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ARTICLE

An analysis of the Local Innovation Agents Program in the production processes of animal husbandry in the Brazilian Northeast

Uma análise do programa Agentes Locais de Inovação nos processos produtivos da criação de animais no Nordeste brasileiro

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Abstract: The Local Innovation Agents Program (ALI) is an initiative of the Brazilian Micro and Small Business Support Service (Sebrae) that offers specialized support to promote increased productivity through innovation. The LIA plays a fundamental role in promoting the competitiveness improvement of Brazilian micro and small companies. The success of the Program in micro and small companies in the commerce and service sectors was responsible for the expansion of the methodology to rural businesses. Given this context, the purpose of this research was to evaluate the impact of the ALI Program methodology on the production processes of animal husbandry (cattle, goats, and sheep) in Rio Grande do Norte, Brazil. To this end, two sub-dimensions of the Innovation Radar were analyzed, before and after monitoring agricultural properties, aiming to identify the operations and procedures adopted to improve the production process and evaluate the solutions chosen to solve property problems. The results demonstrated that the monitored properties showed an improvement of 19.74% in their production processes after monitoring and that the ALI Rural Program methodology had a positive impact on improving the production processes of animal husbandry in RN.

Keywords: innovation, productive management, semi-arid, sustainability, innovation radar.

Resumo: O Programa de Agentes Locais de Inovação (ALI) é uma iniciativa do Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (SEBRAE) que oferece acompanhamento especializado para promover o aumento da produtividade por meio da inovação. O ALI tem um papel fundamental em promover a melhoria da competitividade das micro e pequenas empresas brasileiras. O sucesso do Programa em micro e pequenas empresas dos setores de comércio e serviço foi responsável pela expansão da metodologia para os negócios rurais. Diante deste contexto, o objetivo desta pesquisa foi avaliar o impacto da metodologia do Programa ALI nos processos produtivos da criação de animais (bovinos, caprinos e ovinos) no Rio Grande do Norte, Brasil. Para isto, foram analisadas duas sub dimensões do Radar de inovação, antes e após o acompanhamento das propriedades agropecuárias, visando identificar as operações e procedimentos adotados para melhoria do processo produtivo e avaliar as soluções escolhidas para a resolução de problemas da propriedade. Os resultados demonstraram que as propriedades acompanhadas apresentaram uma melhoria de 19,74% nos seus processos produtivos após o acompanhamento e mostraram que a metodologia do Programa ALI Rural impactou positivamente na melhoria dos processos produtivos da criação de animais no RN.

Palavras-chave: inovação, manejo produtivo, semiárido, sustentabilidade, radar de inovação.

1. Introduction

In the semi-arid region, animal husbandry began in the colonial period (Nunes, 2013) and is currently seen as a crucial activity when dealing with drought (Coutinho et al., 2022). According to Silva et al. (2018), the factors that limit animal production systems in a territory in the outback of Ceará are related to the almost total absence of technical assistance, limited access to credit, the increasing price of inputs, the lack of adapted technologies at low competitive conditions and, in the case of dairy cattle farming, the lack of cooling tanks.

The incorporation of technologies in farming has the potential to significantly increase animal production and productivity, allowing breeders to guarantee quality, reduce costs and profitability (Oliveira et al., 2020). According to the authors, the actions that brought positive impacts on the activity were the improvement in pasture and silage production, attention to animal well-being and health, genetic improvement, and business management. Such advances were often provided by active technical assistance and rural extension (Guimarães & Lima, 2021).

Sebrae's Rural Innovation Journey consists of a cycle of activities aimed at business management, lasting eight months, with the assistance of an Agent during the process. Participation in the Program allows for more organized management and decision-making that is better based on the recording and analysis of information, definition of goals that result in organization and planning to achieve objectives, as well as innovation in production processes. The methodology combines questionnaires, technical visits, quality tools, and improvement plans that focus on five central dimensions that are organized into an Innovation Radar (Borghezan et al., 2023).

In Brazil, until 2021, cattle, sheep, and goat farming totaled around 257 million animals, with 0.9% of this activity concentrated in Rio Grande do Norte (RN) (Instituto Brasileiro de Geografia e Estatística, 2022). According to Garcia et al. (2022), farming depends on the production of important crops, such as soybeans and corn, and, in addition to the absence of very serious weather problems, planning is necessary so that planting and harvesting occur at an appropriate period. According to the institute, the sector shows a trend of improvement, despite the problem of increasing costs reported in an interview by the ABPA market director and the researcher at Embrapa Pecuária Sul, Luis Rua and Vinícius Lampert, respectively (Scot Consultoria, 2022).

According to Brito et al. (2009), cattle breeding is one of the businesses that most requires competence in managing its tasks, as these must interrelate harmoniously to ensure regular production and product availability. Therefore, the Local Innovation Agents Program (ALI Program) included the Rural sector as an important area to be worked on, aiming to guide possible changes that, according to Borghezan et al. (2023), can increase competitiveness, enabling adaptation and overcoming challenges, in addition to taking advantage of opportunities to better position themselves in the market. The research showed that companies from different locations in the country, participating in the ALI program, were positively impacted, mainly in the performance indicators surveyed by the Innovation Radar (Placca, 2020; Lima et al., 2020; Porem & Kunsch, 2021; Silva & Nunes, 2023b).

The ALI Program is a national extension project, the world's largest extension project (Luz, 2017), which aims to effectively contribute to the development and maintenance of the competitive advantage of micro and small companies (MSCs) in Brazil (Silva & Nunes, 2023b). According to Porem & Kunsch (2021), the agent provides systematic assistance and consultancy during in-person visits to MSCs. According to the authors, during services, agents apply tools, methodologies, dynamics, and planning to support the management of MSCs.

Therefore, the purpose of this research was to evaluate the impact of the ALI Program methodology on the production processes of cattle, goats, and sheep breeding in Rio Grande do Norte, Brazil, in the period between August 2022 and November 2023. For this, the specific

objectives were to identify the operations and procedures adopted to improve the production process in animal husbandry and evaluate the solutions chosen to solve problems during the monitoring carried out by the Innovation Agent.

2 Theoretical Foundation

2.1 Farming in the Brazilian semi-arid region

According to SRF Normative Instruction No. 83/2001 (art. 2), rural activity covers agriculture, livestock, plant and animal extraction and exploitation, exploration of zootechnical activities, such as beekeeping, poultry farming, rabbit farming, swine farming, sericulture, fish farming, and others small animal culture, fresh fish capture activity, and transformation of products resulting from rural activity carried out by the farmer or breeder by exclusively using raw material produced in the explored rural area (Brasil, 2001).

In Brazil, rural activities are carried out in around 5 million farming establishments and employ more than 15 million people, in which 77% of establishments are classified as family farming, 72% of owners are individual producers, 81% are male, mostly aged between 35 and 74 years old, and with a low level of education (Instituto Brasileiro de Geografia e Estatística, 2017). According to Fisher et al. (2016), family farming produces basic foods, mainly fresh foods, intended to supply the local and regional population. To make the agricultural property managed by the family viable, several productive activities are developed, featuring pluriactivity, as well as the production of artisanal processed foods.

In 2006, Law No. 11,326 established that a family farmer is one who carries out activities in rural areas, and who does not hold, in any capacity, an area larger than four fiscal modules; that predominantly uses their own family's labor in the economic activities of their establishment or enterprise; has a minimum percentage of family income originating from economic activities from their establishment or enterprise, as defined by the Executive Branch; and runs the establishment or business with their family (Brasil, 2006).

Although family farming is the majority in the country, Navarro & Campos (2014) gathered texts that report the discussion about the difficulties of small producers in competing fiercely with larger producers, as a result of their productive and technological capacity. According to the authors, small producers are the most impacted by the real drop in commodity prices, the increase in wages paid to rural workers, the greater risk inherent to the activity, and the increasing complexity of managing the activity (including the expansion of environmental regulations).

For Fisher et al. (2016), the main difficulties highlighted by producers, in addition to instability in product prices, are low earnings from agricultural activity, insufficient technical assistance, low purchasing power, low volume and production regularity. Furthermore, another aggravating factor is family succession and staying in the countryside due to the lack of prospects for a better life; lack of capital for investments in structuring rural properties; lack of new opportunities in the field; and insufficient land area for crops at profitable and economically attractive levels.

According to Berger et al. (2021), in Brazil, livestock farming, through dairy farming, has an important social and economic role, as it represents a source of monthly income for many farmers, especially family farmers. Likewise, it has a relevant participation in the country's economic activity, as it is present in almost all municipalities, generating jobs in different segments of the production chain.

Livestock exploitation requires a combination of different types of resources, such as the availability and use of the land structure, as well as the basic infrastructure and technologies that

allow the development of this chain (Gurgel & Nunes, 2019). In Rio Grande do Norte, farming carried out in the semi-arid region is exposed to the risks of climate change, such as drought, as well as the unsustainable use of natural resources and degrading agricultural practices, mainly affecting small producers who have few financial and technological resources to add to their production systems (Dias et al., 2021).

In the region of Apodi/RN, livestock farming is mostly carried out by small producers in rustic buildings and facilities, with traditional machinery and equipment (Gurgel & Nunes, 2019). Most producers do not receive technical assistance and are in debt due to droughts in previous years, which prevents them from obtaining financing to optimize production (Gurgel & Nunes, 2019; Aquino et al., 2020). Furthermore, Aquino et al. (2020) report that the performance of family producers in Rio Grande do Norte is negatively affected by the difficulties faced in accessing rural credit at bank branches. According to Dias et al. (2021), the main problems with animal husbandry in the State occurred due to lack of water and lack of adequate soil management.

Thus, the production process management in farming will be described below.

2.2 Management of the farming production process

Managing a process starts from identifying a problem, followed by discovering the root cause, analyzing all its possible variables, and planning objectives, goals, and corrective actions, and may include means to optimize processes such as creating and controlling performance indicators (yield, quality, costs, among others), lean production system, or other methods (Costa Júnior, 2008). According to the author, some expected results from this action would be the improvement of production processes, problem resolution, product quality improvement, waste reduction, and the increase in productivity.

It is important to highlight that, in farming, the production cycle ends with the sale of the live animal or milk (Santos et al., 2007; Silva, 2022). In beef cattle farming, three phases in the production process can be highlighted: Breeding (production of calves that will be sold after weaning), rearing (production and marketing of lean calves for fattening), and fattening (production and marketing of fatted calves) (Santos et al., 2007). In dairy farming, the phases consist of reproduction, nutrition, pre-partum, birth/lactation, rearing, post-partum, and milking (Silva, 2022). According to Silva et al. (2020), reproductive, nutritional, and health management, as well as care with the slaughter process will also influence the producer's results.

Furthermore, in rural companies, factors can influence the production process such as seasonality, food perishability, harvest, and off-season. These factors are caused by the existence and influence of the seasons, introducing the harvest and off-season in periods longer than a year to have a product ready for sale, making price fluctuations one of the main indicators of production seasonality (Santos et al., 2007).

2.2.1 Operations and procedures to improve the farming production process

Given the difficulties faced by rural producers, it is necessary to point out strategies used to guarantee the permanence and strengthening of livestock activity through problem solving, which reflects in the reduction of waste and costs.

According to Berger et al. (2021), the main factors for optimizing production processes were animal health and well-being (vaccination and shade), food (food stock and quality pasture), herd quality (high-lactation animals, genetics and artificial insemination), technical assistance (veterinary), technologies (acquisition of agricultural machinery, irrigation system, Compost

Barn system, mechanical milking and milking parlor, bulk cooler and mobile apps), cooperation (silage production with neighbors, strong cooperative committed to paying for milk), and financial incentives.

2.2.2 Operations and troubleshooting procedures

Health management consists of monitoring animals with the aim of reducing discomfort that causes stress and, consequently, reduction or loss of production quality (Ribeiro, 2021; Salman & Pfeifer, 2020). In Silva's (2022) reports, health management included the adoption of daily hygiene, with vaccination, use of preventive medications against diseases, and routine monitoring exams.

Maintaining an adequate diet is of fundamental importance to guarantee the quality of by-products generated from animal husbandry (milk, meat, and offspring), both from a nutritional and economic point of view. Considering the cost of milk production, feed represents 40 to 80%, and may reach a higher percentage (Ribeiro, 2021; Oliveira et al., 2020). Better quality pasture allows the producer to produce more milk in a smaller area (Berger et al., 2021), so roughage can be produced in irrigated paddocks and complemented with supplementation in troughs. Adequate nutrition will guarantee the production of healthy animals capable of expressing their full potential throughout their productive lives (Silva, 2022).

As the market is highly competitive, livestock farmers have sought to meet demands through precise methods to improve the animals' attributes. Regarding this search, two factors can be highlighted: animal well-being and the final product quality (Lobo, 2021). Profitability in breeding must be the main goal of producers to achieve productivity and economic return (Ribeiro, 2021). These conditions can be achieved through genetic improvement, which consists of the classification and selection of animals, aiming to achieve the best economic value in the activity (Lobo, 2021).

According to Peixoto et al. (2023), animal well-being consists of the state of the organism during its attempts to adjust to the environment. For the author, in the case of livestock farming, some genotypes are more sensitive to certain environmental conditions. In places with a predominance of high temperatures and/or high humidity, the environment needs to be suitable so that animals, especially those with high production, can have thermal comfort, allowing the expression of their genetic potential and productivity maintenance (Peixoto et al ., 2023). Among the improvements made by producers to ensure animal welfare are conditioning in Compost barn (Silva, 2022), an appropriate space, dry and ventilated resting area, with shading to ensure thermal comfort, adequate trough space for food by individuals (ensuring reduced competition), homogeneous groups, and healthy and pleasant environments, in addition to the escape area (Azevedo et al., 2020).

The research by Cruz et al. (2021) states that technical assistance in farming can be carried out by agricultural science professionals, such as veterinarians, agronomists, and zootechnicians. These professionals, from the public or private sector (Cruz et al., 2021), are responsible for updating livestock farmers on innovations in management and equipment (Berger et al., 2021). The presence of a professional is essential for the prevention and adequate control of problems (Ribeiro, 2021), in addition to helping to prepare protocols for vaccination, medications, management, monitoring, and artificial insemination (Silva, 2022).

It is important to highlight that the company needs to have an environment favorable to creation and innovative capacity to adopt new technologies and to maintain commitment during the process (Oliveira et al., 2020). The innovation adoption becomes possible through financial

incentives and incentive policies (Oliveira et al., 2020). Few producers in RN (18.3%) are able to access any type of credit to invest or fund the activities carried out on their sites. This is partly a consequence of the lack of technical assistance to prepare credit projects. Much of the rural credit was applied, both in the form of financing for commercialization costs and in the form of investment, as well as for business and family agriculture (Magro et al., 2019). Among the existing rural credits are the National Program for Strengthening Family Agriculture - PRONAF (Aquino et al., 2020).

The cooperation, according to Mariani (2006), contributes to strengthening the producer, preventing abandonment of the activity. Participation in cooperatives can facilitate access to specialized assistance (Ribeiro, 2021), the purchase of inputs with advantages, and access to financing (Mariani, 2006). Despite the benefits, there is low adherence to cooperativism by the family farming establishments in Brazil, especially in the North and Northeast regions (Silva & Nunes, 2023a).

In addition to the lack of technical assistance and rural extension, management failures are factors that make it difficult for producers to obtain satisfactory results (Porto et al., 2013). According to Berger et al. (2021), of the properties that have zootechnical records, the use of notebooks is the main management tool. Maintaining a history of each animal, with information such as weighing, identification earring number, and body condition score (BCS) is important for production control (Silva, 2022). Only with past data one can analyze and take initiatives to suppress or implement measures that can assist the health management of the herd (Ribeiro, 2021).

2.3 Studies on the production process management

In 2011, the process dimension of the ALI Program that addresses the issue regarding process improvement, in addition to the administrative part, dealt with modifying procedures to generate greater efficiency, quality, flexibility, shorter production cycle, or benefit for third parties (Silva Néto & Teixeira, 2011).

When studying the innovation degree of micro and small companies in the textile-clothing chain in Sergipe, Silva Néto & Teixeira (2011) identified that the process dimension, in comparison to the other dimensions studied, had the lowest innovation degree, both in companies in the capital and in the countryside. According to the researchers, the companies surveyed have improved their processes by modernizing technology but have not invested in production management systems.

When evaluating the Rural Innovation Journey developed in Santa Catarina, Borghezan et al. (2023) observed advances in indicators in all dimensions, in which the mean value of the innovation degree in Santa Catarina enterprises went from 2.30 (DI) to 2.80 (DF), while the national mean for the innovation radar indicator went from 1.90 (DI) to 2.40 (DF). According to them, the indicators that improved the most were: management controls, new products (business models), and innovation in production processes.

In this study by Borghezan et al. (2023), the improvement plans prioritized actions that resulted in the resolution of problems identified in rural enterprises, such as preparing a to-do list and/or action schedules; readjustment of spaces and materials for handling; adjustment in production process; construction, expansion and/or renovation of facilities; acquisition and/or renovation of equipment, materials, and inputs; implementation of protocols for processes; filling out field notebooks; organization and division of tasks; innovations in management practices; among others.

Studies by Gasparini et al. (2017) and Silva et al. (2023) pointed out improvements in the farming production process after changes in daily activities or the implementation of corrective

actions for existing bottlenecks in production, pointing out productive gains, increased production yield, reduced time to obtain the product, process optimization and waste significant reductions.

3 Methodology

Among the 374 family producers or small producers served in Rio Grande do Norte, during cycles 1 and 2 of the ALI Project, 71 producers (19.0%) worked with livestock, carrying out cattle, goat, and/or sheep farming.

Therefore, this research encompassed a target audience of 71 rural properties in the farming sector, with activities focused on cattle, goat, and sheep farming in the state of Rio Grande do Norte, participating in the Sebrae Local Agents for Rural Innovation Program, in the period between August 2022 and November 2023.

The investigation was characterized, in terms of purposes, as descriptive and explanatory, as it observed the variables that were spontaneously linked to the operations and procedures of the productive activity studied (Heerdt & Leonel, 2007). Furthermore, the facts were studied *in situ* and the fundamental concern was identifying the factors that contributed to the impacts on the property's productivity (Heerdt & Leonel, 2007).

Regarding the nature of the data, the research method was defined as qualitative-quantitative, in which a structured script known as Innovation Radar was used, the main tool used in the ALI Program to collect information and scores through standardized interviews. The research was considered qualitative, as it investigated non-statistical samples, individual cases and multiple cases, information and understanding (the meaning) of the behaviors and management methods of rural producers in the farming sector (Amado, 2015). Furthermore, it can be considered quantitative, as it evaluates and analyzes how the methodology influenced the process improvement (Leite, 2015).

The Innovation Radar, the main tool used in the ALI Program, obtained during the diagnosis carried out in the company with the business owner, evaluated 5 dimensions, distributed in 21 sub-dimensions developed in the company (Borghezan et al., 2023). This instrument was created by Sawhney et al. (2006), and adapted to the context of MSEs by Bachmann & Destefani (2008). According to Carvalho et al. (2015), this tool points out the dimensions in which companies in a given sector innovated or were little explored and which, therefore, can differentiate them in relation to their sectoral competitors.

The tool was applied during the first technical visit of Sebrae's Rural Innovation Journey, known as the diagnosis phase (Borghezan et al., 2023). At this point, the Local Rural Innovation Agent learned about the property structure and the processes involved in rural activity. The innovation radar has open questions, of a qualitative nature, about situational issues that are differentiated into numerical scales (1 to 5).

In the operations and procedures sub-dimension, the raised questions were related to the rural company routine, the delegation of tasks, the existence of a to-do list, and the delay in the customer service process (internal and external), while in the resolution sub-dimension of problems, the main question assessed how the rural company reacted in problematic situations.

At the end of the application, the radar reports mean scores, from 1 to 5, where 1 represents absence or development of few actions aimed at developing the dimension, 3 represents the average score, and 5 represents excellence or high development of actions. In addition to the production process dimension, Radar evaluates management controls, marketing and sales, cost reduction and new products (Figure 1).

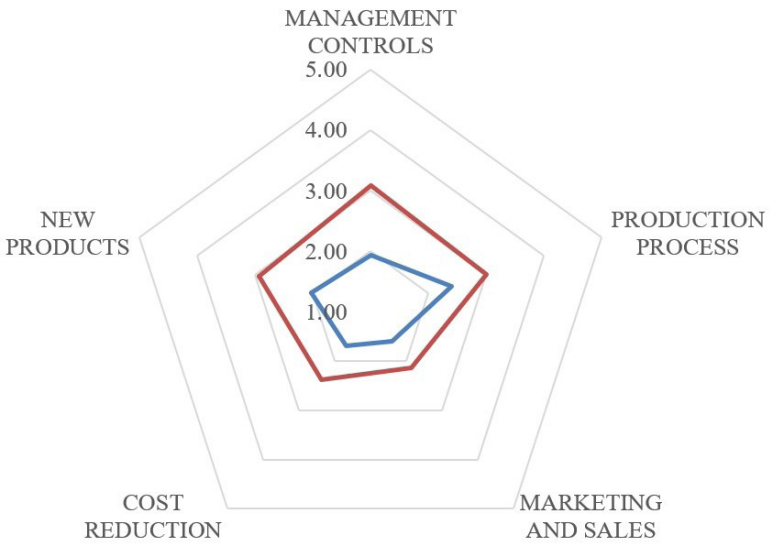


Figure 1. Innovation Radar Diagnosis for the Rural Innovation Journey.
Source: Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (2024).

In addition to the data obtained from the Innovation Radar, the producers provided the values referring to the gross monthly revenue for the beginning month and the month before the end of the monitoring.

The values obtained from the Innovation Radar in RN were tabulated in a Google spreadsheet, shared in the cloud with the State's Local Innovation Agents. Subsequently, interest data was transferred and processed in the Minitab statistical program. The program made it possible to obtain descriptive statistics (mean, standard deviation, maximum, and minimum) and apply the Kolmogorov-Smirnov normality test, adopting a significance level of $p < 0.01$. The evolution of values obtained before and after diagnosis were quantified and compared by calculating percentages. Corrective actions were separated according to the major areas worked on in farming (animal health and well-being, food, herd quality, technical assistance, and technologies).

After normality analysis, the Mann-Whitney test was applied. This non-parametric test was used to determine whether the medians of two independent samples (DI and DF) differed from each other, adopting a significance level of $p < 0.05$. Therefore, we statistically evaluated whether the properties' production process showed improvements after applying the ALI Program methodology (Minitab, 2023).

4 Results and Discussion

4.1 Farming producers in RN description

Among the 374 family producers or small producers served in Rio Grande do Norte, during cycles 1 and 2 of the ALI Program (each cycle lasted 8 months and each agent served up to 15 producers), 71 producers (19.00%) worked with livestock, carrying out cattle farming, goat farming, and/or sheep farming. Of these, 93.00% are men and 7.00% women. Therefore, RN follows the Brazilian trend (Instituto Brasileiro de Geografia e Estatística, 2017), in which men prevail in cattle, goat, and sheep farming activities.

The survey showed that 70.40% of producers focus on raising cattle for milk production and/or for meat, 1.40% are dedicated to sheep farming only, while 28.20% of producers combine

two or more rural activities, which can be beekeeping, poultry farming, goat farming, charcoal farming, fruit farming, pig farming, or cheese farming. The main consortia occur between cattle and sheep farming (9.90%), poultry farming and sheep farming (4.20%), cattle farming and cheese farming (2.8%) (Table 1).

Table 1. Main activities carried out by cattle, goat, and sheep breeders in Rio Grande do Norte.

Activity Type	Amount	%
Cattle Farming	50	70.40
Cattle and Sheep Farming	7	9.90
Poultry and Sheep Farming	3	4.20
Cattle and Cheese Farming	2	2.80
Beekeeping and Sheep Farming	1	1.40
Poultry, Cattle, Goat, and Pig Farming	1	1.40
Poultry and Cattle Farming	1	1.40
Poultry, Goat, and Cheese Farming	1	1.40
Cattle and Goat Farming	1	1.40
Cattle Farming and Charcoal Production	1	1.40
Cattle and Fruit Farming	1	1.40
Goat and Sheep Farming	1	1.40
Sheep Farming	1	1.40
Overall Total	71	100

Source: Prepared by the authors (2023).

The consortium occurs to facilitate the agricultural property managed by the family, where several productive activities are developed, characterizing pluriactivity, as occurs in the production of artisanal processed foods (Fisher et al., 2016). Most producers opt for livestock farming (50.0%), through dairy farming, as it represents a source of monthly income for many farmers, especially family farmers, in addition to generating jobs in different segments of the production chain (Berger et al., 2021).

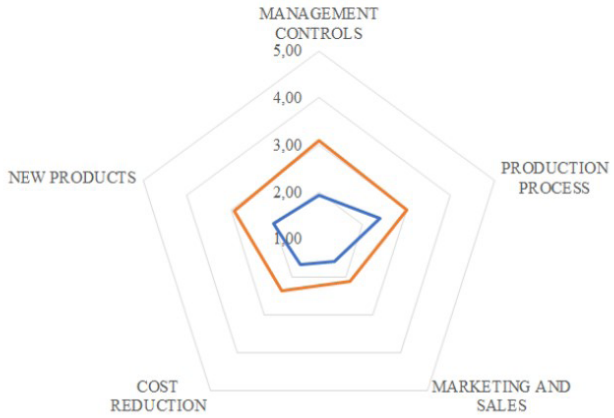
4.2 Management of the farming production process in RN

Results from the Innovation Radar showed that, on average, producers showed progress in all dimensions analyzed. However, the dimension of production processes was the area that had a less significant evolution when compared to the others (Figure 2).

This data corroborates the studies by Silva Néto & Teixeira (2011) who pointed out that the process dimension, compared to the other dimensions studied, had the lowest degree of innovation, especially in companies far from the capital. The Production Process Improvement data collected in the Innovation Radar were close to the mean values of the innovation degree in Santa Catarina and national enterprises, collected by Borghezan et al. (2023), demonstrating similar evolutions throughout the Rural Innovation Journey.

During the studied period, producers reported fluctuations in market prices, such as an increase in input prices and a drop in the sales prices for farming products. Despite this, the mean gross monthly revenue survey pointed to an increase of 117.57%, a sign of improvement in the income of the producers served.

The normality test results showed a non-normal or non-parametric distribution of data, while the Mann-Whitney test showed an improvement in the properties' production process after participating in the ALI Program (Table 2).



Innovation Radar Dimension	Initial	Final	Evolution (%)
Management controls	1,94	3,09	59,28%
Production process	2,40	3,00	25,00%
Marketing and sales	1,59	2,13	33,96%
Cost reduction	1,68	2,38	41,67%
New products	2,03	2,93	44,33%
Monthly revenue survey	R$ 6.729,27	R$ 14.210,39	117,57%

Figure 2. Innovation radar with the mean dimensions evaluated and mean gross monthly revenue recorded in the Rural Innovation Journey diagnoses, before and after.

Source: Adapted from Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (2024).

Table 2. Descriptive statistics and Mann-Whitney test for the initial and final diagnosis of the Production Process dimension collected during the Local Innovation Agent Program.

Innovation Radar Degree	Dimension		Sub-dimension			
	Production Process		Operations and Procedures		Problem Solving	
	Initial	Final	Initial	Final	Initial	Final
Mean	2.40	3.00	3.00	3.80	2.93	4.33
Median	2.33	3.00	3.00	3.00	3.00	3.00
Maximum	5.00	4.33	3.00	5.00	5.00	5.00
Minimum	1.00	1.67	3.00	3.00	2.00	3.00
Standard Deviation	0.6956	0.6138	0.0000	1.0140	0.8840	0.7240
Kolmogorov-Smirnov	0.235 p < 0.010	0.142 p < 0.010	0.531 p < 0.010	0.368 p < 0.010	0.270 p < 0.010	0.288 p < 0.010
Mann-Whitney						
W	3759.00 p < 0.05		703.00 p < 0.05		588.50 p < 0.05	
Confidence achieved	95.03%		95.16%		95.16%	
Difference between medians	-0.67		-0.00		-1.00	
Confidence interval	−1.00 and −0.34		−2.00 and −0.00		−2.00 and −1.00	

Source: Prepared by the authors (2023).

After monitoring, we found that the monitored properties showed an improvement of 19.74% in their production processes, of which 26.67% were in procedures and operations and 47.78% were in problem solving.

The initial diagnosis (DI) of the production process dimension, observed in the properties visited, presented a mean of 2.40. At this level, producers have apparent control over their operations, but with considerable losses during the process, resulting in low productivity and negative effects on the enterprise profitability, which highlights a potential for improving pre-operational processes. In the final diagnosis (DF), the mean was 3.00. After monitoring, producers began to be concerned about anticipating preparation for new harvests, correcting management processes, which resulted in moderate losses of raw materials and/or rework, optimizing financial gains.

At DI, the producers' reports were "we don't have a daily schedule, I think this can improve," "it's difficult to communicate with the employee, we've had quality problems due to their carelessness," "I don't write down what I need to do, so I end up forgetting it," "we have already had the early loss of donkeys during birth, due to lack of prior knowledge and lack of medication control."

In DF, the reports started to be "after you arrived there was no way to forget, because there was a monthly charge (for planning)," "now I have the activity chart and the production schedule, I identify the problems and solutions together with he (collaborator)," "my daughter, who is a veterinarian, helped me with the medication and vaccination of the animals, we had no further losses," "the deaths stopped with the adoption of supplementary salt, I received the milk tank, and I was able to receive visitors from the Consultant who helped me with deworming and vaccination."

Therefore, the ALI Program was a motivation to organize activities, guarantee commitment, and motivate the action plan implementation. These reports reinforce the properties' constant search for high performance and competitiveness to increase profits (Costa Júnior, 2008). In farming, despite other factors influencing the production process, such as seasonality, harvest, off-season (Santos et al., 2007), the ALI program encouraged producers to optimize the performance of properties through improvements in the areas of operations and procedures and resolution of problems.

4.2.1 Operations and procedures to improve the production process in farming

The DI of the operations and procedures sub-dimension had a mean of 3.00, and for DF of 3.80. Therefore, producers started the Program with prior knowledge about operations and procedures; however, without a targeted organization on how to carry out the procedures, generating insignificant financial gains. After monitoring by the Agent, the rural producer has control over his operations, knowing better the activity's production cycle with actions recorded and monitored regularly, making it possible to identify losses.

According to Porto et al. (2013), management failures are factors that make it difficult for producers to obtain satisfactory results. At the beginning of the ALI Program monitoring, although a minority used indicator control notebooks, forms of communication and manual planning, most producers reported that they did not have a daily or monthly agenda, schedules, lists of activities, or tables to monitor the property shares. According to managers, the various day-to-day activities took away the focus on optimizing tasks. Actions were forgotten or incomplete due to lack of notes.

In order to improve the production process management in farming in RN, producers reported the need for delegation, systematization, or review of daily activities. After the ALI, an improvement in the activity flow was observed with the adoption of tools with monthly activity planning, monitoring, a visual board of daily tasks, schedules, or WhatsApp to facilitate communication with employees and the progress of actions on the property. One of the monitored producers managed to use the Ishikawa diagram to identify problems and solutions with the collaborator.

Among the management actions observed for the producers monitored during the Program are the hiring of a person to monitor and follow the activities; the use of a virtual assistant to create task lists, set reminders, organizing activity information at scheduled times and providing weather forecasts; adoption of production schedules to facilitate organization and monitoring of actions; the use of an indicator control board in the stable, in the notebook, in apps, or in electronic spreadsheets; the division of tasks between the family, work management through WhatsApp; and the involvement of other family members who were not active in rural activities.

According to the changes, it is confirmed that in addition to the notebooks, the monitored producers sought tricks and adopted new tools to facilitate farming management, as reported in studies by Berger et al. (2021), Silva (2022) and Borghezan et al. (2023).

4.2.2 Operations and troubleshooting procedures

The DI of the operations and procedures sub-dimension had a mean of 2.93, and for DF of 4.33. Therefore, on average, producers began their Innovation Journey by carrying out some production controls that help identify problems and carry out small corrective actions. After the Journey, producers began to solve and take measures to change daily tasks, ensuring that the problem does not happen again.

Producers reported 13 problems in the production process of animal husbandry that were organized in the Ishikawa Diagram (Figure 3).

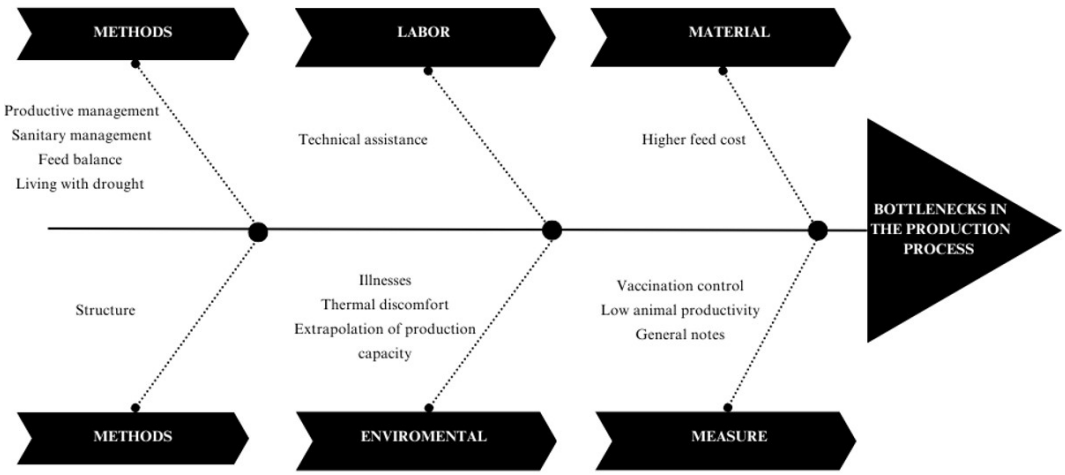


Figure 3. Bottlenecks in the production process of animal husbandry (cattle, goats, and sheep) in Rio Grande do Norte.

Source: Prepared by the authors (2023).

In relation to methods, there is a lack of knowledge on the most productive management, such as creep-feeding and breeding control. Furthermore, it is noticeable that many producers did not apply appropriate techniques to deal with drought. Producers reported the difficulty in maintaining animal health and well-being, with failures in medication control, lack of feed (high purchase costs, use of crops not adapted to drought), low animal productivity (milk, fattening, among others), extrapolation of the property's productive capacity, and absence or low presence of technical assistance. These factors caused higher rates of disease (bovine disease, mastitis, worms, among others) and increased mortality, business seasonality (long periods of females without offspring), low consistency in the sales flow, and accumulation of debts resulting from droughts.

During monitoring, producers focused on corrective actions on improving animal health and well-being (28.17%), ensuring adequate food (21.13%), using technologies to optimize the production process of animal husbandry (18.31%), hiring technical assistance (16.90%), and herd quality (15.49%) (Figure 4).

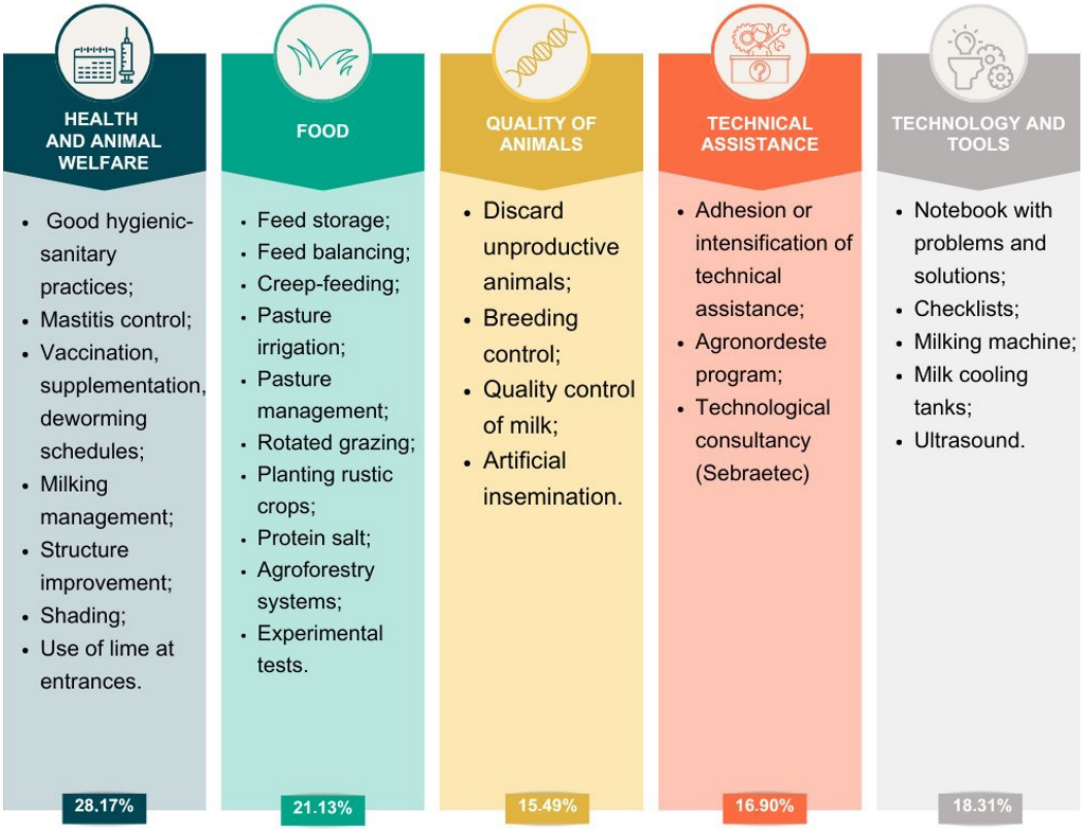


Figure 4. Corrective actions proposed after applying the Innovation Radar and adopted by producers to improve the production process of animal husbandry in Rio Grande do Norte, Brazil.

Source: Prepared by the authors (2023).

Sanitary management based on animal monitoring reduced diseases and mortality, as well as contributing to livestock weight gain, as reported by Ribeiro (2021) and Silva (2022) (Figure 3). In places with a high temperature predominance, such as in the semi-arid region, the environment needs to be suitable so that the animals can have thermal comfort, allowing the expression of their genetic potential and the maintenance of productivity (Peixoto et al., 2023).

By adopting health management and animal well-being actions, such as appropriate space, dry and ventilated resting area with shading to ensure thermal comfort, appropriate trough space for food by individuals (and reduce competition), healthy and pleasant environments (Azevedo et al., 2020).

To avoid problems with the use of products, changing diets, or implementing cultures, some producers have chosen to carry out experimental tests before applying high-cost actions; there was the adoption of the milk bank for breastfeeding as a prevention practice; planting of BRS Capiaçu; use of the dam to plant forage for food and water supply. After monitoring, producers optimized the planting of grasses and palms for the next year; the adoption of rotational grazing in paddocks; the adoption of irrigation management. Thus, producers were able to stock up, improve feed supply and balance, in addition to reducing drought debts.

The innovations adopted helped to maintain adequate nutrition, aiming to guarantee the quality of by-products generated from animal husbandry (milk, meat, and offspring). Knowing that food represents 40 to 80% (Ribeiro, 2021; Oliveira et al., 2020), producers balanced their income, becoming less dependent on external inputs. Furthermore, having fresh pasture available on the property allowed the producer to produce more milk in a smaller area (Berger et al., 2021). Thus, producers felt an improvement in production, due to adequate nutrition, guaranteeing the production of healthy animals capable of expressing their full potential throughout their productive life (Silva, 2022).

The improvement in the quality of the herd, especially in cattle breeding, occurred through the contracting of Sebraetec program for genetic breeding. During ALI's monitoring, producers organized themselves to guarantee control over the production of goats and cattle. In addition, producers began to discard unproductive animals. Through these methods, producers were able to obtain satisfactory results to improve the attributes of the animals, their productivity, and the quality of the final production (Ribeiro, 2021; Lobo, 2021).

Another important factor was the adherence or intensification of the presence of technical assistance (administrative, veterinary, or zootechnician) on the properties. After the Agent's monitoring, the producers started to join the assistance, use new tools, read materials about managing the activities, have greater participation of their family members in the activity, as well as improving the consistency of visits and communication with the professionals through the transmission of more accurate indicators.

In this case, technical assistance was not only responsible for guiding and updating livestock farmers on innovations in management, digital transformation, and tools, but also for strengthening family relationships and promoting possible family succession. This research reinforced the studies by Ribeiro (2021), Berger et al. (2021), and Silva (2022) on the importance of professionals to adequately prevent and control property problems.

During the Program, the Innovation Agent observed the adoption of technologies such as the milk tank for cooperation and collective sales. Such cooperation, according to Mariani (2006), contributed to strengthening the producer, preventing the activity abandonment. Another innovation in the processes was the acquisition of a milking machine, which improved working conditions and ensured that employees remained on the property, in addition to reducing the producer's time in this activity. Producers also adhered to the ultrasound schedule to monitor female conditions and the success of artificial insemination.

Therefore, we observe that the ALI Rural Program created a favorable environment that boosted the creation and innovative capacity to adopt new technologies and maintain commitment during the process, as already observed by Oliveira et al. (2020).

In the study on the Rural Innovation Journey in Santa Catarina and Brazil, Borghezan et al. (2023) pointed out that rural property improvement plans prioritized actions that resulted in the resolution of problems identified in the activities, thus, many actions were linked to the preparation of a to-do list and/or action schedules, adjustment to the production process, implementation protocols for processes, completion of field notebooks and innovations in management practices.

As found in the ALI Rural methodology, other studies, such as Gasparini et al. (2017) and da Silva et al. (2023), pointed out improvements in the agricultural production process after changes in daily activities or implementation of corrective actions for existing bottlenecks in production, pointing out productive gains, increased production yield, reduced time to obtain the product, process optimization, and significant reductions in waste.

5 Conclusions

In this study, we were able to confirm the positive impact of the Sebrae Local Innovation Agent Program on improving the production processes of animal husbandry in RN, Brazil. After monitoring, the monitored properties showed an improvement of 19.74% in their production processes (DI = 2.40; DF = 3.00), of which 26.67% were in procedures and operations (DI = 3.00; DF = 3.80) and 47.78% occurred in problem solving (DI = 2.93; DF = 4.33). Producers mainly adhered to process innovations, and for this they invested in technologies and tools, in addition to counting on the involvement of other family members in the rural activity.

Strengthening the operations and procedures of farming production in RN was possible by improving the activity flow with the adoption of tools such as planning monthly activities, monitoring, visual chart of daily tasks, schedules, or WhatsApp to facilitate communication with employees and progress of actions on the property. The main actions adopted to solve problems focused on improving animal health and well-being (28.17%) and ensuring adequate food (21.13%) for animals.

According to the reports of the monitored producers, the ALI Program was a motivation to optimize the property's performance, guarantee commitment, and induce the implementation of the action plan, generating an average increase in the income of the properties studied. It is important to highlight that, in the segment studied, improving the production process and adapting the product to commercialization sometimes entails high costs and investments to comply with health inspection regulations. Compared to other sectors of the economy, these factors, added to the geographic proximity of customers and competitors, can limit the gain in competitiveness.

A suggestion for future research is the quantification of the financial impacts of each improvement in the company's revenue, considering that many actions have long-term returns. One difficulty faced was evaluating the particular animal husbandry strategies by species (cattle, goats, and sheep) due to the lack of a significant sample number. During the monitoring, we observed a unanimous need of producers for innovations that dialogue with drought, from food production, pasture management, to the strengthening of production chains, associations, and public policies.

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