



Sustainability evaluation of producing soybean municipalities in the state of Mato Grosso

Avaliação da sustentabilidade dos municípios sojicultores do estado de Mato Grosso

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ABSTRACT: The objective of this contribution is to evaluate the level of sustainability of the soybean municipalities in Mato Grosso. Thus, the methodological procedure was based on the proposal of the Sustainability Indicator for Soybean Producing Municipalities (ISMS). The ISMS is composed of forty-two indicators distributed in the social, demographic, economic, political-institutional, environmental and cultural dimensions, classified into critical, alert, acceptable and very good levels of sustainability. In the final evidence about the ISMS, all municipalities of the sample presented a sustainability index at alert level. The municipalities were grouped into three clusters, in terms of the ISMS result. It is concluded that the expansion of soybeans in Mato Grosso territory is distributed in places of potential pressure on ecosystems and biophysical compartments, without the counterpart of elevation of the level of local development. This result signals the priority of reassessing the productive structure in Mato Grosso municipalities, and the reversal of public policies that prioritize the process of agricultural expansion in the regions of Amazonian ecosystems and the preservation of the Cerrado bioma.

Keywords: environment and development; sustainability indicator; sojicultura.

RESUMO: O objetivo desta contribuição centra-se em avaliar o nível de sustentabilidade dos municípios sojicultores de Mato Grosso. Para isso, empregou-se como procedimento metodológico a estimação do Indicador de Sustentabilidade para Municípios Sojicultores (ISMS), composto por quarenta e dois indicadores distribuídos nas dimensões social, demográfica, econômica, político-institucional, ambiental e cultural, classificadas em níveis crítico, alerta, aceitável e muito bom de sustentabilidade. Os municípios foram agrupados em três

clusters, em termos do resultado do ISMS, e os resultados indicam que todos os municípios da amostra apresentaram nível de alerta de sustentabilidade. Conclui-se que a expansão da sojicultura em território mato-grossense distribuiu-se em locais de potencial de pressão sobre os ecossistemas e compartimentos biofísicos, sem a contrapartida de elevação do nível de desenvolvimento local. Esse resultado sinaliza a prioridade da reavaliação da estrutura produtiva dos municípios mato-grossenses e a reversão de políticas públicas que priorizam a expansão da monocultura da sojicultura nas regiões dos ecossistemas Amazônico e do Cerrado.

Palavras-chave: desenvolvimento e meio ambiente; indicador de sustentabilidade; sojicultura.

1. Introduction

The origin of the debate about the capitalist mode of production and damage to the environment emerged in the 1960s, with the study of Rachel Louise Carson (1962). From then on, debate on this subject has intensified, as in the Club of Rome, in 1968, and in the Stockholm Conference, in 1972, when after the publication of the report “The Limits to Growth” (Meadows, 1972) the impossibility of infinite growth with a finite supply of resources was affirmed. Thus, the discussion on sustainability paved the way for an interdisciplinary field of research (Sachs, 2007).

In this context, the need to elaborate and coordinate actions aimed at minimizing the negative externalities generated in the social and environmental spheres, through mitigations of the current model of global capitalist production, is evident. In this scenario, the global challenges of the pressing need to expand food production and preserve the support capacity of ecosystems in the face of climate change stand out (FAO, 2016). Furthermore, due to the need for a systemic approach to the concept of sustainability, studies on the subject should be conducted within a holistic perspective, considering social, demographic, environmental, institutional and cultural aspects in their scope, and with a local focus, given the empirical specificities for the

choice of effective public policies (Vasconcelos & Cândido, 2011).

In the case of Mato Grosso, this comprehensive perspective makes empirical evaluations of this process relevant, due to the significant economic growth in the 2000-2015 period, mainly in agricultural production. The Gross Domestic Product (GDP) of Mato Grosso grew 495% from 2000 to 2015 and the percent change in population growth in the same period was 27.5%. Mato Grosso's economy is based on primary production destined for export. The state is the largest national producer of soybean, corn, cotton and beef, with international competitiveness in the commercialization of these commodities. It is estimated that in 2015, the GDP of Mato Grosso's agribusiness was responsible for 50.5% of the state GDP. Mato Grosso is currently the largest soybean producer in Brazil. In the 2016/2017 harvest, its production was approximately 30 million tons, accounting for 26% of national soybean production and 8% of soybean cultivation worldwide (IBGE, 2016; CONAB, 2016; IMEA, 2017; EMBRAPA, 2017).

Currently, soybean production uses high technological intensity, with the aim of increasing yields per hectare of land and saving labor. This strategy is consistent with the principles launched by the technological package of the Green Revolution, represented by the use of machinery, application

of agricultural defensives (pesticides) and use of synthetic fertilizers (Costa *et al.*, 2017). Although agricultural inputs are used locally, their effects reach watersheds and communities close to agricultural properties, causing impacts such as deforestation, air, soil and water pollution, through the effects of waste of chemical components (molecules) in fertilizers, pesticides and residues, such as lubricating oils (Saikku *et al.*, 2012). This raises many questions regarding the impacts of soybean farming on the dimensions of sustainable development in the municipalities of Mato Grosso.

In the document ‘Cartilha da Sustentabilidade’ (Sustainability Booklet) elaborated by Aprosoja (2015), the institution uses the slogan “agribusiness brings development” and analyzes it using the Human Development Index (HDI). According to Aprosoja, there is a strong correlation between soybean production and socio-environmental macro indicators in Mato Grosso, indicating that eight of the ten best HDIs in the state are from soybean producing municipalities. In a study carried out by Embrapa, Hirakuri *et al.* (2015), based on FIRJAN Index of Municipal Development (IFDM), stress that the development of Mato Grosso is based on agribusiness, and that among the ten best development indexes, nine are from soybean producing municipalities.

Therefore, broader criteria are needed to assess the assumption that the relationship between soybean production and local development is positive. Particular consideration is given to the methodological gap in studies that contemplate few intrinsic dimensions of sustainable development, such as HDI and IFDM indicators, which cover only average per capita income, basic health and education criteria, in addition to tax variables.

Thus, the present study aims to evaluate the sustainability of soybean producing municipalities in Mato Grosso, by proposing the development of the Sustainability Indicator for Soybean Growing Municipalities (ISMS), to verify the influences of soybean production agglomeration on the sustainable development of municipalities. The proposition of an indicator for measuring the sustainability of soybean growing municipalities in Mato Grosso is justified by the need for a real assessment of the development in these locations, since the existing analyzes are based on indicators that disregard environmental, cultural, demographic and institutional issues. Likewise, the prospect of overcoming, within the scope of Mato Grosso's development, the debate that sustains the role of economic growth as the only necessary and sufficient process to meet the final objectives of public policies is considered opportune.

In view of these scientific challenges, the structure of the present study is based on literature discussion about sustainability indicators. This is followed by the identification of the methodological procedures carried out, then the analysis of the estimated evidence and, finally, the conclusive comments are made.

2. Sustainable development and sustainability indicators

There was a significant increase in the number of studies on the relationship between development and the environment in the late 1960s and, since then, several theoretical frameworks have emerged on the subject. The Stockholm Conference, in 1972, was guided by discussions about the links between development and the environment. The study

“The limits to growth”, elaborated by Meadows *et al.* (1972), concerned the thesis of 'zero economic growth', and was a critique of the prevailing model based on the thesis of continuous growth. For Barque (2008), Meadows' work was a well-grounded critique of the traditional view of an inexhaustible nature available for human exploration, and offered realistic prospects of medium-term depletion of raw materials and energy sources.

The term sustainable development is a normative concept, and originated from the nomenclature 'ecodevelopment', in the early 1970s. This term evolved in a context of controversies about the relationship between economic growth and the environment, which were accentuated by the publication of the Club of Rome report, which advocated zero growth as a means of avoiding environmental catastrophe. In this context, the concept of 'eco-development' emerges as a conciliatory proposition, where it is recognized that technical progress effectively relativizes environmental limits, but is not capable of eliminating them, and that economic growth is a necessary, but not satisfactory, condition for the elimination of poverty and social disparities (Romeiro, 2010). For Sachs (1993, p.110), 'eco-development' is defined as "socially desirable, economically viable and ecologically prudent development".

The assessment of sustainable development, as well as its process, is very complex and must be done in a systemic and holistic way, i.e. it must consider the various intrinsic dimensions in its structure. According to Sachs (1993), sustainable development is guided by five dimensions: economic, social, spatial, cultural and ecological. Based on the dimensions presented by Sachs, the need to seek solutions in an integrated manner that contemplate the aspects of each dimension, leaving

aside the reductionist and one-sided view of traditional economics, is highlighted. Such an approach should encompass economic, social and ecological aspects of conservation and change. For Sousa (1994), sustainable development emerges from a new perspective regarding the development model and is based on ethical assumptions that demand two interrelated solidarities: synchronic solidarity (the current generation) and diachronic solidarity (future generations).

In this context, Mueller (2012) emphasizes the existence of interdependence and complementarity between the dimensions of sustainable development and that it will only actually materialize when there is a balance between these dimensions. The specific characteristics and realities of each location must also be considered in the promotion of sustainable development. Thus, sustainability indicators play an important role in consolidating and implementing the development process in a sustainable way, as they make it possible to outline the planning of actions to achieve the established goals.

The economic literature offers several approaches related to the evaluation of sustainable development concepts that demonstrate the “need to develop tools that seek to measure sustainability” (Bellen, 2006, p.41). There are many divergences regarding the adoption and conceptualization of indicators in the context of sustainability. According to Agenda 21 (1995, p. 98), “countries could develop systems for monitoring and evaluation of progress towards achieving sustainable development by adopting indicators that measure changes across economic, social and environmental dimensions”. According to the principles set out in Agenda 21, it is essential to apply a systemic and harmonious approach to the social, economic, institutional and

environmental dimensions as a viable means for the search for balance and social justice regarding environmental protection (Malheiros *et al.*, 2012).

Therefore, sustainability indicators are essential instruments to guide the action of public policies and subsidize the monitoring and evaluation of progress achieved towards sustainable development. They must be understood as a means to achieve sustainable development (IBGE, 2015). From this perspective, the present study employs, as an analytical instrument for empirical evaluation, the sustainability criterion proposed by Martins and Cândido (2008), of municipal scope, and which brings together six dimensions: social, demographic, economic, political-institutional, environmental and cultural. According to the approach advocated by Martins & Cândido (2008), the long time spent in obtaining data and the specificities required for the assessment of sustainability at the local level require innovative means of comparison between the evaluated dimensions. Additionally, the sustainability indicators delimit the need to build mechanisms that guarantee the reliability of data and the representativeness of the analyzed regional aspects.

The model developed by Martins & Cândido (2008) brings together 44 indices that offer a variety of information regarding municipalities. In this indicator, the reported importance of the inductive role of political-institutional and cultural variables stands out, which can often be minimized in assessments of systemic sustainability. Despite its indirect influence, the measurement of the degree of sustainability of a municipality must be based, ultimately, on political-institutional engagement and on the culture disseminated collectively in the locality. This is consistent with the idea that environmental

issues should not be excluded from a broader social discussion process, in which ecosystem resilience is considered as an opportunity in the fight against poverty (Vianna *et al.*, 2009; Abramovay, 2010).

As a consequence of these constitutive processes, Mato Grosso is faced with a scenario of accelerated expansion of agribusiness activities that are intensive in unfavorable impacts on the environment. In particular, the expansion of agricultural production, in regions with fragile agroecological systems, which characterizes a process that needs to be internalized in discussions about the state's economic growth. On the other hand, there is an urgent need to evaluate the growth dynamics of agribusiness in Mato Grosso, which has evidence of favorable effects on the living conditions of its population, in terms of reducing poverty, improving life indicators and expanding access to inclusive institutions and culture. This ambivalence spreads the clash between economic growth, especially in activities related to agribusiness, and the alignment of biophysical constraints on the support capacity of ecological systems.

3. Methodological procedures

3.1. Proposition of the sustainability indicator for soybean producing municipalities - ISMS

In order to develop a sustainability indicator for soybean producing municipalities, a careful assessment of the various existing indicators was carried out. Based on the analysis of its characteristics, the methodology created by Martins & Cândido (2008) – IDSM Municipal Sustainable Develop-

ment Index was used as the basis for the empirical research employed. The reason for choosing this methodology is that IDSM is based on two other already validated calculation and measurement techniques. However, in this case, applied to the municipal scope: IDS – Sustainable Development Index (IBGE); and the Evaluation of Rural Spaces (IICA).

The construction of the ISMS aims to create a sustainability assessment indicator for soybean pro-

ducing municipalities within the municipal scope, through the collection, treatment and analysis of specific sustainability indicators. The methodology of the Sustainability Indicator for Soybean Producing Municipalities (ISMS) was grouped into six dimensions, considering the specificities of soybean agricultural production and its effects on sustainability. Thus, a model based on the construction of 42 indicators was created, which are shown in Table 1.

TABLE 1–Variables, dimensions of sustainable development and source of data.

INDICATOR	SPECIFICATION/ SOURCE	BASE YEAR
Social Dimension		
Life expectancy at birth	Atlas of Human Development in Brazil	2010
Infant mortality	Atlas of Human Development in Brazil	2010
Education	Atlas of Human Development in Brazil	2010
Functional illiteracy	Atlas of Human Development in Brazil	2010
Housing adequacy	Atlas of Human Development in Brazil	2010
Mortality from neoplasms	Health Information Notebook - DATA SUS	2008
Demographic Dimension		
Population growth	Brazilian Institute of Geography and Statistics	2005 and 2015
Ratio of urban to rural population	Atlas of Human Development in Brazil	2010
Population density	Atlas of Human Development in Brazil	2010
Ratio between male and female population	Atlas of Human Development in Brazil	2010
Economic Dimension		
Per capita Gross Domestic Product	Brazilian Institute of Geography and Statistics - IBGE	2015
Industry's share of GDP	Brazilian Institute of Geography and Statistics - IBGE	2015
Share of agriculture and livestock in GDP	Brazilian Institute of Geography and Statistics - IBGE	2015
Trade balance	Department of Foreign Trade (SECEX)	2015
Soybean export in relation to the total exports of the municipality	Department of Foreign Trade (SECEX)	2015
Per capita income	Atlas of Human Development in Brazil – HDI	2010
Income from work	Atlas of Human Development in Brazil – HDI	2010
Gini index of income distribution	Atlas of Human Development in Brazil – HDI	2010
Political-Institutional Dimension		
Social assistance expenses	FINBRA – National Treasury Department	2010
Education expenses	FINBRA - National Treasury Department	2010

Culture expenses	FINBRA - National Treasury Department	2010
Urban planning expenses	FINBRA - National Treasury Department	2010
Environmental management expenses	FINBRA - National Treasury Department	2010
Sanitation expenses	FINBRA - National Treasury Department	2010
Health expenses	FINBRA - National Treasury Department	2010
Access to landline phone services	National Telecommunications Agency	2010
Electoral participation	Regional Electoral Court of Mato Grosso	2010
Number of municipal councils	Brazilian Institute of Geography and Statistics	2010
Intergovernmental transfers from the federal sphere of government	FINBRA - National Treasury Department	2010
Environmental Dimension		
Access to the water supply system	National Sanitation Information System (SNIS)	2015
Access to sewage or septic tank	National Sanitation Information System (SNIS)	2015
Access to urban and rural garbage collection	National Sanitation Information System (SNIS)	2015
Use of pesticides in liters per hectare of agriculture	Collective Health Institute - ISC-UFMT	2010
Deforested area in relation to the area of the municipality	General Coordination of Earth Observation – PODES INPE	2015
Environmental licensing rate for rural properties	Brazilian Institute of Geography and Statistics	2015
Existence of specific municipal legislation to address the environmental issue	Brazilian Institute of Geography and Statistics	2015
Cultural Dimension		
No. of libraries	Brazilian Institute of Geography and Statistics	2010
No. of museums	Brazilian Institute of Geography and Statistics	2010
No. of gyms and stadiums	Brazilian Institute of Geography and Statistics	2010
N° of movie theaters	Brazilian Institute of Geography and Statistics	2010
No of theaters or concert halls	Brazilian Institute of Geography and Statistics	2010
No. of cultural centers	Brazilian Institute of Geography and Statistics	2010

SOURCE: Adapted from Martins & Cândido (2008).

Individual variables have different units of measurement. Therefore, it is necessary that they be transformed into indices, according to their respective scales, for their estimation through factor analysis. Below are the equations that identify the behavior of the indices by their positive and negative relationships with sustainability:

With a positive reaction, we have:

$$I = \frac{x - m}{M - m} \quad 01$$

With a negative reaction, we have:

$$I = \frac{M - x}{M - m} \quad 02$$

The variables used to calculate the ISMS are represented as follows:

I = index calculated referring to each variable, for each analyzed municipality;

x = value of each variable in each municipality analyzed;

m = minimum value considered;

M = maximum value considered;

After completing the procedure for transforming the indicators into indices, so that they can be adjusted according to their respective dimensions, the methodology created by IICA – Inter-American Institute for Cooperation on Agriculture – is used, which adjusts the variables on a scale of variation between 0 (minimum value) and 1 (maximum value), dividing the sustainability level into quartiles. Thus, the type of relationship (positive or negative) of the variables regarding sustainable development is defined. The relationship of each variable is obtained by identifying its behavior, analyzing whether an increase in the indicator favors or disfavors the sustainable development process. So, the variable has a positive relationship when it is found that the higher the indicator, the better the index, and the lower the indicator, the worse the index. As for the negative relationship, the variable has a negative relationship when it is found that the higher the indicator, the worse the index and vice versa (Martins & Cândido, 2008).

The sustainability levels for each indicator are classified into critical, alert, acceptable and very

good level scales. The results are presented on a scale ranging between 0 and 1, classified as follows:

- 0.0000 and 0.2500 – reveal a critical level of sustainability;
- 0.2501 and 0.5000 – describe an alert level of sustainability;
- 0.5001 and 0.7500 – indicate an acceptable level of sustainability;
- 0.7501 and 1.0000 – present a very good level of sustainability.

After standardizing the indicators, the factor loadings of the variables chosen to compose the dimensions of the indicator were estimated. Thus, the next section presents the methodology of principal component analysis (PCA).

3.2. Principal component analysis

Principal component analysis is a data reduction technique that aims to reproduce the maximum original variance of the data, by reducing a large number of observed variables in a smaller number of linear combinations between these variables (Vieira & Ribas, 2011). As Sharma (1996) points out, the principal component analysis technique assumes that there are p variables. Then, p linear combinations can be formed, as shown below:

$$\xi_1 = w_{11}X_1 + w_{12}X_2 \cdots + w_{1p}X_p$$

$$\xi_2 = w_{21}X_1 + w_{22}X_2 \cdots + w_{2p}X_p$$

⋮

$$\xi_p = w_{p1}X_1 + w_{p2}X_2 \cdots + w_{pp}X_p$$

Where $\xi_1, \xi_2, \dots, \xi_p$ represent p principal components, and w_{ij} are the weights of the j -th variable for the i -th principal component; the weights estimated by w_{ij} observe the following assumptions:

i) The first principal component estimated by ξ_1 estimates the maximum data variance, while ξ_2 measures the maximum variance that was not computed by the first component, and so on;

$$\text{ii) } w_{i1}^2 + w_{i2}^2 + \dots + w_{ip}^2 = 1 \quad i = 1, \dots, p$$

iii) $w_{i1}w_{j1} + w_{i2}w_{j2} + \dots + w_{ip}w_{jp} = 0$ for every $i \neq j$

Thus, item (ii) assumes that the sum of the squared weights must be equal to 1, and the equation presented in item (iii) ensures the orthogonality of the new variables. For Azzoni & Latif (2000), the definition of the weights of each variable in the construction of the indicator is based on the coefficients w_{ij} and the percentage of the total variance explained by the principal component. In this case, considering two main components, we have:

$$IV_i = \frac{C_{i1}^2 \cdot P_1}{P_1 + P_2} + \frac{C_{i2}^2 \cdot P_2}{P_1 + P_2} \quad 03$$

Whereas, IV_i represents the weight of variable i in the sustainability indicator, C_i represents the coefficient of variable i in component j , and P_j is responsible for explaining the variance portion of component j . Thus, the calculation of the sustainability indicator for soybean producing municipalities will be carried out as follows:

ISMS = $\sum IV_i * V_i$. Where, V_i represents the index number of variable i .

3.3. Cluster analysis

According to Hair *et al.* (2009, p.430), *cluster analysis* is “a group of multivariate techniques whose main purpose is to aggregate objects based on their characteristics”. *Cluster grouping analysis* consists of a procedure that seeks to group data elements based on similarity or dissimilarity (distance) between them. The groups are determined in order to obtain homogeneity within the groups and heterogeneity between them (Everitt *et al.*, 2011).

As exposed by Härdle & Simar (2007), *cluster analysis* is a set of mechanisms to create groups (*clusters*) of multivariate data. The central proposition is the construction of groups with homogeneous properties in large heterogeneous samples. The groups or *clusters* should be as homogeneous as possible and the differences between the different groups as large as possible. According to the authors, *cluster analysis* can be divided into two main steps:

1. choice of a measure of proximity: and
2. choice of algorithm for creating groups.

When objects are grouped, proximity is usually indicated by some sort of distance. By contrast, variables are usually grouped based on correlation coefficients or as measures of association (Johnson & Wichern, 2014). In this study, the dissimilarity method that uses Euclidean distance as a measure was employed. Euclidean distance between two p -dimensional observations is given by:

$$d_{ik} = \sqrt{(X_{i1} - X_{k1})^2 + (X_{i2} - X_{k2})^2 + \dots + (X_{ip} - X_{kp})^2}$$

$$= \sqrt{(X_i - X_k)' + (X_i - X_k)} \quad 04$$

Thus, the model variables are represented by an X matrix (n x p), where X_{ij} represents the value of jth variable referring to the ith item, so that $i = 1, 2, \dots, n$ $j = 1, 2, \dots, p$. In the matrix, each row vector i represents a sampling unit, while each column vector j represents a variable.

Ward's hierarchical agglomerative clustering method was used in this study. Ward's method is used to identify clusters by maximizing homogeneity within clusters. Ward's hierarchical method is based on minimizing information loss on merging clusters. This method is usually implemented with loss of information due to the error sum of squares (ESS) criterion (Johnson & Wichern, 2014). Hair *et al.* (2009, p.429) define Ward's method as a

hierarchical procedure in which the similarity used to merge clusters is calculated as the sum of squares between the two clusters summed over all variables (...) results in clusters of approximately equal sizes due to its minimization of internal variation.

Mingoti (2007) explains two fundamental principles in Ward's method: each element is considered as a single conglomerate; at each step of the clustering algorithm, the sum of squares within each cluster is calculated. This sum is the square of the Euclidean distance of each sample element belonging to the cluster in relation to the corresponding vector of means of the cluster. According to Johnson & Wichern (2014), initially, a given cluster k ESS_k represents the sum of squared deviations of each cluster item from its mean. Later, if there are k clusters, ESS is defined as the sum of $ESS_k \forall k$ $ESS = ESS_1 + ESS_2 + \dots + ESS_k$. In each analysis step, the merge of each pair of possible clusters is considered. In summary, each cluster consists of a

single item and, if there are N items, $ESS_k = 0$, $k = 1, 2, \dots, N$, then $ESS = 0$. At the other extreme, when all clusters are combined in a single group of N items, the value of ESS is given by:

$$ESS = \sum_{j=1}^n (X_j - X)(X_j - X) \quad 05$$

In this model, X_i is the multivariate vector of measures associated with the jth item and X corresponds to the mean of all items. Thus, the values represented by the sum of squared deviations (ESS) are presented by the vertical axis of a dendrogram, based on the result obtained by Ward's method. In this study, SPSS software was used in cluster analysis.

3.4. Selection of municipalities

The first step for carrying out the empirical evaluation is the selection of the sample of evaluated municipalities. Soy is cultivated in the vast majority of municipalities in the state of Mato Grosso: of the 141 municipalities, 117 grow soy. However, it is necessary to systematize the evaluation of the effects of soy production on the municipalities that carry out this activity in order to identify a significant causal relationship. In view of the above, the choice of selected municipalities to compose the analysis and estimation of ISMS was based on the thirty highest sums of participations between:

(i) the municipal planted area to the total planted area in the state, and the

(ii) ratio of municipal soybean production to total state soybean production, in both cases with a relative share greater than 50%.

Table 2 presents the municipalities selected for analysis.

The selected municipalities are identified according through Table 2, based on their geographic location. The sample consists of thirty municipalities, 21 (70%) municipalities located in the northern mesoregion, 05 (17%) in the northeast mesoregion, 03 (10%) in the southeast mesoregion and 01 (3%) in the southwest mesoregion. The sample information is derived from data from the following databases: Municipal Agricultural Production (IBGE, 2016) and National Supply Company (CONAB, 2016) and Brazilian Institute of Geography and Statistics (IBGE, 2015).

4. Estimation of the sustainability indicator for soybean producing municipalities (ISMS) in Mato Grosso

The estimation of the principal components analysis allowed obtaining the weights of the mu-

nicipal sustainability indicators, from information organized in a broad and systemic perspective of several aspects that lead to the functioning and development of a given locality, based on the indicators that make up the different dimensions of sustainability.

For a better assessment of the sustainability of the thirty soybean producing municipalities that make up the evaluation sample defined for Mato Grosso, the results are presented by dimension, for a quantitative visualization of the contributions and weaknesses of each indicator in local sustainability. The results presented from Table 2 onwards are the standardized estimation results for each variable, according to the procedure presented in the methodological section, within a scale that considers the maximum weight of each indicator. The maximum values identify the weight assigned to each variable based on the principal component analysis estimation. Relative values represent the ratio of the mean of the variable and maximum weight. The weights of the social dimension variables represent 13.44% of the indicator's total weight. Table 3 shows the ISMS results for the social dimension.

TABLE 2 – Municipalities selected for analysis by Mesoregion.

North	Brasnorte/ Campo Novo do Parecis/ Campos de Júlio/ Diamantino/ Feliz Natal/ Gaúcha do Norte/ Ipiranga do Norte/ Lucas do Rio Verde/ Nova Maringá/ Nova Mutum/ Nova Ubiratã/ Paranatinga/ Porto dos Gaúchos/ Santa Rita do Trivelato/ São José do Rio Claro/ Sapezal/ Sinop/ Sorriso/ Tabaporã/ Tapurah/ Vera
Northeast	Água Boa/ Canarana/Querência/ Santo Antônio do Leste/ São Félix do Araguaia
Southeast	Campo Verde/ Itiquira/ Primavera do Leste
Southwest	São José dos Quatro Marcos

SOURCE: Elaborated by the authors.

TABLE 3 – ISMS for the Social Dimension.

Variables	Mean	Maximum	Relative Value
Life expectancy at birth	2.53	3.46	0.7318
Infant mortality	2.67	3.52	0.7567
Education	1.04	2.68	0.3870
Functional illiteracy	0.40	0.52	0.7746
Housing adequacy	0.39	2.92	0.1322
Mortality from neoplasms	0.24	0.34	0.7014
Mean by Dimension	1.21	2.24	0.5806
Total by Dimension	7.26	13.44	0.5404

SOURCE: Elaborated by the authors.

Based on the estimation of the ratio of total relative values and total maximum values of the social dimension, it was found that this dimension reached a sustainability classification of 0.5404, which indicates an acceptable level of sustainability. As for life expectancy at birth, the mean for this indicator for the population of Mato Grosso municipalities was 74.83 years, higher than the national average life expectancy, which is 73.94 years. The infant mortality indicator is related to the availability and access to health services, especially prenatal care. The average infant mortality rate in the municipalities of Mato Grosso was 15.66%, a result similar to the national average of 16.7%. The average mortality from neoplasms in the municipalities represented 11.8% of total deaths. Pignati (2007) noted that the increase in agricultural production in Mato Grosso was concomitant with the use of pesticides and that part of these pesticides are carcinogenic. The author also highlighted the work of Koifman *et al.* (2002) who showed an association between exposure to pesticides and the development of some types of

cancers in some Brazilian states, including Mato Grosso.

The population in the municipalities of Mato Grosso aged in average 25 years or older and with complete primary education was 43.02%, below the national average, which is 50.75%. The situation worsens when higher levels of education are considered. There was an average of 26.96% people aged 25 or over, with complete secondary education in Mato Grosso compared to the national average of 35.83; as for the population aged 25 or over, with higher education, the average was 7.65%, again below the national average, which was 11.27%. In the municipalities of Mato Grosso, the average expectation of years of education is approximately 8 years. Low schooling also reflects on the ability to understand political processes, leading to difficulty in strengthening institutional processes.

The housing adequacy indicator in households expresses the levels of quality of households following some criteria for housing adequacy. On average, 81.64% of households in soybean growing municipalities had adequate housing. Table 4 shows the results of the indicators for the demographic dimension.

TABLE 4 – ISMS for the Demographic Dimension.

Variables	Mean	Maximum	Relative value
Population growth	0.53	1.47	0.3613
Ratio of urban to rural population	1.11	2.56	0.4343
Demographic density	0.04	3.14	0.0139
Ratio of male to female population	0.60	0.78	0.7646
Mean by Dimension	0.57	1.99	0.3936
Total by Dimension	2.28	7.94	0.2873

SOURCE: Elaborated by the authors.

The weights of the demographic dimension variables express 7.94% of the indicator's total weight. The measurement of the ratio of relative values and maximum values of the demographic dimension indicated that sustainability is classified as at alert level, with a result of 0.2873. The results indicate that population growth in soybean growing municipalities between 2005 and 2015 was on average 47.24%, particularly in municipalities such as Ipiranga do Norte, Nova Mutum, Santo Antônio do Leste, Lucas do Rio Verde and Sapezal, which grew by 206, 47%, 116.66%, 112.06%, 110.42% and 90.05%, respectively (IBGE, 2015). Except for Santo Antônio do Leste, all other municipalities are located in the Northern region. Moreover, there was a significant increase in their populations, concomitantly with the consolidation of agricultural activity in this region, especially soybean production.

The ratio indicator between the urban and rural population indicates that the mean ratio for the soybean producing municipalities of Mato Grosso was 0.4334. Approximately 30% of the Mato Grosso population lives in rural areas and 70% in urban areas. This finding highlights the asymmetrical distribution between urban and rural populations, which implies the quality of urban infrastructure and the provision of basic services for the population. For Martins & Cândido (2008), the balance of population in urban and rural areas makes it possible to control the disorderly growth of the urban population. In rural areas, this balance contributes to the strengthening of activities related to agriculture and livestock, aiming at a better quality of life and control of environmental resources both in urban spaces and in rural areas.

The demographic density indicator is related to issues that are not only spatial, but also social, envi-

ronmental and economic, as inadequate population concentration in a given geographic space leads to higher levels of environmental degradation, poverty and unemployment (Martins & Cândido, 2008). Thus, in the municipalities of Mato Grosso, the average demographic density was 4,026 inhabitants per km². However, 80% of the municipalities analyzed are below this average, which characterizes a situation of disparity and heterogeneity in density and demography among the municipalities of Mato Grosso. The representation of male to female populations was more homogeneous in the municipalities analyzed. The female population represents 47.07% of the population, and the male population, 53.11% of the total population.

In short, the alert level reached by soybean growing municipalities reveals an unequal spatial distribution of the Mato Grosso population, showing a greater concentration of the population in the most productive geographic areas. Population growth also corroborates this result, as the differences between municipalities are very expressive. Table 5 presents the results for the economic dimension. It should be noted that the weights of the economic dimension variables correspond to 7.19% of the indicator's total weight, and that the measurement of the ratio of relative to maximum values – 0.5012 – indicates an acceptable level of sustainability.

According to the sustainability level classification proposed by this indicator, the economic dimension has an acceptable economic sustainability, very close to the lower limit. The per capita GDP indicates the average income level of the population. Thus, the average per capita GDP of the municipalities of Mato Grosso was BRL 56.81 thousand. However, when specific income data of the municipalities of Mato Grosso are analyzed, the

results are more pessimistic. The per capita income for residents of soybean producing municipalities of Mato Grosso was on average BRL 727.83 a month, below the minimum wage in effect at the time in Brazil, which was BRL 954.00.

The analysis of income indicators is essential for fighting poverty and reducing inequalities. From this perspective, the sample of municipalities of Mato Grosso shows that on average 5.41% of the population lives in extreme poverty, with a per capita income of BRL 23.81 per month, and 9.85% of the population lives in poverty, with a per capita income of BRL 70.80 per month, below the national average of BRL 75.19 per month. The indicator of earnings from work represents the percentage of income that comes from work, in relation to income from government transfers. On average, 87.71% of income in soybean producing municipalities came from work. This finding demonstrates the popula-

tion's ability to generate income and promote local economic activities, without relying predominantly on exogenous resources.

Mato Grosso's economy relies heavily on the agribusiness sector, especially in the production of soybean, and is characterized as a primary exporting state, being the largest exporter of soybean in Brazil. Thus, it is inferred that, on average, the share of industry in the gross domestic product of soybean growing municipalities was 9.65%, while the share of agriculture represented 40.17% in the composition of the municipal GDP. This result highlights the disparities regarding the diversification of economic activities in the municipalities of Mato Grosso. The institutionally built economic vocation of the state (agriculture) must be consolidated in a more diversified way, and a greater participation of sectors with lower prominence in Mato Grosso, such as industry, must be encouraged.

The balance of trade between soybean producing municipalities has significant differences. On average, the balance of trade of these municipalities was US\$ 229.94 million. Mato Grosso's exports are based on primary goods. Therefore, the soybean sector is the most prominent. It is estimated that among the soybean producing municipalities, soybean exports accounted for an average of 51.63% of the municipalities' exports. Table 6 shows the results of the indicators for the political-institutional dimension. It should be noted that the weights of the variables of the political-institutional dimension reflect 16.57% of the total weight of the indicator and that the estimation of the ratio of relative to maximum values exposes a critical level of sustainability, as its result was 0.2493.

TABLE 5 – ISMS for the Economic Dimension.

Variables	Mean	Maximum	Relative value
Per capita Gross Domestic Product	0.20	0.63	0.3236
Industry share in GDP	0.18	1.26	0.1406
Share of agriculture in GDP	0.36	0.74	0.4799
Trade balance	0.16	0.55	0.2997
Soybean export/total export of the municipality	0.31	0.60	0.5163
Per capita income	1.07	2.08	0.5119
Income from work	0.44	0.59	0.7416
Gini index of income distribution	0.46	0.76	0.6021
Mean by Dimension	0.39	0.90	0.4508
Total by Dimension	3.16	7.19	0.5012

SOURCE: Elaborated by the authors.

TABLE 6 – ISMS for the Political and Institutional Dimension.

Variables	Mean	Maximum	Relative value
Social assistance expenses	0.51	1.06	0.4788
Education expenses	0.47	1.03	0.4563
Culture expenses	0.12	0.74	0.1642
Urban planning expenses	0.22	0.57	0.3819
Environmental Management Expenses	0.02	0.60	0.0308
Sanitation expenses	0.09	0.97	0.0906
Health expenses	0.33	0.59	0.5497
Access to landline phone services	0.06	0.66	0.0940
Electoral participation	0.37	1.60	0.2333
Number of Municipal Councils	0.20	0.29	0.6944
Intergovernmental transfers from the federal sphere of government	8.10	8.46	0.9570
Mean by Dimension	0.95	1.51	0.3756
Total by Dimension	10.49	16.57	0.2493

SOURCE: Elaborated by the authors.

According to the results of the political-institutional dimension, the soybean producing municipalities of Mato Grosso achieved a critical level of sustainability in this dimension. Social assistance expenditures in the soybean producing municipalities of Mato Grosso averaged 3.96% of total budgetary expenditures. Spending on education accounts on average for 27.84% of expenses. However, it can be seen that expenditures are more oriented towards education, particularly elementary education (71.93%), to the detriment of public expenditures in other sectors.

Spending on urban planning in the municipalities of Mato Grosso accounts on average for

10.51% of total expenditure. Municipal budgetary expenses with sanitation represent only 2.02% of total expenses, which are divided into rural basic sanitation (3.76%), urban basic sanitation (86.52%) and other expenses related to sanitation (6.93%). This result shows a great disparity between expenditures in urban and rural areas, and therefore efforts are needed to improve sanitation, especially in rural areas. According to the health expenditure indicator in Mato Grosso, on average 24.59% of total expenditure is allocated to this sector, mainly primary care (54.74%), with the highest share. Access to health services is an essential condition for maintaining the quality of life of the population.

Municipal expenditure on culture and environmental management have similar results, with expenses on culture accounting for only 0.82% of total expenditure, and expenses on environmental management expressing 0.19% of total expenditure. Expenditure on culture is concentrated in the area of cultural diffusion (79.86%). This result is associated with the lack of physical structures and equipment for the dissemination of cultural activities. Expenses with environmental management are distributed in environmental preservation, environmental control, recovery of degraded areas, water resources and meteorology, but only environmental preservation and environmental control are part of municipal expenses, accounting on average for 73.88% and 66.27 % of expenses with environmental management. These values are relatively high. However, this is explained by the fact that municipalities often allocate all expenditures to only one item. It should be noted that 50% of the municipalities in Mato Grosso do not allocate resources to environmental preservation and 76.66% of the municipalities do not allocate resources to environmental control, that

is, expenses with environmental management are restricted to a small portion of the municipalities.

The number of municipal councils is relevant data because it informs about the level of participation and organization of municipalities, creating a collective decision-making system and reducing the influence of individuals. Therefore, it can be seen that the average number of councils in the soybean producing municipalities in Mato Grosso was approximately 6 councils per municipality. Intergovernmental transfers from the federal sphere of government were the indicator with the greatest weight among all dimensions (8.46%), and represented on average 32.55% of the budget revenues of Mato Grosso municipalities. This result explains the vulnerability and dependence on federal government revenues for the composition of budgetary revenues of the soybean producing municipalities of Mato Grosso. The concentration of budgetary resources in the federal sphere makes municipal management difficult, since the reduced or absent tax burden materializes in a context of incapable local governance. In this context, the Kandir Law has a significant impact on the reduced tax collection in the state of Mato Grosso, since the distribution of ICMS collection comprises a portion of the budgetary revenues of the state and municipal governments. Table 7 shows the results of the indicators related to the environmental dimension. The weights of the environmental dimension variables characterize 17.83% of the indicator's total weight.

It should be stressed that the environmental dimension reached a critical level of sustainability due to the result obtained by the estimation of the ratio between the relative and maximum values of this dimension, which was 0.2076. Indicators of basic and environmental sanitation are essential for

TABLE 7 – ISMS for the Environmental Dimension.

Variables	Mean	Maximum	Relative value
Access to water supply system	2.62	3.51	0.7472
Access to sewage or septic tank	0.34	1.91	0.1768
Access to urban or rural garbage collection	2.84	4.01	0.7099
Use of pesticides in liters per hectare of agriculture	6.62	6.80	0.9737
Deforested area in relation to the area of the municipality	0.64	0.89	0.7261
Environmental licensing rate for rural properties	0.08	0.21	0.3667
Existence of specific municipal legislation to address the environmental issue	0.34	0.52	0.6667
Mean by Dimension	1.93	2.55	0.6239
Total by Dimension	13.48	17.83	0.2076

SOURCE: Elaborated by the authors.

assessing the health and infrastructure conditions of the population residing in the municipalities of Mato Grosso. Thus, it was found that, on average, 70.61% of households have access to water supply, 76.84% of households have access to garbage collection, both in urban and rural areas, and 14.56% of residences have access to sewage or septic tanks.

The average use of pesticides in liters per hectare of agriculture was 14.19 liters. It should be noted that the municipality of São José dos Quatro Marcos uses 84.16 liters of pesticides per hectare of planted area. Belo *et al.* (2012) analyzed biological indicators of exposure to pesticides from soybean production in the municipality of Lucas do Rio Verde. The authors found the presence of glypho-

sate and pyrethroid residues among rural workers and the urban population. The authors stressed the presence of pesticide residues in rainwater, which increases the risk of contamination beyond the work area. This type of environmental contamination can reflect on several dimensions, including the incidence of neoplasms.

The indicator of the ratio of deforested area to the total area in the municipality explains that, on average, 25.73% of the areas of the soybean producing municipalities are deforested, and that soybean producing municipalities of the northern region had on average 28.44% of deforested area, more than the average of all municipalities analyzed. Soybean producing municipalities in the northeast region had 14.73% of deforested area, and soybean producing municipalities in the southeast region had on average only 1.99% of deforested area. The only municipality in the southwest region (São José dos Quatro Marcos) had 92.46% of deforested area to the municipal area, the worst result among the analyzed soybean municipalities.

Environmental management indicators are important for establishing actions and implementing environmental policies. On average, 63.33% of soybean producing municipalities did not carry out environmental licensing and 33.33% of municipalities did not have specific legislation to regulate environmental issues. This makes it difficult to implement institutional instruments necessary for environmental management. In addition, the municipal budget crisis compromises environmental management. Table 8 shows the results for the cultural dimension indicators. The weights of the cultural dimension variables make up 37.02% of the indicator's total weight.

TABLE 8 – ISMS for the Cultural Dimension.

Variables	Mean	Maximum	Relative value
No. of libraries	1.04	4.03	0.2583
No. of museums	0.21	7.87	0.0267
No. of gyms and stadiums	0.69	5.85	0.1178
No. of movie theaters	0.22	6.50	0.0333
No. of theaters or concert halls	0.16	8.42	0.0190
No. of cultural centers	0.34	4.35	0.0778
Mean by Dimension	0.44	6.17	0.0888
Total by Dimension	2.66	37.02	0.0144

SOURCE: Elaborated by the authors.

It is inferred that, among the analyzed dimensions, the cultural dimension was the one with the worst result, obtaining a critical level of sustainability based on the estimation of the ratio between of relative values to maximum values, indicating a cultural sustainability of 0.014. The average number of libraries among soybean producing municipalities was 1.33. On average, 0.13% of soybean producing municipalities have museums. The average number of gyms and stadiums was 1.76 gyms per municipality. It is estimated that 0.1% of the municipalities analyzed have a movie theater, 0.13% of the municipalities have theaters, and 0.23% of the soybean producing municipalities in Mato Grosso have cultural centers.

This result reflects the low investment in sectors such as education, sports and leisure and culture, as it implies a lack of libraries, museums, gymnasiums, movie theaters and cultural centers in the municipalities of Mato Grosso. Furthermore, the fact that these municipalities seldom promote artistic, social, recreational and leisure activities demonstrates the inability of local governance,

associated to a low municipal tax base. For Veiga (2010), culture establishes a fundamental relationship between relative income and absolute

human capabilities. Table 9 shows the results of the sustainability indicator for soybean producing municipalities in Mato Grosso.

TABLE 9 – Results of the Sustainability Indicator for Soybean Municipalities (ISMS) for selected municipalities in the state of Mato Grosso.

Municipalities	ISMS	Relative ISMS	Level of sustainability
Primavera do Leste	47.07	0.4707	Alert
Lucas do Rio Verde	45.72	0.4572	Alert
Sinop	44.53	0.4453	Alert
Sorriso	43.50	0.4350	Alert
Diamantino	43.10	0.4310	Alert
Sapezal	42.11	0.4211	Alert
Campo Verde	41.68	0.4168	Alert
Nova Mutum	41.63	0.4163	Alert
São Félix do Araguaia	41.09	0.4109	Alert
Santo Antônio do Leste	40.83	0.4083	Alert
Santa Rita do Trivelato	40.00	0.4000	Alert
Tapurah	39.84	0.3984	Alert
Campos de Júlio	39.75	0.3975	Alert
Água Boa	39.59	0.3959	Alert
Brasnorte	38.98	0.3898	Alert
Campo Novo do Parecis	38.72	0.3872	Alert
Itiquira	38.39	0.3839	Alert
Querência	38.20	0.3820	Alert
Nova Maringá	38.19	0.3819	Alert
Vera	37.86	0.3786	Alert
Paranatinga	37.58	0.3758	Alert
Porto dos Gaúchos	37.45	0.3745	Alert
Tabaporã	37.24	0.3724	Alert
Ipiranga do Norte	36.25	0.3625	Alert
Feliz Natal	36.01	0.3601	Alert
Canarana	35.56	0.3556	Alert
Gaúcha do Norte	35.43	0.3543	Alert
São José do Rio Claro	35.22	0.3522	Alert
São José dos Quatro Marcos	34.52	0.3452	Alert
Nova Ubiratã	33.88	0.3388	Alert

SOURCE: Elaborated by the authors.

As can be seen in Table 9, the ISMS result shows that all analyzed municipalities had a sustainability index at alert level. Although the economic and social dimensions have shown an acceptable level of sustainability, this result can be characterized as possibly temporary, as the acceptable performance of economic indicators is related to greater environmental degradation and loss of the stock of environmental resources. Of the municipalities with the highest rates in of ISMS – Primavera do Leste, Lucas do Rio Verde, Sinop, Sorriso, Diamantino, Sapezal, Campo Verde and Nova Mutum – all are among the ten largest soybean producing and exporting municipalities in Mato Grosso and have also larger areas destined to the production of soybean in the state. However, they also have the highest rates of deforestation. In the aforementioned municipalities, the average deforested area is greater than 1,500 km². The economic indicator biases the result upwards and demonstrates the lack of homogeneity between the dimensions.

The ISMS results contradict the traditional discourse of institutions that represent agribusiness in Mato Grosso that soybean is an activity that drives local development or, as emphasized in an Aprosoja document (2015, p. 10), “agribusiness brings development”. The evaluation results indicate that the claim is questionable. From the application of the proposed methodology, it is inferred that soybean production alone did not determine higher levels of development in the municipalities analyzed. Thus, it should be mentioned that local weaknesses are closely related to dependence on the transfer of federal and state budget resources, in a context of lack of investment capacity of the

municipal administrations, due to the limited generation of local-based budgetary resource collection. This result demonstrates that the much publicized overflow effect of economic growth on social and environmental dimensions does not happen automatically through the agro-export model.

The ISMS results highlight the need for convergence between local actors in the search for alternatives to the sustainable development process, through productive diversification and increased density of industrial activities and higher value-added services. Priority should also be given to resolving the problem of low local tax collection, as the issue of financing public management is essential for the effectiveness of municipal management. According to Santos (2012), the strong dependence on unilateral transfers at the municipal level stems from the limited contributory capacity of the population.

4.1. Cluster analysis

Based on the measurement of the Sustainability Index for Soybean Producing Municipalities (ISMS) for the municipalities of Mato Grosso, *cluster* analysis was used to identify the existence of homogeneous groups in terms of the municipalities' performances. The ISMS estimation considered indicators of the social, demographic, economic, political-institutional, environmental and cultural dimensions. The ISMS result showed that all municipalities are at a sustainability alert level. Figure 1 presents the dendrogram referring to the results estimated by the ISMS.

Dendrogram using Ward's Linkage

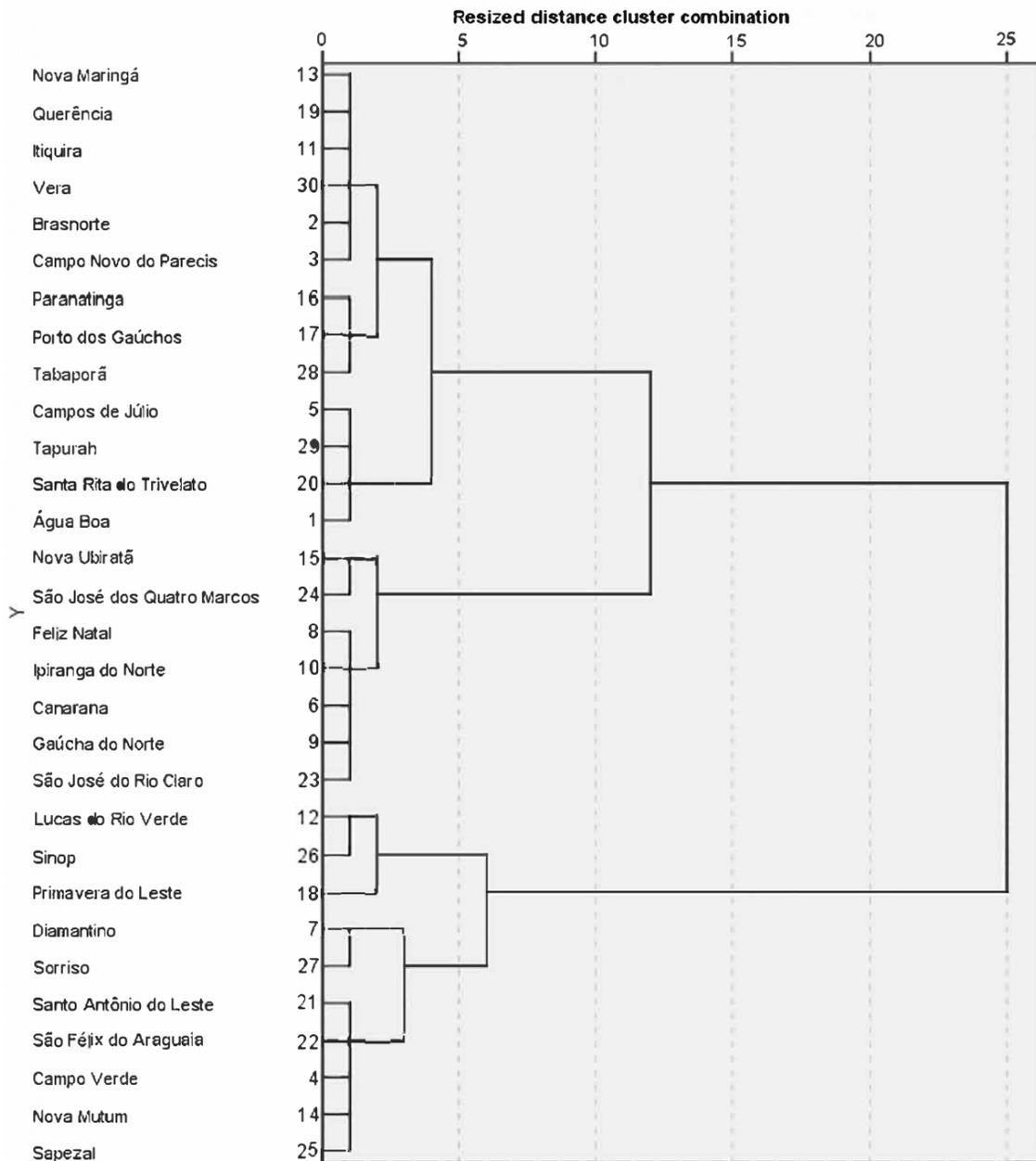


FIGURE 1 – Dendrogram with the representation of clusters.

SOURCE: Research findings, elaborated by the authors.

As can be seen in Figure 1, the soybean producing municipalities were grouped into three *clusters*. In the first *cluster* (from bottom to top) are the municipalities with the best results in terms of ISMS, which are Sapezal, Nova Mutum, Campo Verde, São Félix do Araguaia, Santo Antônio do Leste, Sorriso, Diamantino, Primavera do East, Sinop and Lucas do Rio Verde. In the second *cluster* are the municipalities with the worst results, namely São José do Rio Claro, Gaúcha do Norte, Canarana, Ipiranga do Norte, Feliz Natal, São José dos Quatro Marcos and Nova Ubitatã. The third *cluster* of the dendrogram includes the municipalities with average results in terms of the ISMS, as follows: Água Boa, Santa Rita do Trivelato, Tapurah, Campos de Júlio, Tabaporã, Porto dos Gaúchos, Paranatinga, Campo Novo do Parecis, Brasnorte, Vera, Itiquira, Querencia and Nova Maringá.

Among the municipalities grouped in the first *cluster* are the ten largest soybean producing and exporting municipalities in Mato Grosso. These municipalities are also among the largest municipalities with areas destined for soybean production in the state. However, they also have the highest rates of deforestation. The average deforested area in the municipalities of the first *cluster* is greater than 1,500 km². Except for the municipalities of São Félix do Araguaia and Sinop, which are part of the Amazon biome, all other municipalities belong to the Cerrado biome. It should also be mentioned that in São Félix do Araguaia the deforested area is approximately 4,507 km², and Sinop had 2,489 km² of deforested area (PRODES, 2015).

The results obtained by the municipalities in *cluster* one may be associated with the time when soybeans were included in their economic activities. Except for the municipalities of Sapezal and Santo

Antônio do Leste, in all other municipalities the expansion at the agricultural frontier of soybean occurred between the 1970s and 1980s. This was a period of significant expansion of the agricultural frontier, mainly in the southeast (Campo Verde, Itiquira, Primavera do Leste) and north (Diamantino, Lucas do Rio Verde, Nova Mutum, Paranatinga, Sorriso, Sinop, São José do Rio Claro) regions. of Mato Grosso (IBGE, 2016).

The municipalities concentrated in the second *cluster* belong to the Amazon biome, with the exception of São José do Rio Claro, which is part of the cerrado biome. The average deforested area of municipalities in the Amazon biome is 1,836 km². This result is much more significant in municipalities like Nova Ubitatã and Gaúcha do Norte that had 4,388 km² and 3,596 km² of deforested area, which corresponds to 34.57% and 21.28% of the total area of these municipalities. This lower performance in terms of the ISMS may be related to the expansion of the most recent agricultural frontier in some municipalities, starting in the 2000s. This lower performance in terms of the ISMS may be related to the expansion of the most recent agricultural frontier of some municipalities, starting in the 2000s. This can also be explained by the fact that these municipalities are located in areas of greater environmental impact, e.g. Gaúcha do Norte, Feliz Natal and Canarana, which are located around the Xingu Reserve, and Ipiranga do Norte, Nova Ubitatã and São José dos Quatro Marcos, located in areas of the Amazon biome (PRODES, 2015; IBGE, 2016).

The municipalities with medium ISMS indicators, which are grouped in the third *cluster*, are predominantly in the northern region of Mato Grosso, with the exception of Itiquira (southeast region),

Água Boa and Querência (northeast region), the latter being located in an area belonging to Xingu Park. The municipalities in the third *cluster* are located between the Amazon and Cerrado biomes. In the Cerrado municipalities, the average deforested area is approximately 800 km², with emphasis on Paranatinga, which had a deforestation area equivalent to 2,613 km². In the municipalities in the Amazon biome, this result is worse. The average deforested area in these municipalities was 3,197 km², with emphasis on Brasnorte, with 4,376 km² of deforested area, and Nova Maringá, with 3,198 km² of deforested area, a result above the average of the other municipalities in the third *cluster*. In short, in the three *clusters*, a greater extent of deforested area was observed in municipalities belonging to the Amazon biome (PRODES, 2015). Domingues *et al.* (2014) corroborate the previous analysis and explain that the cultivation of soybean in the northern region of Mato Grosso is directly associated with the deforestation of the Amazon Forest, through monoculture plantations controlled by transnational companies.

The results indicate that the expansion of soybean production has been taking place in areas with a high environmental impact, without the counterpart of raising the level of local development, so that soybean producing municipalities are exporting an environmental stock without replacement in the long term. As a result, environmental externalities must be considered as limits to the expansion of the agricultural frontier, since *cluster* analysis shows greater deforestation and environmental degradation in municipalities that have recently entered the process of expanding soybean production. Therefore, it is necessary to reassess the productive structure of soybean growing in the municipalities of Mato

Grosso, especially the reversal of public policies (in particular, those of an economic nature, such as tax and credit incentives) that encourage the process of agricultural expansion in the regions of the Amazonian ecosystems and the preservation of the remnants of the Cerrado that still exists. Furthermore, the results indicate the urgency of efforts aimed at productive diversification, not only in larger urban centers, but also in the leading municipalities in the production of agricultural commodities. The densification of industrial activities and the diversification of agricultural and livestock production, through the insertion of alternative productive activities, with greater added value, can be means of dynamizing and expanding the municipal endogenous growth.

5. Final considerations

Discussions on sustainable development and its measurement through indicators are essential for the consolidation of policies and actions that promote sustainability in a given geographic location. Thus, an attempt was made to measure the level of sustainability of the soybean producing municipalities in the state of Mato Grosso. The estimation of the Sustainability Indicator for Soybean Producing Municipalities (ISMS) allowed obtaining sustainability indicators organized in the social, demographic, economic, political-institutional, environmental and cultural dimensions. The final estimate of the ISMS indicated that all the soybean producing municipalities analyzed had a sustainability index at alert level. Although the economic and social dimensions have shown acceptable levels of sustainability, this result may be ephemeral, as the acceptable performance of economic indicators was

accompanied by greater degradation of the environment. It should be noted that the variables with the greatest weight for assessing the (un)sustainability of soybean growing municipalities concern the dependence on intergovernmental transfers from the Federal Government, lack of cultural infrastructure, basic sanitation and the use of pesticides in municipal crops. In short, the ISMS results contradict the discourse of representatives of Mato Grosso's corporate agribusiness that soybean would be the vector of local development, since soybean production did not determine higher levels of development in the municipalities analyzed, indicating that the overflow effect of economic growth on the social, environmental, cultural and institutional dimensions does not really happen. In addition, it is inferred from *cluster* analysis that the expansion of soybean production in Mato Grosso has been taking place in areas with high deforestation rates, without the counterpart of raising the level of local development. Thus, environmental restrictions play an important role, not only for preservation, by restricting the expansion of the agricultural frontier, but also for generating incentives for productive diversification and practices for productive intensification, since higher levels of deforestation were identified in municipalities with the worst evaluation results by the ISMS.

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