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Ecological and socio-environmental impacts of conversion to organic dairy farming

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Abstract The main purpose of this study was to analyze the transition of conventional dairy farming to an organic system in family-based agriculture. Eight dairy production units located in the Mato Grosso do Sul state, Brazil, were implemented and evaluated. The findings regarding ecological, environmental, and social impacts of these productive units were presented under a comparative approach, between the years 2012 to 2014. The dataset included information gathered throughout experiment implementation, along with survey responses later taken from representatives of the family units. In these surveys, each variable was assigned a value representing how such change has influenced the activity. After the insertion of coefficients of change for each variable of environmental and ecological indicators per unit of production, an impact factor was automatically calculated through the spreadsheet consisting of weighing matrices of the Ambitec-Agro indicator system. Fifteen out of the 25 analyzed indicators reached values that contributed to an improvement in the migration from conventional to organic production. The mean overall impact factor for a conventional system (μ) was − 0.55, while for an organic, it was 3.82. Among the components that contributed the most to ecological and environmental indexes in the organic system are soil quality ($\mu = 4.7$), biodiversity conservation ($\mu = 2.0$), and environmental recovery ($\mu = -1.5$). There was a 14.55% increase in technology (PIT) with a positive socio-environmental and ecological impact for dairy farmers with the use of technologies introduced in the process of transition to organic milk production system. Through this process, new concepts could be produced considering each family unit project and the local scenario.

Keywords Family-farming · Agroecology · Rural settlements · Dairy cattle · Organic system

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Introduction

The greatest challenge of rural extension programs in settlements has been to exchange knowledge with farmers to maintain agricultural production at sustainable levels for the growing population, without increasing even more degradation and harm to the environment.

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In this sense, extension activities in settlement areas directed to family farming need to be mindful of three main requirements. The first consists of transferring the scientific knowledge to improve yield, both in terms of production and quality, besides better conditions for farmers and consumers. The second comprises the checking of the conditions where such technologies will be implemented, considering local capacity and paying attention to the environmental transformations that might occur. Finally, the third relies on considering the knowledge of settlers while transferring the technologies produced by academic expertise, to suit them to local conditions, making a symbiosis of skills among the involved people.

As a branch of the university, the extension has a social function based on transferring and exchanging knowledge with the society, forming a "two-way road." Therefore, bases for the strengthening of family farming are created, in which the national dairy production stands out. These organizations aim to improve milk quality and provide means to change the domestic production rates, which are below the ideal for consumers in terms of both quantity and quality.

The low technical indexes of the dairy sector, e.g., an average stocking rate of 0.5 animal ha^{-1} of pasture and a mean yield of 1297 kg of milk cow^{-1} year^{-1}, evidence the need for increases to meet consumption demands in Brazil, which would also raise the income of farmers. The Brazilian productive potential of milk lies in a dairy herd of 22,435 million milking cows and 80 million hectares available only in the Cerrado ecosystem (Stock et al. 2011). The above-mentioned indices suggest an urgent and imperative intensification of milk production.

In this context arises organic dairy farming as a current demand of the society. Currently, consumers have demanded product quality at a fair price, healthy from a food safety point of view, and free from biological hazards (brucellosis, tuberculosis) chemical hazards (antibiotics), and produced with less use of artificial inputs and care for the good being. Moreover, there are current concerns about the environment and biodiversity preservation, which come together with the social role of agriculture and livestock, the creation of jobs and income in the countryside, and thereby reducing the rural exodus. All these issues are based on the Brazilian Organic Law and Forest Code (Brasil 2021; Soares et al. 2011, 2012).

In general, the analyses show that organic animal production systems are economically viable, with a diversity of productive arrangements and better gains, because they present differentiated products, besides contributing to plant production through natural fertilizers (Soares et al. 2018; Figueiredo and Soares 2012). The development and adaptation of alternative technologies for these production systems are of great importance for organic agriculture.

Although organic animal production is present worldwide, according to (Willer and Lernoud 2017), the available statistics on the number of organic animals are still incomplete and do not allow an overview of the sector. However, it is possible to observe from the available information the advance of organic animal production mainly in European countries. Thus, the largest participations are sheep and cattle, because they are extensive productions that become easier for organic conversion (Willer and Lernoud 2017).

A socio-environmental approach has gained more importance, wherein the traditional knowledge of people involved in the production is present, associated with new technologies, thus creating conditions to improve and increase production. In family farming, changes in productivity and product quality may arise from aggregating value and increase in family income, providing favorable conditions for the involvement of a larger number of members of the family in production processes. These factors avoiding rural depopulation, especially youth, represent the generational segment for the continuity of small family farm unit production.

The environmental impact assessment (EIA) of these practices and agricultural processes is therefore indispensable for sustainable development, since interaction technology-environment and society, with its multiple interests and objectives, can result in unintentional, indirect, and delayed impacts. It is only by systematic evaluation of these impacts, applying appropriate methods specifically designed and included in an appropriate institutional context, that agricultural technologies can be safely recommended to be adopted (Oliveira et al. 2019).

In view of the need to evaluate and measure the environmental and socioeconomic impacts of these practices and processes, an environmental impact assessment is necessary (Soares et al. 2021). The Ambitec/Animal Production (Soares et al 2015) was developed by the Brazilian Agricultural Research

Corporation-Embrapa, reproducing socioeconomic and environmental impact assessment data and showing with great clarity the factors that increase or decrease the level of impact.

The Ambitec-Agro indicator system allows a clear and concise measurement of the main factors related to the development of agricultural production units and is a tool applicable to environmental certification processes, contributing to sustainable rural development (Irias et al. 2004; Monteiro and Rodrigues 2006; Ávila et al. 2008). The method can be used including ecological-based systems with measurement of the percentage of impacts-PIT of the introduction of new technologies (Soares et al 2015).

Different studies realized utilizing Ambitec method/animal production too showed increase in ecological and socioenvironmental performance indices, with improvements related to practices and technologies used in the transition from conventional to organic milk production (Soares et al. 2015; Campos et al. 2018; Soares et al. 2021). In these studies, assistance activities were also observed to the dairy farmer in the process of adjusting ordinance no. 52 for organic production (Brasil 2021).

The objective of present study was to evaluate the ecological and environmental impacts of a group of family farmers in transition to organic milk production using the Environmental Impact Assessment—EIA by the Ambitec method/animal production.

Material and methods

Experimental environment

Organic dairy units were set up between the years of 2012 and 2014 in the settlement Eldorado II. The area is located in the town of Sidrolândia, state of Mato Grosso do Sul, Brazil. Eight small farms belonging to eight different families, which own eight small dairy herds, were evaluated. The herds were composed of crossbred animals (Holstein × Zebu), raised primarily on pasture and supplemented with corn silage, as well as receiving an alternative health control to comply with Law no. 10831 (Brasil 2003), which is based on the Portaria 52 for organic animal and vegetable productions (Brasil 2021).

The idea of establishing organic dairy experiments in settlement units came from the producers themselves, but it also involved a group of professionals from the Federal University of Grande Dourados (UFGD) and from Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), who sought to meet the demands brought by the farmers while transitioning to an organic system. In 2012, installations started using practical activities in each production unit. In the beginning, meetings were held with the formation of groups of settlers to demonstrate technologies and planned methodologies, listening to stakeholders and assuring that their interests will be fulfilled, as well as verifying whether the university proposals meet their requirements.

Thus, professors from the university, external experts, and farmers of the settlement accompanied each stage. These debates continued over the years of 2012 and 2013 through meetings for experience sharing, crosschecking of results, and promotion of lectures and discussion on the subject.

In 2014, all the producers were again evaluated for current conditions by the Ambitec-Agro method, as previously done, highlighting the socio-environmental and ecological impacts of the agroecological transition from conventional to organic dairy production, as described by (Soares et al 2015). The characterization of producers is described in Table 1.

The major problems related by the producers are associated with a lack of organization towards the neighboring units and production transportation and displacement of the settlers to urban centers, as well as difficulties in organization for collective works. Other difficulties encountered by the producers in the settlement are directed to locomotion (internal and external), as well as the lack of communication among the families and intermediaries attending the community.

All producers believe the solution to these problems would make it easier for the expansion of the productive chain, acquisition of seeds, animals, the organization for planting and harvesting, and, especially, the control of the marketing of products, ensuring planning of the productive chain and increase of profits.

Methodology

The ecological and socio-environmental impacts caused by agricultural technological innovations were assessed by the indicator system Ambitec-Agro method which was developed by Empresa Brasileira

Table 1 Characterization of dairy production units

Producer	Total area (ha)	Pasture area (ha)	Animals (*n*)	Production (L/cow/day)	Other activities
1	9.0	8.5	15	6.9	Honey
2	9.1	7.0	7	5.0	Honey, pepper and guava,
3	9.4	5.0	6	5.9	Honey, poultry, agriculture
4	9.5	8.0	6	5.0	Honey and beef cattle
5	9.0	8.0	6	9.5	Poultry, agriculture, fruit growing
6	9.6	6.8	6	8.5	agriculture
7	9.9	8.0	25	4.0	Poultry, swine, agriculture
8	9.4	8.0	4	8.0	Honey
Average	9.4	7.4	9.4	6.6	

de Pesquisa Agropecuária-Embrapa Meio Ambiente. The system consists of a set of electronic spreadsheets (MSExcel platform) related to the evaluation of four aspects of agricultural activity improvement resulting from technology innovation: (i) its magnitude, (ii) efficiency, and contribution towards environmental, (iii) conservation, and (iv) restoration (Fig. 1).

Each of these aspects consists of a series of indicators of technology environmental performance, constructed by components in automatic weighing matrices. Each matrix has several open cells where the change coefficient obtained in the field for each component is introduced. Also, each matrix has two sets of weighing factors: one related to the importance of the component and the other related to the geographic scale in which the component change coefficient occurred in the case studied. The component change coefficients are obtained in a field interview/survey addressed to the farmer/manager regarding his/her knowledge about the environmental performance of the technology as applied in the specific activity and management system under evaluation (Fig. 2).

The interviews are to be applied to a statistically representative sample of farmers from the entire group adopting agricultural technology under evaluation. It is important to remark that the interviewers should be well trained before going out to the field. In those cases when more than one interviewer is to do the work, it is recommended that, for training purposes, all the interviewers make sure they obtain similar results for each indicator interview the group of farmers.

The indicator system AMBITEC-AGRO is a methodology that comprises three steps. The first step refers to the survey and characterization of the technology applied to the farmers of the evaluated production units. The second step refers to the application of a questionnaire to selected farmers, that is, the representative sample. The third step consists of entering data into the weighing matrices, followed by the composition of partial and aggregated indices to assess the environmental impact of the selected technology.

Once all change coefficients are inserted in the matrices sequentially for the Efficiency, Conservation, and Restoration spreadsheets, the environmental impact coefficient of each indicator is automatically weighed, and the results are graphically expressed. Finally, an environmental impact index (Fig. 3) is calculated for the technology under the specific conditions studied (Rodrigues et al. 2003). With these data, the objective was to understand aspects related to production and environmental contexts, but also the people involved in the process, considering the interrelationship between product quality and quality of life, as stated by the university extension function.

In this context, the knowledge of all the involved people should be given a voice, in which there are no ready-made truths but the building of new avenues where one can listen to the other, as oriented by Freire (2014) so that new solutions could be built. Through the scope of ecological impacts, eight criteria are involved (Soares et al 2015; Soares and Rodrigues 2013), which are environmental conservation and recovery, use of material and veterinary inputs, energy use, use of natural resources, atmosphere, soil quality, water quality, and biodiversity. If both dimensions are planned, the variables are measured based

Environmental Dimension		Social Dimension				
Use of Inputs and Resources Criterion and Indicators:	**Environmental quality criterion and indicators:**	**Costumer Respect Criterion and Indicators:**	**Employment Criterion and Indicators:**	**Income Criterion and Indicators:**	**Health Criterion and Indicators:**	**Management & Administration Criterion and Indicators:**
1. Use of Agricultural Inputs and Resources 1.1. Use of Agrochemicals - Pesticides - Fertilizers - Soil amendments 1.2. Use of Natural Resources-Consumptive use of water- Water for processing- Land area	4. Atmosphere - Greenhouse Gases - Particulate material / Smoke - Foul smells - Noise	9. Product Quality - Chemical residues reduction - Biological contaminants reduction - Inputs suppliers availability - Input suppliers reliability	11. Training 11.1. Training Type - Local short course - Specialization short course - Regular education 11.2. Training Level - Basic - Technical - Superior	15. Net Income generation - Security - Stability - Distribution - Amount	18. Personal and Environmental Health - Endemic diseases sources - Atmospheric pollutant emissions - Water pollutant emissions - Soil contaminants generation - Restriction to sport and leisure practices	21. Farmer Capability and Dedication - Specialized training - Dedicated working time - Family engagement - Use of accountancy system - Formal planning - Certification / Labeling
2. Use of Veterinarian Inputs and Raw Materials 2.1. Use of Inputs-Veterinarian products-Hay / Fodder	5. Soil Quality - Erosion - Organic matter - Nutrient leaching - Compaction	10. Production Ethics 10.1. Animal Welfare & Health - Animal welfare - Access to water sources and forage supplementation - Sanitation and health conditions - Livestock density - Ethical handling, transportation and slaughtering	12. Opportunity and Qualification for Local Employment 12.1. Worker Origin - Farm - Local - Municipality - Region	16. Income Sources Diversity - Agriculture and livestock - Other rural activities - External jobs - Business branching - Financial investments	19. Occupational Safety & Health - Risk exposure - Noise - Vibration - Heat / Cold - Moisture - Chemical agents - Biological agents	
2.2. Use of Raw Materials - Basic raw materials - Raw materials for processing - Agroindustrial additives Feed / Supplements	6. Water Quality - Biological Oxygen Demand - Turbidity - Floating materials / Oil / Scum - Siltation		12.2. Worker Qualification - Untrained - Trained - Specialized - Technical	17. Land Value - Facilities improvement investments - Natural resources conservation - Products / services prices - Compliance to legal aspects - Public services / Tax policies etc.	20. Food Safety & Security - Production guarantee - Food quantity - Food nutritional quality	
3. Use of Energy - Fossil fuels - Biofuels - Biomass - Electricity	7. Biodiversity - Natural vegetation loss - Fauna corridors loss - Species / Varieties losses	10.2. Social Capital - Attention to local social needs - Rural technical assistance projects	13. Job Generation and Engagement - Temporary - Permanent - Partner - Family			
	8. Environmental Restoration - Degraded soils - Degraded ecosystems - Legally-defined Preservation Areas - Mandatory Protection Areas		14. Employment Quality 14.1. Work Legislation - Underage work prevention - Workweek < 44 hs. - Formal contract - Social Security			
			14.2. Fringe Benefits - Housing assistance - Food assistance - Transportation assistance - Health care assistance			

Fig. 1 Integrated principles, criteria, and indicators included in the several modules of the system for impact assessment of agricultural technological inventions (Ambitec-Agro). Source: adapted (Monteiro and Rodrigues 2006)

on coefficients of change, that is, each studied indicator is assigned a value, which represents how much the implantation of the technology has changed the system, given the focus on the improvement of production and the environment.

Each value of the coefficient of change represented a level of influence on the system, which was + 3 for a great positive influence, + 1 for a moderate positive influence, 0 for no influence, − 1 for a moderate negative influence, and − 3 for a great negative influence (Rodrigues et al. 2003; Tupy et al. 2006). In the interviews with farmers, when they evaluated the outreach of experiments installed in the production units in the Eldorado II settlement, pointing out weaknesses and potentials, we used the AMBITEC spreadsheets, in which values varying from − 3 to + 3 were assigned to

Water Quality		Water quality variable: Biochemical Oxygen Demand	Turbidity	Floating materials / Oil / Scum	Siltation	weighing factor check
Weighing factors k		-0,5	-0,25	-0,25	0	-1
Scale of occurence = No-effect	Mark with an X				X	
Near	1					
Proximate	2	-1	-3			
Surrounding	5			-3		
Impact Coefficient = (change coefficients * weighing factors)		1	1,5	3,75	0	6,25

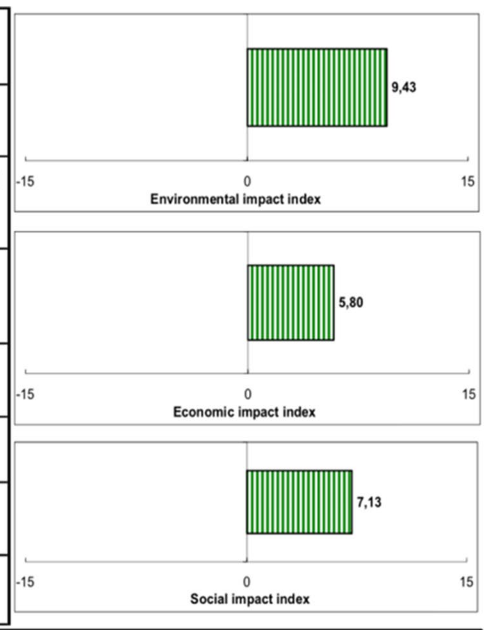
Fig. 2 Typical scaling checklist of the Ambitec-Agro system. Source: adapted Monteiro and Rodrigues (2006)

the respective variable of each indicator, according to the answers given by farmers. To determine the impact indices observed for the criteria, besides the change coefficients, weighting factors related to the importance of each indicator and their geographical scale of occurrence was included (Fig. 2). The values of these weighting factors varied according to their number in the criterion composition (i.e., a normalization step).

Thus, the weighting factors should correspond to a unit (±1), which would be a positive or negative value, depending on the impact direction. If the observed change in the indicator is a favorable effect, the sum of factors will be positive (+1); if it represents a deleterious effect, this sum will be negative (−1). Once the weighting factors have been defined, then change coefficients are inserted according to

Technological Innovation Performance Indicators	Importance weighing factor	Indicator impact coefficient
Use of Agricultural Inputs and Resources	0,05	8,0
Use of Veterinarian Inputs and Raw Materials	0,05	5,0
Use of Energy	0,05	13,0
Atmosphere	0,02	5,0
Soil Quality	0,05	10,0
Water Quality	0,05	6,0
Biodiversity	0,05	15,0
Environmental Restoration	0,05	15,0
Product Quality	0,05	7,5
Production Ethics	0,05	7,0
Training	0,05	8,5
Opportunity and Qualification for Local Empoyment	0,02	2,7
Job Generation and Engagement	0,05	3,2
Employment Quality	0,05	7,0
Net Income Generation	0,05	7,5
Income Sources Diversity	0,025	7,5
Land Value	0,025	3,8
Personal and Environmental Health	0,02	7,0
Occupational Safety & Health	0,02	3,3
Food Safety & Security	0,05	3,5
Farmer Capability and Dedication	0,05	5,5
Trade Arrangements	0,05	6,8
Waste Disposal	0,05	13,0
Institutional Relationship	0,02	13,0
Weighing factor check: 1	Technological Innovation Impact Index	7,97

Integrated indices	
Use of inputs	8,67
Environmental quality	10,20
Customer respect	7,25
Employment	5,35
Income	6,25
Health	4,58
Management	9,56



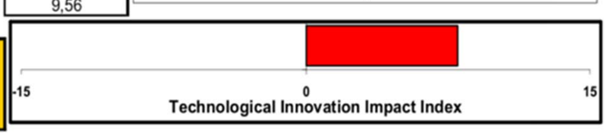


Fig. 3 Final environmental impact assessment of the Ambitec-Agro system. Source: adapted (Monteiro and Rodrigues 2006)

geographical coverage, i.e., as per the scope of the changes observed in the field. This range can be one-off (weighting factor = 1) when the effect is restricted to an area near the environment where the technology was deployed (farm, plot, or enclosure) and local (weighting factor = 2), when the effect extrapolates the field or enclosure and reaches the rural establishment where it is located. It can also be classified as neighboring (weighting factor = 5), when the generated impact exceeds the limits of the entire establishment, extending to the surrounding areas (Fig. 2).

After field observations and data collection with producers were fulfilled and the respective coefficients of change were inserted to the corresponding weighting matrices, the findings were plotted using the impact assessment spreadsheet, for each criterion in specific, as well as their aggregation to compose a general socio-environmental impact index. By combining change coefficients and weighting factors, such an index could be expressed on a scale between − 15 and + 15. After all collections, all the data were organized in a summary table to obtain the means for the evaluated criteria and indicators, then proceeding to descriptive analysis. In this study, a comparative approach was carried out to evaluate the socio-environmental and ecological impacts of the agroecological transition from conventional to organic milk production, which was implemented between 2012 and 2014, in the eight selected production units (Soares et al 2015; Soares and Rodrigues 2013).

To extend the approach and make a comparative analysis, all the data collected about the conditions before and after technology adoption were considered, so that the differences in technical coefficients of the process could be highlighted, in addition to assessing the advances provided by such implementation, based on the method described by Soares et al. (2015).

In this sense, we calculated the percentage of the impact of the technology (PIT). The values obtained within an interval of − 15 to + 15, denoting the impact index caused by the technology implementation, enabled the estimation in the two moments for each individual or a particular production system. This measure can assume positive or negative values, indicating the direction, if the impact index measured between the two moments (before and after the introduction of the technology) was positive or negative, as it can also indicate the intensity or magnitude related to these indexes of impact in the change of moments (Soares et al 2015).

Here follows the description of the calculation:

$$PIT_i = \left(\frac{\mu_{2i} - \mu_{1i}}{AM}\right) \times 100$$

In which:

PITi Percentage of Impact of the Technology for each individual I, i=1...n

μ1i Index of impact after technology implementation at an individual level i

μ2i Index of impact before technology implementation at individual level i

AM Maximum range of Ambitec scale (= 30)

Statistical analyses

The cluster analysis technique was used to classify the farmers according to the environmental impact indicators expressed by the Ambitec-Agro indexes. The identification of homogeneous subgroups in the population by the cluster analysis helped in the joint analysis of indicators with better values among the grouped producers (Hair et al. 2005) that promoted the conversion to the organic system of milk production. "Quadratic Euclidean Distance" was adopted as a measure of similarity and the "Ward hierarchical clustering" as a clustering method. To investigate the possible existence of significant differences between the assessed years of 2012 and 2014, for each variable composing the environmental indicator, a non-parametric Wilcoxon test was performed for paired samples, at a significance level of 5%. These analyses were carried out using the SPSS software (Statistical Package for the Social Sciences) for Windows version 19.0 and the free software R version 2.14.

Results and discussion

When comparing conventional and organic dairy systems by the Wilcoxon nonparametric test, the environmental impact indexes showed differences ($p < 0.05$). The mean overall

Table 2 Indicators of ecological and social-environmental impacts of conventional management in dairy production units in 2012

Conventional-2012									
Indicators	Growers								
	1	2	3	4	5	6	7	8	μ
Indicators of ecological impacts									
Use of agricultural supplies	−1.5	−11.5	−6.0	−5.5	−1.7	15.0	−4.0	−7.7	−2.9
Use of veterinary supplies	−4.5	−2.5	2.5	7.5	−13.5	6.5	3.5	−4.5	−0.6
Energy consumption	−10.5	−4.0	−12	−6.5	−7.5	12.0	−9.0	−5.5	−5.4
Emissions to atmosphere	0.0	−2.2	−3.0	0.6	−2.4	−13.6	−3.0	−2.8	−2.2
Soil quality	3.7	−3.7	−3.7	−7.5	−3.7	0.0	−11.2	−3.7	−3.8
Water quality	−6.7	−0.7	−1.5	7.5	2.7	1.0	3.5	1.2	0.2
Biodiversity conservation	6.0	−0.6	0.0	0.6	−3.0	−4.2	−1.8	0.7	0.2
Environmental recovery	2.0	6.4	6.6	1.0	4.0	−0.4	−1.2	3.0	3.1
Indicators of social environmental impact									
Product quality	6.2	−2.5	10	−5.0	−5.0	−5.0	−7.5	6.2	1.6
Share capital	2.2	1.0	0.6	0.4	0.1	−4.2	−2.4	−0.2	−0.3
Welfare and animal health	4.5	−13.5	−12	−9.5	4.5	−13.5	−15	4.5	−3.9
Capacity	0.0	1.2	4.5	−7.0	1.2	−9.0	2.7	2.2	−0.5
Quality and labor supply	1.6	0.03	1.1	−0.48	0.2	1.62	0.8	1.0	0.8
Job quality	−0.7	−0.7	−0.7	0.0	0.0	−8.2	0.5	4.2	−0.7
Income generating	2.5	5.0	10	2.5	5.0	−15	5.0	5.0	2.5
Diversity of income sources	5.0	2.0	3.2	3.5	4.0	−7.2	3.2	3.2	2.1
Property Value	4.0	5.0	5.0	3.5	7.0	−3.0	2.5	5.0	3.7
Environmental and personal health	−4.8	−1.0	−1.4	−4.4	−1.4	1.6	−1.4	−2.6	1.9
Occupational safety and health	−8.0	−7.0	−7.0	−7.0	−12.0	1.0	−12	−7.0	−7.4
Food safety	−6.0	1.0	1.0	1.0	1.0	−2.8	−1.2	1.0	−0.6
Dedication and profile responsible	−6.0	3.5	4.2	4.2	−3.7	−10.7	−1.5	2.7	−0.9
Condition of commercialization	2.2	−13.0	4.2	2.2	3.5	−4.5	2.7	1.2	−0.2
Residual disposition	1.0	0.0	3.0	0.0	4.0	−2.0	5.0	3.0	1.8
Chemicals management	4.5	−2.25	5.0	3.25	0.0	0.0	0.0	3.2	1.7
Institutional relationship	−0.2	2.0	2.7	0.5	−0.2	−10.5	3.5	2.7	0.1
Environmental impact index	−0.14	−1.52	0.66	0.14	−0.87	−2.61	−0.69	0.66	−0.5

impact index for the conventional system was $\mu = -0.55$ and the organic one was $\mu = 3.82$ (Tables 2 and 3).

The data shows that the implementation of the technology had a great environmental impact potential since it enabled an improved control of environmental contamination derived from an excess of inputs, increasing the economic efficiency of the system.

Out of the 25 indicators analyzed in this study, 17 were significant ($P < 0.05$); however, among them, only 15 contributed effectively to improve the system when migrating from conventional to organic management, but two of them showed no improvement. Besides, the indicators presented expressive values differently, as the new indexes showed both positive and negative values. Also, the different indexes registered for the indicators revealed differences between properties under conventional and under the organic system.

Such indexes can improve over the years since the practices adopted in organic farming, as stated in the legislation (Brasil 2021), contributes to the conservation of natural resources. These data are justified according to the time these practices have been used, besides the processes used in the transition. Time is known to be a representative factor for this process. The variables under study vary with the way the system is applied and as the involved producers absorb and efficiently

Table 3 Indicators of ecological and social-environmental impacts of organic management in dairy production units in 2014

Organic-2014									
Indicators	Growers								μ
	1	2	3	4	5	6	7	8	
Indicators of ecological impacts									
Use of agricultural supplies	−4.75	2.0	−12	10.5	−5.2	−15.0	7.2	0.7	−2.1
Use of veterinary supplies	−1.5	−6.0	−7.5	1.5	7.5	−7.5	0.0	4.5	−1.1
Energy consumption	−5.5	−12	12	7.5	3.0	−12	8.0	−9	−1.0
Emissions to atmosphere	−1.6	−1.2	4.8	4.4	2.4	−1.2	2.2	2.4	1.5
Soil Quality	−3.7	3.7	3.7	15.0	3.7	−3.75	15	3.7	4.7
Water quality	0.0	0.0	−7.5	3.7	1.5	−0.75	0	−2.2	−0.7
Biodiversity conservation	−1.8	3.6	2.4	2.4	3.0	2.1	2.1	2.1	2.0
Environmental recovery	−0.8	−3.4	−4.2	−2.4	−1.6	1.8	0.0	−1.2	−1.5
Indicators of social environmental impact									
Product quality	3.7	7.5	−5	2.5	15.0	11.2	3.7	0.0	4.8
Share capital	0.0	0.9	1.0	1.5	2.2	4.2	1.9	2.5	1.8
Welfare and animal health	13.5	13.5	13.5	13.5	13.5	13.5	15.0	13.5	13.7
Capacity	3.7	3.7	13.5	12.0	3.7	9.0	5.2	6.7	7.2
Quality and labor supply	−0.2	1.0	−1.6	2.5	1.2	−0.5	0.1	1.0	0.4
Job quality	0.7	0.7	0.75	0.0	0.0	8.25	1.5	0.0	1.5
Income generating	15.0	15.0	−5	8.7	7.5	15	10	15	10.2
Diversity of income sources	3.7	6.0	9.7	3.0	6	9.75	9.7	9.7	7.2
Property value	6.7	12.7	6.7	15.0	2	10.5	5.0	10.5	8.7
Environmental and personal health	1.8	−4.8	−2.4	2.8	0.6	−3.0	0.6	1.8	−0.3
Occupational safety and health	−1.0	3.0	−6.0	2.0	12.0	−3.0	12.0	−3.0	2.0
Food safety	3.0	6.0	4.2	6.0	3.0	4.2	1.2	3.0	3.8
Dedication and profile of responsible	7.5	10.5	12.7	10.5	12.7	10.7	7.5	8.2	10.1
Condition of Commercialization	4.5	15.0	12.7	2.2	10.5	6.0	8.2	4.7	8.0
Residual disposition	3.0	12.0	9.0	7.0	12.0	3.0	8.0	6.0	7.5
Chemicals management	−1.2	3.7	−3.5	−7.5	0.0	0.0	0.0	0.0	−0.8
Institutional relationship	0.7	7.5	8.2	8.25	8.2	10.5	10.5	8.2	7.8
Environmental impact index	1.92	4.03	2.42	5.31	4.99	2.92	5.39	3.9	3.8

put the technology into practice. Therefore, we could characterize the units under study as being in a transition phase between conventional and organic systems. As we pointed out earlier, it should be noted that these settled families have brought their past field experiences as employees, sometimes in large farms, where production followed conventional molds. This way, the conversion to an organic production has become a reality only recently, being still in the initial stage.

This stage of adaptation lies not only in the provision of results but also on the learning process of managers, and on the willingness to adopt this new way of producing. Allied to this, it must be considered that before the expropriation, the area had been entirety grown with pastures for cattle raising. After the small lots were established, the land-reform beneficiaries needed to manage the soil by removing the pasture and fertilizing the area to make it suitable for cropping. This task was not easy given the few resources the settlers had, thus delaying the changing process. Therefore, we understand that the maintenance of a dairy activity in the Eldorado II was possible due to the availability of pastures and the ease in marketing milk and dairy products, which together created the bases for its continuity.

For dairy activity, the time required for conversion, as well as the difficulties observed in this process, will depend on how much the farmer was tied to conventional practices and on how much they affect production bases until the beginning of the conversion process. Khatounian (1999) described that a conversion period should not be understood only as "quarantine" for disposal of pesticide residues, but also as a necessary period for reorganization, consolidation, and maturation of new knowledge, combined with greater integration between farmers and the environment.

By analyzing the environmental impact indicators, a significant difference ($P<0.05$) was observed between both systems in terms of atmospheric emissions, soil quality and conservation, biodiversity, and environmental recovery (Tables 2 and 3).

Comparing all the indexes, only environmental recovery changed from a positive to a negative level, that is, from $\mu=3.1$ in conventional to $\mu=-1.5$ in the organic system. This finding appears to have indicated that the adopted organic management might not have been efficient enough to enhance this indicator. The impacts are directly related to information processing and farmer work, which might not have used recovery practices properly.

On the other hand, the criterion of biodiversity conservation and environmental recovery consists of the variables of "conservation and biodiversity" and "environmental recovery" featuring an integrated impact index to this criterion. The variable "environmental recovery" considers the following indicators: degraded soils, degraded ecosystems, areas of permanent preservation, and legal reserves. On the comparison between the indicators of environmental recovery from positive to negative in conventional to organic, in not restoring function and formation of permanent preservation areas and reserve maintenance forests, which take many years to occur and so obtained low values from 2012 to 2014. Even with improved soil indicators, degraded ecosystems and native vegetation, wildlife, and traditional varieties species (indicators that make up the conservation and biodiversity) still were not enough for the maintenance or improvement of the environmental recovery.

The new technology provided no benefit to the atmospheric emission indicator, which was $\mu=-2.2$ in the conventional system and $\mu=1.5$ in organic. This is because the emission of greenhouse gases occurs in two ways: intensive use of chemical fertilizers and agricultural machinery and soil movement (nitrous oxide and carbon dioxide). In the same way, the emission of methane by animals occurs due to low-quality diets, reducing the digestive efficiency of ruminants. In this sense, the atmosphere emissions criterion consists of the variables of emissions of "greenhouse gases," "particulate matter-smoke," and "odors and noises." Questioning the producer about these variables becomes necessary, mentioning the factors which could intensify them and that are related to the use of fertilizers and soil movement, as well as improve the quality of the diets of animals.

The answers were that the improvement in animal nutrition there was a need for the introduction of new grazing areas and bulky in an organic system, although using alternative fertilizers, small areas, and handling manure collection. The responses of the producers were that the improvement in animal nutrition is related to the need to introduce new pasture areas in the organic system, using alternative fertilizers and manure management. We can infer that producers in a conventional system that initiate the adoption a new system, with management of areas, consequently may have increased greenhouse gas emissions, as well as particulate matter, producing odors and noises, thus providing the values of the atmospheric emission criteria observed. Among all ecological impact indicators, soil quality stood out ranging from $\mu = -3.8$ in conventional to $\mu = +4.7$ in the organic system. One of the ways to improve soil quality is adopting organic farming practices, which reduce the use of fertilizers and exclude synthetic pesticides, seeking to replace externally acquired inputs with those found in the farm or nearby (Altieri, 2002 cited by Lima et al. 2007).

This system type reduces soil turnover, favoring recovery of physical and chemical properties, previously deteriorated by intensive or conventional systems (Lima et al. 2007). Other variables were also important and contributed to the soil quality indicator such as soil compaction, which decreased with a reduction in stock number, a characteristic of organic livestock (Soares et al. 2011, 2012). Galharte and Crestana (2010) noted that a larger ground cover helps improve these variables. This proves that even under conventional systems, this technology can be widely used, seeking to improve soil fertility conditions, and hence reduces the use of inputs. Also, about the agroecological practices that interfered with soil productive capacity, we observed that a decrease in the use of heavy machinery for soil tillage favored rapid changes in soil physical properties and prevented compaction (Macedo 2009).

In addition to this factor, the presence of native vegetation cover favors soil particle aggregation, which reduces erosion and improves soil structure, increasing porosity, as observed by the above author when comparing an area of native vegetation with cropping areas, with and without farming and livestock integration. Biodiversity conservation was the indicator that also showed improvements from conventional to organic management, ranging from $\mu = 0.2$ to $\mu = 2$, respectively. This result might have occurred due to the maintenance of permanent preservation areas (PPAs) and legal reserve (LR), as advocated by the process of settlement of the region and observation of environmental legislation (Goméz et al. 2016).

Regarding environmental recovery, indicators changed from $\mu = 3.1$ in conventional to $\mu = -1.5$ in an organic system, which might have been due to less soil plowing under the grazing areas. The indicators agricultural inputs, veterinary inputs, energy consumption, and water quality showed no satisfactory contribution ($P > 0.05$). For the implementation to have a high potential and generate positive impacts on the environment, the use and management of external inputs must be more strictly controlled, which depends very much on the level of managerial qualification and workforce involved, stimulating techniques and practices able to optimize the production system (Tupy et al. 2006).

For socio-environmental impacts, 13 out of the 17 analyzed indicators presented significant differences ($P < 0.05$). These indicators were share capital, animal welfare and health, professional qualification, job quality, income generation, income source diversity, property value, occupational health and safety, food safety and health, food safety, trading conditions, waste disposal, and institutional relationship (Table 3). These results show that the organic management adopted in this study was considered efficient because it can be planned to be productive. In this planning, the property should be considered as a whole, under an integrated view based on management and ecosystem structures, breaking the disciplinary barriers by understanding the farm as a living organism that is dynamic and systemic. Furthermore, the maximum number of operational aspects should be foreseen in this planning (Figueiredo and Soares 2012).

It can also be inferred that the knowledge being built has increased since the beginning of this process, through the interactions among technicians, extensionists, and researchers from public agencies (Van Der Ploeg et al. 2000; Embrapa 2006). An increasing number of meetings to exchange experiences with producers contributed to this result achieved, besides a stronger relationship of trust between farmers and involved team. Here lies the exchange of knowledge that we have already pointed out, which moves the university extension, when scholars and commoners can exchange ideas and raise doubts about their certainties, enabling the expansion of indicators and results. In terms of animal welfare and health, indicators pointed that the dedication and profile of the person in charge, occupational safety and health, trading conditions, institutional relationship, training, and income generation presented the highest values of environmental impact when comparing both systems (Table 4).

The animal welfare index varied in $\mu = 17.56$ from conventional ($\mu = -3.9$) to organic system ($\mu = 13.7$). This might have occurred because producers were raising Holstein-Zebu crossbred cows, which are better adapted to the local climate conditions and management practices used (Tables 2, 3, and 4). For Hurnik (1992), animal welfare is warranted when there is harmony between the animal and its environment, promoting excellent physiological and physical conditions, thus increasing the quality of life for animals. According to Miranda (2011), some practices are essential to improve animal wellbeing such as providing water sources throughout the pastures, facilitating animal access, and avoiding long walks in areas of extensive management. Such a measure can also contribute to combating erosion. Another measure that could help improve this factor is increasing the shaded areas in the pastures both for intensive and extensive management, so that animals could protect themselves from excess heat, particularly during the hottest hours of the day. About trading, institutional relations, and professional training, the values went from $\mu = -0.2$, $\mu = 0.1$, and $\mu = -0.5$ to $\mu = 8.0$, $\mu = 7.8$, and $\mu = 7.2$ when comparing milk production in conventional and organic system, respectively. When comparing both systems, the variation was $\mu = 8.16$, $\mu = 7.72$, and $\mu = 7.72$, respectively.

Table 4 Values of differentiation of environmental impacts indexes between conventional and organic management in dairy production units

Indicators	Organic-2014										
	Growers										
	1***	2***	2***		3**	4**	5***	6*	7**	8***	
Indicators of ecological and environmental impact											
Use of agricultural supplies and resources	−3.25	13.50		−6.00		16.00	−3.50	30.00	11.25	8.50	0.81
Use of	3.00	−3.50		−10.00		−6.00	21.00	−14.00	−3.50	0.0	0.50
veterinary supplies and Mater. P. energy consumption	5.00	−8.00		24.00		14.00	10.50	−24.00	17.00	−3.50	4.38
Emissions to atmosphere*	−1.60	1.00		7.80		5.00	4.80	2.40	5.20	5.20	3.73
Soil quality*	−7.50	7.50		7.50		22.50	7.50	−3.75	26.25	7.50	8.44
Water quality	6.75	0.75		−6.00		−3.75	4.25	−1.75	−3.50	−3.50	−0.84
Biodiversity conservation*	−7.80	4.20		2.40		1.80	6.00	6.30	0.30	1.40	1.83
Environmental recovery*	−2.80	−9.80		−10.80		−3.40	−6.20	2.20	−1.20	−4.20	−4.53
Product quality	−2.50	10.00		−15.00		7.50	20.00	16.25	−3.75	−6.25	3.28
Share capital*	−2.20	−0.10		−0.40		1.10	2.15	8.40	4.35	2.75	2.11
Welfare and animal health*	9.00	27.00		25.50		4.00	9.00	27.00	30.00	9.00	17.56
Capacity*	3.75	2.50		9.00		19.00	2.50	18.00	2.50	4.50	7.72

Table 4 (continued)

Indicators	Organic-2014										
	Growers										
	1***	2***	2***		3**	4**	5***	6*	7**	8***	
Quality and labor supply	−1.89	0.99		−2.73		3.00	0.99	−2.12	−0.75	−0.04	−0.32
Job quality*	1.50	1.50		1.50		0.00	0.00	16.50	1.00	−4.25	2.22
Income generating*	12.50	10.00		−15.00		6.25	2.50	30.00	5.00	10.00	7.66
Diversity of income sources*	−1.25	4.00		6.50		−0.50	2.00	17.00	6.50	6.50	5.09
Property value*	2.75	7.75		1.75		11.20	−5.00	13.50	2.50	5.50	4.99
Environmental and personal health	6.60	−3.80		−1.00		7.20	2.00	−4.60	2.00	4.40	1.60
Occupational safety and health*	7.00	10.00		1.00		9.00	24.00	−4.00	24.00	4.00	9.38
Food safety*	9.00	5.00		3.20		5.00	2.00	7.00	2.40	2.00	4.45
Dedication and profile of responsible*	13.50	7.00		8.50		6.25	16.50	21.50	9.0	5.50	10.97
Condition of commercialization*	2.25	28.00		8.50		0.00	7.00	10.50	5.50	3.50	8.16
Residual disposition*	2.00	12.00		6.00		7.00	8.00	5.00	3.00	3.00	5.75
Chemicals management	−3.25	6.00		−8.50		−10.75	0.00	0.00	0.00	−3.25	−2.47

Table 4 (continued)

Indicators	Organic-2014										
	Growers										
	1***	2***	2***		3**	4**	5***	6*	7**	8***	
Institutional relationship*	1.00	5.50		5.50		7.75	8.50	21.00	7.00	5.50	7.72
Environmental impact index*	2.06	5.56		1.76		5.17	5.86	5.53	6.08	2.91	4.37

*Indicators with a statistically significant difference at 5% of probability in the Wilcoxon test

This was possible because organic milk has a greater insertion in the market, as well as because producers were taking courses and being led by a group of active people, which was an efficient strategy. Allied to this, they received technical assistance, providing support while transitioning. Finally, the dedication of the person in charge and their ability to overcome the barriers for the marketing of organic milk (Soares et al 2011 e Figueiredo and Soares, 2012). A considerable improvement in revenue generation was observed when transitioning from conventional ($\mu = 2.5$) to an organic system ($\mu = 10.2$). This increase is associated with greater financial stability, security, and distribution throughout the year; this fact was influenced by the diversification of income sources after the technological innovation was adopted. The individual contribution of each one of the social and environmental impact indicators might be associated with a higher income generation in the property, as evidenced and reported by the producers themselves.

As a conclusion, this fact is directly related to the increased value-added of an organic product that, even while in the transition process and without certification, provides a monetary valuation passed on to the farmers by the co-ops (Fonseca 2001; Aroeira et al. 2005, 2006). Several studies on the valuation of organic products have been carried out, identifying consumer's recognition and valuation of these products. Other studies have also shown that consumers are willing to pay up to 50% more for organic milk (Aroeira et al. 2006; Fonseca 2001).

Regarding social aspects, the dedication and profile of the person in charge were positively influenced by technological innovation. These indicators might have been influenced by the promotion of various training courses directed to the activity, which were focused on a better understanding of agroecological issues, in organic management and technical and social issues inherent to these principles. There was also an increase in farmers' dedication to establishments, because of the new practices adopted and a greater number of agricultural activities on the farm.

For Gazolla (2004), this increased dedication can also be explained by higher demand for consumption by the family, in the search for food security. In this indicator in the conventional production, the value obtained was of $\mu = -0.9$, passing to $\mu = 10.1$ in milk production. Comparing conventional production and organic production, the variation was $\mu = 10.97$.

The difference between conventional ($\mu = -7.4$) and organic ($\mu = 2.0$) management in milk production units for occupational health and safety indicators was $\mu = 9.4$. By analyzing the indicators social capital, job quality, income source diversity, and waste disposal (Table 4), we noted that the changes from conventional to the organic system were about $\mu = 2.1$, $\mu = 2.22$, $\mu = 5.09$, and $\mu = 5.75$, respectively. These results demonstrate the efficiency of initial capital formation plan, a major concern of farmers with environmental preservation and quality of life of those involved in the production, the feasibility of organic agriculture in producing health food, and the improvements in waste disposal without harming human and animal health and, therefore, minimizing environmental impacts. The increase in the value of properties was due to investments in improvements, greater conservation of natural resources, and increasing prices of products and services as informed by the producers.

This indicator has influenced the adoption of these management practices because once the farmers started investing in agroecological practices, conservation of natural resources improved, leading to improvements in the quality of the soil, infrastructure, and upgrading stimulated by the need to protect the managed areas. In addition to milk, other products of plant origin also went through the transition process, as required by legislation. In this sense, the improvement in food security for the families is associated with the guarantee of greater availability of quality food, which derives from the introduction of the adopted ecological practices, reducing the risks of food contamination, besides providing regularity in the supply. Belik (2003) regards these factors as indispensable for the fulfillment of the food security doctrine. In this line, another aspect to be highlighted is human valuation since producers started to realize that when consuming products free of pesticides, they were taking care of themselves and their family, besides taking care of the water in there used for daily consumption.

This extends to people who buy the products, which means again in terms of respect for life in its entirety. The indicators product quality, labor quality and offer, environmental and personal health, dedication and profile of the person in charge, and management of chemical inputs (Table 2) presented no significant differences ($p > 0.05$). Because it is a transitional period, the data point out that there is a shortage of time to detect changes in these indicators; therefore, in the next evaluations, these values may be different as the producers are receiving guidance on the health and environmental problems caused using pesticides. By comparing the groups of farmers, we found that producers from groups 2, 4, 5, 6, and 7 had the highest values for the agroecological transition between conventional to the organic system, varying from $\mu = 5.17$ to $\mu = 6.08$ (Table 2). Yet, producers from groups 1, 3, and 8 showed the lowest indexes, being of $\mu = 2.06$ and $\mu = 1.76$, respectively.

This shows that different management strategies could have been adopted, resulting in the variations observed. Therefore, the process must continue so that the properties will have efficiency in milk production, improving the work of producers and their employees, by using rationally the environmental resources and optimizing production and profitability in each farm, thus improving the quality of life in rural areas. Furthermore, about environmental concerns, producers 2, 4, 5, 6, and 7 stood out from the rest (1, 3, and 8) with the highest differentiation indexes, both before and after the transition. This is because they were already using good environmental practices, and only a few adjustments were necessary to the witching process, given the requirements of the legislation (Figueiredo and Soares 2012) for organic animal and vegetable production (Brasil 2021).

The clusters were identified through observations of the producers with the best indexes of ecological and socio-environmental impact indicators, as well as those related to the highest differentiation for the grouping according to Tables 2 and 3. In the first cluster analyzed, producer 6 had a mean index for organic production impact of $\mu = 2.92$, mean index of the environmental impact of $\mu = 5.53$, and negative values for indicators of environmental impact differentiation in agricultural inputs ($\mu = -30.0$) and energy consumption ($\mu = -24.0$) interfering with the PIT value (18.5).

However, the same producer stood out from the others in product quality ($\mu = 16.25$), social capital ($\mu = 8.4$), animal welfare ($\mu = 27.0$), training ($\mu = 18.0$), job quality ($\mu = 16.5$), income generation ($\mu = 30.0$), income source diversity ($\mu = 17.0$), property value ($\mu = 13.5$), food security ($\mu = 7.0$), and profile of the person in charge ($\mu = 21.5$). This finding makes it clear that although they are still in a learning process, the techniques adopted for the transition from conventional to the organic system were quite efficient and properly used, enabling results that could generate great savings for having a differentiated and high-class product, what also give them advantages over competitors. Moreover, this producer stood out from the others in the group given his environmental concern; the property had the highest values for differentiation indexes before and after implementation.

As informed during the surveys, he has already been using good environmental practices, requiring only fits with the shift to organic production, as required under the laws (Figueiredo and Soares 2012) for organic systems of animal and vegetal production (Brasil 2021). In the second cluster, producers 3, 4, and 7 were grouped given the indicators of environmental impact differentiation: agricultural inputs and resources, atmospheric emissions, soil quality, animal welfare, and health, personnel training, job offer, income source diversity, occupational safety and health, management of inputs, and institutional relationship (Table 4). Among all, the indicator that most stood out was energy consumption, which had indices of environmental impact differentiation of $\mu = 24.0$ for producer 2; $\mu = 14.0$ for producer 4, and $\mu = 17.0$ for producer 7.

The third cluster identified comprised producers 1, 2, 5, and 8, who reached the best indexes of ecological impact, totaling 14 indicators, including energy consumption, soil quality, water quality, environmental recovery, product quality, income generation, property value, environmental and personal health, occupational safety and health, food safety, the profile of the person in charge, and waste disposal (Table 3). However, those that ranked high were soil quality and animal welfare. The differentiation indexes of environmental impact for soil quality were of $\mu = -7.5$ for producer 1, $\mu = 7.5$ for producer 2, $\mu = 7.5$ for producer 5, and $\mu = 7.5$ for producer 8. For animal welfare, the values were $\mu = -9.0$ for producer 1, $\mu = 27.0$ for producer 2, $\mu = 9.0$ for producer 5, and $\mu = 9.0$ for producer 8. The producers studied in both systems are within the same universe of family farmers, but the responses of the units are not similar, which resulted in the formation of differentiated groups.

This shows that there were different management strategies adopted, considering the conditions of each property, as well as the knowledge that the participants had accumulated. It is also necessary to move forward so that the properties have efficiency in milk production, being able to make the work of the producers and respective employees more efficient, performing a rational use of environmental resources, optimizing production and profitability of each property, besides improving quality of life in rural areas. For this work to be successful, the producer must sustain attention to environmental preservation and provide proper working conditions for the employees, always focusing on the excellence of the final product.

Table 5 Alteration coefficients of the criteria of AMBITEC-AGRO indicator systems between the producers due to the technology effect

Producer	Conventional (2012)	Organic (2014)	Differentiation	PIT (%)
1	−0.14	1.92	2.06	6.9
2	−1.52	4.03	5.50	18.5
3	0.66	2.42	1.76	5.9
4	0.14	5.31	5.17	17.2
5	−0.87	4.99	5.86	19.5
6	−2.61	2.92	5.53	18.5
7	−0.69	5.39	6.08	20.3
8	−0.66	3.57	2.91	9.7
Average	−0.55	3.86	4.37	14.55

Comparing the producers and the transition process verified that the use of technology contributes satisfactorily to the transition from the conventional to the organic system. Verified improvements in the average coefficients started to present positive values with the transition to organic. Average PIT ranged from −0.55 to 3.86 (Table 5) in the study group.

Percentage of 6,23 % in the impact of technologies were observed by Campos et al. (2018), lower than found than did the present study. The authors when evaluated the transition from conventional milk to organic producers to the transition from conventional production in Bacia do Rio Paraná region. However it is considered that conversion activity for organic production improved the same way the union and integration of milk farmers, because it managed to diversify food production, improving income, recovering, and preserving the environment (Campos et al. 2018). The results show that in the organic milk production activity, the environmental resources can be used rationally, optimizing the production and reaching values of profitability in the properties that will provide improvement in the quality of life of the rural environment (Figueiredo and Soares 2012).

The analysis proposed in this study enabled us to point out which indicators have evolved more over the 2 years after adopting the technologies for organic production as recommended in the normative instruction Portaria 52 (Brasil 2021). Among these techniques are pasture management in a rotating system and the use of alternative inputs for fertilization. It should be also necessary to point out that the transition in the eight units overcame the productive dimension by motivating the involved parties to gather and share experiences, which enhanced sociability in the community.

Into this logic is also inserted the importance of university extension, an academic branch through which is possible to exchange knowledge, as a two-way street where everybody is benefited. This gives meaning to the production of knowledge, which only has value when applied in a social context to improve the quality of life of people and the environment in which they live.

Conclusion

Based on the results obtained by Ambitec method, there was a 14.55% increase in technology (PIT) with a positive socio-environmental and ecological impact for dairy farmers with the use of technologies introduced in the process of transition to organic milk production system.

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References

Ávila AFD, Rodrigues GS, Vedovoto GL (2008) Evaluation of the impacts of technologies generated by Embrapa: reference methodology. Embrapa Informação Tecnológica– Brasília, DF : Embrapa Informação Tecnológica, 2008, p 189

Belik W (2003) Perspectivas para segurança alimentar e nutricional no Brasil. Saúde e Sociedade 12(1):12–20

Aroeira LJM, Stock LA, Assis AG, Morens MJF, Alves AA (2006) Viabilidade da produção orgânica de leite no Brasil. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 43, 2006, João Pessoa. XLIII REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA. SBZ, 2006. p. CDROM. Available from: <http://www.sbz.org.br/reuniaoanual/anais/?idiom=pt>. Accessed 4 Apr 2022.

Aroeira LJM, Paciullo DSC, Fernandes EN, Pires MFA, Morens MF, Macedo RdeO (2005) Caracterização da produção orgânica de leite em algumas regiões do brasil. In: REUNIÃO ANUAL DA ASSOCIAÇÃO LATINO AMERICANA DE PRODUÇÃO ANIMAL, 19. 2005. Anais... Tampico: ALPA, 2005

Brasil. Ministério da Agricultura Pecuária e Abastecimento. Lei Federal n° 10831, de 23 de dezembro de 2003. Dispõe sobre a agricultura orgânica e dá outras providências. Diário Oficial da União Seção 1, Página (8), Brasília, DF

Brasil. Ministério da Agricultura Pecuária e Abastecimento. Portaria no 52, de 23 de março de 2021. Estabelece o Regulamento Técnico para os Sistemas Orgânicos de Produção e as listas de substâncias e práticas para o uso nos Sistemas Orgânicos de Produção. Diário Oficial da União, Brasília, DF, 2021

Campos MBN, Soares, JPG, Junqueira AMR, Rodrigues G S, Mol DJS (2018) Impactos sociais, ambientais e econômicos da conversão para produção orgânica: o caso dos produtores de leite da bacia do Rio Paraná iii. In: Estudos em agronegócio construindo competitividade. 1ed. Goiânia: Kelps 3:271–297

Empresa Brasileira de Pesquisa Agropecuária Embrapa - EMBRAPA (2006) Marco referencial em agroecologia. Embrapa Informação Tecnológica, DF, p 70

Figueiredo EAP de, Soares JP G (2012) Sistemas orgânicos de produção animal: dimensões técnicas e econômicas. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 49., 2012, Brasília. A produção animal no mundo em transformação: anais. Brasília, DF: SBZ, 2012. 1 CD-ROM

Fonseca MFAC (2001) Cenário da produção e da comercialização dos alimentos orgânico. In: Fernandes EN, Bressan M, Vilela D (eds) Produção orgânica de leite no Brasil. Embrapa Gado de Leite, Juiz de Fora

Freire P (2014) Pedagogia da Esperança. In: Freire P (Org.). Pedagogia da esperança: um reencontro com a pedagogia do oprimido. 21. ed. Paz e Terra, São Paulo, p 21–272

Galharte CA, Crestana S (2010) Avaliação do impacto ambiental da integração lavoura-pecuária: aspecto conservação ambiental no cerrado. Revista Brasileira de Engenharia Agrícola e Ambiental 14:1202–1209

Gazolla M (2004) Agricultura familiar, segurança alimentar e políticas públicas: Uma análise a partir da produção para autoconsumo no território do Alto Uruguai/RS. Porto Alegre-RS: Programa de Pós-Graduação em Desenvolvimento Rural (Dissertação de mestrado). Universidade Federal do Rio Grande do Sul

Gómez MGS, Soares JPG, Munoz CMG, Carvalho JM (2016) Adequação à legislação orgânica e ambiental:

Estudo de caso de agricultores familiares das bacias hidrográficas dos rios Maranhão e São Bartolomeu no Distrito Federal. Revista Brasileira de Agroecologia (Online) 11:300–309

Hair Jr, Black WC, Babin BJ, Anderson RE, Tatham RL (2005) Análise Multivariada de Dados. Porto Alegre: Bookman, 583p

Hurnik JF (1992) Behaviour. In: Phillips C, Piggins D (Ed.). Farm animals and the environment. Wallingford: CAB Int 13: 235–244

Irias LJM, Gebler L, Palhares JCP, Rosa MF, Rodrigues GS (2004) Assessing the environmental impact assessment of agricul- tural technological innovations – an application of the AMBITEC System. Agric São Paulo, São Paulo 51:23–39

Khatounian CAA (1999) Conversão para a agricultura orgânica. In: II Simpósio sobre Agricultura Orgânica, 1999, São Paulo. Anais do Simpósio sobre Agricultura Orgânica, 2º, 1999

Lima HVD, Oliveira TSD, Oliveira MMD, Mendonça EDS, Lima PJBF (2007) Indicadores de qualidade do solo em sistemas de cultivo orgânico e convencional no semi-árido cearense. Rev Bras Ciênc Solo 31(5):1085–1098

Macedo MCM (2009) Integração lavoura e pecuária: o estado da arte e inovações tecnológicas. Rev Bras Zootec 38(SPE):133–146

Miranda DL (2011) Avaliação do bem-estar animal na bovinocultura de corte brasileira. Brasília: Programa de Pós-Graduação em Ciência Animal (Dissertação de mestrado). Faculdade de Agronomia e Medicina Veterinária, Universidade de Brasília

Monteiro RC, Rodrigues GS (2006) A system of integrated indi- cators for socio-environmental assessment and eco- certification in agriculture. J Technol Manag Innov 1:47–59

Oliveira ER, Muniz EB, Soares JPG, Farias MDFL, Gandra JR, de Araújo Gabriel AM, Malaquias JV, Pereira TL (2019) Environmental impacts of the conversion to organic honey production in family units of small farmers in Brazil. Org Agric 10:187–197

Rodrigues GS, Campanhola C, Kitamura PC (2003) An environmental impact assessment system for agricultural R&D. Environ Impact Assess Rev 23(2):219–244. https://doi.org/10.1016/S0195-9255(02)00097-5

Soares JPG, Aroeira LJM, Fonseca AHF, Fagundes GM, Silva JB (2011) Produção orgânica de leite: desafios e perspectivas. In: SIMPÓSIONACIONAL DE BOVINOCULTURA LEITEIRA, 3.; SIMPÓSIO INTERNACIONAL DE BOVINOCULTURA LEITEIRA, 1., 2011, Viçosa, MG. Anais... Viçosa: Universidade Federal de Viçosa, p 13–43

Soares, JPG, Leal, MA, Salman, AKD, Lopez, GFZ (2018) Manejo da fertilidade de solos em áreas de pastagem orgânica. In: *solos e agroecologia-coleção transição agroecologia*.1 ed. Brasília: Embrapa 4:271-305

Soares JPG, Rodrigues GS (2013) Avaliação social e ambiental de tecnologias da Embrapa: Sistema Ambitec-Agro. In: EMBRAPA meio ambienteartigo em anais de congresso (alice). in: workshop em avaliação econômica de projetos e impactos de tecnologia, 2013, Campo Grande, MS. Workshop... Campo Grande, MS: Embrapa Gado de Corte, 2013.(Embrapa Gado de Corte. Documentos, 203), p 56–66

Soares JPG, Salman AKD, Aroeira LMJ, da Fonseca AH, Sanavria A, da Silva JB, Fagundes GM (2012) Organic milk production in Brazil: technologies for sustainable production. ICROFS News 1:6–9

Soares JPG, Sales PCM, Sousa TCR, Malaquias JV, Rodrigues GS (2021) Environmental impacts of transition from conventional milk production to organic production. Realization 8(16):43–63. https://doi.org/10.30612/realizacao.v8i16.15218

Soares JPG, Sousa TCR, Malaquias JV, Rodrigues GS, Borba-Junior JKF (2015) Impactos ambientais da transição entre a produção de leite bovino convencional para orgânico na Região Integrada de Desenvolvimento do Distrito Federal e Entorno (RIDE/DF). Planaltina, DF: Embrapa Cerrados, 2015. (Embrapa Cerrados. Boletim de Pesquisa e Desenvolvimento, 324), p 45

Stock LA, Zoccal R, Carvalho GR, Siqueira KB (eds) (2011) Competitividade do agronegócio do leite brasileiro. Embrapa Informação Tecnológica, Brasília, DF, p 326

Tupy O, Primavesi O, Camargo AC (2006) Avaliação dos impactos econômicos, sociais e ambientais de tecnologias da Embrapa Pecuária Sudeste. 4. Técnicas de produção intensiva aplicadas às propriedades familiares produtoras de leite. São Carlos: Embrapa Pecuária Sudeste, 2006. (Embrapa Pecuária Sudeste. Documentos, 57), p 38

Van Der Ploeg JD, Renting H, Brunori G, Knickel K, Mannion J, Marsden T, Ventura F (2000) Rural development: from practices and policies towards theory. Sociol Rural 40(4):391–408

Willer H, Lernoud J (2017) The world of organic agriculture. Statistics and emerging trends 2017. Research Institute of Organic Agriculture FiBL and IFOAM-Organics International, pp 1–336