producers/suppliers play an important role in preserving the environment, social cohesion, and territorial balance: producing special quality food, increasing biodiversity, keeping the social reproduction of their families, and expanding diversity in the rural landscape (Muchnik et al., 2008; Pecqueur, 2013).

According to the UN (2007) Environment Programme, indicators and indices are 'information packages' that aim to assess and assist our understanding of different phenomena and the performance of public agencies. Gross domestic product (GDP) is a well-known index, developed at the beginning of the 19th century to measure the growth of nations but using a purely economic focus. Environmental indicators gained relevance after Rio-92, but they have been used since the 1980s (UN, 2011).

Measures for assessing social aspects after the introduction of any change should capture impacts that range from satisfying basic needs to improving the quality of life of people involved in rural activities. In conjunction with indices that cover other dimensions, these indicators should be able to help decision-makers choose the best options for practices that involve the management and/or adoption of technologies aimed at sustainably developing agricultural production (Rodrigues et al., 2010).

2.3 An assessment of the perception of small producers as to the social, economic, and environmental impacts

The Ambitec-Agro method is used in this study as a tool for collecting data by way of field observations and interviews with vertically integrated poultry farmers, to understand how they perceive their transition towards sustainable production, and to inquire about their capacity to capture value in their relationship with the buyer. Developed by the Brazilian Agricultural Research Corporation (Embrapa), it has been used as a consolidated tool since 2003 in rural establishments (Rodrigues et al., 2007). It is based on descriptive electronic spreadsheets, which include social, economic, and environmental aspects. In a practical and low-cost way, it aims to assess the changes in the socio-environmental performance of rural establishments when they adopt a particular technology, in order to help both the producer and the agro-industry with their decisions (Rodrigues et al., 2010).

This method is arranged in integrated modules of socio-economic and environmental indicators and comprises multi-criteria weighting checklists. These include 148 indicators, integrated in 27 criteria distributed across seven aspects related to the impacts resulting from the adoption or implementation of technology in rural activities (Rodrigues et al., 2003, 2010). The impacts are considered into two dimensions:

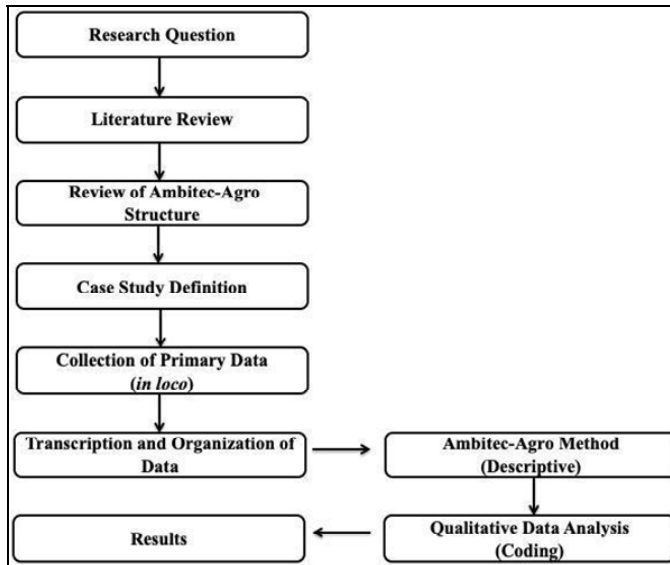
- 1 the ecological impacts, comprising
 - a technological efficiency
 - b environmental quality
- 2 the socio-economic impacts, comprising
 - a respect for the consumer
 - b employment
 - c income
 - d health
 - e management and administration.

Several scientific publications used Ambitec-Agro for assessing either technical and economic feasibility, or environmental and social impacts (Figueirêdo et al., 2010a, 2010b; Novo et al., 2013; Porto et al., 2021; Rodrigues et al., 2003).

3 Method

The study uses a mixed method, in which the quantitative step was responsible for analysing the indicators that influenced the process by which the smallholder farmers transitioned from a traditional poultry-raising method to a sustainability-driven model. The qualitative stage presents a case study of broiler producers working in an alternative integrated system located in the State of São Paulo. The unit of analysis of the study is the smallholder farmers' perceptions about the changes (improvements, impacts) in the production process consequential to the recommendations prescribed by the buyer company.

Figure 1 Methodological organisation of the study



Source: The authors

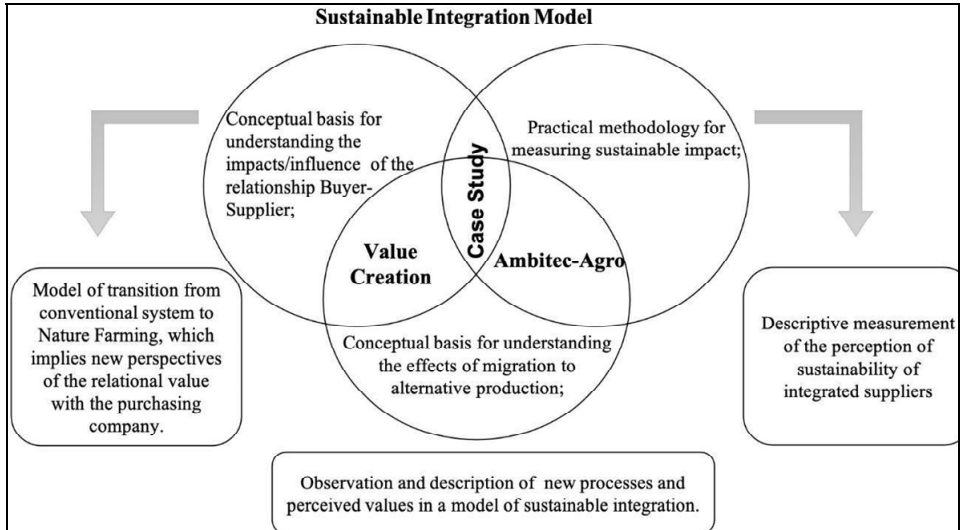
A case study can contribute greatly towards revealing the relationships between the agents of a given, real-world system, allowing for a wealth of understanding regarding inferences and analogies, which would often be difficult to find otherwise. It also follows a protocol about the study organisation, ensuring the quality and transparency of the evidences. A case study offers dynamics that involves theories, structures, and events. It links not only the theoretical aspects but also the reality and functioning of structures in the field. Therefore, it allows a better understanding about the 'how' and 'why' of the relationships between buyer and smallholder farmers (Barratt et al., 2011; Eisenhardt, 1991; Stuart et al., 2002; Yin, 2002). The sequential organisation of the methodology is shown in Figure 1.

3.1 Development of the sustainable integration model

The initial model focused on the transition dynamics of the production system, from a conventional approach to the nature farming system (Xu, 2008), practiced by a poultry processing company and prescribed to the participating smallholder farmers. We were

able to establish how producers perceived sustainability and the new types of organisational value that exist for them and for the integrator itself, be it relational, structural, informational, etc. To do so, we aligned the parameters applied in the Ambitec-Agro method with the concepts of value creation and sustainable chains, as can be seen in Figure 2.

Figure 2 Analytical framework



Source: The authors

Our model was based on the three sustainability dimensions included in Ambitec-Agro:

- a ecological
- b social
- c economic.

The model implies a relationship between smallholder farmers and the poultry company as buyer that transcends strictly market issues, incorporating the conceptual issues that each type of production proposes to those participating in the integrated production system.

Ambitec-Agro was used as a practical reference to foster the understanding of the value creation and appropriation by the smallholder farmers during production system transition and respective ongoing processes. The use of indicators enabled an assessment of the production strategies that promoted efficiency and effectiveness based on the nature farming prescriptions.

3.2 Case selection

The Nature Farming model is based on the writings and guidelines proposed by Mokichi Okada (1882–1955), a Japanese thinker who produced extensively on matters related to culture, economics, education, morals, arts, medicine, religion, and agriculture. Okada considered agriculture as a pillar of support in an ideal society free of disease,

poverty, and conflict. He emphasised the relevant role that farmers play in society, contributing to the health and well-being of people in producing food in accord with the principles and functions of nature, enabling them to build a world in which health, peace, and prosperity predominate. The model has a theoretical basis that favours human health, social responsibility, preservation of the environment, and nature-based practices, thereby meeting the expectations of a growing number of consumers worldwide (Xu, 2008). Spreading this understanding among consumers makes them actors in the process of constructing ideal conditions in the rural environment, naturally expanding the limits of the SSCM in question.

Table 1 Feed conversion, feed and broiler production costs, housing density, pasture area and price of products in different poultry raising systems in São Paulo State, Brazil

	<i>Feed conversion</i>	<i>Feed cost²</i>	<i>Broiler production cost²</i>	<i>Housing density²</i>	<i>Pasture area</i>	<i>Wholesale price</i>
<i>Housing systems</i>	<i>Feed consumption (kg)/weight gain (kg)</i>	<i>US\$/kg</i>	<i>US\$/kg broiler</i>	<i>Broiler/m²</i>	<i>m²/broiler</i>	<i>US\$/kg poultry meat</i>
Conventional	1.65	0.41	1.07 ^a	15.6 ^b	0	1.69
Non-GMO and antibiotics free	1.80	0.54	1.21	12	0	2.85
Free range ¹	2.74	0.54	1.75	10	0.5	4.07
Certified organic	1.75	0.65	1.53	10	0.4	3.54

Notes: ^aEmbrapa Swine and Poultry (2022).

^bBrazilian Association of Animal Protein (2016).

¹slow-growing poultry breeds.

²average weight of 2.5 kg/broiler.

Source: Adapted from data by Korin's veterinary team, interviewed in June 2022

The company denominated buyer in this case is a poultry industry, which is based on the Nature Farming model. It has created innovative processes for animal husbandry and became Brazil's main special food brand. Since 1994, it has developed the production of broilers and eggs without using antibiotics, growth promoters, coccidiostats, and other chemical therapies. The company produces feeds free of genetically modified ingredients and animal by-products, slaughters broilers and sells poultry meat to retailers. The firm created an unprecedented certification program for this production and was the first to hold a certification in animal welfare in Brazil. According to Pinheiro et al. (2018), concerning product portfolio management and eco-design, it reached the level of a mature company, due to considerations regarding the environmental performance in its business decisions, and alignment of supplying smallholder farmers to its values.

As explained, Korin has established an integration system to raise broilers and produce eggs in alternative systems, such as: antibiotic and growth promoters free, GMO free and vegetable feeds, high standard of animal welfare, free range and certified organic. On the contrary, conventional production allows using antibiotics, GMO grains, animal ingredients in feeds, more birds in housing, and pasture is not required, for instance. To summarise the changes challenged to the integrated smallholder farmers, Table 1 presents data comparing different poultry raising systems, according to an

interview with Jorge Xavier de Melo, Korin's Veterinary Department, 29 June 2022. Figures for feed conversion, feed cost and cost of rearing broilers are bigger in Korin production compared to conventional system. However, wholesale prices are significantly higher for Korin poultry meat. Lower housing densities and pasture area are indicators of higher standard of animal welfare in Korin production system.

3.3 Data collection

Data were collected using a semi-structured interview script with 21 broiler producers who participate in the integration system and supply the buyer, located in nine municipalities of São Paulo State. At the time of the research, the company integrated 42 poultry farmers and five egg producers. The data were organised and analysed in a quantitative way using the Ambitec-Agro methodology. We later used a qualitative approach that involved a more in-depth content analysis of the case.

Table 2 Summary of description of the ecological performance criteria

Technological efficiency	¹ Direct land use change	Examines changes with potential to improve use of resources or production, such as prevention of fire, production surplus, carbon sequestration and biodiversity.
	² Indirect land use change	Includes use for non-agricultural activities.
	³ Water consumption	Used for animal husbandry and renewability.
	^{4,5} Use of agricultural inputs and resources	Examples are pesticides, chemical fertilisers, raw materials, veterinary drugs and soil conditioners, and natural resources used, such as water and land.
	⁶ Energy consumption	Consumption of fossil or biofuels, biomass, and electricity.
Environmental quality	⁷ Own-generation, utilisation, reuse, and autonomy in the agricultural area	Efficiency using cogeneration of energy, by-products, change of inputs for soil fertility and pest/disease control, and mitigation of impacts in the three previous criteria.
	⁸ Emissions to the atmosphere	GHG, particulate matter/smoke, odours, and noise.
	⁹ Soil quality	Most important actions for soil degradation and fertility loss.
	¹⁰ Water quality	Related to organic load (effluents, sewage, manure, increased biochemical oxygen demand), turbidity, foam/oils/solid wastes, silting up of water bodies, and use in excess of local water.
	¹¹ Biodiversity conservation and environmental reclamation	Biodiversity conservancy, agro-industrial/rural activities to the recovery of degraded soils, reclamation of ecosystems and natural habitats, according to environmental legislation.

Notes: Superscript numbers refer to the criteria available in Figure 3.

Source: Adapted from Rodrigues et al. (2003), Souza et al. (2017) and Porto et al. (2021)

The criteria to select producers were:

- 1 they have worked in partnership with the buyer for more than two years
- 2 they had previous experience in the conventional production of broilers in a vertical integration system
- 3 they have their own installations and work directly with routine practices for producing broilers
- 4 the farmer's main source of income is producing broilers.

All farmers interviewed fulfilled these requirements and had smallholder conditions, counting with family workforce. These criteria are justified for guaranteeing the same producer profile, with conditions that make it possible to compare their perceptions regarding the main impacts generated by their transition from conventional to the alternative broiler production system of which they currently participate.

Care was taken to ensure transparency when collecting and analysing the data:

- 1 data were collected *in loco* by an independent investigator, thus guaranteeing impartiality and transparency
- 2 all the interviews were recorded and transcribed and the producers authorised and signed a detailed term of consent
- 3 the audio recordings and written material have been filed anonymously by the researchers for consultation purposes
- 4 interviews lasted one hour, on average
- 5 whenever possible, we asked the interviewee's family to be present.

3.4 *Data analysis*

Ambitec-Agro was used as the tool for analysing the data, which is interesting from an investigative and exploratory viewpoint because it helped us to understand the smallholder farmers' perception of sustainability and other resources that can be captured in the farmer/company dynamic relationship. Ambitec-Agro considers the experiences of the interviewed farmers, both before and after they had included a particular technology. It identifies and numerically characterises the changes that occurred and that were transmitted by the farmers in their reports. For this study, the new technology is the transition from traditional integrated broiler production to a production system founded on nature farming prescriptions.

The Ambitec-Agro system arranges seven aspects to describe socio-environmental impacts which incorporate 27 criteria comprising 148 indicators (Figure 3). More details on the Ambitec-Agro methodology can be found in Rodrigues et al. (2010), Rodrigues (2015) or Porto et al. (2021).

The perception about the value created and appropriated by smallholder farmers during the transition towards sustainable farming was considered from the change perception in the application of inputs that affect the environment, as well as economic and social issues during the productive cycle. The social and environmental aspects were approached using a local development perspective regarding the evaluation of sustainability in processes of production and management (Monteiro and Rodrigues, 2006; Porto et al., 2021). Interviewed smallholder farmers attributed coefficients to the

indicators, considering changes observed in their transition towards sustainable farming. Tables 2 and 3 describe criteria and indicators.

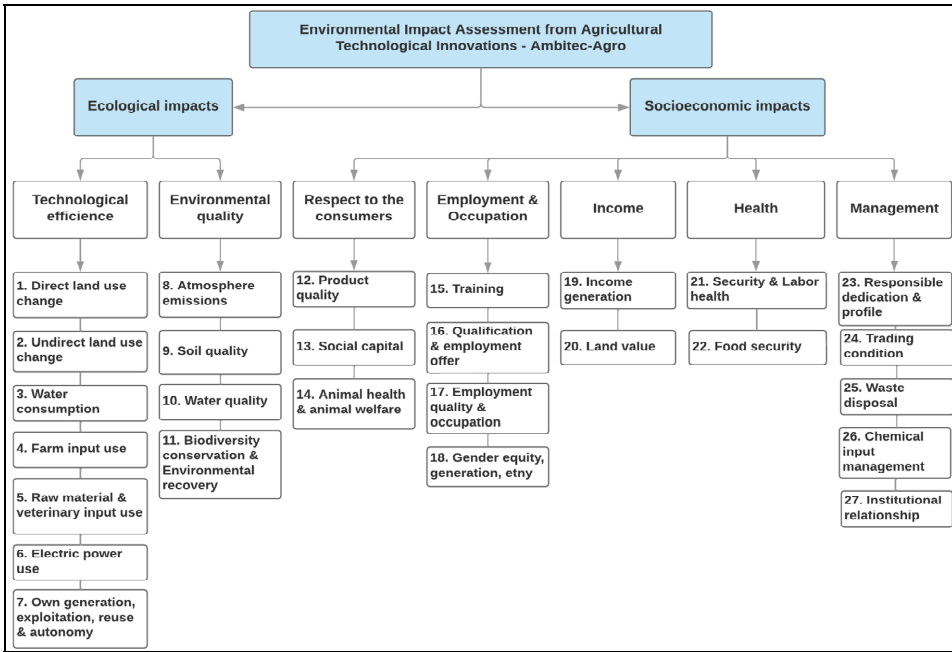
Table 3 Summary of description of the socio-economic performance criteria

Respect to the consumers	¹² Product quality	Examples are chemical residues, biological contaminants, and adequacy of suppliers.
	¹³ Social capital	Cultural interaction between employees and family, participation in social activities, conservation of historical/artistic/cultural heritage, community/environmental education projects, and technology transfer programs.
	¹⁴ Animal health and animal welfare	Related to meeting the animal five freedoms (FAWC, 2009) and legal aspects in organic broiler production (Brasil – Ministério da Agricultura, Pecuária e Abastecimento, 2021).
Employment and occupation	¹⁵ Training	Training of residents of the establishment.
	¹⁶ Qualification and employment offer	Related to qualification for work opportunities, and temporary/permanent hiring.
	¹⁷ Quality of employment/occupation	Minimum wage, maximum working hours, formality and benefits ensured by labour legislation.
	¹⁸ Gender equity, generation, ethnicity	Participation of women, youth and elders, equitable reward, equal opportunities between ethnicities, mutual respect and cultural appreciation.
Income	¹⁹ Income generation	Concerning indicators such as security, stability, amount, diversity of sources and distribution among employees.
	²⁰ Land value	Improvements, protection of natural resources, pricing of products and services, compliance with legislation, infrastructure/tax policy, etc.
Health	²¹ Security and labour health	Exposure to risks and health aspects.
	²² Food security	Access to nutritious quality food (regularity, sufficiency of supply), considering farmers/families, local/regional markets.
Management	²³ Responsible dedication and profile	Training, hours spent on the farm, family engagement, accounting system, formal planning model, certification system/labelling.
	²⁴ Trading condition	Direct/cooperative sales, local processing and storage, transportation, branding, advertising, cooperation with other producers.
	²⁵ Wastes disposal	Recycling and destination of wastes.
	²⁶ Chemical input management	Selective collection, composting, reuse, sanitary disposal, or final treatment.
	²⁷ Institutional relationships	Technical assistance, associations, technological affiliations, and legal services.

Note: Superscript numbers refer to the criteria available in Figure 3.

Source: Adapted from Rodrigues et al. (2003), Souza et al. (2017) and Porto et al. (2021)

Figure 3 Ambitec-Agro (A-A) system and organisation of dimensions, aspects, and criteria (see online version for colours)



Source: Adapted from Rodrigues et al. (2010) and Rodrigues (2015)

Table 4 Impact of the activity and change coefficients of the indicators

<i>Effect of technology innovation under the management conditions studied</i>	<i>Component change coefficient</i>
Major increase in the indicator (>25%)	+3
Moderate increase in the indicator (≤25%)	+1
Indicator unaffected	0
Moderate decrease in the indicator (≤25%)	-1
Major decrease in the indicator (>25%)	-3

Source: Porto et al. (2021, p.6)

Tables 4 and 5 present coefficients and factors utilised in the Ambitec-Agro system [Porto et al., (2021), pp.6–7]. Table 4 presents the values assigned to the indicators’ change coefficients on a Likert-like scale (Brown, 2010). The change coefficients receive weighting factors according to the spatial scale of occurrence of impacts where technological adoption is observed in the Ambitec-Agro system as indicated in Table 5. The system provides some multi-criteria checklists (Figure 4), and Impact Indices are automatically estimated using field data, regarding the indicators’ importance values (*k*) for each criterion, and the indicators’ scales of occurrence in the evaluated farm [Porto et al., (2021), p.7].

Table 5 Weighting factors connected to the spatial scale of occurrence of impacts

<i>Spatial scale of occurrence of impacts on indicators</i>	<i>Weighting factor</i>
Near environment: impact of technology adoption is restricted to the cultivated field, installation or livestock enclosure, or agro-industrial unity	1
Proximate environment: impact extends beyond the 'near' environment, though confined to the limits of the rural or agro-industrial establishment	2
Surrounding environment: observed impact reaches beyond the boundaries of the rural or agro-industrial establishment, affecting neighbouring areas	5

Source: Adapted from Porto et al. (2021, p.7)

Figure 4 Example of impact index calculated with multi-criteria checklist of Ambitec-Agro system: criterion of 'self-generation, utilisation, reuse, and autonomy in the agricultural area' (see online version for colours)

Which changes have been observed in Self-generation, utilization, reuse, and autonomy?								
Self-generation, utilization, reuse, and autonomy in the agricultural area		Variables of self-generation, utilization, reuse, and autonomy					Weighting factor check	
		(co)Generation - motor, electric (solar, wind, hydro, biogas)	Thermal utilization (avoided energy consumption)	Organic fertilizers / manure / compost / organomineral formulations	Green manure / legume N fixation / mycorrhizal inoculation	Biological control / ecological management of pests and diseases		
Weighting factors k		0,3	0,15	0,25	0,15	0,15	1	
Scale of occurrence =	Not applicable	Mark with X						
	Near	1	0	3		0		0
	Proximate	2			3			
	Surrounding	5						
Impact Coefficient = (change coefficients * weighing factors)			0	0,45	1,5	0	0	1,95

Source: Porto et al. (2021, p.7)

Impact indices considered the social and environmental situations of the smallholder poultry farms prior to the transition to sustainable farming and afterward. Ambitec-Agro system proposes the following equations for the resulting indices [Porto et al., (2021), p.4]; equation (1) calculates an impact index for a criterion (I_c) and equation (2) aggregates criteria in the socio-environmental impact index (SII_t) where:

$$I_c = \sum_{c=1}^n (C_{ic} \times S_{ic} \times k_{ic}) \tag{1}$$

I_c social and environmental impact index for criterion c

C_{ic} change coefficient of indicator i in criterion c

S_{ic} weighting factor for scale of occurrence of indicator i in criterion c

k_{ic} weighting factor for importance of indicator i in criterion c

n number of indicators in criterion c .

$$SII_t = \sum_{c=1}^n (II_c \times I_c) \quad (2)$$

SII_t social and environmental impact index for technology t

II_c impact index for criterion c

I_i weighting factor for importance of criterion c in the impact index

n number of criteria.

ATLAS.ti software (version 8) was used to analyse the transcribed data of interviews using the content analysis technique. We were able to systematise the information collected in the field and observe the codes and relational networks that explain the transition dynamics of poultry production systems. This method makes it possible to recognise patterns, discover connections, and organise the data into coherent categories (Sekaran and Bougie, 2016).

Table 6 Protocol of study replication

<i>Criterion</i>	<i>Definition</i>	<i>Application of the criterion</i>
Internal validity	Degree of reliability of the results	<ul style="list-style-type: none"> • Different smallholder farmers with similar characteristics • Presentation of the research question • Presentation of the theoretical reference
External validity	Degree of generalisation of the results in similar scenarios	<ul style="list-style-type: none"> • Specification of the unit of analysis and the context • Description of the case and its context
Reliability	Degree of replication of the study	<ul style="list-style-type: none"> • Presentation of the research protocol and the semi-structured script • Data documentation • Transcription of the interviews • Review by other researchers
Objectivity	Degree of bias of the study	<ul style="list-style-type: none"> • Presentation of the descriptive tables • Presentation of the case selection criterion

Source: Based on Yin (2002)

3.5 Replicating the study

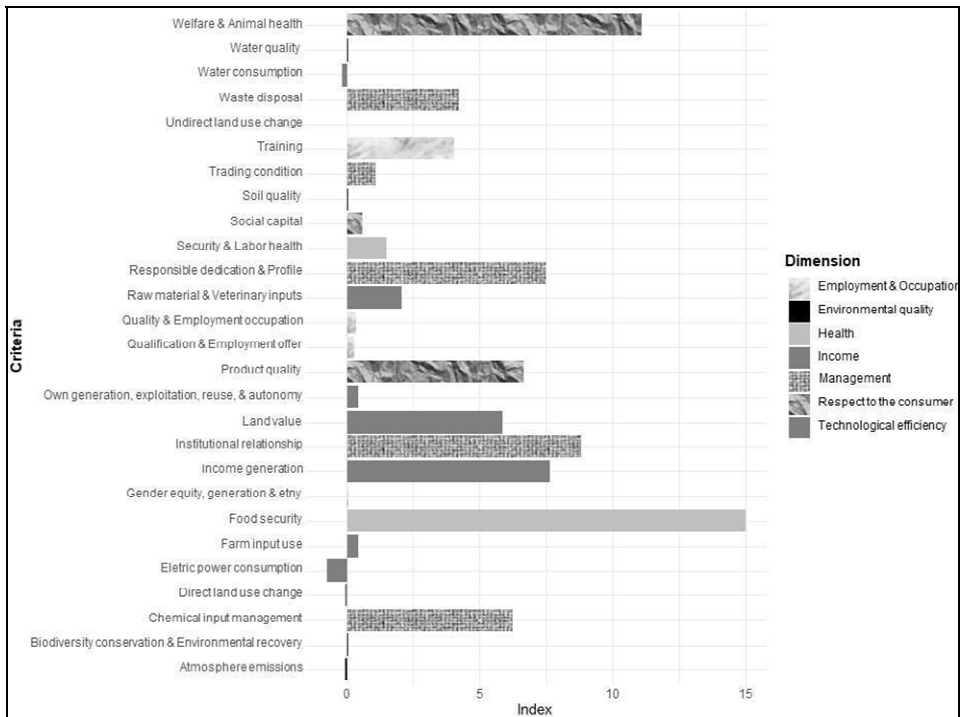
To ensure rigour in the development of the study, a research protocol (Table 6) was carefully documented (Yin, 2002), in which we sought, among other criteria, to interview those smallholder farmers who had had the experience of both production models.

4 Results

4.1 Analysis of the Ambitec-Agro indices

The respondents produce flocks of broilers (<10,000 birds per cycle, with <5 cycles per year) on plots of land ranging from 1.5 to 60 ha. In addition, some interviewees reported producing vegetables and other livestock (i.e., cattle, goats, etc.) on the same property. They also lease adjacent plots for planting sugar cane for sugar and alcohol production mills. The transition of broiler producers from a conventional system to a system based on nature farming has had a greater impact on the social dimension according to the average impact criteria indices proposed by Ambitec-Agro. As shown in Figure 5, the average values of the integrated criteria referring to the ‘environmental quality’ dimension changed positively but were of low intensity ($\mu = -1$ to 0).

Figure 5 Changes in the impact criteria of the social, economic, and environmental dimensions

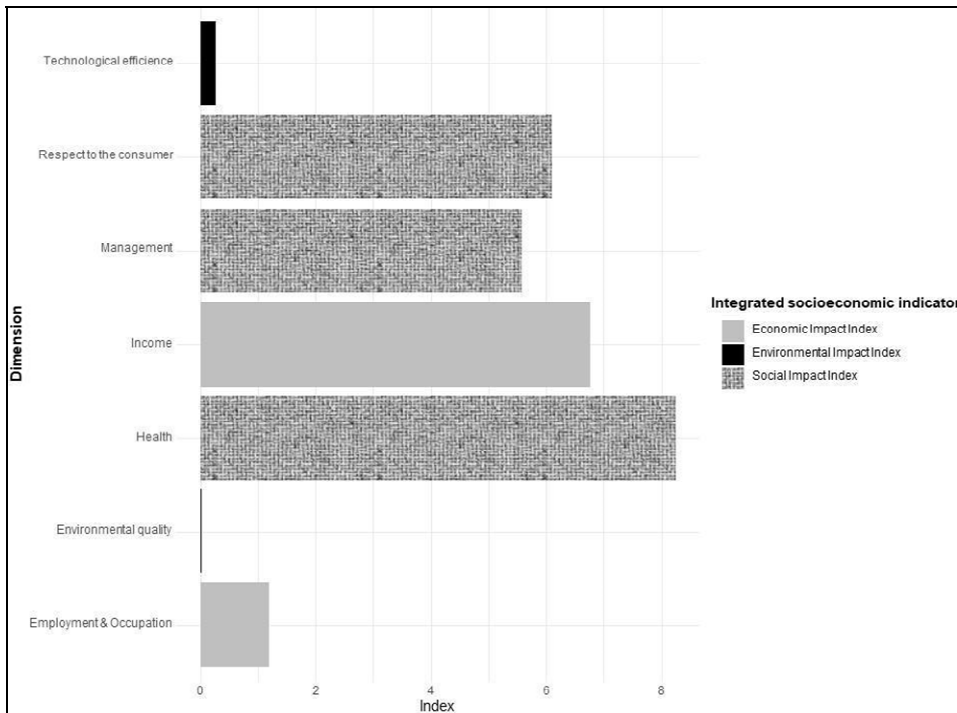


Source: The authors

Notes: In which positive high intensity change (15 to 10); positive moderate intensity change (10 to 5); positive low intensity change (5 to 1); positive very low intensity change (1 to 0); negative very low intensity change (neutral zone; 0 to -1); negative low intensity change (-1 to -5); negative moderate intensity change (-5 to -10); and negative high intensity change (-10 to -15).

Figure 6 presents the results of the integrated impact criteria indices for each socio-environmental aspect considered. The ‘management’, ‘health’, ‘income’, and ‘respect for consumers’ aspects underwent positive changes of moderate intensity, according to the classification criteria we adopted ($\mu = 5.6, 8.3, 6.8,$ and $6.1,$ respectively). The ‘employment and occupation’ aspect, on the other hand, underwent a positive change of low intensity ($\mu = 1.2$). The ‘quality of the environment’ and ‘technological efficiency’ aspects underwent positive changes, also of low intensity ($\mu = 0.0$ and $0.3,$ respectively).

Figure 6 Changes in the three dimensions, according to the methodology proposed by Ambitec-Agro



Source: The authors

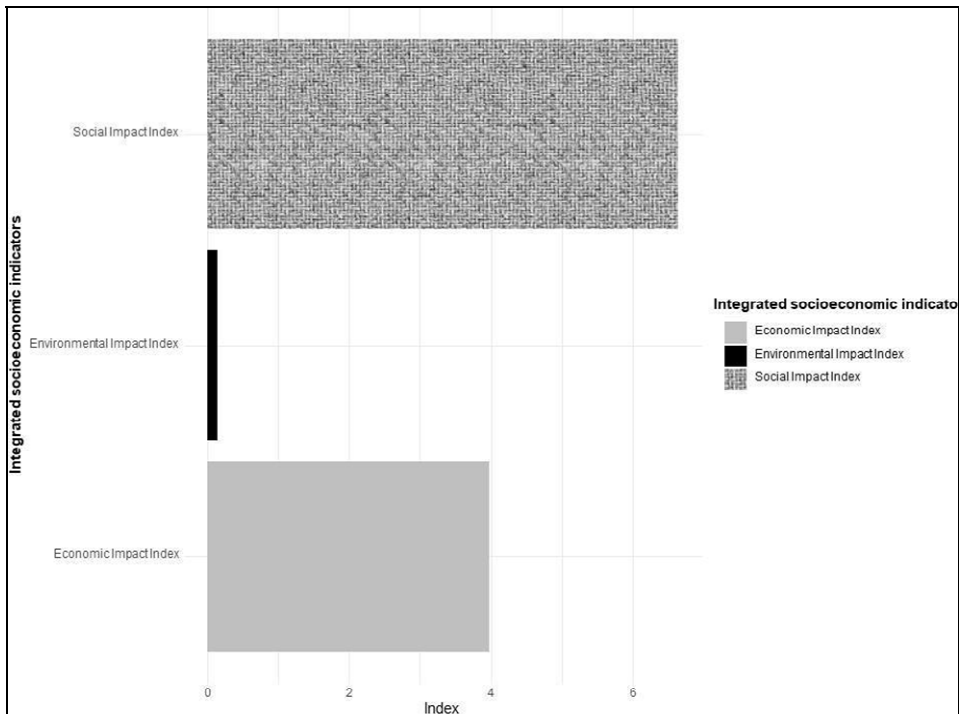
Figure 7 shows that the social impact index underwent a positive change of moderate intensity, while the economic impact index underwent a positive change of low intensity, and the environmental impact index underwent a positive change of very low intensity.

Based on the sustainability dimensions represented here (social, economic and environmental), using the impact indices presented as guidelines, we observed different changes in the production systems transition model. According to the results, when transitioning to a nature farming production system, the smallholder farmers perceived that most values lay in the social and economic dimensions. In the following section, therefore, we describe the efforts made to use the tool for descriptive analysis based on social and economic dimensions to identify the extent to which the interviewees understand the main intangible values.

4.2 The 'system transition' network

For the interviews, the script developed was based on Ambitec-Agro, and it was organised to capture the impacts of the transition from a conventional production system to a nature farming system. Based on the content analysis, we observed categories that systematically explain how integration has had an impact on organisational routines, practices, relationships, and structures. We developed a thematic network consisting of the change categories for complementary purposes in the approach. It comprises three categories that were derived from the script applied, nine subcategories, 12 associated codes, and 99 citations, as shown in Table 7.

Figure 7 Social, economic, and environmental impact indices



Source: The authors

4.2.1 Structural changes in production management

Given the complexity involved in transitioning to a system based on the principles of nature farming, it was noticeable that no major changes were made in the installations necessary for integration; the equipment stayed the same, and there was no need for any physical restructuring of the sheds. Some improvements were made, however, by some farmers, and some difficulties were reported in obtaining financing for investments to improve structures.

At the same time, this evidence points out that the buyer has installed a system in which smallholder farmers can absorb the new system without the need for new resources in terms of infrastructure, the focus being on raising awareness of improvements that

guarantee the quality of the process, in accordance with the prescribed certifications (antibiotic-free and animal welfare).

Table 7 The codes and categorisation in the system transition thematic network

<i>System transition network</i>		
<i>Categories</i>	<i>Primary codes</i>	<i>Secondary codes</i>
Structural change in production management	Technology	Business organisation Automation
Interaction with animals and the new business design	Animal welfare	Technology of animal welfare Raising awareness of animal welfare
	Animal medication	Improvements in relationships
Change in relationships and quality of life	Subsequent demands	Good relationship with the company
	Personal triumphs	Participation in training
	Health of the workers	Structural difficulties
	Food quality	Savings
	Production practices	No change in production
	No change in the quality of life	No change in animal perception No change in relationships

Source: The authors

Table 8 Extracts from the interviews about modifications to the structure and management of production

Structure

Interviewee B – (...) I've been in poultry farming for 15 years! The equipment and structure haven't changed much.

Interviewee E – (...) The management is 90% the same. The equipment is 100% the same. The size of the shed is 100% the same.

Changes in production

Interviewee A – (...) They used more medication, didn't they?! Now with (the buyer) we don't use medication. It's just chlorine ...

Interviewee C – (...) There's a lot of difference. About animal welfare, what we think about most is the medication part ...

Practices and production management

Interviewee B – (...) There was a lot of change. Even getting rid of birds [euthanasia]. They never used to worry about how we got rid of birds [in the conventional system] ...

Interviewee C – (...) After we started using a tarpaulin covering it improved a lot. There was a considerable improvement. (He started covering with a tarpaulin) ...

Source: The authors. Based on the transcriptions

This category of structural change and production management is also evidence of the technological development that affects producers and is related to other codes, such as the automation of equipment, which means more modern systems, but also solutions and adaptations that are introduced by the buyer. Among the differences pointed out as the most recurrent are: antibiotics are not used in rearing birds; ammonia emissions and bad smells are reduced by using microbiological inputs spread in the shelters; broilers have enough room to behave naturally; microbiological inputs under tarpaulin enhance the

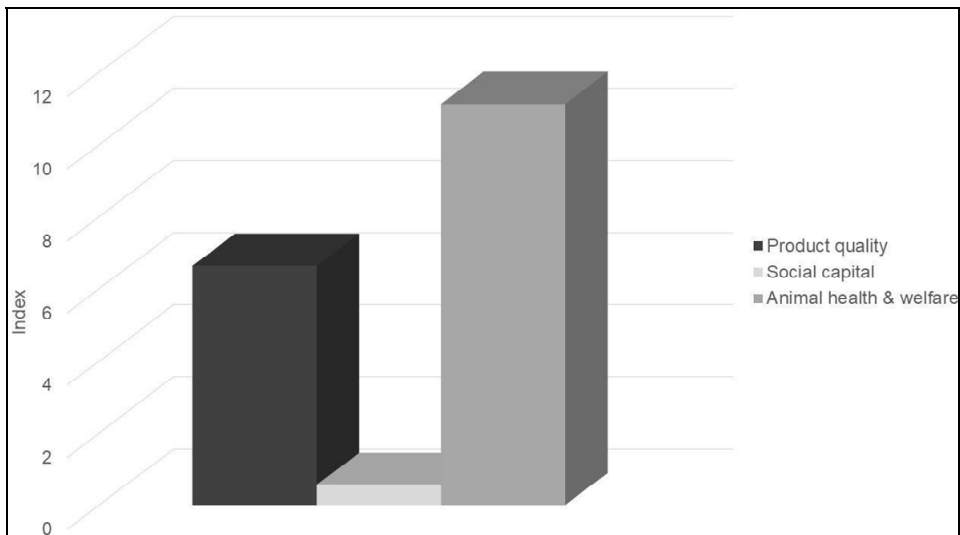
fermentation of the litter after the broilers leave¹, controlling beetles² (synthetic insecticides are prohibited); and dead birds are disposed of properly by composting them. The comments of the farmers (see Table 8) are evidence of the aspects highlighted. Some pointed out that the new practices have intensified the care and maintenance of the shelters, with no additional costs, since the necessary inputs are provided by the company.

Based on the comments of the farmers, we see that conventional broiler production focuses on productivity, using medicines to ensure high yields. The transition of production systems affected the perception of the change both about the conditions and practices that favoured animal welfare, with no use of medication, and more flexible requirements. The main changes in production and animal welfare practices were categorised as being linked to not using medicines (antibiotics) on animals, to some of the technologies that were implemented or adapted, and to the increase in requirements after integration with the buyer.

4.2.2 Changes in the interaction with the animals and a new conception of business

One of the criteria of Ambitec-Agro is 'respect for consumers', and we can see that the issue of animal welfare was positively impacted by integration, by 11.12 points, and by aspects related to product quality. This was also emphasised by the producers and reached 6.64 points; quality was associated with texture, flavour, and appearance when handling the product. The 'social capital' variable, however, showed a very small variation caused by changing systems, with 0.57 points, as can be seen in Figure 8.

Figure 8 The Ambitec-Agro criterion of 'respect for consumers'



Source: The authors

The categories related to respect for consumers criterion are

- a animal health
- b animal welfare, which are the main aspects of nature farming production, and there is a constant concern with the production of the broilers supplied.

The interaction the producer had with the animal before and after the system transition was commonly observed. In conventional production, the interaction between the broilers and the company was merely a question of the capacity/productivity of the business. This interaction was later linked to the quality of the product, to the fact that broilers were free of medication, reared without stress, and have room, among other aspects. This indicates that the natural integration model creates in producers a more humanised idea about the animals and, more broadly, about the business, which generates an opportunity to reflect on animal life and welfare, and how it impacts the quality of the product.

Integration in a new production system may have provided smallholder farmers with the opportunity to understand that their product is closely linked to quality, but also to human health. In some interviews, the producers stressed that they found this satisfying. Producers also talked openly about the new processes and have even started to consume products from the integrator company itself because they believed in the natural production system.

It was also possible to observe that the smallholder farmers had a complex relationship with the use of medicines. Most of them emphasised the buyer's good performance and technical assistance concerning animal treatment. There was also some resistance, with some producers believing there were no negative effects associated with applying antibiotics, which might be linked to custom and the time they worked in a conventional system, even though they came to respect integration into the new system, which had a direct impact on the conception of animal welfare.

The following excerpts highlight comments (see Table 9) that evidence the aspects discussed in this topic, both those linked to the change in the producers' perception of animal welfare and quality, but also linked to the conception of the business itself, with a social value being attributed to the production activity, and not just focusing on the economic return.

Table 9 Extracts from the interviews about interaction with the animals and the new business concept

Interviewee A – (...) There's a lot of difference. About animal welfare, what we think about most is the medication part.

Interviewee F – (...) Yes! They have another view! We began to have another view. When we used to farm chickens conventionally ...

Interviewee I – (...) Look, to tell you the truth, I still look at chickens as a way of making a profit.

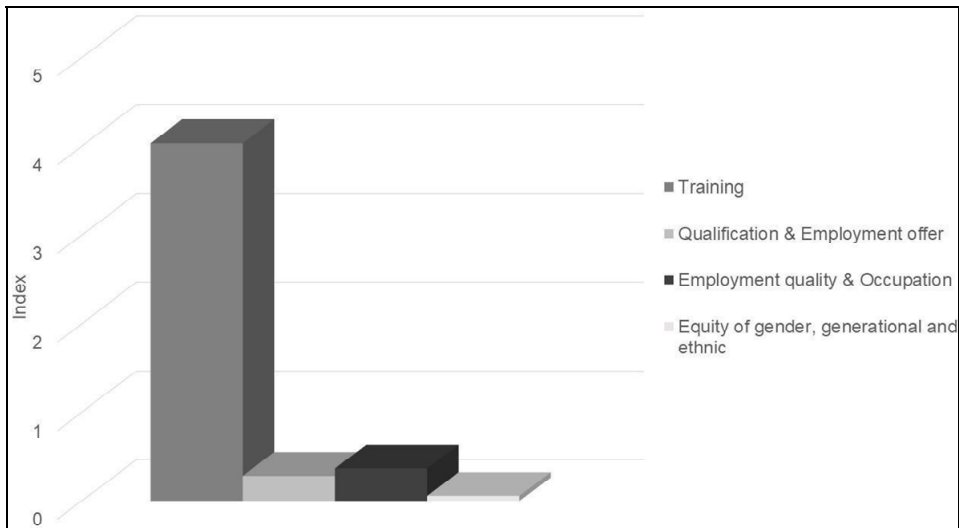
Source: The authors. Based on the transcriptions

The kind of cooperative relationship between the farmers and the buyer may have had an impact on the interaction with their animals. There was a more humanised approach, in addition to respecting the animals and their space. This kind of relationship is directly related to the quality of the product, which goes beyond the idea of antibiotics, and so the business model of these properties was adjusted to a new reality developed as a result of the closer relationship between these sustainable supply chain links.

4.2.3 Relationship changes and quality of life

Discussion in this category centres on the elements that involve the producer's life in the field, whether associated with changes in the relationship with the buyer, the capacity for rural management, participation in training courses, or the relationship with neighbours. Different gains in the relationship with the buyer were highlighted, such as direct communication. It was also pointed out that the neighbours remained the same, and that they had a good relationship. About training, some institutions were mentioned, namely: the buyer, the rural union, the Brazilian Micro and Small Business Support Service (Sebrae), and the fire brigade, with topics that ranged from management and technical issues to work safety.

Figure 9 The Ambitec-Agro criterion of 'employment and occupation'



Source: The authors

A fact that is compared with the 'relational changes and quality of work' category is associated with the social dimension of sustainability, which is an essential element for guaranteeing safety and human development. In Figure 9, it is possible to observe the 'employment and occupation' criterion of Ambitec-Agro, and how both aspects were impacted because of the integration with the buyer. A positive aspect here is the 'training' work that was carried out by the buyer, but also other indicators that were positively impacted, albeit not in a very significant way.

The gain in quality of work as a result of the change in production system was also highlighted, mainly due to the absence of animal medicines or pesticides. Relationships between the buyer and smallholder farmers were highlighted a lot during the interviews. In the case of the buyer, the development of a closer and more direct relationship helped producers solve problems and exchange information, aspects that go beyond technical visits. It was stressed that the relationship is a partnership, with support including facilitating credit lines, access to the company's top management, training, knowledge exchange, regular auditing, problem-solving, and the development of alternative support resources. It is also a partnership that involves an affective relationship with the

smallholder farmers, which appeared when many of them become incorporated. This is mainly due to financial crises or broken contracts with previous conventional integrating companies. As a result, an affective relationship becomes consolidated with the buyer, based on philosophical precepts. The comments below (see Table 10) show the aspects discussed in this topic linked to changes in the quality of work.

Table 10 Extracts from the interviews about relationships and quality in work

Quality in work

Interviewee D – (...) On the contrary! It's like I said: how (the buyer) looks after the birds reduces the risk a lot.

Interviewee E – (...) Eating healthier food. You know what a broiler is made of from start to finish.

Relationships

Interviewee B – (...) What drew my attention to (the buyer) was that because it's small, its communication is more direct.

Interviewee D – (...) I think that the biggest difficulty was that we didn't have a lot of support from the [previous] companies. That made it difficult.

Source: The authors. Based on the transcriptions

One of the main findings of this research was about the influence of this relational dynamic between smallholder farmers and the buyer. Various gains in each of the dimensions that were analysed involve geographical proximity to the buyer, which plays an important role in disclosing solutions that are more efficient and have less impact, either in the technical animal sphere or on the quality of life of the producers.

5 Discussion and conclusions

This study contributes by proposing an application of methodology with descriptive indicators based on crossing mixed methods, using the Ambitec-Agro tool. It allowed the identification and in-depth analysis of the perceptions of smallholder farmers regarding created and appropriated socio-environmental value in the process of transitioning from an input-intensive production system to an alternative poultry production, based on sustainability principles. The method is validated to understand what is perceived as valuable for smallholder farmers who are mainly family rural businesses changing to more sustainable production practices in an emerging country context.

Other studies using the applied set of indicators have assessed the socio-economic and environmental impacts of rural activities, offering elements for impact assessment based on quantitative data (Avila et al., 2015; Figueirêdo et al., 2010a, 2010b; Rodrigues et al., 2010). Our study advanced methodologically by integrating a technique of content analysis (a qualitative step), which deepened the meaning of the results and contributed with evidence obtained beyond the algebraic scope. We believe the use of mixed methods can better describe the phenomenon and A-A is a tool aligned to the TBL framework.

The research applied the Ambitec-Agro tool to indicate that integrated producers perceive social and economic values in sustainability production, even though the literature points out the difficulties inherent in measuring socio-economic impacts. These are mainly financial gains in the final price of the products, as well as social gains in the

quality of life of the producers or environmental gains in the quality of life of animals and consumers. In addition, we were able to map satisfaction and governance improvements.

There is also a relational gain represented by intangible aspects, such as a concern with being healthy, providing animal welfare, and obtaining quality products. A system oriented towards the environment and health stands out in the perceptions cited by the farmers. This finding emphasised the importance of a nature-inspired production and the one health holistic approach, which combines the health of humans, animals, plants, and the environment (Dekker et al., 2020). The relational value is transferred to the producers' own life choices, encouraging them to consciously engage with the philosophy that sustains their economic activities. It became clear that the buyer created shared value (Porter and Kramer, 2011) that was appropriated by the smallholder farmers, albeit more or less intensely in each of the three sustainability dimensions. SSCM is aligned with this concept, in which the company that governs the chain does not lead to power asymmetries but instead to cooperative relationships that enable smallholder farmers to achieve the three dimensions of sustainability.

Authors such as Sharfman et al. (2009) and Ahi and Searcy (2013) suggested that the development of sustainable practices improves the performance of producers based on the solutions developed to replace traditional practices with their inappropriate disposal, inadequate animal welfare conditions, and poor quality of life in the shed installations. The adoption of low-cost innovations, such as the microbiological enrichment of the chicken houses, fermenting process of the litter, and auditing by the buyer, are shown to be efficient in preventing chicken diseases, despite the non-use of antibiotics, growth-promoters, and conventional medicines. Noteworthy too is the fact that the values of the alternative production philosophy have been perceived by farmers, who have incorporated the importance of animal welfare as an attribute of the products into their discourse.

Begum et al. (2019) studied smallholders' activities assessing sustainability in the face of the challenges of the international markets, recommending focus on the social, environmental, and economic issues on the palm oil industry. Based on our results, we agree with this study that a long-term relationship with a buyer willing to share value and support farmers' learning process, brings resilience to the difficult path to achieve sustainability, and perhaps being more assertive than only certification-based schemes.

According to Kähkönen and Lintukangas (2012) and Kleinaltenkamp (2015), efficiency in the supply chain is associated with supplier management and a more collaborative relationship that can offer opportunities to organisations. In our empirical study, smallholder farmers have adapted well to changes in production and the buyer's organisational culture. This synergy between buyer and smallholder farmers has generated a positive image for the organisation, which reinforces the importance of relational value, by which the access to the buyer's top management is ratified. This facilitates listening to and addressing demands and leads to greater efficiency when solving problems. It also ensures that the main differential of the buyer, that is the high animal welfare standard and how it reflects on the product quality, be preserved, and correctly carried out by the smallholder farmers. Therefore, it is increasingly possible to access premium markets, and create value and opportunities.

Smallholder farmers have been struggling to appropriate and participate in value chain exchanges (Dicecca et al., 2016). Sustainable forms of production provide an auspicious solution, and our study contributes through an integrative methodology that may be applied in other sustainable or (certified or not) organic production systems,

bringing light to the perceived benefits. We suggest that future studies apply mixed methods in other agri-food chains to validate and expand the rural innovation (with qualitative step) proposed in this study. In particular, there is a need to develop a better understanding of the social aspects of value creation and appropriation from the perspective of smallholder farmers.

Acknowledgements

Author Luiz Demattê would like to acknowledge the scholarship of the Coordination for the Improvement of Higher Education Personnel (CAPES). The authors would like to thank the School of Business Administration and Economics (EAESP/FGV) for supporting the research and Dr. Geraldo Stachetti Rodrigues from Embrapa for his contribution to the methodology.

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Notes

- 1 A technique that consists of applying bio inputs and covering up the litter in poultry houses using black plastic (PVC tarpaulins) for fermentation. Fermentation increases the microbiological diversity and temperature, eliminating the larvae of *Alphitobius diaperinus* (Panzer).
- 2 The beetle *Alphitobius diaperinus* (Panzer) is an important vector of viruses, bacteria (i.e., *Campylobacter sp.*, *Clostridium sp.*, and *Salmonella sp.*), and protozoa (i.e., *Eimeria sp.*) that cause gastrointestinal lesions in birds after ingestion.