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Environmental Management

Diagnosis of environmental impacts using the SAIA: A case study in the Brígida irrigation project, in the town of Orocó/PE, Brazil

Diagnóstico de impactos ambientais utilizando o SAIA: Um estudo de caso no projeto de irrigação Brígida, no município de Orocó/PE, Brasil

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ABSTRACT

Environmental Impact Assessment (EIA) is a decision-making tool and in many cases is a legal requirement in projects with activities potentially causing environmental degradation. In the case of agroecological projects, negative impacts are not allowed and an assessment is important to identify factors that distance them from the agroecological proposal. Based on the literature, the EIA, in general, is done with electronic spreadsheets, there is no software focused on the process. In view of this, the objective of this article was to carry out a diagnosis of environmental impacts in the Brígida Irrigation Project - Orocó/PE during the planting of different crops and animal husbandry, presenting a system to facilitate this task, named SAIA - Impact Assessment System Environmental, which can point out impacts that detract from an agroecological theme project. For this, after a survey on EIA techniques and agroecological projects, on the basis of scientific works and patents, the SAIA was validated in that Project, with questionnaires being applied with the participating family farming producers, to align the tool to the agroecological proposal. The diagnosis allowed us to conclude that there are negative impacts that keep the Project away from agroecology for all analyzed crops and creations. It is noteworthy that the number of impacts is not fixed for each type of crop, as it depends on how the steps are carried out. Furthermore, there was good acceptance of the tool, with suggestions, which were accepted, bringing SAIA closer to the reality of producers.

Keywords: Agroecology; Leopold matrix; Environmental Impact Assessment; Decision-making

RESUMO

A Avaliação de Impactos Ambientais (AIA) é um instrumento para tomada de decisão e em muitos casos, é uma exigência legal em projetos com atividades potencialmente causadoras de degradação ambiental. No caso dos projetos agroecológicos, não são permitidos impactos negativos e uma avaliação é importante para identificar fatores que os afastem da proposta agroecológica. Com base na literatura, a AIA, em geral, é feita com planilhas eletrônicas, não existindo um software voltado ao processo. Diante disto, o objetivo deste artigo foi realizar um diagnóstico de impactos ambientais no Projeto de irrigação Brígida - Orocó/PE durante o plantio de diferentes culturas e criação de animais, apresentando um sistema para facilitar esta tarefa, nomeado SAIA – Sistema de Avaliação de Impactos Ambientais, o qual pode apontar impactos que desvirtuam um projeto da temática agroecológica. Para isto, após levantamento sobre técnicas de AIA e projetos agroecológicos, nas bases de trabalhos científicos e de patentes, foi realizada validação do SAIA no referido Projeto, sendo aplicados questionários com os produtores da agricultura familiar participantes, para alinhamento da ferramenta à proposta agroecológica. O diagnóstico permitiu concluir que ocorrem impactos negativos que afastam o Projeto da agroecologia para todos os cultivos e criações analisadas. Ressalta-se que o número de impactos não é fixo para cada tipo de cultivo, pois depende de como as etapas são realizadas. Ademais, houve boa aceitação da ferramenta, com sugestões, as quais foram acatadas, aproximando o SAIA da realidade dos produtores.

Palavras-chave: Agroecologia; Matriz de Leopold; Avaliação de Impactos Ambientais; Tomada de decisão

1 INTRODUCTION

Interactions between humans and nature have caused catastrophic damage to the environment and can lead to a collapse of human existence if nothing is done (BATISTA *et al.*, 2017). Practices aimed at reversing this situation are urgent and the assessment of environmental impacts is a tool that has the potential to help in this process.

The Environmental Impact Assessment (EIA) is a set of procedures that aim to identify and classify potential impacts that an action or construction may cause to the environment, predicting the scope and damage of these impacting activities (Enríquez-de-Salamanca, 2018). This assessment, carried out by technicians and specialists, helps entities to create projects that do not harm the environment (Sanguinetto, 2011).

The procedures established in the EIA allow knowing the possible environmental impacts before decision-making on the acceptance or not of the execution of a project, still in its planning phase. Consultation and popular participation are integral parts of this assessment, making EIA a participatory environmental management tool (Jay *et al.*, 2007).

Many of the activities that are harmful to the environment come from the so-called conventional agriculture, which causes severe environmental impacts, such as soil degradation, water waste, environmental pollution and loss of genetic diversity. In these cases, the solution is to opt for a model that proposes sustainable agriculture, as is the case with agroecology (Gliessman, 2000).

Any project has the potential to generate environmental impacts. By definition, agroecological projects should only bring positive impacts, but a minimum of negative impacts can be generated (Gliessman, 2000). To guarantee the quality of projects of this nature, it is necessary to assess the environmental impacts, to certify that the projects are in accordance with the agroecological proposal.

Agroecology, agroecological transition or involving territorial development projects necessarily need a thorough assessment of environmental impacts, with the objective of eliminating, or at least mitigating negative impacts both on the environment, on the territory and the communities that live there. In this case, all the environmental conditions characteristic of these types of projects must be analyzed, analyzing the soil, water, air, fauna, flora and everything related to human life and any element that may influence their daily lives, bringing benefits or harm (Altieri, 2008).

A literature review showed that there is no standard for the assessment of environmental impacts, making the task of decision makers more difficult, as they need to understand how the model used is being portrayed, before reading the information presented in it. In addition, all EIA models found in the literature have disadvantages that can hinder broad access to information.

Another point noted is that the models proposed in the bibliography are made manually, using only text/table editing tools, image editors or electronic spreadsheets, so they were not developed to perform standardized or specific calculations for purposes assessment of environmental impacts, generally resulting in reports with different methodologies and formats for each assessment.

A technological survey (search for anticipation) showed that the market lacks an automated tool for assessing environmental impacts. This lack is severely accentuated when we talk about agroecological projects, agroecological transition or territorial development.

This work aims to obtain a diagnosis of possible critical impacts and attention that distort the activities carried out in the irrigation project Brígida - Orocó/PE from the agroecological theme during the planting of banana, papaya, tomato, string beans, cassava, yam, onion, as well as a goat breeding and a chicken breeding. On the occasion, a complete, standardized environmental impact assessment tool was presented, with broad access to information, in the form of a dynamic computer application, focused on the agroecology or territorial development theme, as well as research on the acceptance and adequacy of the aforementioned innovative technology with family farm producers participating in the research.

2 MATERIAL AND METHODS

The research used two methodologies, bibliographic research and field research. In the bibliographical research, a survey was carried out on the techniques for assessing environmental impacts and on agroecological projects and territorial development in the scientific work bases of CAPES for access to CAFE (CAPES/MEC, 2020), Scielo (SCIELO, 2020), Scopus (Elsevier, 2020) and Google Scholar, as well as technological prospecting through patent searches in the Questel Orbit (Questel, 2020), Patentinspiration (Aulive, 2021) and INPI (INPI, 2020) databases. This bibliographic survey allowed the development of the proposed tool. An application developed in the Object Pascal programming language, using the

Delphi integrated development environment, produced by the Borland company, with a native Paradox database.

To ensure the tool's focus on agroecological projects, all validation was carried out in rural enterprises, with family farm producers and all adjustments proposed by the producers aligned the tool to the agroecological proposal, since, according to Santos and Curado (2012), although agroecology does not have family farming as a premise, this niche is ideal for its development, as the economic, cultural, social and environmental bases of agroecology can be more easily strengthened and respected in family farming.

After implementation, the SAIA was taken to the field. The chosen location was the Brígida irrigation project, located in the town of Orocó/PE, as many of the lots belong to families that practice family farming, one of the focuses of agroecology. The Brígida project is an irrigation project, within the agrarian reform project, promoted by the Brazilian government, for the settlement of families in the region of Orocó/PE.

The project entrance is about 7 km (7,000 m) from the urbain center of town. The project has just over 8,300 hectares (83,000,000 m^2), of which around 1,500 hectares (15,000,000 m^2) are irrigated. It has ten agrovillage and more than four hundred settled families. This information was obtained from a conversation with producers in the region. The Brígida project neighbors indigenous villages, such as the village “Atikum Brígida”, a territory demarcated for the Atikum people.

The investigation on the acceptance and/or need for adaptation of the technology was made with eight family farming producers of the Brígida irrigation project where the participants used the tool and, subsequently, answered the questionnaire containing 37 questions about the usability and importance of the application, given the information generated. The questions aim to learn about the cycles of the crop, from soil preparation to harvesting, whether or not pesticides, synthetic fertilizers and other non-natural products were used, and the standard questions of the SUS scale (System Usability Scale). On that occasion, there was the environmental impact assessment was carried out, with an agroecological focus, from the perspective of the AIA, of the producers who used the tool presented here.

3 RESULTS AND DISCUSSION

Initially, bibliographic studies were carried out on agroecological projects and techniques for assessing environmental impacts. The most commented technique in the works is the Leopold Matrix, with the highest number of publications, such as Falk, Rubert *et al.* (2019), Gebler and Longhi (2018), Josimovic, Petric and Milijic (2014), Sajjadi , Aliakbari *et al.* (2017) and others, proved to be a more widespread and complete tool to perform this task, however, an original matrix, proposed by Luna Bergere Leopold in 1971, presents, according to several authors, some disadvantages.

In order to eliminate these disadvantages and bring the project closer to the agroecological proposal, the matrix used in the tool it was one Leopold-derived matrix, which, instead to analyze only two criteria, as in the original matrix, analyzes twelve, namely:

- Value, whether the impact is positive or negative;
- Order, whether the impact is direct or indirect;
- Spatial, which delimits an area affected by the impact;
- Temporal, which says how long the impact will last;
- Dynamic, if the impact is temporary, cyclic or permanent;
- Plastic, to know if it is reversible or not;
- Cumulativity, which says that the impact interacts with others;
- Magnitude, if its intensity is weak, medium or strong;
- Significance, which tells how relevant it is in the affected area;
- Sensitivity, says how sensitive the affected element is to the impact;
- Conditions Whether the impact occurs under normal conditions in the region or only in exceptional circumstances;

- Resistance, which says if you can eliminate the impact, mitigate it or if nothing can be done.

These criteria of impacting activities affect the environment, in factors presented in table 1.

Table 1 – Environmental factors

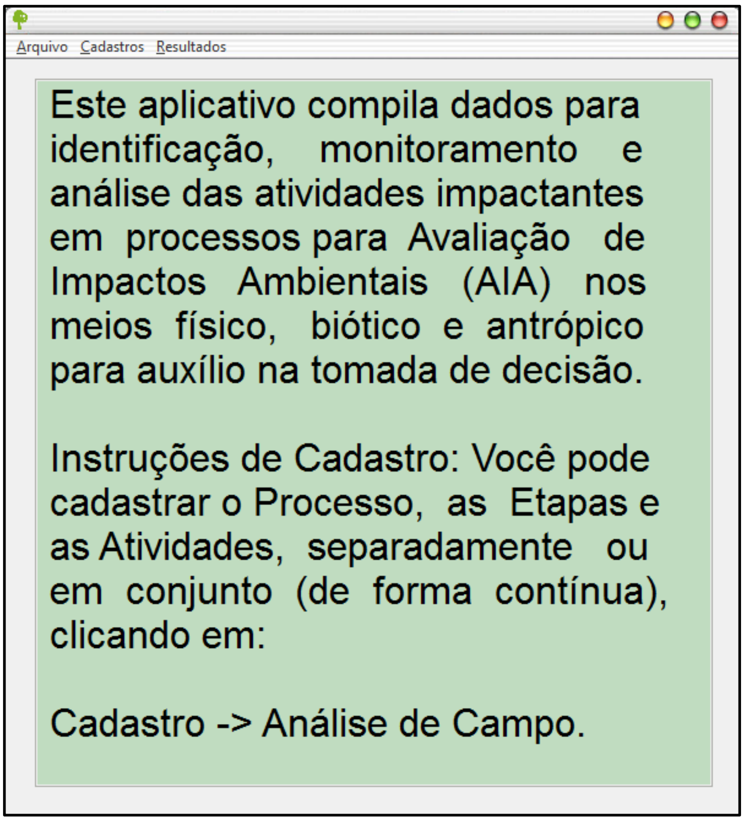
physical environment	Air: Solid particles and Gases and vapors; Water: Contamination of water; Soil: Edaphic Contamination;
biotic environment	Reduction of biodiversity in fauna and flora;
anthropic environment	Local Economy; Infrastructure; Technology; Quality of Life; Health; Regional Development; Landscaping; Final Product Quality;

Once the requirements were defined, the Impact Assessment System Environmental - known as SAIA due to Brazilian origin.

The system basically consists of two sets. The Registration and Results module. In the Registration module, the user can enter the data of a Process, its Steps and the activities that impact each step, in two ways: “Sequential” or “In parts”. The "Sequential" Register is indicated for carrying out the environmental impact assessment "in loco", that is, observing the project, in it, the data is entered in a progressive linear sequence, where the system will request as information sequentially and gradually, a after another. In the registration “In Parts”, the user can navigate between the registered data, enter new data or change the data in the order that he/she finds most convenient.

In the “Results” module, the user can select a registered process and the system automatically assembles the Derived Matrix of Leopold with critical analysis for the registered values. Criticality appears in color format. Red means high criticality, yellow means medium criticality and white means low or no criticality. It is also possible to view a summary report with the most critical activities of the project, in addition to allowing the user to generate comparative charts between the related criteria. The application's main screen can be seen in Figure 1.

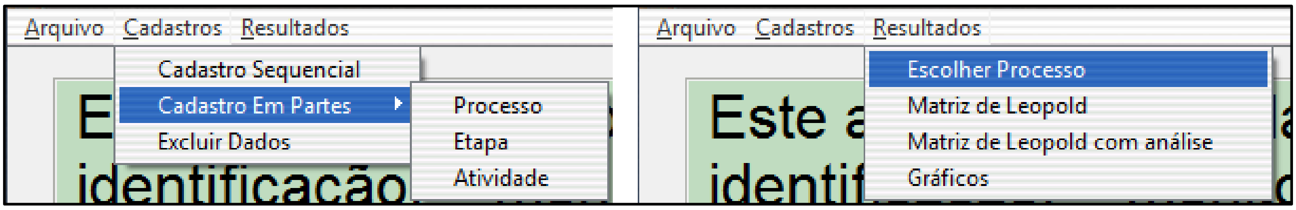
Figure 1 – SAIA main screen



Source: authors (2021)

Figure 2 contains, in detail, the access screen to SAIA modules. In it, it is possible to see the access to the Sequential registration module and the registration In Parts, where the option is up to the user. You can also see access to the results module. To access the summary report, you must first generate the Leopold Matrix with analysis to access the menu that generates the criticality report.

Figure 2 – Access to System Modules



Source: authors (2021)

The eight settlers from the Brígida project who participated in the survey, carried out from March 26 to 28, 2021, were volunteers, using convenience sampling. All signed the Informed Consent Form (TCLE) approved by the ethics committee at CAEE nº 28324819.8.0000.5196. Each participant was given access to the SAIA and instructions for use. After using the tool, they answered a quiz related to the usability and importance of its use in view of the results generated.

In more detail, at the time of the volunteers' participation, they were asked to use the SAIA to assess the environmental impacts of agricultural crops or animal husbandry existing in their respective lots with real information on the culture/breeding currently installed. As a result, the impact assessment on the planting of bananas, papaya, tomatoes, string beans, cassava, yams, two onion plantations, in addition to a goat breeding and a chicken breeding was obtained. The products are for family consumption and the surplus is sold at Ceasa, located in the seat of the Orocó town.

Banana planting: The process starts with soil preparation. The soil is plowed, harrowed and furrowed, then the seedlings are placed, taken with a pick from the original plant. The time between banana planting and harvesting is 10 to 11 months. During this period, there is fertilization with synthetic fertilizer every 30 days and irrigation every 8 days. Pesticides are not used.

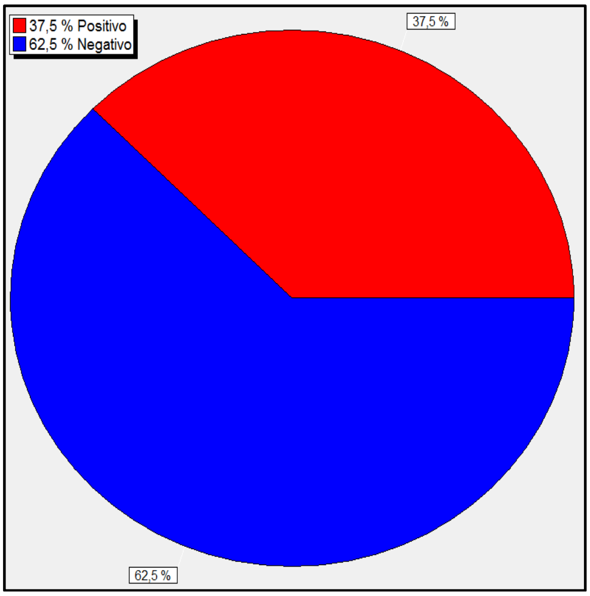
Figure 3, generated by SAIA, contains the Leopold Matrix for the assessment of environmental impacts from the crop. Figure 4, also generated by SAIA, contains the graph that shows that there are more negative impacts than positive, however, according to the matrix, most negative impacts are of low magnitude and easily mitigated. The positive impacts, mainly in the anthropic environment, are the most relevant. Regarding the agroecological character, it is still necessary to replace synthetic fertilization with natural fertilizers and give the proper destination to branches and other elements, dispensed in the soil, at the time of harvest.

Figure 3 – Leopold Matrix for Banana Crop

ETAPA	ATIVIDADES	Meio Físico - Ar	Meio Físico - Ar	Meio Físico - Agua	Meio Físico - Solo	Meio Biótico - F/F	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico
		Partículas Sólidas	Gases e Vapores	Contaminação	Contaminação	Redução da Diversidade	Economia Local	Infraestrutura	Tecnologia	Qualidade de Vida	Saúde	Desenvol. Regional	Paisagismo	Qual. do Prod. Final
Preparar Terra	Arar Terra	NDLCTRPFrPBNE·	NDLCTIAFrPBNM·	x	x	NDLCTRAFrPBNE	PDLCCIAFrMMNI·	x	x	x	x	xxLMCRAFrMMNI	NDLCTRAFrPBNM	PDLMTRAMéMMNI
Preparar Terra	Grade e Sulcos	NDLCTRAFrPBNE	NDLCxRAFrPBNM	x	x	NDLCTRAFrPBNM	PDLCCRPFrMMNI·	x	x	x	x	PDLMCRAMéMMNM·	NDLCTRAFrPBNM	PDLCTRAFrPMNM
Manutenção	Adubação	NDLCTRAFrMMNM·	NDLCTRAFrMMNI·	NIRMCRPMéMMNI·	NILCTRAFrPBNM	NDLCTRAFrPMNM	PDRCCRAFrGMNM·	x	x	x	NDLCTRPFrPBNM·	PDRCCRAFrMMNM·	x	PDLCCRPMéMMNM·
Colheita	Corte de Galhos	x	x	NDLCCRAFrPBNM	PDLCCRAFrMBNM	x	x	x	x	x	x	x	x	x

Source: authors (2021)

Figure 4 – Graphic of the Value criterion for banana crop



Source: authors (2021)

Papaya planting: Initially, soil preparation takes place. The soil is plowed, harrowed and loins are made, for later implantation of the seedlings. The time between planting and harvesting of papaya is 8 months, during this period, there is fertilization with synthetic fertilizer every 20 days, application of pesticides, also every 20 days, and irrigation every 8 days.

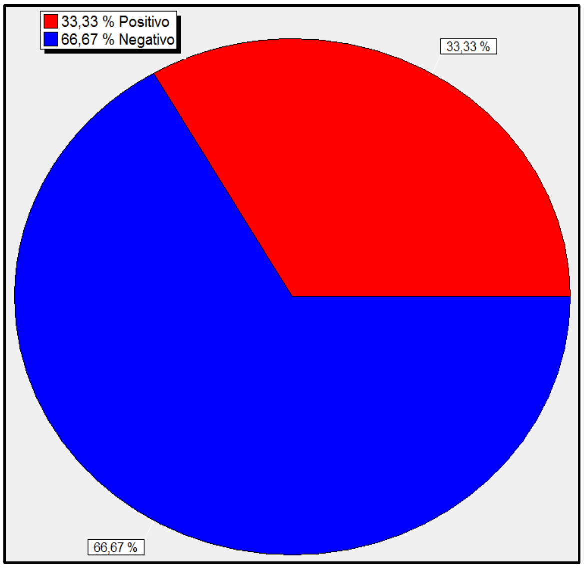
Figure 5 contains the Leopold Matrix for the Papaya crop and Figure 6, the Value criterion graph. There is an even greater amount of negative impacts than those presented in Banana, with the application of pesticides being the most impactful activity of this crop. To adjust the crop to the precepts of agroecology, it will be necessary to replace chemical pesticides with natural pesticides, typical of the region, and replace synthetic fertilization with natural fertilizers.

Figure 5 – Mother of Leopold from Papaya

ETAPA	ATIVIDADES	Meio Físico - Ar	Meio Físico - Ar	Meio Físico - Água	Meio Físico - Solo	Meio Biótico - F/F	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico
		Partículas Sólidas	Gases e Vapores	Contaminação	Contaminação	Redução da Diversidade	Economia Local	Infraestrutura	Tecnologia	Qualidade de Vida	Saúde	Desenvol. Regional	Paisagismo	Qual. do Prod. Final
Preparar Terra	Arar Terra	NDLCTRAFrPBNE	NDLCTIAFrPBNM·	x	x	NDLCTRAFrPMNM	PDLCTRAFrMMNM	x	x	x	x	PDLCTRAMéMMNM	NDLCTRAFrPBNM	PDRMCRAMéMMNM·
Preparar Terra	Grade e Lombo	NDLCTRAFrPBNM	NDLCTIAFrPBNM·	x	x	NDLCCRAFrPBNM	PDLCCRAFrMMNM	x	x	x	x	PDRMCRAFrMMNM·	NDLCTRAFrPBNM	PDRMCRAMéMMNI·
Manter a planta	AplicDefensivos	NDRCCRPMéGMNM·	NDRCCRPMéGMNM·	NIRMCIPMéGMNM·	NDLMCRPMéGMNM·	NDLCCRAMéGMNM·	PDLCCRAFrPBNM	x	x	NIRMCRAFoGMNM·	NDRCCRPMéGMNM·	x	x	PDLCTRAMéMMNI
Colheita	Corte de Galhos	x	x	NDLCCRAFrPBNM	PDLCCRAFrMBNM	x	x	x	x	x	x	x	x	x
Manter a planta	Adubação	NDLMCRAFrPBNM·	NILMCRAFrPMNM	NIRMCRAMéGMNM·	NDLCCRAFrMMNM·	x	PIRMCRAFrMBNM	x	x	x	NDLCCRAMéGMNM·	x	x	PDRMCRAMéMMNM·

Source: authors (2021)

Figure 6 – Value criterion graph for papaya cultivation



Source: authors (2021)

Tomato planting: The planting of tomatoes is done with seeds, in the seedbed and then transplanted to its final location, which must already be plowed, harrowed and furrowed to receive the plants. The time between planting and harvesting is around 90 days. During this period, pesticides are applied to prevent moths and weeds once a week, fertilization with synthetic fertilizers every 20 days and irrigation every 3 days.

The Figure 7 contains the Leopold matrix for planting the crop. The amount of negative impacts is similar to those registered in the papaya culture. In the matrix, we see positive impacts mainly in the anthropic environment, more in what concerns the movement of the local economy and in the quality of the final product. The negative impacts are more concentrated in the physical and biotic environments. To adapt the crop to the agroecological proposal, it is necessary to replace synthetic pesticides and fertilizers with natural ones, and it is also possible to implement agroecological techniques to keep possible undesirable species away from the planting areas, without the need for chemical pesticides.

Figure 7– Leopold matrix for tomato planting

ETAPA	ATIVIDADES	Meio Físico - Ar	Meio Físico - Ar	Meio Físico - Água	Meio Físico - Solo	Meio Biótico - F/F	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico
		Partículas Sólidas	Gases e Vapores	Contaminação	Contaminação	Redução da Diversidade	Economia Local	Infraestrutura	Tecnologia	Qualidade de Vida	Saúde	Desenvol. Regional	Paisagismo	Qual. do Prod. Final
Preparar Terra	Arar Terra	NDLCTRAFrPBNM	NDLCTRAFrPBNM	x	x	NDLCTRAFrPBNM	PDRMTRAFrMMNM·	x	x	x	x	PDLCTRAFrPBNM	NDLCTRAFrPBNM	PDLMCRAFrMBNM
Preparar Terra	Grade e Sulcos	NDLCTRAFrPBNM	NDLCTRAFrPBNM	x	x	NDLCTRAFrPBNM	PDRMCRAFrMBNM·	x	x	x	x	PDLMCRAFrPBNM	NDLCTRAFrPBNM	PDRMCRAFrMBNM·
Plantio	Implantar mudas	NDLCTRAFrPBNM	NDLCTRAFrPBNM	x	x	x	PDRMCRAFrMMNM·	x	x	x	x	PDRMCRAFrMBNM·	NDLCTRAFrPBNM	PDRMCRAMéMMNM·
Manter a Planta	Adubação	NDLCTRAFrPMNM	NDLCTRAFrPMNM	NDLCTRAFrMBNM	NDLCTRAMéMMNM·	NDLCTRAFrPBNM	PDLCTRAFrMBNM	x	x	x	NDLCCRAMéPBAM	PDLMCRAFrMBNM	x	PDRMCRAFrMBNM·
Manter a Planta	Defensivo	NDLCTRAMéMANM·	NDRCTRPMéMANM·	NDRCTRPMéGAAM·	NDLCTRPMéGANM·	NDRCTRPMéMANM·	PDRMCRAMéMBNM·	x	x	NDLCTRAFrPMNM	NDLMCRAMéMMAM·	x	x	NDRMCRPFrMMNM·
Produto Final	Colheita	NDLCTRAFrPBNM	x	x	x	x	PDRMPRAMéGMNM·	x	x	PDLMCRAMéGMNM·	x	PDRMCRAMéGMNM·	x	PDRMCRAMéGMNM·

Source: authors (2021)

Rope Bean Planting: String bean planting is done with a precision manual planter. The process begins with soil preparation, where it is plowed and harrowed, using a tractor. Then the producer places the seeds with the planter. The time between planting and harvesting is around 90 days and collection is done with a tractor, to separate the straw from the grain. The maintenance of the plant is given by the use of synthetic pesticides every 15 days and irrigation every 8 days, without using fertilizers.

The Figure 8 contains the Leopold matrix for planting the crop. The amount of negative impacts is similar to those of tomato and papaya. Almost all negative impacts are caused by the use of pesticides. The other negative impacts are temporary and low magnitude being easily mitigated. Positive impacts are identified mainly in the anthropic environment, with an emphasis on the local economy and the quality of the final product. The use of synthetic pesticides is the only item that distances planting from agroecology, which does not allow its use, therefore, replacing them with natural pesticides solves this issue.

Figure 8 – Leopold matrix for planting string beans

ETAPA	ATIVIDADES	Meio Físico - Ar	Meio Físico - Ar	Meio Físico - Água	Meio Físico - Solo	Meio Biótico - F/F	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico
		Partículas Sólidas	Gases e Vapores	Contaminação	Contaminação	Redução da Diversidade	Economia Local	Infraestrutura	Tecnologia	Qualidade de Vida	Saúde	Desenvol. Regional	Paisagismo	Qual. do Prod. Final
Preparar Terra	Arar e Grade	NDLCTRAFrPBNM	NDLCTRAFrPBNM	x	x	NDLCTRAFrPBNM	PDLMCRAFrMBNM	x	x	x	x	PDLCTRAFrMBNM	NDLMCRAFrPBNM·	PDLCTRAFrMBNM
Manter a Planta	Defensivo	NDLCCRAFrMMNM·	NDLCCRAMéMMNM·	NIRCCRPMéMMAM·	NDLCCRPMéGMNM·	NDLCTRAFrPBNM	PDLMCRAFrPBNM	x	x	NILMTRAFrMMNM	NDLLCRAMéGMNM·	x	x	NDRCCRAMéMMAM·
Manter a Planta	Irrigação	x	x	NIRMCRAFrMMAM	x	x	x	x	x	x	x	x	x	PDLMCRAMéGMNM·
Produto Final	Colheita	NDLCTRAFrPBNM	NDLCTRAFrPBNM	x	x	x	PDRCTRAFrMMNM	x	x	x	x	PDLCTRAFrMBNM	x	PDLCCRAFrMBNM

Source: authors (2021)

Planting of cassava: The planting of cassava, which can be seen in Figure 9, starts with the preparation of the soil, using a tractor. The soil is plowed and then furrowed, can be done loins. It's not done grid. The planting is done with wood extracted from the plant and its harvest takes place between 7 to 8 months after planting. The maintenance of the plant is done only with irrigation every 8 days and cleaning done manually with a hoe.

Figure 9 – Cassava plantation in the Brígida project

Source: authors (2021)

Figure 10 contains the Leopold matrix for planting the crop. There are practically no impacting activities. The only impacting activity is the time to plow and furrow the land, but the impacts are of low magnitude, low significance and are easily mitigated/eliminated. Of the crops evaluated, this is the only one that is in accordance with the agroecological proposal, since there is no use of chemical/synthetic inputs, nor significant damage to the environment.

Yam planting: The planting of yam is very similar to that of cassava and starts with the preparation of the land. The land is plowed and furrowed, without harrowing. The way of planting is also with material extracted from a specimen and the time between planting and harvesting is also 7 to 8 months. The big difference between yam and cassava is in plant maintenance. In yams, in addition to irrigation every 8 days, synthetic fertilizer is used every 20 or 30 days and two applications of chemical defensives, to avoid the proliferation of weeds.

Figure 10 – Leopold matrix for planting cassava

ETAPA	ATIVIDADES	Meio Físico - Ar	Meio Físico - Ar	Meio Físico - Água	Meio Físico - Solo	Meio Biótico - F/F	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico
		Partículas Sólidas	Gases e Vapores	Contaminação	Contaminação	Redução da Diversidade	Economia Local	Infraestrutura	Tecnologia	Qualidade de Vida	Saúde	Desenvol. Regional	Paisagismo	Qual. do Prod. Final
Preparar Terra	Arar e Sulcar	NDLCCRAFrPBNM	NDLCCIxMéPMNM·	x	x	NDLCTRAFrPBNM	PDRMCRAFrMBNM·	x	x	x	x	PDLMCIAFrMBNM·	x	PDLMCIAMéMMNM·

Source: authors (2021)

Figure 11 contains the Leopold Matrix for the culture. It is possible to see several negative impacts, in all environments, whether physical, biotic and anthropic, especially in relation to the use of synthetic and defensive fertilizers. It is worth highlighting the impact of high criticality (in red), in the anthropic environment with regard to the health of people around the plantation, in the activity of applying pesticides. Eliminating the use of pesticides and synthetic fertilizers is an important attitude that can to yam planting stay the agroecological standards.

Figure 11 – Leopold matrix for yam planting

ETAPA	ATIVIDADES	Meio Físico - Ar	Meio Físico - Ar	Meio Físico - Água	Meio Físico - Solo	Meio Biótico - F/F	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico
		Partículas Sólidas	Gases e Vapores	Contaminação	Contaminação	Redução da Diversidade	Economia Local	Infraestrutura	Tecnologia	Qualidade de Vida	Saúde	Desenvol. Regional	Paisagismo	Qual. do Prod. Final
Prepar Terra	Arar e Sulcar	x	NDLCCIAFrPBNM·	x	x	NDLCTRAFrPBNM	PDLMCRAFrMMNM·	x	x	x	x	PDLMCRAFrPMNM	NDLCTRAFrPBNM	PDLMCIAMéMMNI·
Manter a Planta	Defensivo	NDLCCIAMéMANI·	NDRCCIPMéGMNM·	NIRMCIPMéGMNM·	NDLCTIAMéGMNM·	NDRCCRPMéMANM·	PDLMCRAFrPBNM	x	x	NDLLCIAMéMMNI·	NDLLCIPMéGMNI.	x	x	NDLCCRPFrMMNM·
Manter a Planta	Adubação	NDLMCIAFrMMNM·	NDxCCIPFrPMNI·	NDLMCIAMéGMNM·	NDLMCRPMéMMNM·	x	PxRMCRAFrMBNM	x	x	x	NDLLCIAFrMMNI·	x	x	PDRMCIAMéMMNI·

Source: authors (2021)

Onion Planting: In preparing the land for planting the onion, the soil is plowed, harrowed and furrowed. Then, the seedling is placed from a bench. The time between planting and harvesting is 90 days. To maintain the plant, are added water every 2 days, synthetic fertilizer every 15 days and pesticide/vermicide every 7 or 8 days. Harvesting is done manually.

For the onion crop, two producers participated in the research, so figures 12 and 13 contain Leopold matrices for their planting process. There is a certain similarity between the matrices. The negative impacts arising from the activity of plowing, harrowing and furrowing the land are of low magnitude and easily mitigated. Synthetic fertilization and the use of pesticides are the cause of negative impacts of greater magnitude, critical and sometimes irreversible. It draws attention to the highly critical impact of soil contamination identified in one of the matrices. The positive impacts are concentrated in the anthropic environment and are relevant to the regional community. To adapt to agroecological concepts, it is necessary to replace fertilizers and synthetic pesticides with natural elements that harmonize with the environment.

Figure 12 – Leopold matrix for onion planting (1)

ETAPA	ATIVIDADES	Meio Físico - Ar	Meio Físico - Ar	Meio Físico - Agua	Meio Físico - Solo	Meio Biótico - F/F	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico
		Partículas Sólidas	Gases e Vapores	Contaminação	Contaminação	Redução da Diversidade	Economia Local	Infraestrutura	Tecnologia	Qualidade de Vida	Saúde	Desenvol. Regional	Paisagismo	Qual. do Prod. Final
Preparar Terra	Arar Terra	NDLCTRAFrPBNE	NDLCTRAFrxBNM	x	x	NDLCTRAFrPBNM	PDRCCIAFrMMNM	x	x	x	x	PDRCCRAFrMBNM	x	PDRCTxAMéMBNM
Preparar Terra	Grade e Sulcos	NDLCTRAFrPBNM	NDLCTRAFrPBNM	x	x	x	PDRCCIAMéMBNM	x	x	x	x	PDRMTRAFrMBNM	x	x
Manter a planta	Adubação	NDRCCRAMéMMAM	NDRCCRAMéMMAM	NDRMCRAMéMMNM	NDLMCRAMéMMNM	NDLCTRAFrPMNM	PDRCCRAMéMBNM	x	x	x	NDLMCRAFrMMAM	PDRCCRAFrMMNM	x	PDLCTRAFrMBNM
Manter a planta	Defensivo	NDLCCRAFrPMNM	NDRCCRAMéMMNM	NDRCCRAMéMMAM	NDLCCRAMéMMNM	NDRMCRAFrPMNM	PDLCTRAFrPBNM	x	x	NDLCCRAMéMANM	NDLMCRAMéMANM	x	x	NDRMCRPFrMAAM
Produto Final	Colheita	NDLCTRAFrPBNM	x	x	x	x	PDRMCRAMéGMNM	x	x	PDLCTRAMéGMNM	x	PDRMCRAMéGMNM	x	PDLCCRAMéGMNM

Source: authors (2021)

Figure 13 – Leopold matrix for onion planting (2)

ETAPA	ATIVIDADES	Meio Físico - Ar	Meio Físico - Ar	Meio Físico - Agua	Meio Físico - Solo	Meio Biótico - F/F	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico
		Partículas Sólidas	Gases e Vapores	Contaminação	Contaminação	Redução da Diversidade	Economia Local	Infraestrutura	Tecnologia	Qualidade de Vida	Saúde	Desenvol. Regional	Paisagismo	Qual. do Prod. Final
Preparar Terra	Arar Terra	NDLCTRAFrPBNM	NDLCTIAFrPBNM	x	x	NDLCTRAFrPMNM	PDLMCRAFrMMNM	x	x	x	x	PIRMCIAFrMMNI	x	PDLMCRAFrMBNM
Preparar Terra	Grade e Sulcos	NDLCCRAFrPBNM	NDLCCIAFrMBNM	x	x	x	PDRMCRAFrMMNM	x	x	x	x	PIRCCRAFrMBNM	NDLCTRAFrPBNE	PDLMCRAFrMMNI
Manter a Planta	AplicaDefensivo	NDRCCIAMéGMNM	NDRCCIPMéGMNM	NIRMCIPMéGMNM	NDRMCIPMéGMNM	NDLMCRAMéMANM	PIRMCRAFrPBNM	x	x	NILMCRAMéPMNM	NDLLCIAMéMANM	x	x	PDLMCIAFrMMNI
Manter a Planta	Adubação	NILCCIAFrPBNM	NDLCCIAFrPMNM	NDRMCIAMéMMxM	NDLCCRAFrMBNM	x	PDRMCIAFrMBNM	x	x	x	NDLLCIAMéMMNM	x	x	PDRMCIAMéMMNM
Produto Final	Colheita	NDLCTRAFrPBNM	x	x	x	x	PDRMCIAMéGMNM	x	x	PDLMCIAFrMMNM	x	PDRMCIAMéMMNM	x	PDRMCRAMéGANM

Source: authors (2021)

Goats Breeding: The raising of goats is not carried out on the project's plots, but in prepared spaces, within the area where the breeder's house is located, in the agrovillages. It is an extensive cattle-raising type, where the animals are raised loose, in a “semi-open regime”. They are released in the morning and return to their spaces in the late afternoon.

To begin the creation, the site where the pigsty will be built is fenced off, which has an average area of 32m^2. With the pigsty ready, the animals are bought. Feeding is made with mineral salt and plants from the caatinga that the animal eats while it is free. Once a year the animal is vaccinated with vermicide.

According to Fabricante *et al.* (2015), this type of management causes several negative impacts on the caatinga, as the animals eat a lot of native vegetation, break branches and even trees, hanging and climbing to reach the highest leaves.

Figure 14 contains the Leopold matrix for raising goats. The producer omitted the problems caused by the animals when released into the wild. In the matrix, we identified more positive impacts than negative ones. The negative impacts revolve around preparing the land and setting up the pigsty. These impacts are local and only affect the construction area.

To approach the agroecological proposal, breeding needs to follow a more confined management, but one that promotes the animal's well-being. It is necessary to follow precise methods for managing pastures, herds and facilities, as well as care with food and veterinary treatment (Cavalcante *et al.*, 2007).

Figure 14 – Leopold's Mariz for goat rearing

ETAPA	ATIVIDADES	Meio Físico - Ar	Meio Físico - Ar	Meio Físico - Água	Meio Físico - Solo	Meio Biótico - F/F	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico
		Partículas Sólidas	Gases e Vapores	Contaminação	Contaminação	Redução da Diversidade	Economia Local	Infraestrutura	Tecnologia	Qualidade de Vida	Saúde	Desenvol. Regional	Paisagismo	Qual. do Prod. Final
Preparar Local	Cercamento	x	x	x	x	NDLCTRAFrPBNM	PDLCTRAFrPBNE	PDLLPRAFrMBNE·	x	PDLLTRAFrMBNE	x	PDLCPRAFrMBNE	NDLLPRAFrPBNM·	PDLCTRAFrMBNM
Preparar Local	Criar Chiqueiro	NDLCTRAFrPBNM	NDLLPRAFrPMNM·	x	NDLLPRAFrMMNM·	NDLLPRAFrPMNM·	PDRCTRAFrPBNM	PDLLPRAFrMBNM·	x	PDLCPRAFrMBNM	x	PDLCTRAFrPBNM	NDLLPRAFrPBNI·	PDLMCRAFrMBNM
Manter Criação	Vacinação	x	x	x	x	x	PDLCTRAFrPBNM	x	x	PDLCCRAMéGMNM·	PDRCCRAMéGMNM·	PDRMCRAMéGMNE·	x	PDRCPIAMéGMNI·

Source: authors (2021)

Chicken Breeding: Hens are also reared in prepared spaces, within the area where the breeder's house is located, in the agrovillages, however, unlike goats, the hens are always kept confined in the spaces as shown in Figure 15.

To start breeding, the first step is to set up the chicken coop. Stakes demarcating the area are placed, then a screen is placed that surrounds the entire perimeter. Then, cement is placed to better fix the stakes. Finally, the fixation of the perch, the feeder and the drinking trough. Animals are bought, usually 1 rooster and 20 to 30 chickens are placed in the spaces.

Figure 15 – Chicken breeding, Orocó/PE town

Source: authors (2021)

The animals are fed daily, with laying and fattening rations. They also eat corn every 4 or 5 days and leftovers from lunch and fruit from the breeder's house. Water is provided daily. Every 3 months, animals are given a vaccine to fight worms.

Figure 16 contains the Leopold matrix for raising chickens. Almost all impacts are positive. The only negative impact that draws attention is that, within the chicken coop area, the soil becomes sterile, and no vegetation is born. This is due to the manure from the chickens themselves, which contaminates the soil with micro and macro nutrients (Sales, 2005). As the creation and the area used are small, this impact ends up being of low significance.

To bring the creation of the agroecological proposal closer together, Sales (2005) recommends access to the sun and green forage, for at least 3 hours a day, organic and balanced food, appropriate breeding, veterinary and hygiene practices.

Figure 16 – Leopold matrix for raising chickens.

ETAPA	ATIVIDADES	Meio Físico - Ar	Meio Físico - Ar	Meio Físico - Água	Meio Físico - Solo	Meio Biótico - F/F	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico	Meio Antrópico
		Partículas Sólidas	Gases e Vapores	Contaminação	Contaminação	Redução da Diversidade	Economia Local	Infraestrutura	Tecnologia	Qualidade de Vida	Saúde	Desenvol. Regional	Paisagismo	Qual. do Prod. Final
Galinheiro	Cercamento	NDLCTRAFrPBNM	x	x	x	NDLLPRAFrPMNM·	PDLMCRAMéGBNM·	PDLCPRAFrGBNM·	x	PDLCPRAFrMBNM	x	x	NDLLPRAFrPBNI·	PDLCTRAFrPMNE
Galinheiro	Parte Interna	x	x	x	x	x	PDLCCRAFrMBNM	PDLCPRAFrMBNM	x	PDLCTRPFrMBNM	PDLCPRPFrMBNM·	PDRMCRAFrMMNM·	x	PDRMCRPFrMBNM·
Galinhas	Alimentação	x	x	x	NDLLPRAMéPANM·	x	PDRMCRAFrMBNM·	x	x	PDLMCRAMéMMNM·	x	PDRMCRAFrMBNM·	x	PILMCRAFrGMNM

Source: authors (2021)

Despite being projects involving family farming, the analysis of these matrices shows that most crops are still far from agroecological practices. SAIA also made it possible to identify the most critical positive points and, therefore, favorable to agroecological projects, as well as the negative ones and, therefore, what should be changed. A summary of this assessment can be seen in table 2, which contains information on the percentage of relevant impacting actions, both positive and negative. These data allow us to conclude that, among the cultures analyzed, yam and papaya are those with the highest percentage of negative impacts (not necessarily critical), while cassava and chicken farming characterize the projects with the greatest positive impacts. There are almost no critical negative impacts on the Brígida project, on the other hand, no high-reaching positive impacts have been identified. Despite the results, the producers were interested in using techniques that are less harmful to the environment, but they do not know how to do it. Thus, there is a need for technical training, for which government policies have an important role.

According to Caporal and Costabeber (2004), the transition from a traditional method to an agroecological model is complex and must be done in well-planned steps. Otherwise, switching from scarce and harmful inputs to natural inputs and sustainable practices will not achieve the expected goals.

It is also noteworthy that the greater number of impacting actions (those resulting from activities that generate any type of impacts, whether harmful or beneficial) from one type of crop does not mean concluding that this crop is more or less agroecological. For tomato cultivation, for example, larger amounts of impacting actions were identified (43), however, only 08 (18.6%) are medium negative and no impact is critical negative. On the other hand, yam, with only 22 impacting actions, generates 13 (59.1%) average negative impacts and one (01) critical negative impact, which was identified based on the analysis of pesticide application, in relation to the effects for the health of the worker.

Table 2 – Summary of impacting actions of the analyzed projects

Project Type	High Positives	Average Positives	Critical Negatives	Negative Medium	Impacting actions
Banana	0	06 (24%)	0	06 (24%)	25
Papaya	0	04 (12,5%)	0	13 (40,6%)	32
Tomato	0	12 (27,9%)	0	08 (18,6%)	43
String Beans	0	01 (4,3%)	0	07 (30,4%)	23
Cassava	0	03 (50%)	0	01 (16,7%)	06
Yam	0	03 (13,6%)	1 (4,5%)	13 (59,1%)	22
Onion (1)	0	06 (18,2%)	0	13 (39,4%)	33
Onion (2)	0	11 (33,3%)	1 (3%)	11 (33,3%)	33
Goats	0	06 (27,3%)	0	05 (22,7%)	22
Chickens	0	08 (44,4%)	0	03 (16,7%)	18

It is also added that as described in Table 2, the number of positive or negative impacts is not fixed for each type of crop, but depends on how the steps are carried out, that is, they may differ between projects, even for one same cultivation. In this case, each producer can define different quantities and forms of application for pesticides or fertilizers, for example.

In the questionnaires, everyone acknowledged that their activities generate environmental impacts, but they never made an assessment. Some have never worried about it, but most claim it is not a legal requirement, nor is it asked to purchase loans, so they were never interested in evaluating it, although they felt it was important. They also stated that, until then, they had no knowledge of the Leopold Matrix or any other impact assessment technique. They also informed that, if necessary, they would like to use a computerized tool to carry out this task.

About SAIA, the difficulties and problems pointed out were:

- Lack of knowledge in the use of computers in general;
- Difficulty in differentiating the activity of step;
- Some menu items were cited as confusing;
- The colors in the table that did not differentiate criticality between positive and negative impacts;
- Some shades of color on the chart were too close, making it difficult to see;
- There is no way to change the name of the activity after it is registered, only the process and step;

About the usability of SAIA, 87.5% said they would use the application frequently, 75% found it easy to use, but of these, 66% said they would initially need someone helping to make use of the application. 62.5% felt confident using the system and 87.5% found the interface pleasant to use. All stated that the results generated by the system are important and 62.5% claimed that they thought it was clear how the information appears in the system. The data show a good acceptance of the tool.

The app presented the environmental impacts on family farming projects. The impact assessments carried out showed producers the activities most impacting the environment and the surrounding communities of the projects they carried out. At first, most participants do not see how they could do it differently, but it has certainly generated interest and an outside incentive could make the agroecological transition happen for them.

In order to improve the acceptance of SAIA, accepting the suggestions of the producers and also based on the observations in its use, the following adjustments were made in the application:

- The menu has been renamed with more common terms used in registration applications;
- In the display of the turbocharged matrix, where the criticality was given only by the colors red (high criticality), yellow (medium criticality) and white (low or no criticality), two new colors were included, with this, the criticality levels were changed to to be:
    - Red: highly critical negative impacts;
    - Yellow: negative impacts of medium criticality;
    - White: positive and negative impacts of low or no criticality;
    - Cyan blue: positive impacts of medium criticality;
    - Green: highly critical positive impacts.

With these change, it is expected that agroecological projects will only have impacts on the colors green, blue cyan and white, being more easily identified the points that need adjustments in a possible agroecological transition.

- A revision was made to the colors generated the graph, leaving the tones much more distant from each other;
- A menu item was created, on the activity screen, where the user can change the name of a previously chosen activity;
- A help button was placed on the activity registration screen, with useful information about registration;
- The generation of new reports with differentiated information was implemented.

4 CONCLUSIONS

The environmental impact assessments carried out in the Brígida project showed producers the activities that have the most impact on the environment and the surrounding communities of the crops and creations they carry out. Despite being family producers, whose environment is very suitable for the development of agroecology, the diagnosis allowed us to conclude that the producers, in the cultures and creations analyzed, do not follow the agroecological proposal, especially in the stages of fertilization and use of artificial pesticides, also indicating that the occurrence of negative impacts does not depend on the cultivation/breeding but on the production process adopted.

Among the analyzed crops and creations, the onion, the yam and the papaya had the most negative impacts, on the other hand, cassava and chicken farming had the lowest proportion of these impacts, being closer to the agroecological proposal. Despite this, they all have great potential to carry out a satisfactory agro-ecological transition, as producers were interested in improving their forms of production, but they do not know how to do it, which can be concluded by the need for technical and governmental incentives in this regard.

The application SAIA - Environmental Impact Assessment System proved to be efficient to identify, in a simple, standardized and objective way, the environmental impacts in family farming projects, making it promising to replace the use of electronic spreadsheets in the assembly of the matrix derived from Leopold, for the assessment of environmental impacts, providing dynamism, standardization and broad access to information to decision makers.

The tool was well accepted by producers, despite the fact that there is no legal requirement for an environmental impact study on the properties and the little experience in the use of computer systems by some volunteer research participants. Some suggestions for improvements in the SAIA interface and usability were given by the producers, others were observed during the use of the application, which were accepted and implemented. Among the necessary changes, the changes in the user interface texts and color differentiation between positive and negative impacts on the matrix stand out. These changes bring the application closer to the participants' reality and allow a better visualization of the results, expanding the tool's application potential.

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