Environmental impacts and infrastructure in Agrarian Reform settlements in Minas Gerais, Brazil

Impactos ambientais e infraestrutura de assentamentos da Reforma Agrária em Minas Gerais, Brasil

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ABSTRACT

The existence of adequate infrastructure aims to meet the basic human needs, contributing to local development, poverty reduction and social inequalities. The aim of this article is to analyze the potential environmental impacts arising from infrastructure conditions in agrarian reform settlements in the State of Minas Gerais - Brazil. The methodology is based on the Leopold Matrix, which considers the environmental components: water pollution, soil degradation, land use and quality of life, in a sample of 1,270 lots. The variables analyzed were: water supply; sanitation; disposal of wastewater, dry waste, pesticide packaging and veterinary medicinal products; distribution of electricity and paving of public roads. The results indicate that the impacts are of greater negative potential in the Northern Mesoregion of Minas Gerais (70%), followed by Triângulo Mineiro/Alto Paranaíba (60%), proving the hypothesis that the incipience in infrastructure conditions results in a greater negative environmental impact.

Keywords: Rural settlements. Environmental Impact. Leopold Matrix. Sustainable development.

RESUMO

A existência de infraestrutura adequada visa atender às necessidades humanas básicas, contribuindo com desenvolvimento local, redução da pobreza e desigualdades sociais. O objetivo deste artigo é analisar os potenciais impactos ambientais decorrentes das condições de infraestrutura em assentamentos da reforma agrária, no estado de Minas Gerais, Brasil. A metodologia apoia-se na Matriz de Leopold, que considera as componentes ambientais: poluição da água, degradação do solo, uso do solo e qualidade de vida, em uma amostra de 1.270 lotes. As variáveis analisadas foram: abastecimento d'água; esgotamento sanitário; destino das águas servidas, do lixo seco, das embalagens de agrotóxicos e dos medicamentos veterinários; distribuição de energia elétrica e pavimentação das vias públicas. Os resultados apontam que os impactos são de maior potencial negativo na Mesorregião Norte de Minas (70%), seguido pelo Triângulo Mineiro/Alto Paranaíba (60%), comprovando-se a hipótese de que a incipiência nas condições de infraestrutura resulta em maior impacto ambiental negativo.

Palavras-chave: Assentamentos rurais. Avaliação de Impacto Ambiental. Matriz de Leopold. Desenvolvimento sustentável.

1 INTRODUCTION

The guidelines of the II National Program for Agrarian Reform (*PNRA*) establish that agrarian reform is part of a national development project, labor generator and food producer. Agrarian reform is implemented by the actions of the National Institute of Colonization and Agrarian Reform (*INCRA*), promoting gender equality, the right to education, culture and social security in reformed areas, as well as sustainable development (BRAZIL, 2003).

In the case of federal settlements of agrarian reform, *INCRA* is responsible for providing the necessary infrastructure. According to Choguill (1996) the infrastructure should mainly cover water supply, proper disposal of effluents and solid waste, access to electricity and roads. The existence of adequate infrastructure aims to meet basic human needs, contribute to the local development process, reduce poverty and social inequalities (INSTITUTO NACIONAL DE COLONIZAÇÃO E REFORMA AGRÁRIA, 2020). It results in quality of life and relates to the process of socio-spatial formation of the settlements.

Therefore, the infrastructure deficiency in the settlements is directly related to the possibilities of development and the quality of life of families (INSTITUTO DE PESQUISA ECONÔMICA APLICADA, 2010). When infrastructure is not made available, a relationship of state dependence and precariousness can be established in more poor regions. On the other hand, the provision of adequate infrastructure can drive development, not only of the settlement, but of the entire region (LEITE et al., 2004).

The relations between infrastructure and development and, more specifically, the process of adapting the infrastructure to favor the development of settlements, involves the understanding of specificities and the process of socio-spatial formation of the settlements (INSTITUTO DE PESQUISA ECONÔMICA APLICADA, 2010).

In this sense, Bruno and Medeiros (2001) affirm that problems related to infrastructure contribute to the evasion of the settlers. This occurs when the state does not perform functions or the infrastructure is implemented differently from the will or need of settled families, especially with regard to the availability of water, electricity, housing, transportation and teaching services.

Ribeiro et al. (2011) when studying the *Barranco do Mundo* Settlement Project, in Tocantins state (Brazil), point out that 33.3% of the causes of evasion occurred and 85% of the improvements pointed out as necessary are related to infrastructure problems.

Medeiros (2010) records that several studies point to the precariousness of the settlements in relation to infrastructure and draw attention to the configuration of rural "favelas"[1] that help the settlers abandon their plots. On the other hand, Heredia et al. (2005) record that the infrastructure of the agrarian reform settlements is quite precarious, but even so, there is an improvement in income and living conditions, with the prospect of greater long-term economic stability, in clear contrast to the poverty and social exclusion that families suffered before being integrated into settlement projects.

Due to the environmental bias, the implementation of agrarian reform policies results in the area cutout in lots, which consolidate rural settlements in the country. Without disregarding the intentionality of this fact with regard to land deconcentration and improvement of the quality of life of family farmers, this article raises the hypothesis that the absence or precariousness of infrastructure conditions in the settlements may result in negative environmental impacts.

Environmental impact is defined as a change in the physical, chemical and biological properties of the environment, resulting from human activities and affecting the health, safety and well-being of the population; social and economic activities; the biota; the aesthetic and sanitary conditions of the environment and the quality of environmental resources (BRASIL, 1986).

Environmental Impact Assessments (*AIA*), according to Pimentel and Pires (1992), are studies to identify, predict, interpret and prevent the environmental effects that certain activities can cause to health, human well-being and the environment. Several authors have studied environmental impacts on land reform settlements.

Leal (2003) focuses his studies on social and environmental impacts, analyzing the dimensions of access to health, education, housing, public policies, among others. Van de Steeg et al. (2006) studied the environmental impacts of Brazilian land reform from 1985 to 2001, in 4,340 settlements, with 458,000 families. The Environmental Quality Index (EQ) was used, focusing on the degradation of areas resulting from exploration activities. The results showed low environmental quality for the North and Northeast, intermediate values for the Midwest and Southeast and high environmental quality for the South.

Araújo (2007), in turn, addresses sustainability in local development and states that the poor condition of roads makes it difficult to flow production and increases the isolation of communities from settlements in relation to urban ones.

Morais et al. (2012) evaluated the environmental impact on seven properties of two rural settlements in the state of Mato Grosso. They used the *APOIA - Novo Rural* System, which expresses the Environmental Impact Index (*IIA*) based on 62 indicators, on a scale between zero (worst situation) and one (better situation). The reference value 0.70 was adopted to indicate that the productive activity developed in the

1 | Brazilian shantytowns.

property does not generate negative changes in the local environment. The *IIA* demonstrated that there is no commitment of environmental quality on the part of the activities developed in the studied settlements and that agricultural practices are compatible with the environmentally sustainable development standard.

Leite, Sobral and Barreto (2011), in Espírito Santo state (Brazil), evaluated the environmental impacts through the Leopold Matrix, adapting it to classify social impacts as well. The activities considered were: burning of solid waste, burning for the cleaning of the land, generation of effluents, hunting of birds with sling by children and young people, water supply system and water scarcity for irrigation. The authors conclude that the minimization of environmental and social impacts involves the mobilization of the community, which culminates in the improvement of the quality of life of families and stimulates the fixation of those settled in the field.

This same methodology was used by Martins (2014), with satisfactory results, to evaluate the environmental impacts of the *Grotão* Stream basin, in Ceilândia city (Brazil), covering urban and rural areas, in the construction and operation phases of the projects on its banks.

Brandão and Souza (2006), Farias et al. (2018) and Schneider and Peres (2015) return the focus to deforestation in land reform settlements in Amazon, but without relating it to existing infrastructure.

In view of the above, this article aims to analyze the potential environmental impacts arising from the infrastructure conditions of the agrarian reform settlements in the Northern Mesoregions of Minas Gerais and Triângulo Mineiro/Alto Paranaíba, in the State of Minas Gerais, Brazil. Its contribution lies in the diagnosis of the infrastructure conditions of the studied settlements, providing subsidies for the development of public policies aimed at the region.

2 CHARACTERIZATION OF STUDY MESOREGIONS

2.1 MESORREGION NORTE DE MINAS

The northern mesoregion of Minas Gerais, created by IBGE in 1990, occupies a territorial area of 128,450.6 km² (IBGE, 2011). The historical process of occupation of this mesoregion began in the seventeenth century, from the movement of expansion of livestock, along the São Francisco, and the western part belonged to Pernambuco and the eastern part, to Bahia. Between the 17th and 18th centuries, the region was occupied by cowboys, originally from Bahia and Pernambuco, who climbed the São Francisco, and by the *Bandeirantes*[2] from São Paulo. This mesoregion is an area of transition between the southeast and northeast regions of the country (PEREIRA, 2007).

Data from the Demographic Census recorded 1,492,715 inhabitants, a population that is irregularly distributed throughout the territory. The population density is 12.54 inhabitants/km², an average lower than the Brazilian population, which is 19.92 inhabitants/km². The counties have a rural population higher than the urban population, of which 52.80%. Norte de Minas Gerais has the per capita income declared below the minimum wage, being R$ 455.33 (IBGE, 2011).

The geographical characteristics, such as: low soil fertility, low rainfall index, together with *cerrado* vegetation in transition to *caatinga*, led Norte Mineiro to have cattle raising and subsistence agriculture as the basis of its economy. Drought has caused a steady and progressive exodus throughout the region, even agriculture is seriously compromised due to the reduction of the annual rainy season (SANTOS, 2017).

In the Northern mesoregion of Minas Gerais, the cultivation of forage sorghum as the main crop predominates, which is responsible for the feeding of cattle. The region also stands out in banana

2 | Pathfinders who explored Brazil's inland from the southeast up to the northwest.

production, accounting for 29.9% (243,685 tons) of the state's production; among the main producing regions of Minas Gerais; along with the Regions of the Doce and Central Rivers (MINAS GERAIS, 2018).

2.2 MESORREGION TRIÂNGULO MINEIRO/VALE DO PARANAÍBA

The region that is now occupied by the Triângulo Mineiro was called *Sertão da Farinha Podre* and was first occupied by Caiapó Indians (VEDUVOTO and BRITO, 2013). The Mesoregion of the Triângulo Mineiro/Alto Paranaíba has an excellent geographical location in relation to the regions with strong economic, social and political dynamics, with a privileged position in the heartland of the country.

The relief of the Mesoregion, for its excellent combination of flat areas of stoned land, allowed the practice of extensive agriculture with the use of machinery. The pletan water distribution network of affluent in the drainage area of the Grande and Paranaíba rivers, in addition to important watercourses, such as the Araguari, Uberabinha and Tejuco rivers, allowed the achievement of high hydraulic potential and favored regional growth (OLIVEIRA, 2017).

The Triângulo Mineiro/Vale do Paranaíba occupies a territorial area of 90,540.6 km², registering a population of 2,144,482 inhabitants, with only 8.6% of this total resident of the rural area. It has a population density of 23.69 inhabitants/km². This mesoregion has a declared per capita income of R$ 908.04 (INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA, 2011). The state of Minas Gerais is responsible for 6% of the national grain production (corn, beans, soybeans, cotton, wheat, sorghum, peanuts, sunflower and castor bean) producing 14.3 million tons in 2017, and its production is concentrated in the mesoregion Triângulo Mineiro/Vale do Paranaíba and Northwest.

The state also stands out in meat production, the number of animals slaughtered in 2016 was in the order of 2.6 million heads, being the Triângulo Mineiro/Vale do Paranaíba leader in this production. In the last ten years, the region has led the ranking of the main state regions with the highest number of animals (MINAS GERAIS, 2018).

3 METHODOLOGY

The study was developed within the framework of the RADIS/UFMT project (PROJETO DIAGNÓSTICO PARA REGULARIZAÇÃO AMBIENTAL DOS ASSENTAMENTOS DA REFORMA AGRÁRIA, 2018). Self-declaratory questionnaires of socioeconomic and environmental nature were applied to settled family farmers, through visits to the previously scheduled lots, preceded by stages of sensitization and mobilization. The settlements surveyed are located in the Northern Mesoregions of Minas Gerais and Triângulo Mineiro/Alto Paranaíba Mesoregions, in Minas Gerais. The sample consists of 1,270 lots, distributed in ten counties and 33 rural settlements (Table 1, Figure 1).

The methodology adopted to assess environmental impacts is based on the Leopold Matrix (LEOPOLD, 1971), considering the environmental variables: water supply; sanitation; disposal of wastewater, solid waste, pesticide packaging and veterinary medicinal products; distribution of electricity and paving of roads (Figure 2). These variables were defined based on the questionnaire and its relationship with the infrastructure of rural settlements.

Table 1 | Sample by Mesoregion, Counties and Settlements

Mesoregion	*County*	*Numbering and name of the Settlement Project as shown in Figure 1*	*Number of settlements per county*	*Number of lots per mesoregion*
North	Bocaiúva	32. Paraíso Salobro	1	91
	Montalvânia	33. Santa Engrácia32	1	
Triângulo Mineiro/ Alto Paranaíba	Campina Verde	9. Nova Capão Alto	10	456
		10. Inhumas		
		12. Primavera		
		14. São José da Boa Vista		
		15. Nova São José da Boa Vista		
		16. Campo Belo		
		17. Bela Cruz/ Palmeira		
		18. Córrego Fundo II		
		19. Nova Rio da Prata		
		20. Cachoeirinha II		
	Gurinhatã	5. Vargem do Touro	4	225
		6. Nova Piedade Barreiro		
		7. Nova Rosada		
		8. Divino Rosa		
	Ituiutaba	21. Douradinho	3	104
		22. Engenho da Serra		
		23. Renascer		
	Perdizes	29. Santa Luzia	3	128
		30. Bom Sucesso II		
		31. Guariba		
	Prata	24. Nova Cachoeirinha	2	104
		25. Sidamar		
	Santa Vitória	Nova Jacaré Curiango	4	130
		2. Porto Feliz		
		Paulo Freire		
		Nova Santa Inês		
	São Francisco de Sales	11. Boa Vista	2	32
		13. Queixada		
	Veríssimo	26. 21 de abril	3	138
		27. Rio do Peixe		
		28. Irmã Doroty		

Source: Diagnostic project for environmental regularization of agrarian reform settlements (2018).

The characteristics of the classes were adequate for the rural environment based on Topanotti (2002) and based on data on the Brazilian rural area. From these data, the numerical references of the classes (from 1 to 4 for each environmental indicator, in increasing order of impact meaning) were established (Chart 1). In the stage of environmental impact assessment, scores 2, 3, 5 and 7 were assigned for each of classes 1, 2, 3 and 4, respectively.

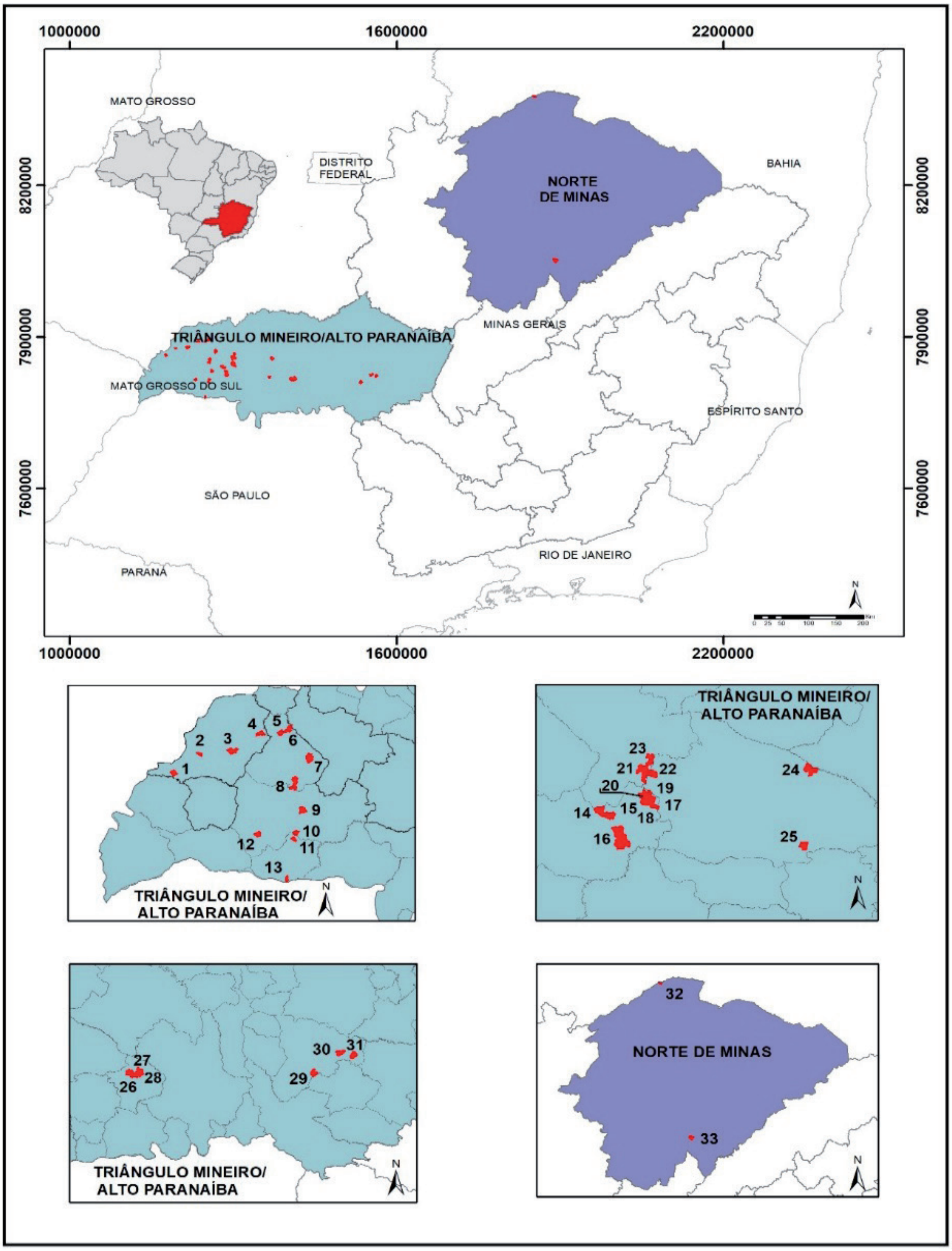

Figure 1 | Location of Settlement Projects (PAs) by Mesoregions of Minas Gerais - Brazil

Source: Prepared by the authors.

Does the dwelling have access to water?
- ☐ yes
- ☐ no

Where does the water consumed in the house come from?
- ☐ public plumbing network
- ☐ community plumbing network
- ☐ shed or spring of water
- ☐ artesian well
- ☐ ordinary well
- ☐ collective well
- ☐ stream, creek or river
- ☐ cistern
- ☐ water reservoir/dam

Does the lot have rural electrification?
- ☐ yes
- ☐ no

What kind of network is supplying the lot?
- ☐ 1 phase
- ☐ 2 phases
- ☐ 3 phases

What is the disposal of veterinary medicine packaging?
- ☐ not used
- ☐ grounding hole
- ☐ open cast
- ☐ incineration
- ☐ storage in the lot
- ☐ public withdrawal

What is the disposal of the wastewater?
- ☐ cesspool or sinkhole
- ☐ septic tank or ecological treatment
- ☐ other
- ☐ there is none

What is the disposal of pesticide packaging?
- ☐ not used
- ☐ grounding hole
- ☐ open cast
- ☐ incineration
- ☐ storage in the lot
- ☐ public withdrawal
- ☐ return
- ☐ reuse

What is the disposal of household solid waste?
- ☐ public withdrawal
- ☐ collection point
- ☐ grounding hole
- ☐ incineration
- ☐ open cast
- ☐ recycling

What is the condition of the access roads to the lot?
- ☐ good
- ☐ even
- ☐ bad

What is the allowed period to access the roads?
- ☐ permanent access
- ☐ seasonal access
- ☐ permanently interrupted access

What are the kind of roads?
- ☐ gravel
- ☐ dirt

Figure 2 | Questions applied in the field data collection instrument

Source: Adapted from Diagnostic Project for Environmental Regularization of Agrarian Reform Settlements (2018).

Table 2 - Classes of environmental indicators

Environmental indicators	*Classes and Characteristics*		*References*
Water supply	1	More than 24% (lots) supplied by the public network and/or 30% by individual artesian well and/or cistern and/or shed (spring)	According to PNAD (2015), Minas Gerais has 24% of rural households connected to the water supply network. The Brazilian state with the lowest supply is 35%.
	2	Less than 35% (lots) supplied by water reservoir and/or dam and/or ordinary well and/or more than 30% (lots) supplied by stream (river/creek)	
	3	More than 35% (lots) supplied by water reservoir and/or dam and/or ordinary well	
Sanitary sewage	1	More than 14% (lots) destined to the public network	According to PNAD (2015): the rural area of Minas Gerais has 13.8% lots with a collection network; the average launch of water, cesspool and open cast in Brazil are 19.73% and 16.35% are treated in septic tank in Minas Gerais.
	2	Less than 20% (lots) launches into watercourse and/or cesspool and/or open cast and/or more than 17% in septic tank	
	3	From 20% to 50% (lots) launches in watercourse and/or cesspool and/or open pit	
	4	More than 50% (lots) launches into water course and/or cesspool and/or open pit	
Disposal of wastewater	1	More than 14% (lots) launches in the public network	
	2	Less than 20% (lots) launches in the open and/or more than 17% in Fat box/septic tank /sink hole and/or fat box/sink hole and/or sink hole	
	3	From 20% to 50% (lots) launches in the open cast	
	4	More than 50% (lots) launches in the open cast	
Disposal of pesticide packaging	1	More than 41% of (lots) public withdrawal and/or return, return and/or storage in the lot	According to IBGE (2011), in the Southeast region only 40.55% of the rural area allocates waste with direct or indirect withdrawal.
	2	Less than 20% (lots) destined in grounding hole and/or open cast and/or incineration	
	3	From 20% to 48% (lots) destined in grounding hole and/or open cast and/or incineration	
	4	More than 48% (lots) destined in grounding hole and/or open cast and/or incineration	
Disposal of solid waste	1	More than 41% of (lots) have public withdrawal and/or collection point and/or recycling	According to IBGE (2011), in the Southeast region only 40.55% of the rural area allocates waste with direct or indirect withdrawal.
	2	Less than 20% (lots) destined in grounding hole and/or open cast and/or incineration	
	3	From 20% to 48% (lots) destined in grounding hole and/or open cast and/or incineration	
	4	More than 48% (lots) destined in grounding hole and/or open casts and/or incineration	

Environmental indicators	Classes and Characteristics		References
Disposal of veterinary medicinal product packaging	1	More than 41% of (lots) have public withdrawal and/or return, return and/or storage in the lot	Defined by the authors
	2	Less than 20% (lots) destined in grounding hole and/or open cast and/or incineration	
	3	From 20% to 48% (lots) destined in grounding hole and/or open cast and/or incineration	
	4	More than 48% (lots) destined for grounding hole and/or open cast and/or incineration	
Avaiability of power (electricity)	1	More than 80% has mono, bi or three-phase network	
	4	Most lack of electrification	
Paving roads	1	Most considered the roads good	
	2	Most considered the roads even	
	3	Most considered the roads bad	

Source: Prepared by the authors.

After assigning the weights of the classes (1, 2, 3 or 4) and scores (2, 3, 5 or 7), the magnitude of impact is calculated by Equation 01, where the sum of the weights, regarding this study, is equal to twenty. For the calculation of the magnitude of normalized impact, the values of the scores are related to the scale from 1 to 10, with 10 being the maximum value of the magnitude of impact.

$$Magnitude\ of\ impact = \frac{\sum(Score\ x\ Weight)}{\sum Weight} \qquad \text{(Equation 1)}$$

Based on Topanotti (2002), environmental components that suffer some kind of anthropic impact related to the problem of low infrastructure of the settlements were selected, i.e.: water pollution, soil contamination, land use and quality of life.

From the understanding of how each of the environmental components influences the infrastructure of the settlements, the relevance of each of them was attributed, the latter being a subjective value of 1 to 3 according to Leopold (1977). In the present study, values according to Topanotti (2002) were adopted, being 3, 2, 3 and 3 for environmental components water pollution, soil contamination, land use and quality of life, respectively.

The maximum value of the environmental impact caused by the lack of infrastructure is the extreme situation that the environment supports and, in this methodology, it is calculated in the matrix using the magnitude in its acme, that is, ten. The impact score according to Equation 2 represents its relevance and the percentage of the impact caused is the ratio of the maximum impact value to the calculated score.

$$Impact\ score = \Sigma\ (Magnitude\ x\ Relevance) \qquad \text{(Equation 2)}$$

4 RESULTS AND DISCUSSION

In the scope of the variables researched, the theme of access and the origin of the water that supplies the settlements is initially highlighted. The results indicate that, in Triângulo Mineiro/Vale do Paranaíba, there are 30.5% of the lots supplied by cistern, 5.7% per individual artesian well and 24.1% per spring or slope. In the Northern mesoregion of Minas Gerais, there were a large number of non-respondents (39.1%), however, considering the valid questionnaires, 17.4% and 16.4% of the lots are supplied by collective artesian well water and cistern, respectively (Table 2).

Table 3 | Water supply (%)

Indicators / Mesoregion	*Norte de Minas Gerais*	*Triângulo Mineiro/Vale do Paranaíba*
Public plumbing network	1.0	0.0
Community plumbing network	13.2	0.6
Single artesian well	7.3	25.7
Collective artesian well	17.4	10.7
Cistern	16.4	30.5
Water reservoir	1.0	0.1
Dam	0.8	1.9
Stream / creek / river	3.4	2.9
Shed (spring)	0.4	24.1
Did not answer	39.1	3.6
Class	**2**	**1**

Source: Adapted from Diagnostic Project for Environmental Regularization of Agrarian Reform Settlements (2018).

Due to its climatic characteristics, there is no large bodies of water in the Northern region of Minas Gerais, which leads to infer that the supply is usually made by dam and cistern. There was a significant amount of lots with supply from the community network, which is an interesting alternative in the area of infrastructure. However, this water is coming from means such as rivers, streams, sheds, collective artesian well and even water reservoirs. Therefore, its availability is subject to change of level according to the rainfall regime. Based on the high percentage of non-respondents, class 2 was assigned the most consistent with the reality of the place.

Leite et al (2004) identified in settlements distributed throughout Brazil, that access to water takes place in 37 and 27% of them, by common and artesian wells, respectively; 34% per spring; 18% by rivers, 10% in dams; 5% by public plumbing network and 43% by other forms. As can be seen, there is a predominance of collection in wells in both studies.

As for the disposal of the wastewater, 39.8 and 50.2% have its disposal in the open air, in the northern mesoregions of Minas Gerais and Triângulo Mineiro/Vale do Paranaíba, respectively. There was a large number of non-respondents - 56.2% in the first and 34% in the second. This absence of data may be a justification for the Triângulo Mineiro mesoregion presenting worse conditions regarding this criterion, although it is a region of greater economic development (Table 3).

Table 4 | Disposal of wastewater in mesoregions (%)

Indicators / Mesoregion	*Norte de Minas*	*Triangulo Mineiro/Vale do Paranaíba*
Fat box/septic tank/sink hole	2.3	5.1
Fat box/sink hole	1.4	4.0
Sink hole	0.3	6.8
Open cast	39.8	50.2
Did not answer	56.2	34.0
Class	**3**	**4**

Source: Adapted from Diagnostic Project for Environmental Regularization of Agrarian Reform Settlements (2018).

According to the criterion of class assignment in relation to the disposal of the wastwater, it is concluded that in the Northern Mesoregion of Minas Gerais, the class is 3 and in Triângulo Mineiro/ Vale do Paranaíba, the class is 4 (Table 3).

According to the Brazilian Institute of Geography and Statistics (IBGE, 2011), 49.9% of households in the rural area of the Southeast macro-region incorrectly allocate the effluent produced. In the Northern mesoregion of Minas Gerais, according to the State Sanitation Information System (2017), considering the urban and rural region, only 42.2% of households have coverage of the effluent system. Considering, as a fact, that the infrastructure conditions of the urban area are better than rural ones, it is concluded that the rural area is in an unfavorable situation in the general context.

According to Leite et al. (2004), 80% of national settlements have no disposal for wastewater; 16% sink directly in rivers; 40 and 35% target them to the common and septic tank, respectively, and only 1% to the public plumbing network. The reality in the studied settlements accompanies the national one, where most have the water served arranged in the open cast, without any type of treatment or disposal.

In the criterion of sanitary sewage disposal (Table 4), in Triângulo Mineiro/Vale do Paranaíba, the highest percentages of disposal occur in septic tank/sinkhole (27.6%) and well (32.4%), as well as in Norte de Minas Gerais (14.9%) and (18.2%), respectively. The occurrence of 10.4% of the lots with open effluent stake in the Northern mesoregion of mines is highlighted.

Table 5 | Disposal of sanitary sewage (%)

Indicators / Mesoregion	*Norte de Minas Gerais*	*Triangulo Mineiro/Vale do Paranaíba*
Septic Tank/Sinkhole	14.9	27.6
Septic Tank/Ecological Treatment	0.5	4.5
Toilet	0.0	0.7
Open cast	10.4	0.8
Sinkhole (dark well)	18.2	32.4
Did not answer	56.2	33.9
Class	**2**	**3**

Source: Adapted from Diagnostic Project for Environmental Regularization of Agrarian Reform Settlements (2018).

In the Triângulo Mineiro/Vale do Paranaíba mesoregion, the percentage of treatment, septic tank/ Sinkhole and Septic Tank/Ecological effluent treatment is 32.1%, falling into class 3. Despite presenting a better picture than Norte de Minas Gerais, the disposal of sanitary effluent is still inadequate. Both mesoregions have an expressive amount of sewage disposal in a sink hole (dark well), that is, dump without treatment directly into the environment.

Surface water can be contaminated mainly in the absence of sewage infrastructure and inadequate disposal of waste, and may contaminate the soil and, consequently, the water table. The watercourse when in contact with organic waste causes imbalance in its components, for example, oxygen is consumed in an accelerated manner, causing eutrophication and, consequently, changes in the dynamics and structure of biological communities, in addition to a sharp drop in aquatic biodiversity, among others (CALLISTO, MORETTI and GOULART, 2001).

The study by Jove (2018), in a hydrographic basin in Peru, also using the Leopold Matrix, pointed out that water contamination impacts the physical environment (soil, water and air), the biotic environment (flora and fauna) and the socioeconomic environment. The methodology allowed identifying both positive and negative impacts. Regarding the positive impacts found (16%), these result from the generation of jobs in the activities developed, although they are directly related to 84% of negative environmental impacts.

Regarding the land use indicator, this is related to the production system, in terms of pesticide use, crop management, fire adoption, among others. Inadequate disposal of chemical packaging (medicine and pesticides) is a potential risk of soil microbiota alteration and affects the growth, distribution and biological cycle of plant species (BARCELÓ & POSCHENRIEDER, 1992).

The disposal of domestic solid waste was classified as 3 and 4 in the Northern mesoregions of Minas Gerais and Triângulo Mineiro/Vale do Paranaíba, in which the main disposal is incineration - 38.5 and 52.4%, respectively (Table 5).

Table 6 | Disposal of domestic solid waste (%)

Indicators / Mesoregion	*Norte de Minas Gerais*	*Triangulo Mineiro/ Vale do Paranaíba*
Public Withdrawal	0.4	3.9
Collection point	0.1	6.9
Recycling	0.0	0.0
Grounding Hole	2.5	0.8
Open Cast	2.5	1.7
Incineration	38.5	52.4
Did not answer	55.8	33.9
Class	**3**	**4**

Source: Adapted from Diagnostic Project for Environmental Regularization of Agrarian Reform Settlements (2018).

Based on the result and considering the high percentage of non-respondents, both mesoregions follow the Brazilian rural panorama regarding the disposal of solid waste, which presents 79.4% of inadequate disposal, according to the Brazilian Institute of Geography and Statistics (IBGE, 2011).

The proper disposal of empty packages of pesticides is determined by Federal Law No. 9,974 (BRASIL, 2000) which establishes principles for the management and environmentally correct disposal of empty poison packaging, based on shared responsibilities among all agricultural production agents – farmers, distribution channels and cooperatives, industry and public authorities. According to the National Institute of Empty Packaging Processing (2018), 95% of pesticide packaging sold in Brazil is recyclable, once it is properly washed.

In the criterion of disposal of pesticide packaging (Table 6), in Norte de Minas Gerais there is purposeful burning in 30.2% of the lots. In the Triângulo Mineiro/ Vale do Paranaíba, the return type is destined in 28.1% of the lots. Thus, the mesoregions are classified in 3 and 2, respectively. It is observed that, even with the large percentage of non-respondents, the Northern mesoregion of Minas Gerais burns a large portion of its waste.

Table 7 | Disposal of pesticide packaging (%)

Mesoregion	*Norte de Minas Gerais*	*Triangulo Mineiro Vale do Paranaíba*
Public Withdrawal	0.7	0.7
Return	17.8	28.1
Storage in the lot	0.9	3.4
Grounding Hole	4.0	0.1
Open cast	0.2	0.5
Incineration	30.2	6.8
Did not answer	46.1	60.4
Class	**3**	**2**

Source: Adapted from Diagnostic Project for Environmental Regularization of Agrarian Reform Settlements (2018).

Regarding the disposal of veterinary drug packaging, the Northern Mesoregions of Minas Gerais and Triângulo Mineiro/Vale do Paranaíba were classified as 4 and 3, respectively. It is observed that there is a large percentage of residue burning in both mesoregions.

In Triângulo Mineiro/Vale do Paranaíba there is 21.6% of storage in the lot and 10.9% of public withdrawal. Norte de Minas Gerais has 9.6% of disposal in hole, 6.1% of storage in the lot and 4.8% of public withdrawal (Table 7).

Table 8 | Disposal of veterinary medicine packaging (%)

Mesoregion	*Norte de Minas Gerais*	*Triangulo Mineiro/ Vale do Paranaíba*
Public withdrawal	4.8	10.9
Storage in the lot	6.1	21.6
Grounding Hole	9.6	0.9
Open cast	0.6	0.1
Incineration	42.4	30.4
Did not answer	36.5	36.2
Class	**4**	**3**

Source: Adapted from Diagnostic Project for Environmental Regularization of Agrarian Reform Settlements (2018).

It is worth mentioning that Martins (2014), when analyzing the water from the *Grotão* Stream watershed, observed that the springs are contaminated as they supply rural productive areas (agriculture and livestock) and constant monitoring of water should be carried out, aiming to diagnose its quality for the use of rural residents themselves and also of downstream cities. It also highlights the contamination of water from the springs due to the use of pesticides and the inadequate dumping of their containers on rural properties.

The Federal Government, in November 2003, created *Luz para Todos*[3], a social program aiming to provide free electricity to the rural population. As a whole, in 2016 and 2017, 500,000 families had access to electricity in fifteen Brazilian states (SILVA, 2018).

On this theme, both mesoregions are class 1 (Table 8). Of the interviewees, 96.7 and 87.2% answered that they had access to single-phase electricity in the Northern mesoregions of Minas Gerais and Triângulo Mineiro/Vale do Paranaíba, respectively.

The national panorama reveals that 78% of the lots of rural settlements have electricity and 22% do not. Of the settlements served by the electricity grid, 27% have supplied all its lots and 23%, most of them (Leite et al., 2004). It is noteworthy that the electricity supply service is considered essential by the Federal Constitution (BRASIL, 1988).

Table 9 | Electrification of Lots (%)

Mesoregion	*Norte de Minas Gerais*	*Triangulo Mineiro/ Alto Paranaíba*
Three-phase electrification	2.8	0
Biphasic electrification	10	3.3
Single-phase electrification	87.2	96.7
Lacks electrification	17.2	1.5
Did not answer	39	2.5
Class	**1**	**1**

Source: Adapted from Diagnostic Project for Environmental Regularization of Agrarian Reform Settlements (2018).

3 | "Light for All".

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Access to electricity has a positive impact on the expansion of work capacities and community development prospects, being used for domestic applications and for the expansion of knowledge (ESCOBAR, 2014). Leite et al (2004) state that the main claim in settlements after access to land has been the provision of electricity.

The lack of paving of the roads is a problem that can affect the quality of life of the settlers. It hinders mobility, causes dust in the dry season or prevents traffic, especially during the rainy season. The practice of using gravel to improve traffic can cause accidents, as it increases the chances of slippage.

It was found that the paving in the Northern mesoregion of Minas was classified by 37.3% of the settlers as "bad", 59.7% of them "without gravel" and 36.7% allowing free access throughout the year. In Triângulo Mineiro/Vale do Paranaíba, the access roads to the lot were classified as "good" by 26% of the settlers, 63% of them "without gravel", allowing free access throughout the year in 58.2% of them.

Access to the lot is of fundamental importance due to the need for access to health and transportation of production, the latter being fundamental for the permanence and survival of the family farmer.

Table 10 | Paving within the Settlement (%).

Mesoregion	*Norte de Minas Gerais*	*Triangulo Mineiro/ Alto Paranaíba*
Gravel	10.6	3.2
Without gravel (dirt road)	59.7	63.0
Free access throughout the year	36.7	58.2
Seasonal access	31.9	7.5
Permanently interrupted access	1.7	0.5
Good	4.4	26.0
Even	28.5	21.6
Bad	37.3	18.6
Did not answer	29.8	33.8
Class	**3**	**1**

Source: Adapted from Diagnostic Project for Environmental Regularization of Agrarian Reform Settlements (2018).

Roads with good paving and constant maintenance can impact trade near the settlement, since they approach and facilitate the access of settlers to drain production and also acquire goods and services.

Considering the classes obtained, Figure 3 presents, comparatively, the behavior of the classes of environmental components selected for the study, in the two mesoregions.

The two mesoregions studied have similar infrastructure conditions regarding the availability of electricity and disposal of sanitary sewage. Triângulo Mineiro/Vale do Paranaíba presents better infrastructure conditions related to water pollution, disposal of pesticide packaging and veterinary medicines, justified by being a region closer to large centers, and having a large number of settlers associated with cooperatives, which enable a better organization for compliance with industry standards.

The paving infrastructure of the roads is worse in the settlements of Norte de Minas Gerais, because they are less assisted by maintenance actions.

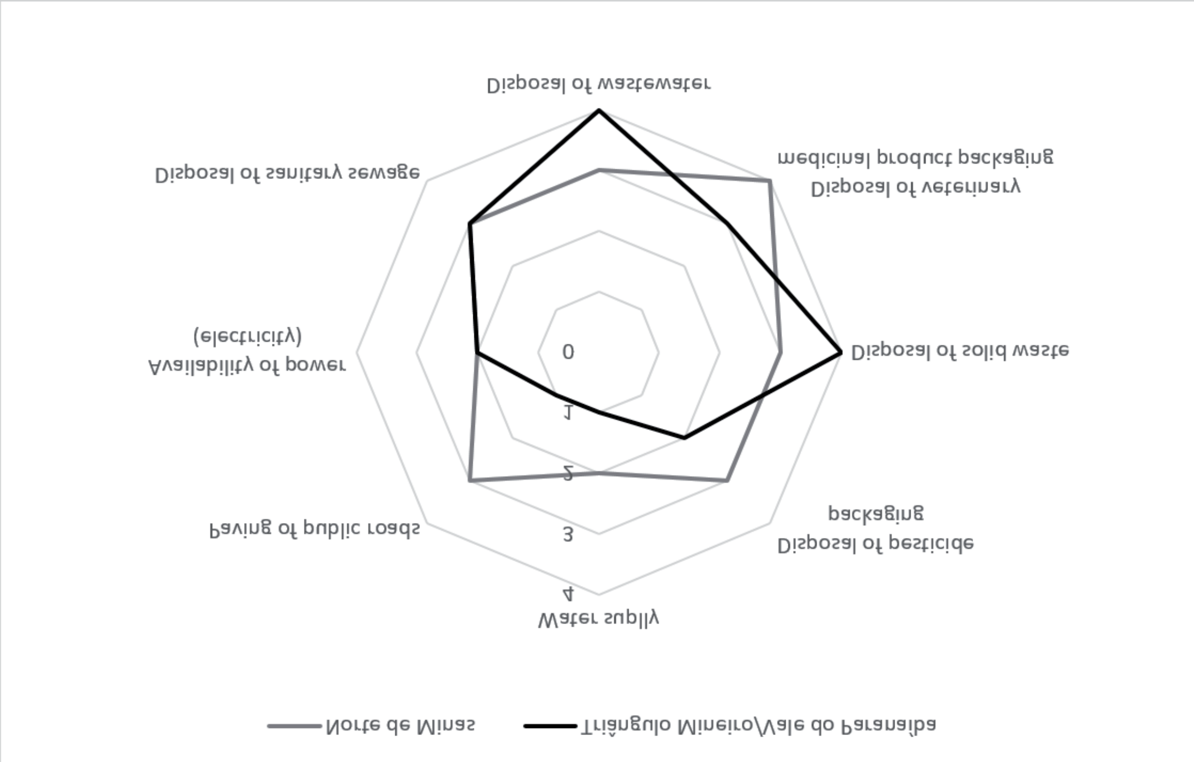

Figure 3 | Behavior of the classes of environmental components in the two mesoregions studied

Elaboration: The Authors.

Table 10 shows the calculation of the magnitude of impacts, where the sum of weights equal to 20 and the magnitude of the normalized environmental impact in the scale from 0 to 10 corresponding to 7.0 and 6.0, for the Northern mesoregions of Minas Gerais and Triângulo Mineiro/Vale do Paranaíba, respectively.

Table 11 presents the impact of infrastructure in the Northern mesoregions of Minas Gerais and Triângulo Mineiro/Vale do Paranaíba, at 70% and 60%, respectively. The more incipient the infrastructure, the greater the environmental impact on each component. It is concluded, therefore, that the infrastructure conditions of the Northern Mesoregion of Minas Gerais cause greater negative environmental impact when compared to the Triângulo Mineiro/ Vale do Paranaíba (Table 11).

Table 11 | Magnitude of environmental impacts

Environmental Impact	*Environmental Indicators Class*		*Norte de Minas Gerais*		*Triângulo Mineiro/ Alto Paranaíba*		*Weight*
			*Score**	*Class*	*Score**	*Class*	
Lack of infrastructure	Water supply		2	3	1	2	3
	Disposal	Sanitary sewage	3	5	3	5	3
		Wastewater	3	5	4	7	3
	Disposal of solid waste	Domestic	3	5	4	7	3
		Pesticide packaging	3	5	2	3	3
		Packaging of veterinary medicinal products	4	7	3	5	3
	Avaiability of electricity grid		1	2	1	2	1
	Paving roads		3	5	1	2	1
Σ (score x weight)			97		91		
Σ weight							20
Σ (score x weight) / Σ weight			4.85		4.55		
Magnitude of normalized environmental impact on scale 1 to 10			7.0		6.0		

Legend: *Class 1 = 1 point; Class 2 = 3 points; Class 3 = 5 points and Class 4 = 7 points

Source: The Authors

Table 12 | Environmental Impact Assessment Matrix

Environmental Component \ **Environmental Impact**		**Water contamination**	**Soil Degradation**	**Land use**	**Quality of life**	**Total**
Norte de Minas Gerais	Lack of infrastructure	7 / 3	7 / 2	7 / 3	7 / 3	
	Impact score	21	14	21	21	77
	Maximum impact value					110
	Percentage of impact caused					70%
Triângulo Mineiro/ Alto Paranaíba	Lack of infrastructure	6 / 3	6 / 2	6 / 3	6 / 3	
	Impact score	18	12	18	18	66
	Maximum impact value					110
	Percentage of impact caused					60%

Elaboration: The Authors. Source: Diagnostic project for environmental regularization of agrarian reform settlements (2018).

4 FINAL CONSIDERATIONS

The multiple use of the natural environment, associated with increased demands and degradation itself, paves the way for a wide range of tensions and disputes, especially in rural areas, usually devoid of infrastructure.

The National Agrarian Reform Policy contributes to land deconcentration and improvement of the quality of life of family farmers. The initial hypothesis of this article that the absence or precariousness of infrastructure conditions in the settlements may result in negative environmental impacts is proven, since it is verified that the impacts are of greater negative potential in the Northern mesoregion of Minas than in Triângulo Mineiro/Vale do Paranaíba, corresponding to 70 and 60%, respectively.

The variables researched were: water supply, sanitary sewage, disposal of wastewater, disposal of dry waste, disposal of pesticide packaging, disposal of veterinary drug packaging, distribution of electricity and paving of public roads.

The infrastructure of rural settlements in relation to these variables is the responsibility of the public authorities. As a correlated report, the absence or failures of the responsible institutions contribute to the negative impacts on the environment. Regarding the methodology adopted for the evaluation of impacts, the Leopold Matrix was found to be efficient in pointing out the indicators with the greatest potential for negative impact. In addition, the use of this matrix can be useful as a tool for environmental managers and public agencies.

This study finds limits on the possible amounts of blank answers of the questionnaire, which may incur some deviation of the results. In future studies it will allow to prove its efficiency in pointing out significant socio-environmental impacts, or inferring the need to insert, remove or adjust some of the indicators of the matrix, as well as subsidize the planning for an action in favor of environmental conservation.

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