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INDICATORS OF SOCIO-ECONOMIC AND ENVIRONMENTAL SUSTAINABILITY OF AGRARIAN REFORM SETTLEMENTS IN MINAS GERAIS – BRAZIL

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ABSTRACT

Rural development, in the perspective of socio-environmental sustainability, aims to stimulate the processes of territorial planning through attributes, such as the natural environment, the economy and the social characteristics. From this perspective, this article aims to analyse the indicators of socio-economic and environmental sustainability of 1034 rural lots in settlements of agrarian reform by the federal government, in Minas Gerais State, Brazil. The methodology of the Sustainability Barometer is used, a tool that combines indicators of dimensions related to the welfare of the environment and human well-being. The results show that the environmental dimension is potentially sustainable, due to the low index of existing degraded areas. The socio-economic dimension presents itself as potentially unsustainable, considering the low schooling of the settlers and the need to complement the income outside the lot. The conception of sustainable development emphasizes the complementarity of the processes through which rural settlements pass through, where multiple dimensions should occur in synergy. However, the results show the main problems experienced by the researched population and enables, through analysis, the visualization of the main interactions between people and the ecosystem and can provide elements for the definition of priority actions and public policy development.

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INTRODUCTION

In Brazil, the National Policy of Agrarian Reform constitutes a public management instrument that seeks to carry out processes of land reorganization, through the creation of rural settlements destined for the population that does not have access to legitimate possession of land. The Agrarian Reform is foreseen in the Brazilian Constitution, which assigns to the Federal Government the competence for the expropriation of land that is not fulfilling its social function, understood as its use in a rational and appropriate way, preserving the environment and observing the legislations governing labour relations (BRASIL, 1988). This policy promotes a better distribution of land in the rural environment, since, in Brazil, there is a high rate of soil concentration. According to the 2017 Agricultural Census (BRASIL, 2017), 1.935.839 rural establishments of up to 10.000 ha were registered, occupying an area of 7.711.580 hectares and 2.400 rural establishments occupying an area of 51.823.420 hectares, representing 4 owners/ha and 21.593 owners/ha, respectively, evidencing the imbalance in the distribution condition of Brazilian lands. The National Institute for Colonization and Agrarian Reform (INCRA) is the federal agency responsible for the implementation of the National Agrarian Reform Policy (PNRA) which, through processes of dispossession of private rural properties or regularization of vacant land, creates the rural settlements, conceptualized by Bergamasco and Norder (1996, p. 7) as being "agricultural production units [...] aimed at the reordering of land use, for the benefit of landless rural workers or with little land [...], it also involves the availability of adequate conditions for land use and encouragement to social organization and community life". In Brazil, there are 9.444 rural settlements distributed in all the Federation Units, among these 414 settlements are located in the State of Minas Gerais (DATALUTA, 2017). Cleps et al. (2016) record that, in the aforementioned state, between the years 1985 and 2014.411 rural settlements were created, mostly located in the Northwest, North and Triângulo Mineiro/Alto Paranaíba Regions, with a total inappropriate area of about 1 million of hectares. The process of land decentralisation through the creation of rural settlements presents positive aspects in the social environment, regarding the fairest distribution of income and improvement of the quality of life of family farmers. In the natural environment, it can result in positive or negative impacts, hypothesis is corroborated by Ferreira Neto et al. (2009) that, when researching the economic development of rural settlements in the Northwest of Minas Gerais, stressed the need for analysis of the active impacts of the process of creating settlements incorporating environmental and socioeconomic variables.

Rural development, in the perspective of socio-environmental sustainability, has among its goals, stimulating the processes of territorial planning through attributes such as the natural environment, the economy and the social characteristics that relate and constitute what Sachs (1986; 1992; 1993; 2000) calls the dimensions of sustainable development. Several authors addressed the socio-economic and environmental impacts in rural settlements, such as Alves and Bastos (2010), Leite Júnior et al. (2013) and Silva, Ferreira and Sousa (2017). It is Important to highlight authors who used methodologies of analysis through sustainability indicators, such as Passos and Sousa (2005), Barreto, Khan and Lima (2005), Lima and Lopes (2012) and Souza et al. (2017), since the systems of indicators can be approached in different geographic scales and their effectiveness is measured through the ability to give positive responses in mitigating or resolving socio-environmental problems, subsiding the elaboration of public policies and territorial management. Thus, it is understood that the indicators are information that allows describing, classifying, ordering, comparing or quantifying in a systematic way, aspects of a reality in order to meet the needs of decision makers. The Sustainability Barometer (BS) is a methodology for assessing sustainability developed by the researcher Prescott-Allen (1997; 2001), with the endorsement of the *International Union for Conservation of Nature and Natural Resources (IUCN)* and the *International Development Research Center (IDRC).* It synthesizes mathematically quantitative and semi information that, through mathematical operations, results in numerical values compared to a standard scale defining the stage in which the socio-environmental sustainability of different geographic contexts (KRONEMBERGER *et al*., 2012).

Thus, this article aims to analyse the indicators of socio-environmental sustainability of rural settlements in the State of Minas Gerais, with the source of information the database of the Diagnostic Project for Environmental Regularization of the Agrarian Reform Settlements (RADIS/UFMT), developed by the Federal University of Mato Grosso (UFMT) and the National Institute of Colonization and Agrarian Reform (INCRA). The RADIS/UFMT Project is an important tool for verifying the social, economic and environmental situation of rural agrarian reform settlements in the state of Minas Gerais and has as prerogatives the environmental regularization of rural settlements Through the Rural Environmental Registry (CAR), the Diagnosis of Agrarian Systems and the elaboration of academic researches to subsidize the proposition and direction of public policies. It provides a range of relevant information that, systematic through appropriate methodology, results in indicators of socio-environmental sustainability. Subsidized by the described approaches, the first section of this article records and discusses the main concepts pertinent to the theme, following the description of the methodological trajectory crossed and, the third section, discusses the analysis of results with a view to proposing parameters for the improvement of sustainable development indicators of rural settlements in the state of Minas Gerais-Brazil.

Theorical Bases: Since its disclosure by Brundtland (1987), the concept of sustainable development has been widespread in the globalized world and it is applied to multiple themes involving policies, programs and social groups. Such terminology may suffer some variations according to the context in which it is inserted, however, the assumptions placed maintains a fundamental aspect: the idea that it is possible to occur socio-environmental development and the maintenance of natural elements in a single process and geographic context, meeting the needs of the generations of present time and future time. From this perspective of interpretation, Sachs (1986; 1992; 1993; 2000) analyses the contradictions between economic growth and environmental conservation, concluding that it is possible for society to achieve socio-environmental sustainability to the extent that develop integrated actions in six dimensions, namely: social, economic, ecological, spatial or territorial, cultural and political. For the author, in the political dimension of environmental sustainability, on a national scale, democracy, the guarantee of human rights and social cohesion is important. On the international scale, it emphasizes the guarantee of peace and cooperation, the need for precautionary principle in the management of natural elements, the prevention of negative global changes, the protection of biological and cultural diversity and the management of global heritage, as a common heritage of mankind. With regard to social sustainability, it recommends the establishment of a development proposal that ensures stable growth, with equitable distribution of income, guaranteeing access to education, health and social welfare policies to all social classes. This dimension is intrinsically related to the economic sustainability pertinent to the more effective and efficient management of public and private investments, with the financial autonomy of the countries. Among other aspects, the author records the need for balanced economic development, food security; the capacity for continuous modernization of the production instruments, the reasonable level of autonomy in scientific and technological research and the fair division of income obtained by economic activities. In relation to ecological sustainability, Sachs (1986; 1992; 1993; 2000) emphasizes the expansion of the capacity to use nature, with a lower level of impact on the environment and human groups. It proposes the development of clean technologies, the use of renewable energy sources and the practice of recycling among other environmental conservation actions. The spatial or territorial dimension is related to the distribution of urban and rural areas, with the need to balance between human settlements and economic activities in view of the destruction of fragile ecosystems due to the lack of control in the occupation processes. Cultural sustainability is approached by the author in the context of the modernization of the customs and traditions of the populations, as a result of the intense movement of globalization where, recommends respect for diversity and plurality. Rossetto (2004), subsidised by the assumptions of Sachs (2000), states that cultural sustainability does not mean the maintenance of aspects of the tradition and the way of life of the unaltered populations, and, yes, it means the permanence of the cultural aspects that resist innovations, admitting the emergence of cultural elements of modernity that appropriate and/or transform the knowledge and values built through the ages. Under the aegis of environmental ethics, Leff (1998) emphasizes that social groups have the right to choose to retain or not aspects of their culture and traditions and the right to direct their own destiny, participating in the management of natural resources that integrate the landscapes where they live. The analysis of the multiple dimensions of sustainable development refers to the conclusion that all aspects that lead to the welfare of the natural and social environment should be considered with the same degree of importance, resulting in the balance of the relations of human groups between themselves and these with nature. Thus, sustainable development only occurs through the multidimensional integration of several aspects considered pillars for the conservation of nature and society. The theoretical propositions on sustainable development have triggered a plurality of national and transnational public policies, influencing various sectors of the political and social systems, with special relevance to the primary sector represented by agriculture, considered on a global scale, as one of the main economic activities that generate income and impacts (positive and negative) in the natural environment. In this perspective, several deliberations have emerged about the role of environmental conservation in rural areas. Brandenburg (2017) emphasizes that the "greened" rural emerges in Brazil by the work of family farmers, neo-rural descent who return to the countryside via national policy of agrarian reform. It also mentions that the practices of preservation and conservation of nature are the result of everyday life, the world of small farmers' lives and development agents with this worldview. Thus, in the context of current societies, the market starts to incorporate in its logic an environmental rationality leading farmers, entrepreneurs, and even state agencies to invest in agriculture that opposes the use of pesticides and harmful practices to natural and social environment.

Without disregarding other important aspects of the process of sustainable development of rural areas, Caporal (2004), mentions a period of agro-ecological transition, which constitutes the transformation of the productivity model of conventional agriculture to a model where the management of natural resources is carried out from the perspective of environmental conservation, resulting in more balanced indices of sustainability, stability, productivity, equity and quality of life in the agricultural activity. The management of the processes of sustainable development of rural spaces requires diagnoses that reveal the multiplicity of aspects of agriculture and the economic and cultural practices of the different social groups, hence the need to generate Indicators that allow the knowledge of the positive and negative impacts and enable the reorganization of the public policies of development. In 2002, The United Nations (UN) Sustainable Development Commission (SDC) published a work called Indicators of Sustainable Development: Guidelines and Methodologies (DISANO, 2002), which proposes the analysis of 57 indicators organised in four dimensions: Environmental, Social, Economic and Institutional. The document points out as criteria for the selection of sustainability indicators, the need to be comprehensible, unequivocal, conceptually understood and, as far as possible, represents an international consensus, especially if they are to measure the stage of sustainable development of countries. It also stresses that indicators should be limited and sufficiently comprehensive to capture the multidimensional nature of sustainable development and that the use of many indicators results in difficulty in interpreting. Therefore, the choice should be judicious to elect central themes that clarify the proposed objectives. Some indicators may be positive in one aspect and negative in another resulting in potential conflicts. However, this fact should not be seen as a sign of ambiguity, on the contrary, these cases reinforce the need to interpret results in a balanced and integrated way. CSD indicators advise adapting suggested indicators to meet national needs and circumstances. Bellen (2004; 2007) analysed the methods and tools to create and apply sustainability indicators and concluded that the most used by specialists are the *Ecological Footprint Method (EFM)*, the *Dashboard of Sustainability (DS)* and the *Barometer of Sustainability (BS).* The *Ecological Footprint Method (EFM*) was proposed by Wackernagel & Rees in 1996, and its main foundation is the ecological dimension, that is, the environment must be used in function of its load capacity, accounting for the flow of matter and energy. Thus, in order to live within a sustainable model, society must ensure that natural goods are used at a speed that allows their regeneration. The *Dashboard of Sustainability (DS)* was led by the *Consultative Group on Sustainable Development Indicators (CGSDI)* and consists of a theoretical model to perform the aggregation of different indicators and indexes with four different scopes: ecological, social, economic and institutional, used in conducting analyses between different countries.

By analysing the method of Barometer of Sustainability (BS), Bellen (2004; 2007) highlights its importance as an evaluation tool that combines a series of indicators of varying dimensions, related to the welfare of the environment and human well-being. It also emphasizes its application from the local scale to the global, allowing comparisons between different locations. The systematic combination of several indicators reveals the situation of the site in relation to sustainable development, also allowing comparisons between socioeconomic and natural conditions. The methodology of *Barometer of Sustainability (BS)* has been used in Brazil to select and analyse the level of sustainability of multiple geographic contexts. Kronenberg et al. (2004) applied the methodology of the Sustainability Barometer in the Jurumirim River Basin in Angra dos Reis, Rio de Janeiro/Brazil with the objective of aggregating sustainable development indicators under the ecological and human optics. With regard to the tool, the authors emphasize its relevance to evaluate the stage of sustainable development on a local scale and also to direct the actions of public managers and local community. Silva (2014) used the Sustainability Barometer in 12 settlements resulting from agrarian reform in the State of Pará-Brazil and concluded that the aforementioned technique allowed analysing in a systemic view the situation of the settlements, allowing the comparison of two modalities. As an unfolding of the research published article selecting four themes (social, economic-productive, organizational and environmental), with 28 indicators (SILVA; VIEIRA, 2016). The research showed that the two categories of rural settlements presented as characteristic the precariousness of basic services, although the projects of differentiated settlements showed greater potential for economic sustainability and ecological. The adoption of sustainability indicators allows the elaboration of comparative studies, since they are applicable in multiple geographic contexts, constituting an effective methodology for measuring sustainability and the development of a sector productive.

METHODOLOGY

The methodology adopted for the development of this work is focused on the referential built by Prescott-Allen (1997; 2001) called Sustainability Barometer conceptualized by the author as "a tool to measure and communicate the welfare of a society and progress towards sustainability "(op. cit. p. 01). The territorial cut of the research consists of the settlements travelled by the team of data collection in the Project Radis/UFMT in Minas Gerais between 2017 and 2018, totalling 17 municipalities, 28 settlements and 1.034 rural lots, located in the following Geographic Mesoregions: Central Mineira, Jequitinhonha, Northwest of Minas Gerais, North of Minas and Triângulo Mineiro/Vale do Parnaíba (Table 1, Figure 1). Subsequently, subsidized by the Database of the Project RADIS-UFMT, we selected a set of information that contemplated the demographic, social, environmental, economic dimensions of the lots and families interviewed in rural settlements in order to selection of indicators. For each indicator, a Local Performance Scale (LPS) was established, according to the average of the values individually assigned to each of them by the specialists in collective analysis (Table 3). It is noteworthy that in the methodology of the Sustainability Barometer the scales of some indicators follow a direct logic, that is, the higher its value, the more sustainable the system, other indicators, however, follow the inverse logic, that is, the lower its value, more sustainable is the system, so some scales have the smallest value as maximum and the highest as minimum. Thus, the scale can be ascending or descending according to the relationship established between the indicator and the sustainability expressed by it. For example, the indicator "Number of residences with fossa and sinks" has a growing scale in relation to sustainability, that is, the greater the number of residences that meet this condition, the more sustainable the reality is studied, since it improves the sanitation and quality of life, reducing the incidence of diseases. For the indicator "Number of residences that remove water from a collective well; semi artesian well; artesian well", the situation is reversed, i.e., the greater the number of residences that access the water by this condition, the more negative is the impact provided, since the groundwater changes and its access is diminished by the remainder of the population, in addition to the potential risk of contamination in open wells. The Sustainability Barometer Scale (SBS), in turn, has the limits established according to Table 4. Then, the data from the RADIS/UFMT (2018) bank were searched for each indicator, which is called DLx. This numerical value DLx was transposed to the Sustainability Barometer Scale (SBS), as shown in Figures 3a and 3b, when the relationship between indicator and sustainability is increasing and decreasing, respectively.

Table 1. Settlements and Municipalities that compose the research sample

Mesoregions	Municipalities	Settlements	Lots numbers
Jequitinhonha	Jequitinhonha	PA Brejão	31
Northwest of Minas	Bonfinópolis de Minas	PA Assa Peixe	51
	Buritis	PA Gado Bravo	31
	Buritis	PA Nova Esperança	9
	Presidente Olegário	PA Santa Maria	41
	Buritis	PA Santa Mônica	22
	Presidente Olegário	PA Santo Antônio	159
	Bonfinópolis de Minas	PA Santo Antônio Lages	8
North of Minas	Juvenília	PA Grota do Escuro	85
	Joaima	PA Guanabara	25
	Pintópolis	PA Nova Nazareth	25
	Manga	PA Santa Lúcia	14
	Vargem Grande do Rio Pardo	PA Vale do Guará	16
Triângulo Mineiro	Ituiutaba	PA Chico Mendes	50
	Ituiutaba	PA Divisa	27
	Prata	PA Douradinho ll	1
	Ituiutaba	PA Engenho da Serra	1
	Ibiá	PA Morro Alto	40
	Ibiá	PA Myrian	15
	Campo Florido	PA Francisca Veras	35
	Campo Florido	PA Nova Santo Inácio/ Ranchinho	115
	União de Minas	PA Pontal do Arantes	97
	Santa Vitoria	PA Porto Feliz	1
	Ituiutaba	PA Renascer	2
	Ibiá	PA Santo Antônio II	50
	Patrocínio	PA São Pedro	41
	Ibiá	PA Treze de Maio	10
Central Mineira	Pompeu	PA Paulista	32
Total	17	28	1.034

In the second stage, the hierarchical structure proposed by Prescott-Allen (1997; 2001) was adapted, with a systemic approach, three dimensions of sustainability: environmental, economic and social, considering as system the 28 rural settlements researched, and as subsystems, the natural environment of 1.034 rural lots, with the respective characteristics of nature management (Figure 2). Thus, it constituted a set of seven themes (basic sanitation, sustainable management practices, land uses, income, social welfare, health and education) and seventeen indicators (Table 2), for which the sources/values and goals of references for the Construction of the Local Performance Scale (LPS), contemplating parameters of national, state and global references and obeying the criterion of flexibility and relevance for the reality to be analysed (KRONENBERGER et al., 2004, SILVA, 2014, SILVA; VIEIRA, 2016).

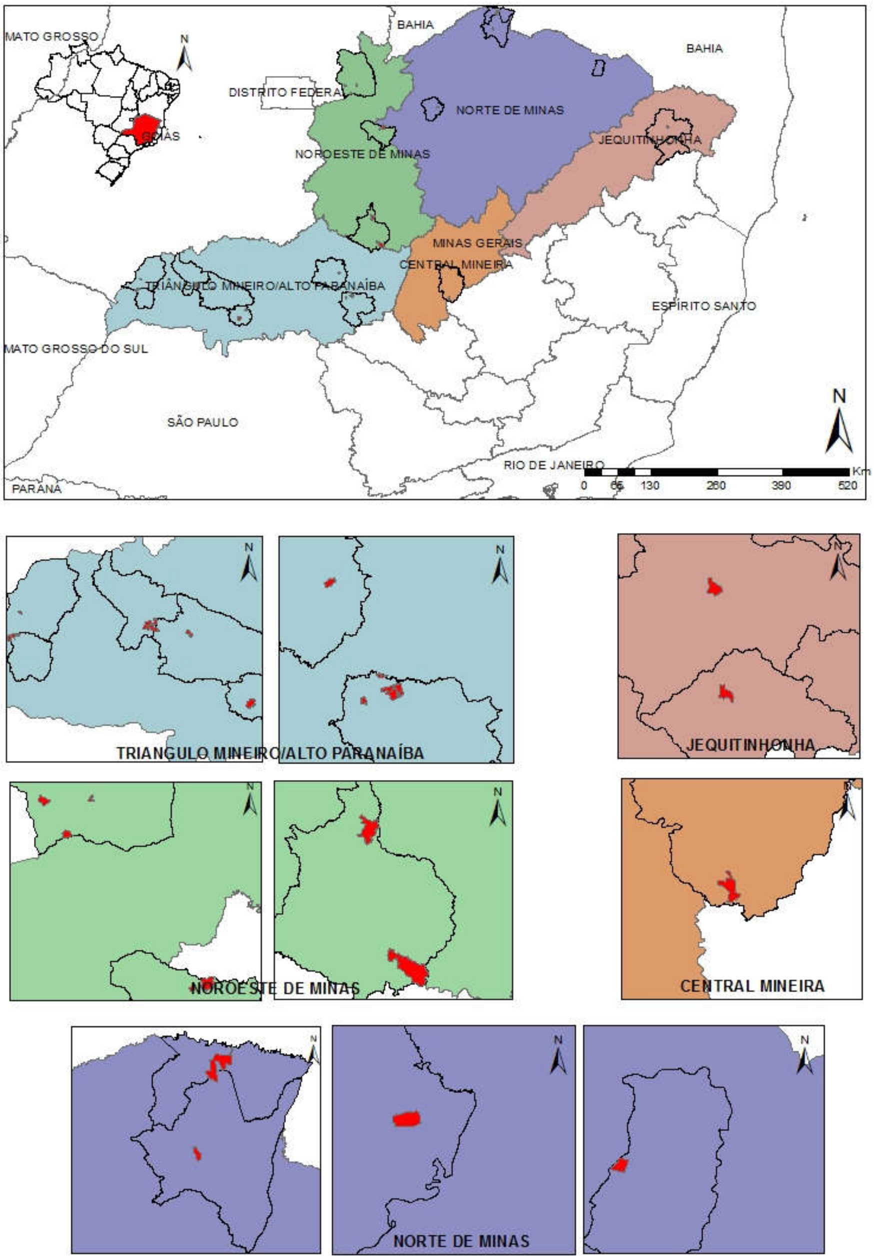
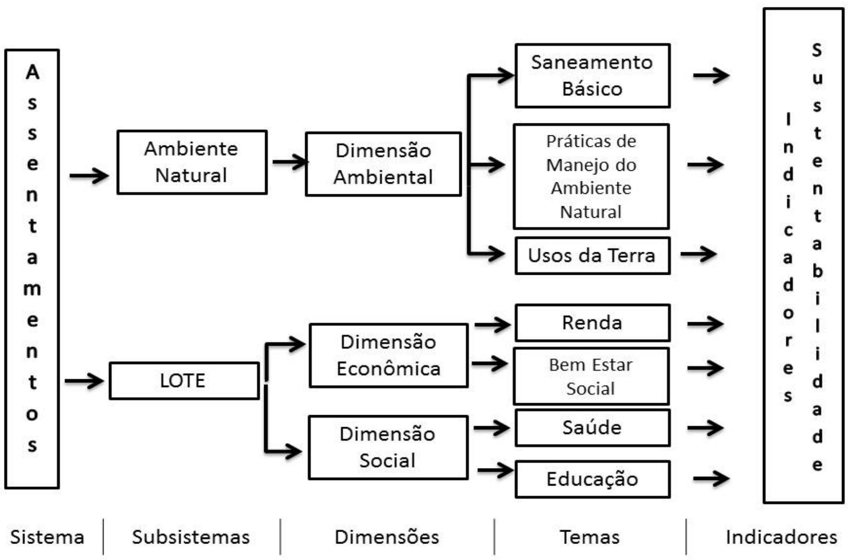


Figure 1. Location of settlements in the Mesoregions of the State of Minas Gerais



Source: Elaborated by the authors

Figure 2. Hierarchical Structure for the selection of sustainability indicators of rural settlements in the State of Minas Gerais *(Settlements; Natural Environment, Dimension Environment, Basic Sanitation, Natural Environment Management Practices, Land Uses; Lot, Economic Dimension, Social Dimension, Income, Social Welfare, Healthy, Education; Sustainability indicators)*

Table 2. Indicators of sustainable development for each indicator and respective sources of references for the construction of the performance scale

Indicators	References
Number of residences with fossa and/or sinks.	a) Federal Law No. 11.445, of January 5, 2007- Establishes the national guidelines for basic sanitation (BRAZIL, 2007); b) Decree No. 7.217, of June 21, 2010- Regulates Law No. 11.445 (BRAZIL, 2010): in its goal of the fundamental principle-universalization of access (100% of the population attended).
Number of residences with no sanitary sewage system	
Number of residences with septic tank or ecological treatment	
Number of residences that have access to water	-Diagnosis of Water and Sewage Services 2016 (BRAZIL, 2016): The sewage collection index of the state of Minas Gerais is 64.41% of the dwellings and total population of the state of Minas Gerais served with sanitary sewage is of 14.885.443 inhabitants; -Federal Law 9.433 of January 08, 1977- Establishes the National Policy on Water Resources (BRAZIL, 1977); -Law 13.199 of January 29, 1999 – Provides on the State Policy on Water Resources and gives other measures (MINAS GERAIS, 1999) in its fundamental Principle I – The water is a public domain asset; -National System of Information on Water Resources (SNIRH) (ANA, 2018): the total water service index in the state of Minas Gerais is 82.25% of the dwellings and total population attended with water supply is 17.031.732 inhabitants.
Number of residences that remove water directly from springs or rivers	
Number of residences that remove water from a collective well, semi artesian well or artesian well.	
Lots numbers that develop environmental conservation practices [1]	-Total area of forest or natural forests destined to permanent preservation or legal reserve (ha) in the rural area of the state of Minas Gerais (BRAZIL, 2017): 6.991.237, 00ha in 369.989 rural establishments; -Total area with agroforestry systems (ha) in the rural area of the state of Minas Gerais (BRAZIL, 2017): 1.039.799, 00ha in 41,651 rural establishments; -Number of rural establishments in the state of Minas Gerais that used organic fertilization up to 30/09/2017 (BRAZIL, 2017): 74.309 rural establishments.
Lots numbers that develop environmentally harmful practices [2]	-Number of rural establishments in the state of Minas Gerais that used pesticides (BRAZIL, 2017): 166.300 rural establishments.
Total degraded areas	-Total area of lots of settlements surveyed by RADIS/UFMT (2018): 30.623, 65ha; -Total area of the settlements surveyed by the RADIS/UFMT (2018): 51.585, 27ha. -Total Area of the state of Minas Gerais: 58.652.073, 00ha (BRAZIL,2017); -Total rural area of the State of Minas Gerais: 37.900.000, 00ha (BRAZIL, 2017).
Total native forest area	-Total area of native forest or natural forests in the rural area of the State of Minas Gerais (BRAZIL, 2017): 1.205.833, 00ha in 43.742 rural establishments.
Total forested area	-Total planted forests in the rural area of the State of Minas Gerais (BRAZIL, 2017): 1.922.255 ha in 41.280 rural establishments.
Number of farmers receiving total annual gross income up to R$ 20,000.00	- PMDI 2016 – 2027 (MINAS GERAIS, 2015).
Number of farmers acquiring income with economic activities outside the lot	- Atlas of Human Development of Brazil (PNUD, 2010)
Number of families benefiting from a government social programme	- PMDI 2016 – 2027 (MINAS GERAIS, 2015).
Number of families participating in associations or cooperatives	- Atlas of Human Development of Brazil (PNUD, 2010)
Number of respondents who have the complete fundamental level	-Total rural population by gender and age who know how to read and write (BRASIL, 2017-a). -Net schooling Rate of elementary school, according to planning region and RMBH – Minas Gerais – 2013 (MINAS GERAIS, 2013). -Percentage of people aged 18 years or older with complete fundamental in the State of Minas Gerais (PNUD, 2017): 26,5%
Number of families that have access to a health post	-Place where he sought medical or health care by region of planning and RMBH – Minas Gerais – 2013 (MINAS GERAIS, 2013); -Atlas of Human Development of Brazil (PNUD, 2010)

[1] Environmental conservation practices: protection and conservation of slopes; recovery of ciliary forests; reforestation for the protection of springs; stabilization of gullies; green fertilization; use of manure for fertilization, among others.

[2] Environmentally harmful practices: use of burnt; soil drainage, pesticide use, final destination of agrochemical packaging (does not return and uses for other purposes; burns; throws away).

Table 3. The Local Development Scale (DSL) of each indicator

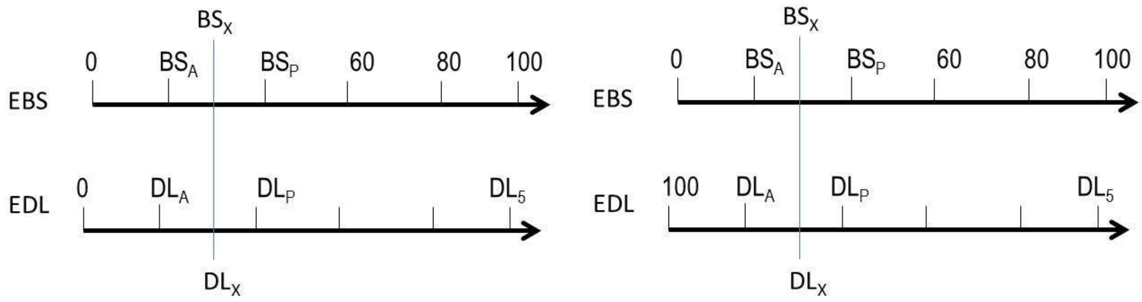
Indicators (DLx)	**Dark** Unsustainable	**Poor** Potential Unsustainable	**Middle** Intermediate	**Good** Potential Sustainable	**Great** Sustainable
Number of residences with sump/sinkhole (%)	0<DLx≤10	10<DLx≤35	35<DLx≤65	65<DLx≤85	85<DLx≤100
Number of residences with no sanitary sewage system (%)	100<DLx≤85	85<DLx≤65	65<DLx≤35	35<DLx≤10	10<DLx≤0
Number of residences with septic tank or ecological treatment (%)	0<DLx≤10	10<DLx≤35	35<DLx≤65	65<DLx≤85	85<DLx≤100
Number of residences that have access to water (%)	0<DLx≤5	5<DLx≤10	10<DLx≤40	40<DLx≤80	80<DLx≤100
Number of residences that remove water directly from springs or rivers (%)	100<DLx≤90	90<DLx≤60	60<DLx≤10	10<DLx≤5	5<DLx≤0
Number of residences that remove water from a collective well; Semi artesian well; Artesian well (%)	0<DLx≤5	5<DLx≤10	10<DLx≤40	40<DLx≤80	80<DLx≤100
Lots numbers that develop environmental conservation practices (%)	0<DLx≤20	20<DLx≤40	40<DLx≤60	60<DLx≤80	80<DLx≤100
Lots numbers that develop environmentally harmful practices (%)	100<DLx≤60	60<DLx≤30	30<DLx≤20	20<DLx≤10	10<DLx≤0
Total Degraded Areas (ha)	100<DLx≤50	50<DLx≤25	25<DLx≤20	20<DLx≤15	15<DLx≤0
Total Native Forest Area (ha)	0<DLx≤15	15<DLx≤25	25<DLx≤40	40<DLx≤65	65<DLx≤100
Total Forested Area (ha)	0<DLx≤15	15<DLx≤25	25<DLx≤40	40<DLx≤65	65<DLx≤100
Number of farmers receiving total annual gross income up to R $20,000.00 (%)	100<DLx≤80	80<DLx≤60	60<DLx≤40	40<DLx≤20	20<DLx≤0
Number of farmers acquiring income with economic activities outside the lot (%)	0<DLx≤50	50<DLx≤75	75<DLx≤80	80<DLx≤90	90<DLx≤100
Number of families receiving some kind of social program (%)	0<DLx≤25	25<DLx≤50	50<DLx≤75	75<DLx≤90	90<DLx≤100
Number of families participating in association/cooperatives (%)	0<DLx≤20	20<DLx≤40	40<DLx≤60	60<DLx≤80	80<DLx≤100
Number of respondents who have only the incomplete elementary level (%)	0<DLx≤20	20<DLx≤40	40<DLx≤60	60<DLx≤80	80<DLx≤100
Number of families that have access to a health post (%)	0<DLx≤20	20<DLx≤30	30<DLx≤50	60<DLx≤80	80<DLx≤100

Source: Elaborated by the authors

Table 4. Scale of the Sustainability Barometer (EBS), where "x" is the indicator studied

0<x≤20 Dark (Unsustainable)	20<x≤40 Poor (Potential Unsustainable)	40<x≤60 Middle (Intermediate)	60<x≤80 Good (Potential Sustainable)	80<x≤100 Great (Sustainable)

Source: Adapted from Prescott-Allen (1997; 2001)



a) b)

Source: Adapted from Prescott-Allen (1997; 2001)

Figure 3. Transposition of EDL for EBS from an indicator of increasing relationship with sustainability

Subsequently, the value of the indicator data was located in the EDL, as well as the anterior (DL_A) and posterior (DL_P) points. The five numerical values of the two scales (EDL and EBS) were aligned, determining the relative position of the ED_L in the EB_S scale.

The transposition was performed through the mathematical process called simple linear interpolation, with which a new set of data (BS_X) is constructed from a discrete set of previously known point data (DL_A, DL_P, BS_A and BS_P and DL_X), as demonstrated by Equations 1 to 5.

$$\frac{DL_A - DL_X}{BS_A - BS_X} = \frac{DL_A - DL_P}{BS_A - BS_P}$$ Equation 1

$$(DL_A - DL_X).(BS_A - BS_P) = (DL_A - DL_P).(BS_A - BS_X)$$ Equation 2

$$\frac{(DL_A - DL_X).(BS_A - BS_P)}{(DL_A - DL_P)} = (BS_A - BS_X)$$ Equation 3

$$-BS_X = \frac{(DL_A - DL_X).(BS_A - BS_P)}{(DL_A - DL_P)} - BS_A\ ,$$ Equation 4

multiplied by (-1)

$$BS_X = \left[\frac{(DL_A - DL_X).(BS_A - BS_P)}{(DL_A - DL_P)}.(-1)\right] + BS_A$$ Equation 5

On that:
DL_X: indicator value according to study data;
DL_A: value of the scale immediately preceding the DL_A;
DL_P: value of the scale immediately after DL_A;
BS_X: value corresponding to the transposition of DL_A to EBS;
BS_A: value of the scale immediately preceding the BS_X;
BS_P : value of the scale immediately after BS_X.

All BS_P were calculated, differentiated weights were attributed, according to the reality of the site, and in this study, all the indicators received equal weights. The $_{BSP}$ value of each indicator gives the name of Degrees.

The analysis of the Sustainability Indicators was carried out in an integrated manner and according to the Sources/Values and Reference Goals established for the Performance Scale. In view of the assumptions of the Sustainability Barometer (BS), the dimensions were divided into two components: the welfare Index of Societies that aggregates the social and economic dimensions and the Ecological Welfare Index, which aggregates the management of natural features (PRESCOTT-ALLEN, 1997; 2001). These indices were calculated using the arithmetic mean of the indicators that comprised them, obtaining indicators of the themes, dimensions and subsystems. Subsequently, a two-dimensional graph was generated that presents the local sustainability situation.

RESULTS AND DISCUSSION

The dimensions of sustainability in the rural settlements of Minas Gerais: The process of sustainable development requires the analysis of its multiple dimensions, moreover, it is appropriate to mention that an indicator should be analysed from all points of view, that is, the causes and consequences may be positive or negative in accordance with the perspective of the approach. Another factor to be emphasized in the analyses carried out is the impact of externalities, that is, due to the absence of specific quantitative data on family farming in Minas Gerais, we have taken as benchmarks that represent the situation of general theme. Table 5 shows the values assigned to each indicator (DL_X), according to RADIS/UFMT (2018). The indicators "Number of residences with sump/sinkhole", "Number of residences that do not have sanitary sewage system" and "Number of residences that have septic tank or perform ecological treatment" presented Degree of 60, 73 and 23 considered as Medium (intermediate), Good and Poor (potentially unsustainable), respectively. In Brazil, the basic sanitation is defined by Federal Law No. 11.445, of 5, January 2007, as the "set of services, infrastructures and operational facilities of drinking water supply [...] sanitation" (BRASIL, 2007). Although legislation has as a fundamental principle the universalization of access to basic sanitation services, the rural residences do not have public service of drinking water and sanitary sewage. Therefore, there is no protocol for the use of watershed water. On the other hand, the importance of adequate disposal of solid and liquid waste and the conservation of water quality is a fundamental factor for the promotion of human health, because when disposed in an inadequate way, they become conducive to the attraction of animals that constitute vectors of various diseases. Moreover, the availability of water resources has been a matter of growing concern among countries, given that it is experiencing the irregularity of natural water distribution and the scarcity of drinking water in the globalized world. For family farmers, access to water is a basic condition for family maintenance and productive activities, streams and springs are important references to the production system, to the extent that they influence the conduction of the domestic garden, in irrigation and animal husbandry.

The Scale of the Sustainability Barometer showed that, in the settlements surveyed, the number of residences that has access to water is located on the scale considered sustainable (Grade = 94). However, in relation to the withdrawal of water directly from the springs or rivers, it is located in an intermediate scale (Grade = 48) and the removal of water from wells is in the potentially sustainable scale (Degree = 62). The situation described is corroborated by Galizoni et al. (2008-a), which analyses the region of the Alto-Middle São Francisco, inserted in the Caatinga biome, in the Northern Region of the State of Minas Gerais, semi-arid region and target of irrigation projects, whose waters come from San Francisco River and its main tributaries.

Table 5. Values of local indicators (DL_X) and Grades of the Sustainability Barometer

Sub system	Dimensions	Topic	Indicators	(DL_X) Unit	(DL_X) (%)	Grade Dimension	Grade Subsystem	Grade System
Natural Environment	Environmental	Sanitation	Residences with cesspit/ sink	667	64,51	60	57	44
			Residences with no sanitary sewage system	188	18,18	73		
			Residences with septic tank or ecological treatment	142	13,73	23		
			Residences that have access to water	984	95,16	95		
			Residences that remove water directly from springs or rivers	320	30,95	52		
			Residences that remove water from a collective, semi-artesian or artesian well	433	41,88	61		
		Environmental management practices	Lots that develop environmental conservation practices	724	70,02	70		
			Lots that develop environmentally harmful practices (use of pesticides)	151	14,60	71		
		Land uses	Degraded area (gullies, impacted by camp (ha)	91,76	0,18	100		
			Native wood area (ha)	5.937	11,51	26		
			Wooed area (ha)	118,03	0,23	1		
Lot	Economic	Income	Farmers receiving total annual gross income up to R$20,000.00	553	53,48	47	30	
			Farmers who acquire income from economic activities outside the lot	631	61,03	24		
	Social	Social welfare	Families receiving some kind of governmental social program	131	12,67	10		
			Families participating in associations or cooperatives	480	46,42	46		
		Education	Respondents who have only the complete fundamental level	138	13,35	13		
		Health	Number of families that have access to a health post or hospital unit	405	39,17	40		

Source: RADIS/UFMT (2018)

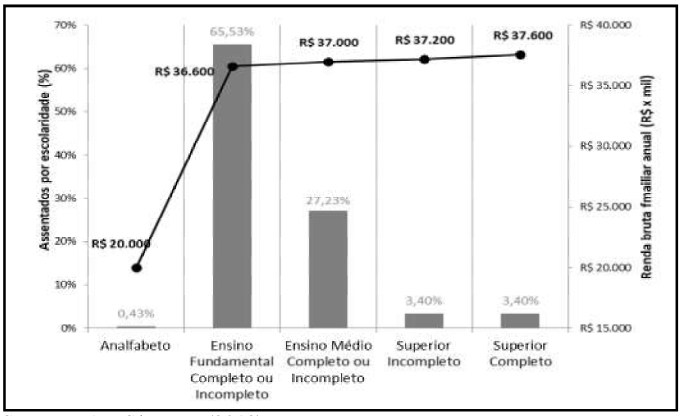
Ribeiro et al. (2000) affirm that in the rural communities of Alto Jequitinhonha the water source and the stream are important references for the organization of society and production systems. It highlights the importance of access to water for the income of family farming, since such access allows the creation of animals and the cultivation of vegetables that represent goods for commercialization, guaranteeing the domestic budget and food complementation. In the Jequitinhonha Valley, the springs are references to work organization, mainly the feminine, which performs domestic activities and seeks to save time to have access to water. As associated, the catchment systems are organized through water streams that come out of the higher shed than the house, supplying the kitchen and other domestic uses.

The research shows that the quantitative scarcity of water occurs partly, due to a lower natural availability of the resource, which has been accentuated because many sources have decreased or dried up; but also, because the available waters were concentrated by large farms that use them for livestock breeding and irrigation. In relation to the withdrawal of the collective well water, semi-artesian or artesian well, Galizoni et al. (2008-a) emphasizes that, in rural communities, the combination or change of techniques of capture and access to water, implies rearrangements in the regulation of waters, passing from community control for the control of the public power. Usually, the drilling of artesian wells occurs through the mobilization of families, by assignment through governmental programs or, even, by political sponsorship.

Such changes in the forms of water management imply an unequal distribution of this resource, due to the absence of community norms, constituting it as an object of conflict, which may result in concentration of use by people who have more income and power political. The analysis of Local Indicators allows the elaboration of a scenario that points to the need for mitigating measures, since the rivers are natural gatherers of the landscapes, reflecting the use and occupation of the soil of their respective watershed. The removal of water from rivers or directly from the springs is preceded by alterations in the ciliary forests and may result in silting and homogenization of the bed of the water bodies and a reduction in the diversity of the fauna and flora. In the surveyed settlements, it was recorded that the number of lots that develop environmental conservation practices such environmental conservation practices are in the potentially sustainable scale (Grade = 70). Among these practices are the protection and conservation of slopes, recovery of riparian forests, and reforestation for the protection of springs, stabilization of gullies, green fertilization, and use of manure for fertilization among other actions aimed at recovery of the quality of the natural environment. The number of lots that develop environmentally harmful practices, specifically, the use of pesticides, presented Grade = 70, also classified as Good or potentially sustainable. Thus, environmental management practices are impactful and will not be sustained over time, using the effects of this impact on the local population itself. Moreover, what is observed in the rural area of the State of Minas Gerais is a strong pressure of the productive economic system, composed of large and small properties, on the natural elements resulting in environmental degradation.

Thus, external factors contribute to the environmental degradation of rural settlements, as recorded by Galizoni (2008-b) who researched rural communities of Alto Jequitinhonha, Minas Gerais and concluded that the main externalities affecting the water supply and quality were the planting of eucalyptus by reforestation firms, which did not respect the springs, resulting in their disappearance and in siltation; The planting of large-scale coffee in the silting; the deforestation of native vegetation for coal and dams built for the irrigation of coffee plantations, as a consequence, several rural communities were left without access to water. Other externalities were pointed out by Teixeira; Camargo Martins Junior (2018) who sought to understand the levels of temporal progression of the degradation of the Cerrado Biome in an area located in the Upper Middle São Francisco, in the North of Minas Gerais, which stands out for its mineral, agricultural and forestry potentiality of eucalyptus, concluding that the disorderly use of soil and water coupled with the effects of drought deficit have left these inhospitable areas and the substitution of grazing activity by intensive agriculture contributes to the acceleration of erosive processes and environmental degradation. The Sustainability Barometer Scale revealed that in the surveyed settlements, the total of degraded areas is found in the range considered sustainable, with Degree = 100, and it is important to highlight here that, what was considered as a degraded area by the collection of data, are areas in which they have already operated mining, impacted by gullies or eroded. However, the preserved native wood (Grade = 29) and the total of forested areas (Degree = 1), are found in the scales Poor (potentially unsustainable) and Bad (unsustainable). Almeida et al. (2017) compared the use and occupation of soils between the years 2003 and 2014 and evaluated their chemical attributes in the rural settlements Paco Paco, Bom Sucesso and Poço da Vovó, located in the Northern region of the State of Minas Gerais, concluding that, in all settlements there was an increase in the exposed soil, the cultivation areas and, consequently, reduction of the natural vegetation. Moreover, the significant growth of the exposed soil areas is not directly proportional to the increase in cultivated areas, since most areas are abandoned, without use for agriculture. For family farming, the quality of life and the abundance of food depend on the type of relationship they develop with nature through the productive systems. Therefore, environmental sustainability is directly linked to economic and social sustainability. In the rural settlements surveyed, the Scale of the Sustainability Barometer considered as the basis of analysis in relation to income, the value of the monthly minimum wage in 2018 that was R$ 954.00. The results show that in the indicator "Number of farmers receiving total annual gross income up to R$ 20.000.00", the surveyed batches were located in the intermediate range (Degree = 47). The number of farmers who acquire income from activities outside the lot is expressive, 61% of them, generating a Poor condition (Potentially Unsustainable) of Grade = 24. The Scale of the Sustainability Barometer pointed out that the number of families receiving some governmental social program in the surveyed settlements is in the poor or unsustainable range (Degree = 10). Therefore, families do not depend on public welfare policies and the income obtained from the lot is not sufficient, and it is necessary to carry out work performed outside the lot, may signal to the weaknesses inherent to the National Program of Agrarian Reform (PNRA) that, even with credit policies and technical assistance, is unable to support the family farmer to withdraw the income from the land in quantity that meets his needs.

These characteristics have been observed in Brazil since the end of the years 80 of the XX Century, and were published in studies conducted by Silva (2001), demonstrating that agricultural occupations are the ones that generated the lowest income and the pluriactives families, in which their combine agricultural and non-agricultural activities to increase significantly. Moreover, many of the families ceased to guarantee their survival with income from work on the land, directly relying on income transfers in the context of social policies such as retirements and pensions. The promotion of income for families in the field allied to sustainable rural development was treated in China by Li, Deng and Zhou (2019), who discussed how to raise and maintain rural families above the poverty line, concluding that the path to this relates to the ability to utilize accessible resources, learn new knowledge, and exploit external resources, which in turn provides the livelihood resilience of rural households. Regarding the constitution of associations and cooperatives, the rural settlers surveyed are located in the Scale of the Barometer of Sustainability as medium sustainability (Degree = 46). The social organization of family farmers presents itself as an alternative for the insertion of agricultural production in the market collectively, mainly through the National School Feeding Program (PNAE) that establishes the purchase of foodstuff directly from family farming and its organizations, prioritizing traditional rural communities and agrarian reform settlements. To access this policy, family farmers need to be organized in associations or cooperatives and at least 55% of the volume of their production benefited, processed or marketed must necessarily carry out the economic activities of partners or cooperates. This reality has highly relevant international significance in terms of understanding power relations in rural contexts and identifying opportunities for community empowerment, since it was also verified by Mckee (2015), in research on a period of revision of the agrarian reform legislation in Scotland during which it indicates the need for greater empowerment of the community in order to guarantee successful looks that generate employment and income. Also Knickel et al (2018) point out that informal network can balance different interests and approaches, which is essential for integrated rural development strategies and projects. The number of respondents who have the complete fundamental level is classified as potentially unsustainable (Grade = 13), since 13% of respondents declared this condition. The number of families with access to health clinics is classified as medium (Grade = 41). It is concluded that in the surveyed settlements, there is an unmet demand and that the opportunities for schooling are insufficient mainly in the high and higher education levels. It as evidenced that income and schooling are directly proportional (Figure 5), which means that with the population of the settlers, schooling is a means of improving quality of life.

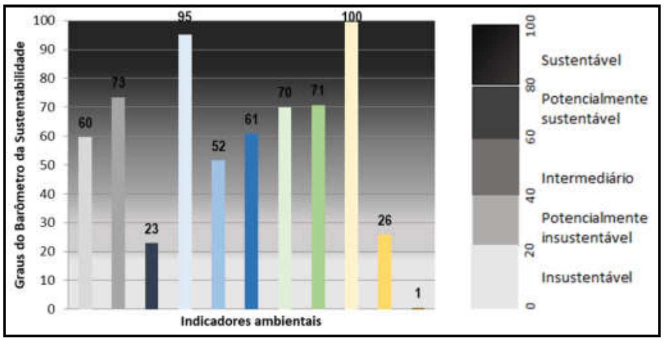


Source: RADIS/UFMT (2018)

Figure 5. Schooling and annual gross family income (*Settled on schooling; Illiterate; Finished or Incomplete Basic Education; Finished or Incomplete High School; Incomplete Higher Education; Finished Higher Education; Annual family income)*

The methodology of the Sustainability Barometer applied to the indicators of the State of Minas Gerais – Geographic Mesoregions of Triangulo Mineiro/Alto Paranaíba; Northwest of Minas Gerais; North of Minas and Jequitinhonha point out that the 28 settlements and 1.034 rural plots are in the intermediate sustainability scale in terms of the environmental dimension (Grade = 57), as shown in Figure 6.

In this aspect, we highlight the existence of conservation practices of cultivation on the part of the settlers, the most frequently being Plowing and grading for soil preparation (28%), Fallow or rest of soils (11%), Renovation of pastures (10%), Use of manure and compost for soil organic fertilization (9%), Planting level (6%), Use of crops for renovation/renewal/recovery of pastures (5%), among others, such as use of terraces, organic fertilization, protection and conservation of slopes, use of Plant compound for soil organic fertilization, green fertilization (use of plants for soil organic fertilization), application of inoculants, reforestation for protection of springs, stabilization of gullies and recovery of ciliary forests (Figure 7).



Number residences with cesspit/ sink (%)
Number residences with no sanitary sewage system (%)
Number residences with septic tank or ecological treatment (%)
Number residences that have access to water (%)
Number residences that remove water directly from springs or rivers (%)
Number residences that remove water from a collective, semi-artesian or artesian well (%)
Numbers lots that develop environmental conservation practices (%)
Numbers lots that develop environmentally harmful practices (use of pesticides) (%)
Total Degraded Area (expressed in hectares)
Total Native Wood Area (expressed in hectares)
Total Wooed Area (expressed in hectares)

Figure 6. Sustainability Barometer for environmental indicators (Degree of Sustainability Barometer; Environmental Indicators; Sustainable; Potentially Sustainable; Intermediate; Potentially Unsustainable; Unsustainable)

From the universe of settlers interviewed, 11% reported making use of pesticides in isolation or associated with conservationist practices, which positively impacts the environmental dimension. In the socioeconomic dimension, the results show that it presents itself as potentially unsustainable (Degree = 35), as well as the social dimension (Degree = 30) (Figure 8). This result corroborates with Knickel et al. (2018), who in 14 countries demonstrated that there is an observable decrease in socio-ecological resilience in farms and rural communities in recent decades.

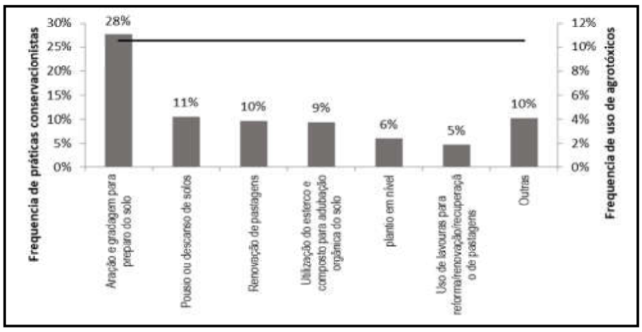
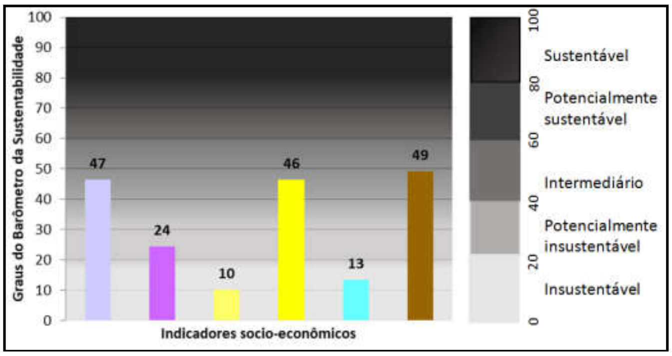


Figure 7. Frequency of occurrence of conservationist practices and use of pesticides (Frequency of Conservationist Practices; Aeration and grading for soil preparation; Fallow or soil rest; Renewal of pastures; Use of manure and compost for soil organic fertilization; Planting level; Use of crops for renovation, renewal and recovery of pastures; Others; Frequency of pesticide uses)

Thus, the relationship between the dimensions of the natural environment (Degree = 57) and the socioeconomic environment of the lot (Degree = 30) can be expressed resulting in an unsustainable condition of the studied settlements (Figure 9). Considering the settlements, the system results in Degree = 44, considered as Intermediate according to the methodology adopted. It is emphasized, as well as Janker, Mann and Rist (2019) that the evaluation methods used may not adapt to the conditions of the researched sites, because they do not consider the particularity of cultural and institutional values. Defining what is or is not sustainable, or what needs exist, how they are prioritized, and whether they are not met, adds a subjective component that needs to be captured.



Number of farmers receiving total annual gross income up to R $20,000.00 (%)
Number of farmers acquiring income with economic activities outside the lot (%)
Number of families receiving some kind of governmental social program (%)
Number of families participating in association/cooperatives (%)
Number of respondents who have only the incomplete basic education (%)
Number of families that have access to a health post (%)

Figure 8. Sustainability Barometer for socio-economic indicators *(Sustainability Barometer Grades; Socio-economic indicators; Sustainable; Potentially Sustainable; Intermediate; Potentially Unsustainable; Unsustainable).*

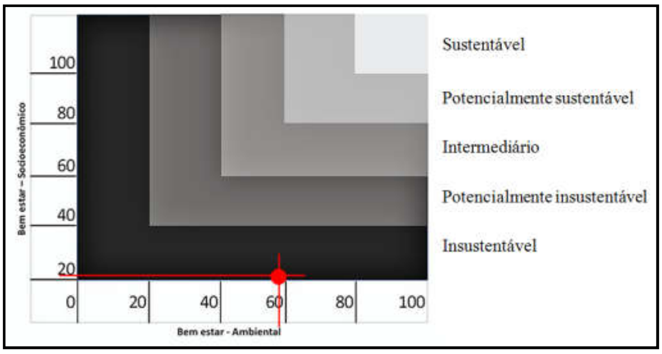


Figure 9. Sustainability Barometer for subsystems (Social Welfare; Environment Welfare; Sustainable; Potentially Sustainable; Intermediate; Potentially Unsustainable; Unsustainable)

The conception of sustainable development emphasizes the complementarity of the processes through which rural settlements pass through, where multiple dimensions should occur in synergy. However, the results of the Barometer show the main problems experienced by the researched population and enables, through analysis, the visualization of the main interactions between people and the ecosystem and can provide elements for Definition of priority actions and elaboration of public policies.

Conclusion

The results of the research allow concluding, primarily, the need for advances in the social context in the settlements, which can provide better quality of life to the settlers, guaranteeing the livelihood of cultivation and management in the lot.

This need was well portrayed when it relates the income obtained in the lots and the schooling of its farmers, evidencing that access to education drives economic development. Another look is due to the need to promote access to public health, but concomitantly with actions that promote the implementation of sanitary sewage systems, since lots that do not have sewage is implemented is high, contributing to a the promotion cycle of vectors that cause disease.

The incentive to conservationist practices is also necessary, through technical advice and training of the settlers, incorporating notions of preservation and environmental conservation, which allows the increase of production, with low environmental impact.

It is understood that in order for the process of land decentralization to be made viable through settlements, the National Policy of Agrarian Reform must manage the access to water, promoting it throughout the year, since this factor limits production and income generated by lots.

The strengthening of cooperatives and associations should be encouraged, through collective actions that can be replicated in several plots and settlements, to effectively promote the increase in income and schooling of the settlers.

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