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Comparative Analysis of Brazilian Methods to Assess Sustainable Development in Farms

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Abstract: The aim of the present research is to analyze differences and similarities in Brazilian methods used to assess farms' sustainable development, namely: Ambitec-Agro, APOIA-NovoRural and ISA. Meta-study was the adopted method. According to the results, all three methods (Ambitec-Agro, APOIA-NovoRural and ISA) presented similarities to, and differences from, each other. The choice for the method demands special emphasis on decision-making about what to be analyzed in the farms, namely: technology, agricultural activity or the farm as a whole. In addition, based on the indicators, the three methods were previously set and it made their choice impossible.

Keywords: Agribusiness; sustainable development; methods; assessment; farm.

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Introduction

The present article is an analysis of similarities and differences among three Brazilian methods applied to assess farms' sustainable development (SD); therefore, a set of issues was associated with these methods. The used modern farming practices stood out among these issues since they can lead to long-term ecosystem service losses (Foley *et al*., 2005), to the contamination of lakes, rivers and the atmosphere due to nitrogen application (Therond *et al*., 2017), to land-use changes and to the consequent emission of gases associated with climate change (IPCC, 2014), to insect resistance due to intensive use of pesticides, to negative effects on biological-regulation ecosystem services (Therond *et al*., 2017), to poverty (Aquino; Gazolla; Schneider, 2016) and even to labor analogous to slavery (Leão *et al.*, 2021).

Farming SD can take place by promoting sustainable agricultural production forms based on both social inclusion and environmental protection actions (Seidler *et al.,* 2018). However, it is necessary to assess these farms' degree of sustainability based on methods to monitor agroecosystems in order to achieve effective advancements in farms' contribution to SD (Binder; Feola; Steinberger, 2010; Marchand *et al*., 2014; De Olde *et al*., 2016; De Olde *et al*., 2017).

According to Lampridi, Sørensen and Bochtis (2019), the most often adopted methods to assess farms' sustainable development are based on indicators, which are understood as parameters or values deriving from other parameters that, in their turn, describe the state of a given phenomenon (De Olde *et al*., 2017). Ferreira *et al.* (2012) stated that indicators can be understood as instruments to measure changes in a given system and to assess current scenarios and their behavioral trends, as well as to set comparison degrees at time and space scale.

Several international methods were developed to measure farming sustainability based on indicators. De Olde *et al.* (2016) listed approximately sixty published methods and highlighted the most cited ones, namely: MESMIS (Framework for Evaluación de Sistemas de Manejo de Recursos Naturales), which embodies Sustainability Indicators (Masera; Astier; López Ridaura, 1999) like IDEA (Indicateurs de Durabilité des Explotations Agricoles) (Briquel *et al*., 2001), and the Method for Integrated Agricultural Sustainability (MOTIFS) (Meul *et al*., 2008).

Methods have been developed in Brazil to measure farms' SD, including AMBITEC (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006), APOIA-NovoRural (Rodrigues *et al*., 2010) and Sustainability Indicators in Agroecosystems - ISA (Ferreira *et al*., 2012).

The number of methods to assess farms' sustainable development raises the following questions: what are the differences between these methods? What does each of them analyze? What are the contributions of their use in different agricultural and rural development styles? De Olde *et al.* (2017) corroborated these questions' relevance by highlighting the lack of a comprehensive aspect of the sustainability assessment methods available and of their features when it comes to helping and supporting users at the time to select the most important one.

The lack of a comprehensive aspect is linked to the fact that methods can have different purposes, such as research, certification, self-assessment, consumer information, agricultural advice, policy development, or decision-making support (De Olde *et al.*, 2017). Furthermore, sustainability assessment methods can focus on different system's analysis levels such as product, field, farm, and region, as well as cover one, or several, environmental, economic, and social sustainability dimensions (De Olde *et al.*, 2017).

There are comparative studies aimed at international methods. They compare IDEA, SAFA, and RISE (Binder; Feola; Steinberger, 2010); MOTIFS (Marchand *et al.*, 2014); IDEA and MESMIS (Cândido *et al.*, 2015); RISE; SAFA, PG, IDEA (De Olde *et al.*, 2016); IDEA, RISE and MOTIFS (Seidler *et al.*, 2018). However, based on the analysis applied to the bibliographic references, there is a lack of comparative studies aimed at methods developed in Brazil.

The general aim of the current article was established by taking into consideration the relevance of assessing farms' SD and the lack of a comprehensive aspect of the methods available to analyze differences and similarities among Brazilian methods applied to assess these properties' sustainability.

A comparative study focused on the three Brazilian methods was carried out in order to reach the study aim. Results have shown that the three methods: Ambitec-Agro, APOIA-NovoRural, and ISA, presented similarities to, and differences from, each other, and they are the trade-offs to be analyzed at the time to decide the method to be adopted. Special emphasis must be given to decision-making about what to be analyzed in farms, namely: technology, agricultural activity, or the farm as a whole. Finally, the current results help decision-makers to make choices based on science, because it leads to decisions substantiated by the association between a method and users' final goal (Marchand *et al.*, 2014, Soulé *et al.*, 2021).

Brazilian methods to assess SD in farms

Method to assess the environmental impacts of agricultural technological innovations - AMBITEC-Agro

In 2002, the Brazilian Agricultural Research Corporation (EMBRAPA) [Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)] created a system to assess environmental impacts caused by the use of technological innovations in agriculture, because it sought to find a tool aimed at assessing sustainability, the so-called AMBITEC-Agro method (Lima *et al.*, 2014). The aim of this method lied on providing a simple, practical, and low-cost approach applicable to the multi-criteria assessment applied to socio-environmental impacts, to a wide variety of technological innovations and to rural activities, with emphasis on R&D projects developed by Embrapa and by their partners in the Brazilian agricultural research system (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006). Impact assessment results were used to compose EMBRAPA's Social Balance Sheet (Rodrigues, 2015).

Method Ambitec-Agro consisted of a set of multi-criteria matrices comprising technological-innovation performance indicators and new management practices used in farming activities. This method takes into consideration two impact types and seven assessment sub-dimensions. The ecological impact, which includes technological efficiency and environmental quality, was the first herein analyzed impact type. The socio-environmental impact, which includes respect for consumers, work/employment, income, health, and management, was the second analyzed impact type (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006). These seven dimensions were subdivided into 27 criteria that, in their turn, were related to 148 indicators. These criteria can be weighted based on both indicators' impact and relevance. Yet, if one takes into account the observed impacts, these criteria can be weighted as follows: (0) does not apply, (1) punctual, (2) local, (5) surroundings. The importance weighing the indicators can be split between indicators associated with a given criterion and the total sum of indicators' weight distribution, which must be 1 (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006).

The method presents the technology impact index after all indicators' coefficients are inserted in the matrices. This index is expressed by the criterion's weighted mean importance, multiplied by the observed performance coefficient. The method also provides environmental, economic, and social impact indices. Assessment indices are graphically expressed based on a scale ranging from -15 to +15 (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006), and it allows producers/managers to decide about the criteria accounting for the strongest impact on these actors' activity. It also helps decision-makers and managers to define policies and instruments to improve the performance of rural technologies (Lima *et al.*, 2014).

Method AMBITEC-Agro has been applied to assess the environmental impacts of planting vegetables, among others (Lima *et al.*, 2014). According to the results, adopting direct planting technologies applicable to vegetables has led to positive environmental impact, mainly when it comes to soil conservation (Lima *et al.*, 2014). AMBITEC-Agro was also adopted to analyze the impact of Palm cultivation, which is one of the oilseeds presenting the greatest potential for biodiesel production, besides high potential to sequester carbon, to generate income and to restore altered areas (Monteiro *et al.*, 2013).

Weighted Environmental Impact Assessment Method applicable for Novo Rural Activities - APOIA-NovoRural

Method APOIA-NovoRural was developed by EMBRAPA, in 2003. It was created to measure farming environmental impacts on a given agroecosystem (Rodrigues; Campanhola, 2003).

This method emerged from the need identified by Rodrigues and Campanhola (2003) to create a tool to match the wide variety of agricultural and non-agricultural activities developed under different environmental conditions in Brazil. Rodrigues and Campanhola (2003) did not find a fully satisfactory method to match some emerging activities in Novo Rural method, so they proposed the so-called APOIA-NovoRural

method, which is based on the following principles: to be applicable to any activity in the Brazilian rural environment; to meet the rigor required by the scientific community and to simultaneously allow its practical use by farmers/rural entrepreneurs; to gather ecological, economic and social aspects in an adequate and sufficient number of specific indicators; to be computerized and to provide a final integrated measurement of a given activity's environmental impact.

The developed method uses a set of electronic spreadsheets (MS-Excel platform) comprising 62 indicators subdivided into five assessment dimensions, namely: landscape ecology, environmental quality (subdivided into atmosphere, surface water, groundwater, and maintenance of soil yield capacity), sociocultural values, economic values, and management (Rodrigues *et al.*, 2010). In total, 24 of the 62 indicators were subdivided into two scales: 1) to assess the increase or decrease in the factors that have an impact on the analyzed indicator; 2) to assess impacts' participation on farming activities. The other 38 indicators were measured based on absolute values, right in the farm (Rodrigues *et al.*, 2010).

An impact index and a general index of activities' contributions to the sustainability of the analyzed farms were the outcomes of the aforementioned process, based on a scale ranging from 0 to 1. In addition, this process also provides an index for the following dimensions: landscape ecology, sociocultural values, economic values, and management, as well as for sub-dimensions 'atmosphere', 'water', and 'soil yield capacity maintenance' (Rodrigues *et al.*, 2010).

This method has been applied to territorial environmental management, rural development programs at national scale, productive sectors, and agricultural production chains, as well as to production systems and to environmental protection areas' surroundings (Rodrigues *et al.*, 2010). According to Ramos Filho *et al.* (2004), APOIA-NovoRural has proven to be a useful method for producers, individually or in groups. Yet, it is also an important method for public policy managers because it substantiates actions aimed at sustainable local development. APOIA-NovoRural was used to assess the environmental performance of activities aimed at Agritourism (Ramos Filho *et al.*, 2004) in ten farms in São Paulo States' hinterlands. Another study assessed the environmental performance of family farms focused on producing organic horticulture products, and that were associated with Coopermin Cooperative, in Mineiros municipality – Goiás State (Lopes; Sturza, 2022). The environmental performance of organic horticulture and conventional horticulture in this same region was also assessed in 2003 (Rodrigues *et al.*, 2003).

Sustainability Indicators in Agroecosystems - ISA

ISA was developed by Minas Gerais Agricultural Research Corporation – EPAMIG [Empresa de Pesquisa Agropecuária de Minas Gerais – EPAMIG] in partnership with Minas Gerais State Technical Assistance and Rural Extension Company - EMATER-MG [Empresa de Assistência Técnica e Extensão Rural do Estado de Minas Gerais – EMATER-MG], the State Forest Institute – IEF [Instituto Estadual de Floresta – IEF], Embrapa,

Federal University of Minas Gerais and João Pinheiro Foundation - which is an entity of Minas Gerais State's government that provides technical support to the State Secretariat for Planning and Management and to other state operational systems (Ferreira *et al*., 2012). The aim of ISA method is to perform a social, economic and environmental diagnosis of the farm as a whole (Ferreira *et al*., 2012) and to help farmers to manage their rural properties by improving the quality of their production system and of the environment, as well as by minimizing environmental weaknesses within the properties' boundaries, since it can compromise the sustainability of agroforestry activities (Costa *et al*., 2013).

The method is divided into seven dimensions, namely: economic balance, social balance, farms' management, soil yield capacity, water quality, production systems management and ecology of agricultural landscapes. Each of these sub-dimensions is also subdivided based on indicators that, altogether, represent 23 indicators (Ferreira *et al*., 2012).

The method provides an index based on the mean recorded for the scores given to the 23 indicators by taking into account 0.7 as a reference value for good environmental, social, or economic performance (Ferreira *et al*., 2012). The method application tool plots graphs and tables that aggregate the indices and topics to help public managers identifying socioeconomic vulnerabilities, environmental weaknesses, and monitoring programs (among others). It appeared efficient to measure economic and social balance, property management, soil and water quality, production system management, landscape diversification, and native vegetation conservation status (Ferreira *et al*., 2012).

ISA was applied to assess farms. Two studies that have used ISA are highlighted: Ferreira *et al*. (2012) applied ISA to more than 500 farms in Minas Gerais State; Silva *et al*. (2017) adopted ISA to implement the environmental service payment program (PSA) aimed at proposing a socioeconomic and environmental diagnosis of the assessed site. ISA was proved efficient in disclosing the region's reality.

Methodology

Meta-study was the adopted method (Paterson, 2001) because it is featured by assessing the results and processes described in previous research. In addition, the meta-study method focuses on theoretical frameworks that point towards research questions and guides interpretations of results found in previous studies (Timulak, 2011).

Three national methods to assess farms' sustainability were analyzed as analysis object: the assessment method applied to the method aimed at assessing the environmental impacts of agricultural technological innovations - Ambitec-Agro (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006), Weighted Environmental Impact Assessment Method applicable for Novo Rural Activities - APOIA-NovoRural (Rodrigues *et al*., 2010) and Sustainability Indicators in Agroecosystems - ISA (Ferreira *et al*., 2012). These three methods were initially chosen because they were developed and used by Brazilian research and rural extension organizations, and because of these methods mainstream position among national researchers in Brazil (Rodrigues *et al*., 2010; Gabrielli *et al*., 2023).

The comparative assessment of sustainable development methods applied to farms

opened room for the following questions: what are the differences between these methods? What does each of them analyze? What are the contributions of their use to different agricultural and rural development types?

These three methods were compared through normative and systemic dimensions in order to answer to the aforementioned questions, as originally proposed by Binder, Feola and Steinberger (2010) and improved by Marchand *et al.* (2014) and De Olde *et al.* (2016) (Table 1). The choice for these dimensions regarded the fact that they are categories developed and internationally acknowledged to compare methods (Binder *et al.*, , Feola and Steinberger (2010;); Marchand *et al.*, 2014, De Olde *et al.*, 2017). Furthermore, they have already been used in several studies aimed at this comparison type, such as the case of comparative studies based on international methods adopted to compare IDEA, SAFA, and RISE (Binder; Feola; Steinberger, 2010); RiSE; SAFA, PG, and IDEA (De Olde *et al.*, 2016); and IDEA, RISE and MOTIFS (Seidler *et al.*, 2018).

The normative dimension takes into account five important issues: objective and target audience, underlying sustainability concept, defining goals and assessment types - which refer to regulatory standards, targets, limits and ranges. The systemic dimension plays a key role in the selection and design of assessment indictors. Two issues must be taken into consideration within this dimension, namely: simplicity, which must be presented as simple as possible; sufficiency, which regards the complexity necessary to achieve a successful assessment.

Table 1 - Comparative analysis framework applied to methods adopted to assess farms' sustainability: normative and systemic dimensions.

Dimensions	Analysis category	Descriptions
Normative	Aim	General aim of the method
	Target public	Who does the method interests to?
	Sustainability concept	Adopted sustainability concept
	Origin of targets and indicators	How were sustainability assessment targets defined?
	Hierarchy levels and indicators	Hierarchical levels of sustainability assessment. What are the assessed indicators?
	Scoring and aggregation method	Assessment method of data aggregation indicator
	Function of the method	Purpose of the method
Systemic	Simplicity	Using simplicity for method understanding and representation purposes
	Sufficiency (complexity and parsimony)	Use of the complexity necessary for a successful assessment Interaction between the indicators addressed in the method

Source: Elaborated by the authors (based on Binder *et al.*, , Feola e Steinberger (2010;); Marchand *et al.*, 2014; De Olde, 2017).

Analysis data were collected from both main publications and tool handbooks related to the three assessed methods (Table 2).

Table 2 – Analyzed documents

Methods	Material
Ambitec-Agro	(Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006). (Lima *et al.*, 2014). (Monteiro *et al.*, 2013). (Rodrigues; Kitamura, 2003) (Rodrigues; Pimenta; Casarini, 2016) Excel spreadsheet website: https://www.cnpma.embrapa.br/forms/apoia.php
APOIA-NovoRural	(Ramos Filho *et al.*, 2004) (Demattê Filho , 2014). Excel spreadsheet website: www.cnpma.embrapa.br/forms/apoia.php
ISA	(Silva *et al.*, 2017) (Ferreira *et al.*, 2012). Excel spreadsheet website: www.epamig.br/projeto-isa/

Source: Elaborated by the authors (2022)

Normative and systemic dimensions of the analyzed methods

The normative dimension regards analyzing objective (1), unit of analysis (2), target audience (3), concept of sustainability (4), origin of indicators (5), origin of goals (6), methods' hierarchical levels (7), and data aggregation (8) and function (10). Each of these dimensions is discussed below. Table 3 provides a summary of the recorded results.

With respect to objective (1), the three methods assess environmental, social, and economic impacts seen as changes in the three aforementioned dimensions, which can be positive or negative. However, the question regarded factors generating the impacts observed on each of the methods, the so-called unit of analysis (2). The Ambitec-Agro method aims at assessing the impacts of a given technology (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006). Examples of assessed technologies include (a) Direct Planting System applied to Vegetables (Lima *et al.,* 2014) and (b) analysis of Palm cultivation impact on both income generation and the restoration of altered areas (Monteiro *et al.*, 2013). The aim of APOIA-NovoRural, in its turn, is to understand the impacts of selected activities on farms (Rodrigues; Campanhola, 2003, Rodrigues *et al.*, 2010). Examples of assessed activities include (a) the environmental performance of agrotourism (Ramos Filho *et al.*, 2004) and (b) the environmental management of farming activities in the natural agriculture hub, Ipeúna municipality – São Paulo State (Demattê Filho, 2014). Finally, the aim of ISA is to assess the impacts of what happens in the farm as a

whole. It does not lie on making any analysis cuts, as observed in the previous methods (technology or activity) (Ferreira *et al*., 2012). Examples of analysis applied to the farm as a whole include a) ISA system application in more than 500 farms in Minas Gerais State (Ferreira *et al*., 2012); b) using ISA to implement the Environmental Services Payment (PSA) program (Silva *et al*., 2017).

When it comes to target audience (3), all methods are similar to each other, with emphasis on rural producers, farmers and public managers, agricultural promotion, and rural development (Ferreira *et al*., 2012; Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006; Rodrigues *et al*., 2010).

The aim of the sustainability concept category (4) was to analyze the triple bottom- line dimensions. ISA comprises 23 indicators and places greater emphasis on the environmental dimension (13 indicators), as well as on the social (5 indicators) and economic dimensions (5 indicators) (Silva *et al*., 2017; Ferreira *et al*., 2012, EPAMIG, 2020). APOIA-NovoRural adopts 5 multi-attribute approach criteria that encompass 62 indicators. It also places greater emphasis on the environmental dimension (45 indicators), and similar emphasis on the social (9 indicators) and economic (8 indicators) dimensions (Rodrigues *et al*., 2010; EMBRAPA, 2003a). Ambitec-Agro uses 27 criteria, which are divided into 148 indicators, with emphasis on the environmental dimension (77 indicators), which is followed by the social (54 indicators) and economic (17 indicators) dimensions (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006; EMBRAPA, 2003b).

The following analysis focused on the origin of the indicators (5) and the targets (6). Indicators are pre-established in all methods. None of the assessed methods evidenced the possibility of including any non-pre-established indicator (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006; Rodrigues *et al*., 2010; Silva *et al*., 2017). APÓIA-NovoRural and ISA adopt the baseline of 0.7 for the targets (Rodrigues *et al*., 2010; Silva *et al*., 2017), and this is a difference from Ambitec-Agro, which assesses changes within a given time interval (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006).

As for hierarchical levels (7), Ambitec-Agro and APOIA-NovoRural have 3 aggregation levels (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006; Rodrigues *et al*., 2010). However, Ambitec-Agro has the largest number of indicators (148) in comparison to APOIA-Novo Rural (62). ISA presents a smaller number of aggregation levels (2) and indicators (23) (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006); yet, it has a smaller number of aggregation levels (2) and indicators (23) (Ferreira *et al.,* 2012).

Table 3 - Summary of similarities and differences in normative aspects

Dimension	Categories	Comparison
Normative	(1) Goal	Similarities Environmental, economic and social impacts
	(2) Analysis unit	Different units Ambitec-Agrotechnology APOIA-NovoRural: carried out activities ISA: property as a whole.
	(3) Target public	Similarities farmers Public managers of agricultural promotion and development
	(4) Sustainability concepts	Similarities *Triple bottom line* analysis.
	(5) Origin of indicators	Similarities Pre-established indicators
	(6) Origin of targets	Different targets APOIA-NovoRural and ISA adopt a baseline of 0.7 Ambitec-Agro evaluates the changes that occurred between two moments, with different degrees and qualities (positive or negative).
	(7) Hierarchical levels	Similarities presence of more than one hierarchical level
	(8) Data aggregation	Different forms of aggregation Ambitec-Agro: the result is presented through a column graph, generating an index that varies between – 15 (maximum decrease = decrease in impact) and + 15 (maximum increase = increase in impact). APOIA-NovoRural and ISA: utility scale ranging from 0 to 1, with the baseline value of environmental compliance standardized at 0.7.
	(9) Possibility of weighting the indicators	Different weighting possibilities Ambitec-Agro: weighs 1) the weight of each indicator and 2) the scope of the impact APOIA-NovoRural; considers 1) severity of impact and 2) scope of impact ISA: no possibility of weighting
	(10) Function of the tool in an environmental management system	Different functions Similar in terms of presenting a diagnosis. ISA stands out for its ability to propose action plans in the tool itself.

Systemic	(11) Simplicity	Similarities Results in graphical and easy-to-understand form.
	(12) Sufficiency and parsimony	Similarities Integrative approach to the dimensions of sustainable development Emphasis on the environmental dimension of sustainable development.
	(13) Interactions between indicators	Similarities Indicators independent from each other.

Source: Elaborated by the authors (2023).

Data aggregation (8) goal was to assess whether data aggregation generate sustainability indices, or not. Ambitec-Agro uses a multi-criteria spreadsheet, according to which, each indicator is scored from -3 (negative impact) to 3 (positive impact), weighted by the weight recorded for each indicator and by the scope of the observed impact (1, 2, and 5, for specific, local and surroundings, respectively). Indicators' relative weights within the 27 criteria can be changed by method users, depending on the need of the analyzed context, as long as the total is equal to 1, in each criterion. The result is expressed in column graph, which generates an index ranging from -15 (maximum decrease = impact decrease) to +15 (maximum increase = impact increase). Criterion 'indicators' aggregation' cannot be weighted (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006; EMBRAPA, 2003b).

APOIA-NovoRural presents two weighting procedures based on fixed values: 1) impact severity based on a varying scale, but with fixed weighting, whose sum is up to 1; 2) scope (0: unchanged; 0.25: punctual; 0.50: local; 0.75: surroundings; 1.00: regional). Changes caused by the activity can be measured based on absolute values recorded for each indicator (before and after the activity), which are transformed into a value function that relates it to the activity's environmental performance within a utility scale ranging from 0 to 1, with baseline environmental compliance value set at 0.7. Criterion 'indicators' aggregation' cannot be weighted (Rodrigues *et al.*, 2010; EMBRAPA, 2003a).

ISA does not demand weighting its indicators because they present the same weighting. An index is generated for each indicator, and it ranges from 0 to 1, based on functions that assign values to variables. It is done by comparing the value measured at the farm to the reference value, and by using weighting factors for each assessed parameter. Value 0.7 is the baseline or the sustainability threshold. The system automatically generates a final index based on the mean of scores assigned to the 23 indicators. The assessment method automatically generates tables and radar charts that gather indicators into topics (Ferreira *et al.*, 2012; EPAMIG, 2020).

The idea of function (10) was to analyze this category (function) based on four steps found in an environmental management system, namely: planning, organizing, implementing, and controlling (Barbieri, 2012). The three assessed methods enabled generating a diagnosis; however, ISA differs from the others, because it also allows "action plan" propositions. ISA has a "diagnosis" spreadsheet and an "action plan preparation" spreadsheet in Excel form for method application, the so-called adaptation plan, which is prepared by a technician and provides proposals and a schedule for assessment conclusion. This process allows for controlling the resulting diagnosis. It also allows rural producers to take actions in their properties in order to accomplish sustainability. Assessments should be carried out periodically to compare improvements or, setbacks, in the analyzed indicators (Ferreira *et al.*, 2012; EPAMIG, 2020).

APOIA-NovoRural generates a "diagnostic" report provided to farmers when all assessments are complete. Results combined based on the integrated dimensions (ecological, economic, sociocultural) give decision-makers an overview of rural activities' positive and negative effects on local sustainable development. This scenario makes it easier to

select and recommend encouragement policies or control measures. The authors of this method emphasize the relevance of monitoring the recommended actions because they can provide better guidance and monitoring aimed at local sustainable development (Ramos Filho *et al*., 2004; EMBRAPA, 2003a).

Ambitec-Agro generates a "diagnostic" spreadsheet synthesized into an index resulting from EIA (Environmental Impact Assessment). The last stage of this process lies i n interpreting these indices and on recommendation for management alternatives and technologies capable of minimizing negative impacts and enhancing positive impacts to help monitor both these indices and sustainable local development (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006; EMBRAPA, 2003b).

Two categories were analyzed in the systemic dimension: simplicity (11) and sufficiency (12). Table 3 provides a summary of the herein recorded results. The three methods present simplicity (11) results in an easy-to-understand graphic format. As for sufficiency (12), the three methods explicitly mention the relevance of an integrative approach applicable to sustainability that addresses the three sustainability dimensions (triple bottom line). However, when it comes to a number of indicators, Ambitec-Agro presents the greatest complexity, which is represented by the largest number of indicators in the three dimensions, in comparison to APOIA-NovoRural (intermediate complexity) and ISA (greater parsimony). However, all of them emphasize the environmental dimension of sustainable development.

Discussion

The goal of identifying similarities (Table 3) was to deeply discuss three of these similarities, namely: 1) the concept of sustainable development, 2) the origin of indicators, and 3) sufficiency of the methods' parsimony.

As for the first similarity, the three methods encompass the concept of sustainable development, which means much more than sustainability. Sustainability can be understood as the ability to keep a system alive, i.e., how long a system can be maintained (Cruz; Mena; Rodriguéz-Estevez, 2018). The word sustainability is related to the ability of sustaining oneself. From an ecological and even economic viewpoint, this word implies exploiting a given resource without exhausting it – to maintain it forever (Mikhlailova, 2004).

The concept of sustainable development emerges from the discussion about the likely economic growth reconciliation without natural resources depletion (Veiga, 2010). This process is based on the association between society and the environment, which is also fundamental to social equity (Veiga, 2010). Sustainable development has different concepts, but the one most often adopted by organizations defines it as development matching the needs of the present generation without compromising the ability of future generations to meet their own demands (Brundtland, 1987). It is added with the need of taking into consideration at least three pillars: social, environmental, and economic (Elkington, 1997), as well as with institutional, cultural, or ethical dimensions, including

governance, efficiency, motivation, values, and other essential factors to achieve stable human prosperity (Cruz; Mena; Rodriguéz-Estevez, 2018).

An attempt to clarify the difference between these two concepts is observed in the framework proposed by Kattes, Parris and Leiserowitz (2005), based on the Brundland Report, which summarizes and differentiates aspects about what should be sustained based on the aspects that should be developed. Kates, Parris and Leiserowitz (2005) emphasized that nature (land, biodiversity, ecosystems), life support (ecosystem services, resources, environment), and community (cultures, groups, and places) should be sustained, whereas people (children, life expectancy, education, equity, equality of opportunities), economy (prosperity, productive sectors, consumption) and society (institutions, social capital, states and regions) should be developed.

The three methods have a common feature regarding the second similarity: impossibility of choosing the indicators, because they are pre-established in all three methods. This common feature was mentioned by De Olde *et al.* (2016) and Soulé *et al.* (2021), according to whom, one of the most important features of methods developed to analyze sustainable development in farms should be the possibility of selecting indicators, and this is in opposition to what was found in the herein analyzed Brazilian methods. The criticism by De Olde *et al.* (2016) was based on a survey carried out with experts in this field, which stood out for a lack of consensus among participants about the most important indicators to assess SD. De Olde *et al.* (2016) explained that personal contexts can make individuals prioritize different indicators.

By discussing the selection of indicators, De Olde *et al.* (2017); De Olde *et al.* (2016) and Chopin *et al.* (2021) argued that stakeholders' (farmers, governmental agents, among others) participation in discussions on the selection of indicators is essential to the assessment process, because their inclusion in these discussions allows developing and outspreading more robust sustainable development concepts by creating a sense of belonging and responsibility among them. It is worth highlighting the difference between rural producer and farmer. A rural producer owns delimited lands and they may (or not) engage in agricultural activities, but they play a specific role in their management (Rosa, 2023). On the other hand, a farmer basically cultivates the soil (Rosa, 2023). Furthermore, stakeholders' participation in this process opens room for discussions about reference, for debates, arguments, challenges and counter-criticism differences. This is a positive element, because it is part of the vital process to interpret the sustainable development concept, to improve dialogue and to learn about the sustainable development of the herein analyzed farms (De Olde *et al.*, 2017).

This interaction among parties becomes a joint learning process and helps developing knowledge aimed at managerial decision-making in these farms (Binder; Feola; Steinberger, 2010). This process increases stakeholders' awareness and leads to commitment, understanding, and shared trust, which provides relevant and specific assessments on farm to improve sustainability performance (Binder; Feola; Steinberger, 2010). It is also necessary to take into account that the interaction between agricultural systems and their environment requires reflections on different factors, such as the space and time

scale, institutional behaviors, and knowledge types, and it demands different indicator types and sustainability method functions (De Olde *et al.*, 2017; De Olde *et al.*, 2016, Chopin *et al.*, 2021).

Furthermore, the need of including the likely selection of indicators can be seen as opportunity, because a whole range of knowledge types can lead to a more rigorous exploration of indicators and to a more solid assessment development. It is so, because multiple knowledge types are brought together and emphasize the need of including plural worldviews in a flexible framework set for indicators' selection (De Olde *et al.*, 2016, Chopin *et al.*, 2021).

According to De Olde *et al.* (2016), it is important developing modular methods as likely solution to the problem brought by indicators' origin and choice. These methods could be applied by final users to subsets of indicators available for sustainability assessment depending on project goal and associated local conditions. Thus, this process would allow stakeholders to carry out their own indicators' selection and designing process; however, it must be done through a well-documented fashion to make the analysis and the comparisons easier. This possibility would make assessments more transparent, transformative, and long lasting, besides allowing a deeper understanding of a system's sustainability within a systemic approach, which involves this very system's context and interactions (De Olde *et al.*, 2016). The SAFA method has already shown progress in this regard, and it enabled choosing the indicators (De Olde *et al.*, 2017).

The third similarity between the compared methods lied on lack of interactions between indicators. Soulé *et al.* (2021) stated that this particular feature has been poorly addressed by the methods, despite the recommendation by Binder, Feola and Steinberger (2010) to treat it as one of the assessment criteria. Recently, the third generation of methods to assess sustainable development in farms was launched, and it provided constructed indicators that correspond to bond synergistic or cross-cutting indicators. Demattê Filho (2014) concluded that sustainability assessments must explore an interrelated approach applicable to multidimensional indicators in agricultural systems by assessing both the system's parts, separately, and their parts' associations. The systemic representation of different indicators can be used as an example of likely interactions by assessing either nitrogen flows or losses in agricultural systems (Küstermann; Christen; Hülsbergen, 2010).

The aim of identifying differences (Table 3) was to deeply discuss the unit of analysis in each method. Ambitec-Agro mostly assesses the impacts of a given technology (Rodrigues; Campanhola, 2003; Monteiro; Rodrigues, 2006). The aim of APOIA-NovoRural is to understand the impacts of selected "activities" on farms (Rodrigues; Campanhola, 2003, Rodrigues *et al.*, 2010). Finally, ISA's goal is to assess the impacts of events on the "farm as a whole". There is no problem in having different objects of analysis, as observed in the analyzed methods. However, this statement reinforces the need of being clear about the assessment purpose and of relating this very purpose to the respective assessment tool. Consequently, different sustainability analysis methods applicable to farms are needed to reflect different analysis purposes (De Olde *et al.*, 2016; Chopin *et al.*, 2021).

The different objects of analysis observed in the analyzed methods are capable of

giving different contributions to local development policies and agricultural production systems, among others, when their impacts are assessed through methods linked to these topics.

With respect to territorial development, APOIA-NovoRural allows understanding the environmental impacts of activities linked to enterprises that operate in multiple sectors (agricultural production, agroindustry, marketing), as observed in the study carried out by Ramos Filho *et al.* (2004) about Agrotourism. However, if the aim of the study is to understand environmental impacts on farms' territorial development, the three herein assessed methods can contribute to their own unit of analysis. This process is highlighted by the study on coconut production carried out through APOIA-NovoRural by Rodrigues, Martins and Barros (2018). Monteiro (2013) assessed different palm oil production technologies based on Ambitec-Agro method. Gabrielli *et al.* (2023) assessed farms in Minas Gerais State through ISA.

Agricultural system types are based on chemical inputs, biological inputs and biodiversity (Therond *et al.*, 2017). The three analyzed methods have the potential to help better understand environmental impacts by observing the different objects of analysis of each method. APOIA-NovoRural applications substantiated by the reach of different agricultural systems has already been evidenced in several studies, for instance, for Integrated Agricultural Production Systems (Calegario *et al.*, 2010); precision agriculture (Rodrigues *et al.*, 2008); organic and agroecological agriculture (Rodrigues *et al.*, 2010) or natural agriculture (Dematt̂ Filho, 2014). The other two methods (AMBITEC-Agro and ISA) did not have applications featuring the reach of different agricultural systems, but it is possible making this inference based on studies about technologies applied to the production of different palm oils based on the Ambitec-Agro method (Monteiro, 2013) or on the study on farms in Minas Gerais State carried out through ISA (Gabrielli *et al.,* 2023).

Final considerations

The present research was guided by the analysis of differences and similarities among Brazilian methods adopted to assess farms' sustainability. According to the comparative analysis, the three methods (Ambitec-Agro, APOIA-NovoRural and ISA) present similarities to, and differences from, each other, which are the trade-offs to be analyzed at the time to choose the method to be adopted. Special emphasis should be given to decision made about setting the items to be analyzed in farms, namely: technology, agricultural activity or the farm as a whole.

When it comes to likely limitations observed for the Brazilian methods regarding their application in farms, it is important to state that all indicators were previously established and that such a feature has impaired their choice. This outcome has limited the process to include in Brazilian methods the understanding of sustainability by rural producers, stakeholders, as well as the local features to be analyzed in the farms. On the other hand, standardized methods, such as the three analyzed ones, have the potential to be used to certify some rural properties. In addition, they can contribute to learning

processes and to the start of dialogues with rural producers about their farms' sustainable development.

If one has in mind the continuity of new research on the herein approached lines of work, it is important to point out the convenience in reducing the complexity of methods to be adopted. Yet, it is essential to focus on improving the applied methods to select sustainability indicators based on peculiarities of farms' environmental, economic, and social conditions in the region to be assessed.

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Análise Comparativa Métodos Brasileiros de Avaliação do Desenvolvimento Sustentável em Propriedades Agrícolas

Laura Gonçalves Osorio
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Resumo: A presente pesquisa tem o objetivo de analisar as diferenças e similaridades dos métodos brasileiros de avaliação do desenvolvimento sustentável em propriedades agrícolas: Ambitec-Agro, APOIA-NovoRural e ISA. O método utilizado foi o de meta-estudo. Os resultados indicaram que os três métodos Ambitec-Agro, APOIA-NovoRural e ISA possuem cada um com suas similaridades e diferenças. Como conclusões, na escolha do método, deve-se dar especial ênfase à decisão sobre a delimitação na propriedade agrícola do que vai ser analisado (uma tecnologia, uma atividade agrícola ou a propriedade como um todo). Além disso, os três métodos partem de indicadores e foram estabelecidos a priori, o que impossibilita a opção de escolhê-los.

Palavras-chave: Agronegócio; desenvolvimento sustentável; métodos; avaliação; propriedade agrícola.

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Análisis Comparativo de Métodos Brasileños para Evaluar el Desarrollo Sostenible en Agricultura

Johnson Morancy
Helenilza Ferreira Albuquerque-Cunha
Alan Cavalcanti da Cunha

Resumen: Esta investigación tiene como objetivo analizar diferencias y similitudes de los métodos brasileños para evaluar el desarrollo sustentable en establecimientos agropecuarios: Ambitec-Agro, APOIA-NovoRural e ISA. La metodología utilizada fue meta-estudio. Los resultados indicaron que los tres métodos, Ambitec-Agro, APOIA-NovoRural e ISA tienen entre sí similitudes y diferencias. Como conclusión, en oportunidad de elegir el método, debe otorgarse especial énfasis al alcance que tendrá el análisis a realizar en el establecimiento agropecuario (una tecnología, una actividad agrícola o el establecimiento en su conjunto). Adicionalmente, los tres métodos parten de indicadores establecidos a priori, lo cual imposibilita su elección.

***Palabras-clave*:** Agronegocios; desarrollo sustentable; métodos; evaluación; establecimiento agropecuario

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