Periódico Eletrônico
Fórum Ambiental da Alta Paulista
ISSN 1980-0827 – Volume 18, número 3, 2022

Safety index of individual basic sanitation systems in rural area

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ABSTRACT
The safe access to water and sanitary sewer are human rights, and there is a lack of indexes which evidence if rural areas have safe access levels to these services and others which compose basic sanitation in Brazil. The goal of this work was to elaborate a safety index of rural sanitation at household level, and to apply it in three typologies of rural communities in the state of Goiás: rural settlements, *quilombola* and riparian communities. For such, the research was developed in five steps: 1) Choice of indicators and sub-indicators; 2) Definition of goals and hierarchical structure; 3) Attribution of due weight to the indicators and sub-indicators; 4) Formulation of the rural sanitation index (ISS_{Rural}); and 5) Evaluation of the safety level in 48 rural areas. The proposed ISS_{Rural} was composed of six indicators, of which four are associated to basic sanitation components, one is related to habitability conditions and one related to health issues. Four sanitation safe levels have been established, according to the ISS_{Rural} score level: Critical, unsafe, partially safe and safe, being that only the last one guarantees the existing sanitation services' safety. Applying the index in 48 rural areas, none of the communities have reached the "safe" level for the ISS_{Rural} and only three areas have reached such level for at least one indicator, which was Rainwater Management. This work proposed an index which has evidenced the safety levels associated to basic sanitation in rural areas, from data at household level, and can be applied with the goal of prioritizing investments, plans and projects which may have greater impact in the population's sanitation safety, as well as contributing to ensure the human right of access to water and sanitary sewer.

KEYWORDS: Water; Sanitary sewer; Indicators.

Introduction

The United Nations Organization (UN) established that safe access to water and sanitary sewer in urban and rural areas is a human right, so that the participating countries must implement public policies to guarantee such right to their population (UN, 2010). The National Program for Rural Sanitation (NPRS) established goals of short, medium and long term for a period of 20 years (2019-2038) aiming to promote the universalization of access to basic sanitation services according to the text in Federal Law n. 11.445 (BRASIL, 2007), updated by Law n. 14.026 (BRASIL, 2020). In that sense, the NPRS proposes the use of indicators while auxiliary tools to follow the sanitary situation and the prioritization of investments in the sector.

In order to evaluate regions, the sanitation indexes can be used to analyze the sanitary vulnerability to which a population is exposed to, allowing for the identification of those which are subject to greater risk of health problems related to environmental healthiness. Such indexes can be used in the profile of urban sanitation, easing the comprehension of reality and granting the evaluation of coverage and provision of basic sanitation services, and aiding in public resources management (LIMA; ARRUDA; SCALIZE, 2019). Examples of application of indexes to present a scenario of the basic sanitation situation throughout the world can be found, as it has been done by Djonú et al (2018), which applied the Sanitation Index (SI) in a precarious neighborhood of the city if Bissau, in Guinea-Bissau, taking into consideration the individual sanitation solutions. Or, in the attempt of picturing not only the sanitary sewer, water supplying and hygiene situation, but also connect such matters to the local poverty condition, Giné-Garriga and Perez-Foguet (2013), have proposed the construction of an index which evaluates poverty in rural areas of Kenya, using data at household level. However, the authors have pointed the need of improvement of the index, especially regarding the choice of indicators.

Beyond being used to measure the degree of water supplying and sanitary sewer services providing degree, indexes are used to represent a certain status in which a region is found. Luh, Baum and Bartram (2013) developed an index to verify the state of equity regarding the access to water in which the countries are found, considering structural issues, status of the process and indicators which the countries present in the moment of the study. One of the limitations is the application only for national scale and not being applicable to other dimensions of the human right to water.

With the goal of analyzing the sanitation situation, Bernardes, Bernardes and Gunter (2018) proposed the Rural Household Index of Environmental Healthiness (RH/IEH) evaluating the individual sanitation for the Amazonas' riparian communities, considering the degree of risk associated to the solutions used without access to the collective network. The difficulty to collect data regarding the application of questionnaires in the households was detected, as well as in the capacitation of agents which collect such information. There also is a problem related to the impossibility of evaluation of a historical series, once that the data depends of such collection. In this context, Braga, Bezerra and Scalize (2022) advanced in the evaluation of environmental healthiness in rural areas, including the aspects of health, socioeconomic, services and housing conditions, as well as water supplying, sanitary sewer, solid waste and rainwater management, which compose the basic sanitation. The proposed index, Environmental Healthiness Index (ISA_{Rural}) has allowed the identification of communities with precarious healthiness situation and which of them requires more attention. However, the level of basic sanitation services safety level existing in the area have not been ascertained.

The rural communities usually have no access to collective networks of supplying and sanitary sewer, therefore it is of extreme importance to use means of evaluating basic sanitation in these places (VALE; RUGGERI JUNIOR; SCALIZE, 2022). Thus, Silva, Monteiro and Seibel (2008) elaborated the Index of Offer of Public Services (IOPS), which aims to examine the rural conditions of aspects such as health, sanitation and education, highlighting the need to amplify the debate regarding vulnerability indicators of the rural populations, besides the urgency in creating databases which can amplify such research.

The safe access to water, according to the WHO, occurs when there is no significant risk to health upon consuming said water, making it safe to use despite of its stage of life (WHO, 2017). Similarly, the safe access to sanitary sewer networks protect human health of the adverse effects to it caused by human excreta (WHO, 2018). However, no index which verifies the safety of access to water or systems of sanitary sewer in any scale have been observed.

It is therefore verified that the existing sanitation indexes have limitations related to their use, concerning compatibility between distinct places and the verification of the state of safety regarding the existing service. Besides that, there is great difficulty related to the lack of data availability, especially in the rural area, having also the complexity in the obtaining of such information. The indexes show to be a relevant tool for the evaluation of the sanitation situation, but it needs improvements so that it can be effectively applied and thus allow for the diagnostic and monitoring of the rural areas. In this context, the present article had as its objective to elaborate an applicable sanitation safety index in rural communities at household level, and determine it in rural settlements, *quilombola* and riparian communities of the state of Goiás.

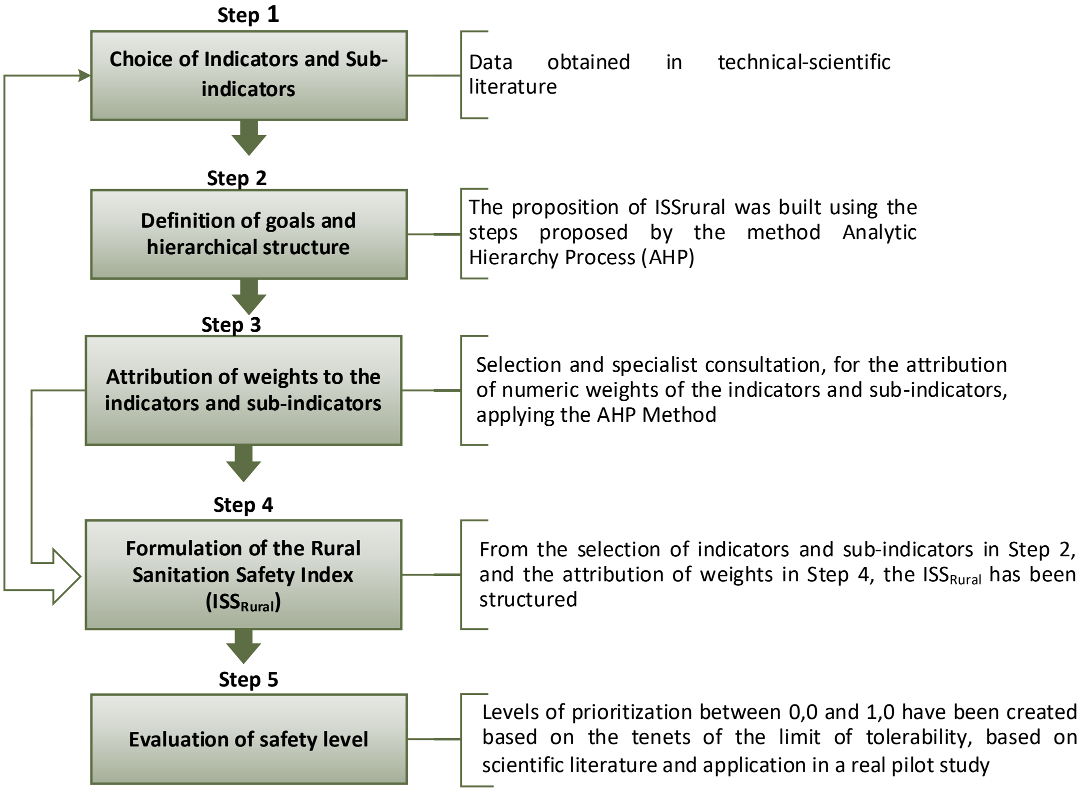
Materials and Method

The research was structured in two parts, being initiated with the proposition of a Rural Sanitation Safety Index (ISSRural) of the community for individual solutions, at household level, and the second was dedicated to its application in rural areas of the state of Goiás.

Proposition of the Rural Sanitation Safety Index (ISS_{Rural})

The ISS_{Rural} must be applied considering the intra-household conditions, that is, at household level. Collective infrastructures which attend the households are not considered within this index. However, household practices which occur independently of the water supply source must be considered. Therefore, the proposition of the ISS_{Rural} happened in five steps (Figure 1), which are described in the subsequent items.

Figure 1 – Flowchart of the construction of the Rural Sanitation Safety Index (ISS_{Rural})



Source: Drafted by the authors.

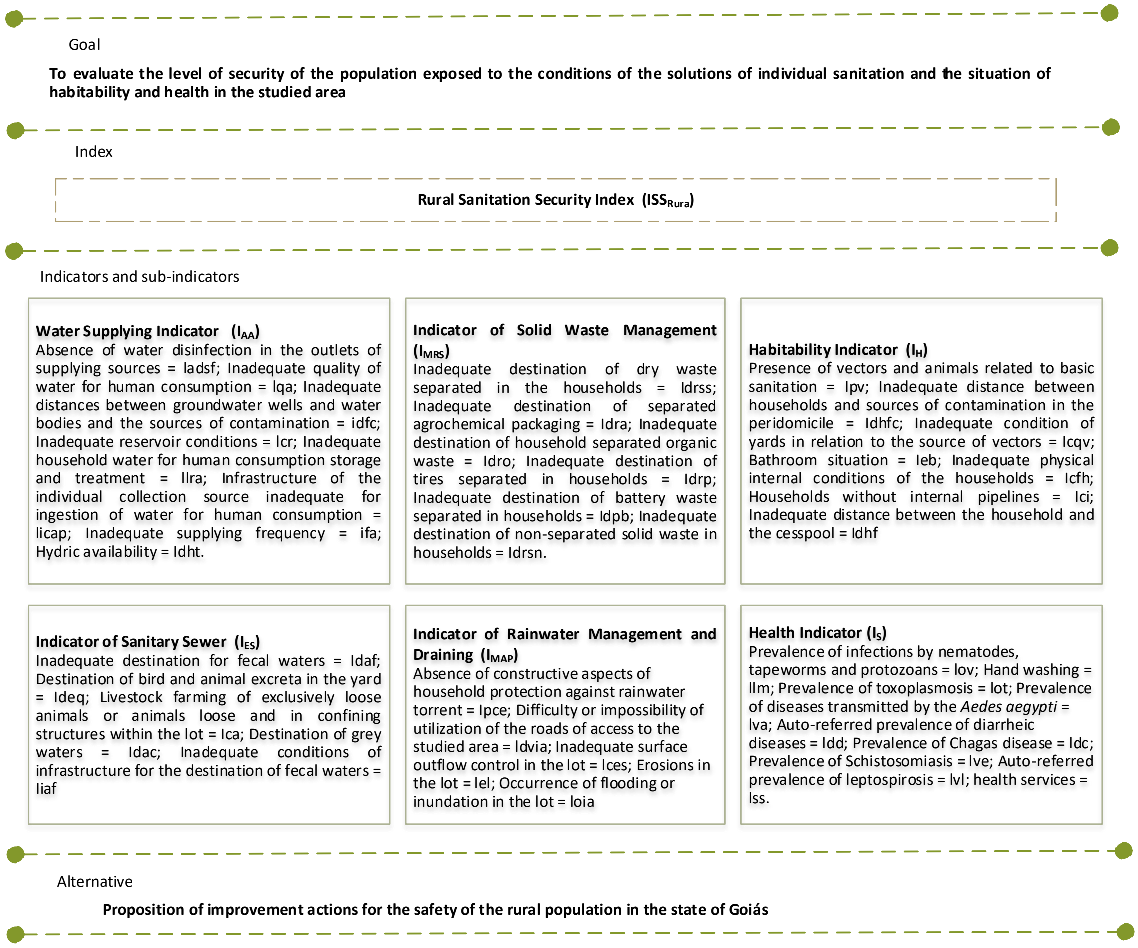
Step 1 – Choice of indicators and sub-indicators

The necessary indicators and sub-indicators to compose the ISS_{Rural} were determined from data obtained in technical-scientific literature. The proposition and definition of such elements were made according to theoretical, conceptual and legal aspects of the risk factors related to basic sanitation, habitability and health. Besides that, the studies conducted by Giné-Garriga and Perez-Foguet (2013), which worked with the evaluation of water safety index and poverty were also taken into consideration, and Braga, Bezerra and Scalize (2013), which have proposed a Rural Environmental Healthiness Index (ISA_{Rural}) to evaluate the conditions of the sanitation, sewer and hygiene services in health applied in rural and traditional communities of the state of Goiás, in the SanRural Project scope.

Step 2 – Definition of goals and hierarchical structure

For the construction of this step, the *Analytic Hierarchy Process* (AHP) method was used, following the steps proposed by Saaty (1987), starting from the hierarchic structure formation, defining objectives, index, indicators, sub-indicators and alternative (Figure 2).

Figure 2 – Flowchart of the definition of hierarchic structure, goals, index, indicators and sub-indicators



Source: drafted by the authors.

The general objective of the hierarchic structure and the indicators and sub-indicators took into consideration the good practices and legal aspects related to basic sanitation, habitability and health, as described in the Appendixes 1 to 6.

Step 3 – Attribution of weights to the indicators and sub-indicators

a) Selection of the specialists and application of the *Analytic Hierarchy Process* (AHP)

The specialists were selected due to their experience and specific work area for each indicator of the four components of basic sanitation (water supplying, solid waste management, sanitary sewer and rainwater management), household (house and yard) and health of different regions of Brazil.

The attribution of weights to the indicators and sub-indicators by the specialists with knowledge in the area was made using an *Excel* chart, developed by Goepel (2013). It was developed according to the definition of hierarchic structure, goals, indicators and sub-indicators of the ISS_{Rural}.

Each specialist has made the peer to peer comparison for each indicator and sub-indicator, applying the judgement scale proposed by Saaty (1987), attributing weight of 1 to 9 according to the importance of the analyzed criteria (Table 1).

Table 1 – Fundamental scale of weights to be attributed to the indicators and sub-indicators used in building the ISS_{Rural}

Weight	Judgement	Meaning
1	Equally important	Both criteria have contributed equally to the goal
3	Moderate Importance	Both criteria have moderate importance regarding one another
5	More important	The experience and judgement strongly favor one criterion in relation to the other
7	Much more important	One of the criteria is quite strongly favored over the other and its importance can be proved in practice
9	Extremely important	The evidence favors one criterion over the other with the utmost degree of certainty
2, 4, 6 and 8	Intermediate values	

Source: Saaty (1987).

Once the comparisons in pairs were conducted, the consistency of judgements was verified, through the Consistency Reason (CR) which, according to Saaty (1987), the maximum CR value should not get past 0,10 or 10%, since trespassing this value indicates that the judgements were inconsistent and the comparison matrix cannot be validated, making another round of judgement necessary.

Step 4 – Formulation of the Rural Sanitation Safety Index (ISS_{Rural})

The ISS_{Rural} was formulated by the indicators and sub-indicators obtained in Step 1 and the weights attributed by specialists in Step 3, being elaborated the ISS_{Rural} with the sum of the weight multiplied by each indicator.

Step 5 – Evaluation of safety level

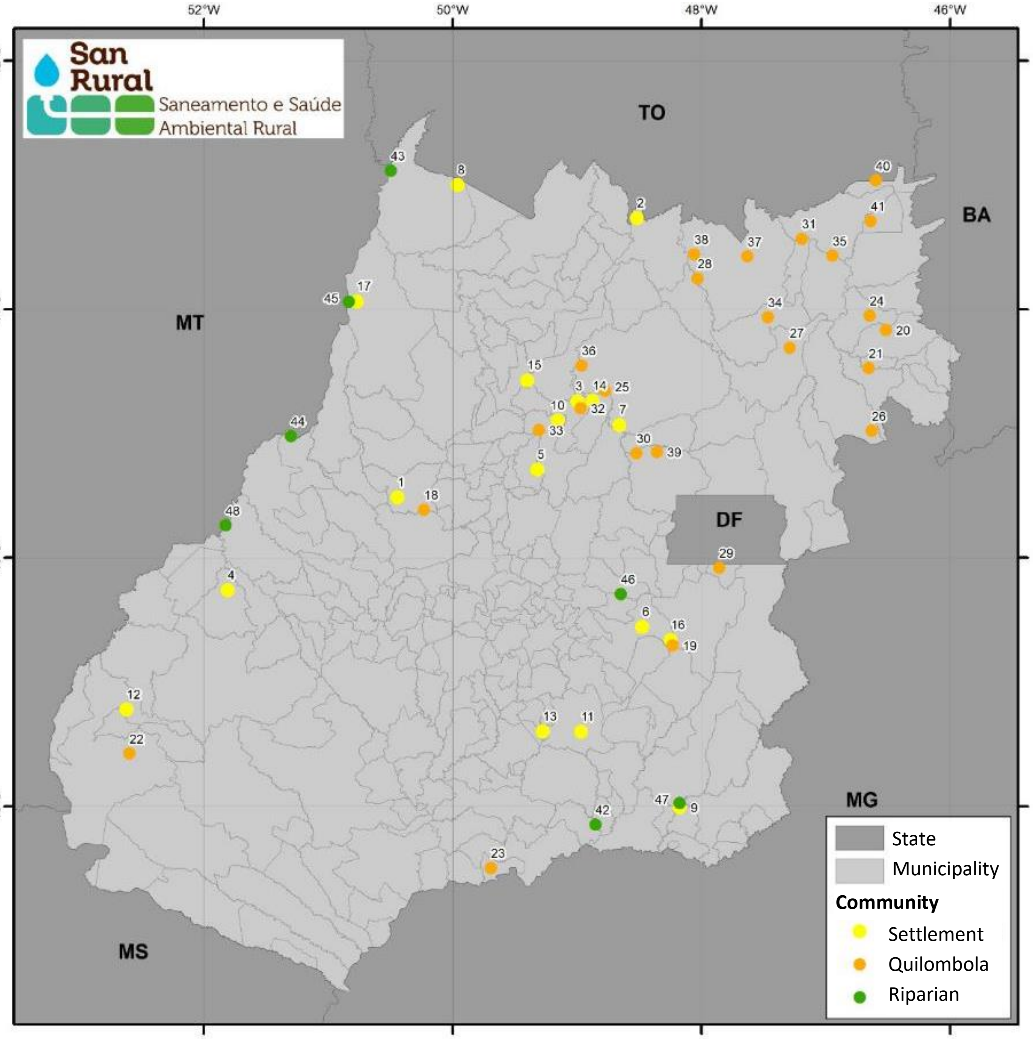
To evaluate the ISS_{Rural} safety level and its indicators, a few levels of prioritization contained between 0,0 and 1,0, which define the level of safety for decision-taking. It was proposed based on the tenets of tolerability limit proposed in risk management and in Braga, Bezerra and Scalize (2022), considering the four basic sanitation components, household (house and yard) and health. The validation of these levels happened based on the application of a real case study, dubbed pilot project with field data collection, obtained in the development of the Project Sanitation and Environmental Health in Traditional and Rural Communities of Goiás (SanRural). The rural area used was the João De Deus Settlement, located in the municipality of Silvânia/GO, and had 18 households with an average of 2,91 inhabitants per household (SCALIZE; BEZERRA; SANTO FILHO, 2020).

Application of the ISS_{Rural} in rural areas

Area of study

The area of study took place in rural and traditional areas of the state of Goiás, being 17 rural settlements, 24 *quilombola* communities and 7 riparian communities, in a total of 48 rural areas (Figure 3). These areas presented a total of 1646 households with a population of 4867 inhabitants, obtained from the sampling number defined with a qualitative-quantitative approach through descriptive, inferential and census-oriented research, adopted in the products published in the scope of the Project SanRural.

Figure 3 – Spatial distribution of the 48 rural areas pertaining to the study located in the state of Goiás, Brazil



Source: drafted by the authors.

Primary data survey

The data used to calculate the ISS_{Rural} came from Project SanRural, developed by the Federal University of Goiás (UFG) and sponsored by the National Health Foundation (Funasa), of which the authors make part. The data was collected *in loco*, comprising socioeconomic, sanitation and health aspects through the application of a checklist and pocket formulary (diagnosis regarding socioeconomic conditions, habitability, health and sanitation of the families and observation of their houses and yard). The project was approved by the UFG Research Ethics Committee, under n. CAAE 87784318.2.0000.5083.

Application of the ISS_{Rural}

From the data collected on the field, the indicators and sub-indicators which composed the ISS_{Rural} were calculated with the use of *Microsoft Excel*. The results were presented for each studied community, as well as prioritized from worst to best sanitation safety condition among them, according to the score levels of safety proposed in this study.

RESULTS

Indicators and sub-indicators of the ISS_{Rural}

The analysis of the studies found in technical-scientific literature and Giné-Garriga & Perez-Foguet's (2013), as well as Braga, Bezerra and Scalize's (2022) studies made it possible to list 6 indicators and 41 sub-indicators (Table 2) which composed the ISS_{Rural}.

Goals of the indicators and sub-indicators

Aiming to ease reading and understanding, the goal of each indicator and sub-indicator is listed in the Appendixes 1 to 6, along with their formulae and description.

Attribution of weights to indicators and sub-indicators

Table 2 presents the quantity of specialists invited to participate in the research within their area of work. They were sent to 101 specialists, obtaining 51 responses, which represents 50,1% of effectiveness.

Table 2 – Definition of the specialists for the attribution of weights to the indicators and sub-indicators used in the construction of the ISS_{Rural}

Area of work	Number of participating specialists	
	Invited	Respondents
I_H	15	9
I_S	15	8
I_{ES}	13	8
I_{MRS}	22	9
I_{MAP}	15	8
I_{AA}	21	9
Total	**101**	**51**

Note: Habitability indicator = I_H; Health Indicator = I_S; Sanitary Sewer Indicator = I_{ES}; Solid Waste Management Indicators = I_{MRS}; Rainwater and Drainage Management Indicators = I_{MAP}; Water Supplying Indicator = I_{AA}.

Thus, the weight attributed by specialists, using the AHP method, are inserted in Table 3, along with the Consistency Reason (CR) of the indicators and the Absolute Error (EA) of the indicators and sub-indicators, making it possible to obtain the Rural Sanitation Safety Index (ISS_{Rural}) (Equation 1). The CR of the weight attributed to the indicators resulted in 2,2%, below 10%, according to the recommended by Saaty (1987).

$$ISS_{Rural} = 0,319\ I_{AA} + 0,163\ I_{ES} + 0,111\ I_{MRS} + 0,05\ I_{MAP} + 0,102\ I_{H} + 0,255\ I_{Saúde} \quad \text{(Eq. 1)}$$

Where: Water Supplying Indicator = I_{AB}; Sanitary Sewer Indicator = I_{ES}; Solid Waste Management Indicator = I_{MRS}; Rainwater Management Indicator = I_{MAP}; Habitability Indicator = I_H and Health Indicator = $I_{Saúde}$.

Table 3 – Indicators and sub-indicators with their respective adopted symbols and weights attributed by the specialists, containing the Consistency Reason (CR) of each indicator and Absolute Error (EA)

Indicator and sub-indicator	Symbol	Weight	CR (%)	EA (%)
Water Supplying Indicator	I_{AA}	**0,319**	**0,9**	**6,7**
Infrastructure of the individual collection source inadequate for the ingestion of water for human consumption	Iicap	0,054	NA	1,2
Absence of water disinfection on the outlet of the supplying sources	Iadsf	0,254		3,7
Inadequate distances between groundwater wells and water bodies and the sources of contamination	Idc	0,130		1,8
Inadequate reservoir conditions	Icr	0,076		1,1
Inadequate water supplying frequency	Ifa	0,100		1,4
Inadequate of the water for human consumption	Iqa	0,225		3,4
Inadequate household water for human consumption storage and treatment	Ilra	0,069		1,0
Hydric Availability	Idht	0,093		1,7
Sanitary Sewer Indicator	I_{ES}	**0,163**	**0,4**	**3,8**
Inadequate conditions of infrastructure for the destination of fecal waters	Iiaf	0,233	NA	1,8
Inadequate destination for fecal waters	Idaf	0,372		3,8
Grey waters destination	Idac	0,079		0,7
Livestock farming of exclusively loose animals or animals loose and in confining structures within the lot	Ica	0,092		0,8
Destination of yard excreta	Ideq	0,224		2,7
Solid Waste Management	I_{MRS}	**0,111**		**2,6**
Inadequate destination of non-separated solid waste in households	Idrsn	0,287	NA	2,8
Inadequate destination of tires separated in households	Idrp	0,109		2,9
Inadequate destination for infectious waste separated in households	Idri	0,055		1,0
Inadequate destination of battery waste separated in households	Idpb	0,043		0,6
Inadequate destination of dry waste separated in the households	Idrss	0,264		5,1
Inadequate destination of organic waste separated in households	Idro	0,077		4,7
Inadequate destination of separated agrochemical packaging waste	Idra	0,165		1,7
Indicator of Rainwater Management and Draining	I_{MAPP}	**0,050**	**0,8**	**1,6**
Difficulty or impossibility of utilization of the roads of access to the studied area	Idvia	0,204	NA	3,8
Inadequate surface outflow control in the lot	Ices	0,123		1,6
Absence of constructive aspects of household protection against rainwater torrent	Ipce	0,198		1,6
Occurrence of flooding or inundation in the lot	Ioia	0,319		5,0
Erosions in the lot	Iel	0,156		1,2
Habitability Indicator	I_{H}	**0,102**	**1,9**	**1,1**
Bathroom Situation	Ieb	0,201	NA	6,0
Households without internal pipelines	Ici	0,128		4,1
Inadequate distance between the household and the cesspool	Idhf	0,085		1,3
Inadequate internal conditions of the household	Icfh	0,200		4,6
Inadequate distance between households and sources of contamination in the peridomicile	Idhfc	0,125		2,9
Inadequate condition of yards in relation to the source of vectors	Icqv	0,103		1,9
Presence of vectors and animals related to basic sanitation	Ipv	0,158		1,6
Indicador de Saúde	I_{S}	**0,255**	**1,8**	**6,5**
Hand washing	Ilm	0,140	NA	3,0
Auto-referred prevalence of diarrheic diseases	Idd	0,160		4,0
Prevalence of diseases transmitted by the *Aedes aegypti*	Iva	0,150		3,5
Prevalence of Schistosomiasis	Ive	0,060		1,2
Auto-referred prevalence of leptospirosis	Ivl	0,070		1,1
Prevalence of Toxoplasmosis	Iot	0,060		1,0
Prevalence of infections by nematodes, tapeworms and protozoans	Iov	0,180		4,8
Prevalence of Chagas Disease	Idc	0,080		1,9
Health Services	Iss	0,100		3,1

Source: Drafted by the authors.

Periódico Eletrônico
Fórum Ambiental da Alta Paulista
ISSN 1980-0827 – Volume 18, número 3, 2022

Safety Level

From the guidelines adopted in the methodology, four safety levels were proposed, with their respective score range, where in each level a description and suggestion for decision-taking are presented (Table 3). It is observed that the Critical level requires immediate action, being chosen by the score range above 0,75 up to 1,0. The same procedure must be employed for the other safety levels.

Table 4 – Safety level of the rural sanitation by score range in the ISS_{Rural}

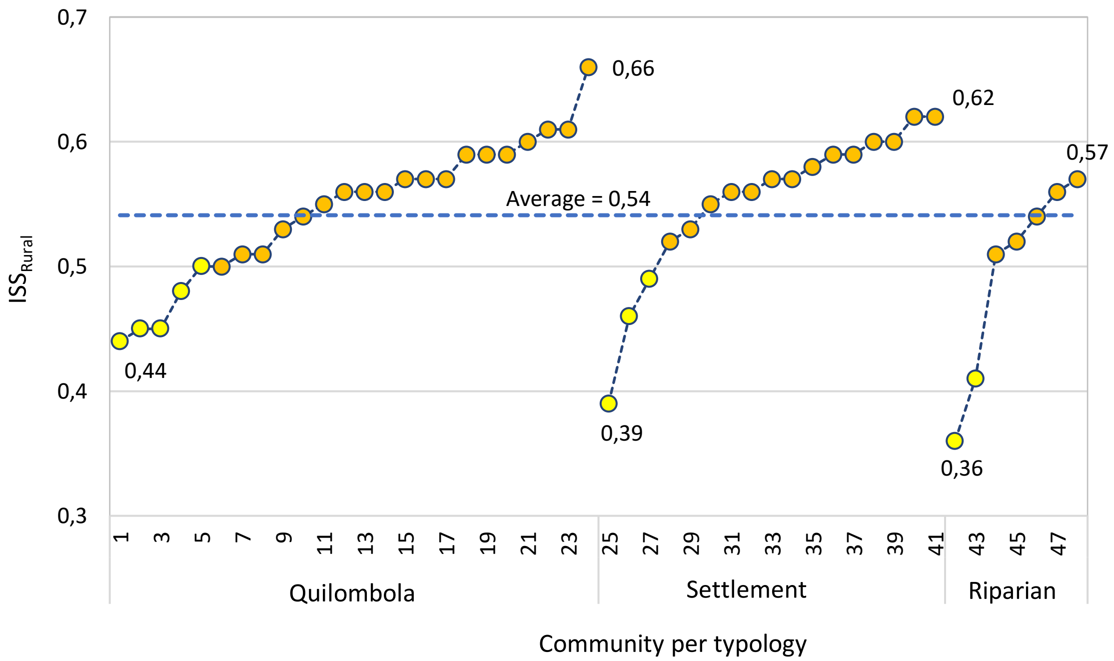
Safety level	Score level in the ISS_{Rural}
Critical: in an emergency situation and situations of disease outbreaks and aggravation of waterborne diseases for which **IMMEDIATE** adoption of control measures is required to reduce it to a tolerable safety level.	$0,75 < ISS_{Rural} \leq 1,00$
Unsafe: it is necessary to **PRIORITIZE** the adoption of control measures to reduce it to a tolerable safety level.	$0,50 < ISS_{Rural} \leq 0,75$
Partially safe: attention level, demands the **PLANNING** of adoption of control measures in order to reduce it to a tolerable safety level.	$0,12 < ISS_{Rural} \leq 0,50$
Safe: requires the **MAINTENANCE** of the routine control measures previewed in the improvement, monitoring and verification plans.	$0,00 \leq ISS_{Rural} \leq 0,12$

Source: drafted by the authors.

Application of the ISS_{Rural} in rural communities of the state of Goiás

In Figure 4 the distribution of ISS_{Rural} per community within each typology is presented. It is possible to observe an average ISS_{Rural} of 0,54, leading to an "unsafe" safety level, varying from 0,36 (Povoado Veríssimo – riparian) to 0,66 (Comunidade José de Coleto – *Quilombola*). It has been observed that 10 communities (20,8%) present a safety level of "**partially safe**", being the ISS_{Rural} on the range: $0,12 < ISS_{Rural} \leq 0,50$. The remaining (79,2%), stayed at "**unsafe**", as ISS_{Rural} on the range: $0,50 < ISS_{Rural} \leq 0,75$. In Table 5 are presented the results of each indicator and the ISS_{Rural} of each community.

Figure 4 – Distribution of ISS_{Rural} of the communities in function of their typology



Source: Drafted by the authors.

Table 5 – Results of each separate indicator and the ISS_{Rural} of each studied community

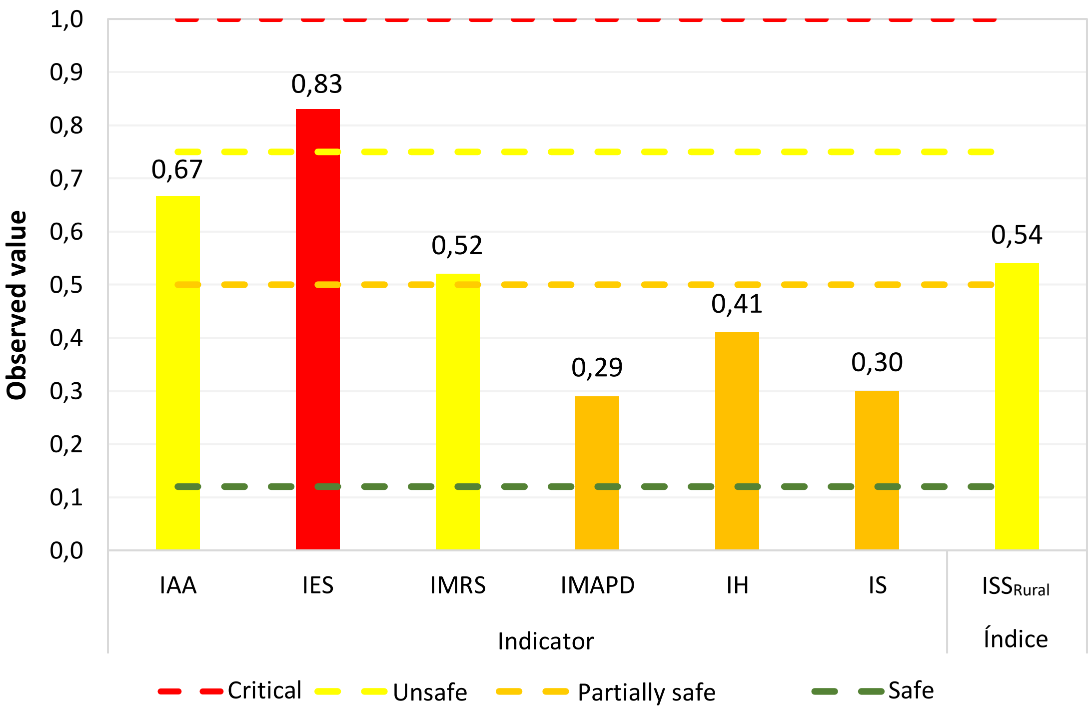
N	Community Name	I_{AA}	I_{ES}	I_{MRS}	I_{MAPD}	I_H	I_S	ISS_{Rural}
1	Comunidade Povoado Moinho	0,48	0,80	0,16	0,34	0,35	0,32	0,44
2	Comunidade Castelo/Retiro e Três Rios	0,51	0,80	0,54	0,21	0,35	0,21	0,45
3	Comunidade de Cedro	0,41	0,90	0,48	0,13	0,40	0,29	0,45
4	Comunidade Vazante	0,61	0,84	0,19	0,29	0,28	0,33	0,48
5	Comunidade Córrego do Inhambú	0,65	0,81	0,33	0,22	0,32	0,33	0,50
6	Comunidade de Mesquita	0,71	0,86	0,31	0,24	0,33	0,23	0,50
7	Comunidade de Baco Pari	0,41	0,85	0,87	0,40	0,52	0,27	0,51
8	Comunidade dos Almeidas	0,77	0,61	0,58	0,11	0,37	0,22	0,51
9	Comunidade de Quilombolas de Minaçu (Povoado Vermelho)	0,51	0,82	0,89	0,28	0,47	0,29	0,53
10	Comunidade de Extrema	0,65	0,90	0,37	0,38	0,36	0,34	0,54
11	Comunidade Sumidouro	0,74	0,85	0,43	0,29	0,38	0,29	0,55
12	Comunidade do Forte	0,62	0,92	0,86	0,32	0,36	0,24	0,56
13	Comunidade de Quilombo de Pombal	0,77	0,92	0,51	0,31	0,34	0,21	0,56
14	Comunidade de Taquarussu	0,74	0,84	0,57	0,31	0,48	0,24	0,56
15	Comunidade Água Limpa	0,76	0,92	0,47	0,23	0,51	0,23	0,57
16	Comunidade São Domingos	0,46	0,91	0,81	0,21	0,68	0,43	0,57
17	Comunidade da Fazenda Santo Antônio da Laguna	0,81	0,83	0,55	0,35	0,30	0,23	0,57
18	Comunidade de Pelotas	0,73	0,86	0,55	0,22	0,62	0,32	0,59
19	Comunidade do Quilombo do Magalhães	0,74	0,84	0,82	0,23	0,42	0,27	0,59
20	Comunidade de Mimoso (Queixo Dantas)	0,67	0,81	0,61	0,27	0,43	0,48	0,59
21	Comunidade Rafael Machado	0,79	0,80	0,46	0,33	0,40	0,42	0,60
22	Comunidade de Porto Leucádio	0,83	0,82	0,58	0,19	0,47	0,34	0,61
23	Comunidade Canabrava	0,76	0,84	0,58	0,41	0,38	0,41	0,61
24	Comunidade de José de Coleto	0,72	0,86	0,91	0,28	0,50	0,49	0,66
25	Julião Ribeiro	0,65	0,37	0,39	0,07	0,30	0,22	0,39
26	Pouso Alegre	0,46	0,80	0,41	0,08	0,39	0,39	0,46
27	Taruma	0,70	0,51	0,52	0,17	0,38	0,32	0,49
28	João de Deus	0,72	0,73	0,44	0,27	0,47	0,25	0,52
29	Engenho da Pontinha	0,70	0,97	0,50	0,38	0,39	0,15	0,53
30	Monte Moria	0,75	0,56	0,55	0,30	0,34	0,44	0,55
31	Céu Azul	0,70	0,93	0,51	0,35	0,39	0,27	0,56
32	Itajá II	0,73	0,84	0,46	0,37	0,42	0,27	0,56
33	Madre Cristina	0,73	0,97	0,41	0,39	0,45	0,28	0,57
34	São Sebastião	0,74	0,83	0,72	0,31	0,54	0,19	0,57
35	Piracanjuba	0,84	0,80	0,39	0,37	0,44	0,30	0,58
36	Lageado	0,85	0,90	0,49	0,32	0,39	0,25	0,59
37	Rochedo	0,73	0,86	0,44	0,27	0,39	0,31	0,59
38	Santa Fé da Laguna	0,78	0,89	0,81	0,23	0,40	0,25	0,60
39	São Lourenço	0,78	0,93	0,40	0,41	0,42	0,35	0,60
40	Arraial das Antas II	0,72	0,93	0,56	0,50	0,63	0,36	0,62
41	Fortaleza	0,78	0,87	0,72	0,29	0,39	0,38	0,62
42	Comunidade Povoado Veríssimo	0,25	0,89	0,25	0,44	0,29	0,22	0,36
43	Comunidade Arraial da Ponte	0,37	0,83	0,35	0,15	0,33	0,33	0,41
44	Comunidade Itacaiú	0,69	0,78	0,21	0,17	0,33	0,36	0,51
45	Comunidade Fio Velasco	0,59	0,96	0,26	0,55	0,42	0,29	0,52
46	Comunidade Registro do Araguaia	0,76	0,84	0,40	0,31	0,35	0,26	0,54
47	Comunidade Olhos D'Água	0,65	0,85	0,55	0,34	0,33	0,39	0,56
48	Comunidade Landi	0,81	0,87	0,55	0,22	0,41	0,22	0,57
Average		0,67	0,83	0,52	0,29	0,41	0,30	0,54

Source: Drafted by the authors.

It is also possible to observe on Table 5 that the safety level pointed with “Critical” was observed in 89,6% of the communities for the IES, 29,2% for the IAA and 14,6% for the I_{MRS}. On the other extremity, that is, the "Safe" level, it has been observed for the I_{MAPD} in only 6,3% of the communities.

In Figure 5 are evidenced the average results found for the 48 communities. It is observed that no indicator was classified as "Safe". However, 50% (I_{MAPD} = 0,29, I_H = 0,41 and I_S = 0,30) obtained the "Partially safe" level, 33,3% (I_{AA} = 0,67 and I_{MRS} = 0,52) "Unsafe" and 16,7% (I_{ES} = 0,83) "Critical", resulting on an average ISS_{Rural} deemed "Unsafe".

Figure 5 – Average safety level found for each indicator and for the ISSRural of the researched communities



Source: Drafted by the authors.

CONCLUSIONS

The present work made the following conclusions possible:

- The ISS_{Rural} may be applied for the elaboration of safety plans in rural areas, especially in those where basic sanitation individual solutions are predominant;
- The average ISS_{Rural} of the communities was classified in the "unsafe" safety level, leading to the need for bigger attention from the managers and the implementation of effective public policies;
- The most worrisome situation was observed for the I_{ES}, as such indicator presented the "critical" safety level in 89,6% of the communities, highlighting that immediate improvement measures should be directed towards the aforementioned sanitation component;
- None of the communities has presented a ISS_{Rural} safety level at the "Safe" marker; besides that, except for the results in three communities for the IMAPD indicator, no other indicator has presented the "Safe" safety level on any instance;

- Upon using the ISS_{Rural} to represent the safe access to water and the distance from sanitary sewers, a visible need to invest in plans, projects and actions which implement or amplify barriers to protect the population from health risks to which they are exposed, given that no community has presented the "Safe" safety level was evidenced;
- When associating the sub-indicator results which compose the ISS_{Rural} with data collected on the field, it is possible to build improvement plans with the goal of mitigating the risk levels until they reach the "Safe" level.

Among the index limitations, it is pointed that the ISS_{Rural} does not measure the coverage to the community's levels regarding the water supplying, sanitary sewer, solid waste and rainwater management, health and habitability. Therefore, it is restricted to the evaluation of sanitation conditions at household level, not including, thus, the existing collective sanitation infrastructures, but including the household practices which occur independent of the supplying source.

Lastly, it is recommended to apply the index in other typologies of rural communities, besides integrating the results found to plans and projects aimed towards the aforementioned communities, especially in the prioritization of investments.

ACKNOWLEDGEMENTS

To the National Health Foundation (FUNASA), for the financial support, through the Project named *Saneamento e Saúde Ambiental em Comunidades Rurais e Tradicionais de Goiás* (SanRural) - TED 05.

REFERENCES

BERNARDES, Carolina; BERNARDES; Ricardo Silveira; GÜNTHER; Wanda Maria Risos. Proposta de índice de salubridade ambiental domiciliar para comunidades rurais: aspectos conceituais e metodológicos. **Engenharia Sanitária e Ambiental**, v. 23, n. 4, p. 697-706, 2018. Available on: https://doi.org/10.1590/S1413-41522018141631. Accessed on 14 dez. 2022.

BRAGA, Debora Lima; BEZERRA, Nolan Ribeiro; SCALIZE, Paulo Sergio. Proposition and application of an environmental salubrity index in rural agglomerations. **Revista de Saúde Pública**, v. 1, p. 1-16, 2022. Available on: https://doi.org/10.11606/s1518-8787.2022056003548. Accessed on 14 dez. 2022.

BRASIL. Lei nº. 11.445, de 05 de janeiro de 2007. Estabelece as diretrizes nacionais para o saneamento básico; cria o Comitê Interministerial de Saneamento Básico; altera as Leis nos 6.766, de 19 de dezembro de 1979, 8.666, de 21 de junho de 1993, e 8.987, de 13 de fevereiro de 1995; e revoga a Lei nº 6.528, de 11 de maio de 1978. (Redação pela Lei nº 14.026, de 2020). **Diário Oficial da União**, Brasília, DF, 8 jan. de 2007. Available on: https://www2.camara.leg.br/legin/fed/lei/2007/lei-11445-5-janeiro-2007-549031-norma-pl.html. Accessed on 19 mar. 2022.

BRASIL. Lei nº. 14.026, de 15 de julho de 2020. Atualiza o marco legal do saneamento básico e altera a Lei nº 9.984, [...], a Lei nº 10.768, [...], a Lei nº 11.107, de 6 de abril de 2005, [...], a Lei nº 11.445, de 5 de janeiro de 2007, para aprimorar as condições estruturais do saneamento básico no País, a Lei nº 12.305, [...], a Lei nº 13.089, [...], e a Lei nº 13.529, de 4 de dezembro de 2017, para autorizar a União a participar de fundo com a finalidade exclusiva de financiar serviços técnicos especializados. **Diário Oficial da União**, Brasília, DF, 15 jul. de 2020. Available on: https://www.in.gov.br/en/web/dou/-/lei-n-14.026-de-15-de-julho-de-2020-267035421. Accessed on 01 out. 2022.

BRASIL. Ministério da Saúde. **Programa Nacional de Saneamento Rural**. Brasília: Funasa, 2019. 260 p. ISBN: 978-85-7346-065-0. Available on: www.funasa.gov.br/documents/20182/38564/MNL_PNSR_2019.pdf. Accessed on 02 out. 2022.

DJONÚ, Patricia *et al.* Objectives of sustainable development and conditions of health risk areas. Express search results were developed in the period 2015-2017. **Ambiente & Sociedade**, v. 21, 20p. 2018. Available on: https://doi.org/10.1590/1809-4422asoc0091r1vu18L3TD. Accessed on 14 dez. 2022.

GOEPEL, Klaus D. Implementing the analytic hierarchy process as a standard method for multi-criteria decision making in corporate enterprises - A new AHP Excel template with multiple inputs. *In*: **Proceedings of the International Symposium on the Analytic Hierarchy Process**, Kuala Lumpur, Malaysia, 10 p., 2013. Available on: https://doi.org/10.13033/isahp.y2013.047. Accessed on 14 dez. 2022.

GINÉ-GARRIGA, Ricard; PEREZ-FOGUET, Agustí. Unravelling the Linkages Between Water, Sanitation, Hygiene and Rural Poverty: The WASH Poverty Index. **Water Resources Management**, v. 27, p. 1501 – 1515, 2013. Available on: https://doi.org/10.1007/s11269-012-0251-6. Accessed on 14 dez. 2022.

LIMA, Aline S. C.; ARRUDA, Poliana N.; SCALIZE, Paulo S. Indicador de salubridade ambiental em 21 municípios do estado de Goiás com serviços públicos de saneamento básico operados pelas prefeituras. **Engenharia Sanitária e Ambiental**, v. 24, p. 439-452, 2019. Available on: https://doi.org/10.1590/S1413-41522019188336. Accessed on 14 dez. 2022.

LUH, Jeanne; BAUM, Rachel; BARTRAM, Jamie. Equity in water and sanitation: Developing an index to measure progressive realization of the human right. **International Journal of Hygiene and Environmental Health**, v. 216, n. 6, p. 662-671, 2013. Available on: https://doi.org/10.1016/j.ijheh.2012.12.007. Accessed on 14 dez. 2022.

SILVA, Rafael da; MONTEIRO, Felipe Mattos; SEIBEL, Erni José. Vulnerabilidade social e oferta de serviços públicos no mundo rural. Duas moedas e uma só face? **Revista Grifos**, n. 24, v. 17, p. 93-108, 2008. Available on: https://doi.org/10.22295/grifos.v17i24.246. Accessed on 14 dez. 2022.

SAATY, R. W. The analytic hierarchy process - what it is and how it is used. **Mathematical modelling**, v. 9, n. 3-5, p. 161-176, 1987. Available on: https://doi.org/10.1016/0270-0255(87)90473-8. Accessed on 14 dez. 2022.

SCALIZE, Paulo Sergio; BEZERRA, Nolan Ribeiro; SANTO FILHO, Kleber do Espírito. Aspectos de participação da comunidade. *In*: SCALIZE, P. S. (org.). **Diagnóstico técnico participativo da Comunidade João de Deus**: Silvânia – Goiás: 2018, v. 48, cap. 2, p. 37-49. Goiânia: Cegraf UFG, 2020. E-book (214p.). (Coleção DTP Projeto SanRural). Available on: https://sanrural.ufg.br/wp-content/uploads/2022/02/DTP_JOAO_DE_DEUS.pdf. Accessed on 14 dez. 2022.

UNITED NATIONS. **Resolution n. 64/292 -** The human right to water and sanitation General Assembly, 2010. Available on: http://www.un.org/es/comun/docs/?symbol=A/RES/64/292&lang=E. Accessed on 30 mar. 2022.

VALE, Gabrielle Brito; RUGGERI JUNIOR, Humberto Carlos; SCALIZE, Paulo Sérgio. Service and precariousness of sanitary sewage in rural communities in the state of Goiás, Brazil. **Engenharia Sanitária e Ambiental** (online), v. 27, n. 6, p. 1067-1075, 2022. Disponível em: https://doi.org/10.1590/S1413-415220220160. Accessed on 14 dez. 2022.

WHO. WORLD HEALTH ORGANIZATION. **Guidelines for drinking-water quality**: fourth edition incorporating the first Addendum. 4. ed. Geneva: World Health Organization, 2017. Available on: https://www.who.int/publications/i/item/9789241549950. Accessed on 14 dez. 2022.

WHO. WORLD HEALTH ORGANIZATION – WHO. **Guidelines on sanitation and health.** Geneva: World Health Organization, 2018. Available on: https://www.who.int/publications/i/item/9789241514705. Accessed on 14 dez. 2022.

Appendix 1 – Indicator of water supplying and its sub-indicators used for the composition of the ISS_{Rural} with formulae, scoring, description and purpose

Water supplying indicator: I_{AA} = 0,054 Iicap + 0,254 Iadsf + 0,130 Idfc + 0,076 Icr + 0,100 Ifa + 0,224 Iqa + 0,069 Iat + 0,093 Idht

Goal I_{AA}: To evaluate the degree of health risk due to the inadequate situation of the water supplying sub-indicators' risk factors

Sub-indicator	Risk factor (inadequate)	Formula	Description	General goal	Origin
Infrastructure of the individual collection source inadequate for the ingestion of water for human consumption (Iicap)	1. Shallow well dug without a wall or height lower than 50cm, absence of pavement around it, no protection lid nor cover with improvised material, lack of fence, burying or erosion process, pipeline with leakage and wrapped with rubber, water withdrawal with bucket and rope, among others; 2. Shallow or Deep Tubular Well without lid, no fence, leaking pipeline wrapped with rubber, improvised shelters such as jerry cans, tarp, among others; 3. Rainwater cistern, presence of residues in the collection through, lack of first rainwater discarding device, no lids or with improvised materials, cracks and splits, among others; 4. Source and surface spring, absence of riparian forest, no protection fence and protection devices for water collection (consult Brasil, 2019).	Iicap = $\frac{Dric}{Drsai}$	Dric= number of households in the rural cluster which use an Individual Alternate Solution (SAI) which possesses inadequate infrastructure. Drsai = total number of households in the rural cluster which use the SAI.	Quantify and analyze the households which use inadequate sources to propose improvement measures.	Created
Absence of water disinfection in the supplying sources (Iadsf)	Households without treatment, be it for filtration and/or disinfection in the supplying source's outlet.	Iadsf = $\frac{Drds}{Drt}$	Drds= number of households in the rural cluster which did not perform disinfection in the source's outlet. Drt = total number of households in the rural cluster.	Quantify the households which did not performed disinfection in the main sources outlets	Created
Inadequate distances between groundwater wells and water bodies and the sources of contamination (Idfc)	Distances below 15m from cesspools, the shallow wells' supplying sources, springs and surface sources at a distance shorter than 100m from other contamination points (pig sty, corrals, chicken coops, cesspools, residue clusters, among others)	Idfc = $\frac{Drfc}{Drtps}$	Drfc= number of households in the rural cluster with inadequate distances between shallow wells and surface sources, and sources of contamination. Drtps = total number of households in the rural cluster which make use of shallow wells and surface sources for ingestion.	Analyze and quantify the households which have Analisar e quantificar os domicílios que possuem distâncias inferiores das recomendações legais ou normativas, entre os mananciais e as fontes de contaminações	Created
Inadequate reservoir conditions (Icr)	Reservoir without a lid or with improvised lid, cracked, with rubber-tied pipeline, overflow system without protection screen, evidences overflowing, no hygiene maintenance in a period over 6 months, among others	Icr = $\frac{Drrd}{Drtr}$	Drrd = number of households in the rural cluster with a house reservoir (water tank/tower) with inadequate phytosanitary infrastructure. Drtr = total number of households in the rural structure which use reservoirs.	Analyze and quantify the households which have house reservoirs and its phytosanitary conditions (covered reservoirs, hygiene maintenance every six months, using only water and sodium hypochlorite) to determine vulnerability of the reservoirs and possible spots of water contamination, proposing measures and improvements	Adapted from Braga, Bezerra and Scalize (2022)
Inadequate water supplying frequency (Ifa)	Supplying interruption more than once per month	Ifa = $\frac{Drfa}{Drt}$	Drfa= number of households in the rural cluster with inadequate frequency. Drt = total number of households in the rural cluster	Veryfy the water supplying frequency in the rural households, as this fact might lead people to seek for other sources which may be contaminated, putting the inhabitants at high health risk situations	Adapted from Braga, Bezerra and Scalize (2022)
Inadequate quality of water for human consumption (Iqa)	Parameter analyzed outside of the limits of the Potability Decree	Water Quality Index (Iqa)	Iqa > 95% - Score = 0 Iqa between 80% and 94,9% - Score = 0,25 Iqa between 65% and 79,9% - Score = 0,5 Iqa between 45% and 64,9% - Score = 0,75 Iqa <45% - Score = 1	Analyze the amount of water from the main supplying source for rural households according to the Water Quality Index (Iqa) using the Canadian Model	Created
Inadequate household water for human consumption storage and treatment (Ilra)	Absence of any household interior treatment, be it through filtering (cloth or filter), boiling or disinfection, with recipients which are not frequently washed, are uncovered, cracked or with sludge formation, among others	Ilra = $\frac{Drla}{Drtrc}$	Drla= Number of households in the rural cluster that have no adequate water storage or treatment. Drtrc = total number of households in the rural cluster.	Identify the households which do not perform water treatment (filtration, boiling, disinfection, among others) or protection measures within the houses (storage containers cleaning) used for the ingestion or preparation of food	Created
Total hydric availability (Idht)	Outflow of a water body which is not capable of covering the demands or with a loss for the Q95 outflow (outflow with grant of permanence in 95% of the time)	Idht = criterion	Total hydric availability, criterion: adequate = 0; inadequate = 1, Resolution CERHi n. 22/2019 (GOIÁS, 2019).	Verify the hydric availability in households, as this fact is an obstacle for body and food hygiene, besides leading people to seek for other sources which might be contaminated, putting them into dangerous situations	Braga, Bezerra and Scalize (2022)

Source: Drafted by the authors.

Note: Absence of water disinfection in the outlets of supplying sources = Iadsf; Inadequate quality of water for human consumption = Iqa; Inadequate distances between groundwater wells and water bodies and the sources of contamination = idfc; Inadequate reservoir conditions = Icr; Inadequate household water for human consumption storage and treatment = Ilra; Infrastructure of the individual collection source inadequate for ingestion of water for human consumption = Iicap; Inadequate supplying frequency = ifa; Hydric availability = Idht.

Appendix 2 – Indicator of sanitary sewer and its sub-indicators used to compose the ISS_{Rural} with formulae, score, description and purpose

Indicator of Sanitary Sewer: I_{ES} = 0,233 Iiaf + 0,372 Idaf + 0,079 Idac + 0,092 Ica + 0,224 Ideq

Goal I_{ES}: Evaluate the degree of health risk due to the inadequate situation of the sanitation sewer sub-indicators' risk factors

Sub-indicator	Risk Factor (inadequate)	Formula	Description	General Goal	Origin
Inadequate conditions of infrastructure for the destination of fecal waters (Iiaf)	Septic tank and/or sinkhole without a lid and/or with improvised lid, with cracks and splits, wall lower than 50cm in height, absence of surrounding pavement, burying or erosion process in the surroundings, absence of vent pipe, among others	Iiaf = $\frac{Driaf}{Drtbfs}$	Driaf= number of households in the rural cluster with inadequate sceptic tank or sceptic tank with sinkhole infrastructures. Drtbfs = total number of households in the rural cluster which have bathroom and use sceptic tanks or sceptic tanks with sinkhole.	Quantify and analyze the households which use sceptic tanks or sceptic tanks with a sinkhole without adequate infrastructure to send fecal waters to, determining the vulnerability of populations exposed to odors, vectors, helminths, bacteria, among others	Created
Inadequate destination for fecal waters (Idaf)	Destination of excreta or fecal water straight into the soil, surface sources and/or spilled into black sceptic tanks or outhouse without toilet seat or inadequate structure (refer to constricting aspects inside item 4.5.1.1 of Brasil, 2019)	Idaf = $\frac{Drian}{Drt}$	Drieq= number of households in the rural cluster with inadequate destination for the excreta and black water. Drt = total number of households in the rural cluster.	Identify the households that throw fecal water into the yard, determining the vulnerability of populations exposed to odors, vectors, helminths, bacteria, among others	Created
Inadequate destination of grey waters (Idac)	Destination of grey water from the kitchen and shower, without a grease box. For the grey water, the destination is deemed inadequate when sent straight into the soil, surface source, without previous treatment or rudimentary cesspools	Idac = $\frac{Drac}{Drt}$	Dracq= number of households in the rural cluster with inadequate destination of grey water. Drt = total number of households in the rural cluster.	Identify the households that throw grey water, after or not, from the grease box into the yard, determining the vulnerability of populations exposed to odors, vectors, helminths, bacteria, among others	Created
Livestock farming of exclusively loose animals or animals loose and in confining structures within the lot (Ica)	Animals raised on the loose within the lot	Ica = $\frac{Drcas}{Drtca}$	Drcas= number of households in the rural cluster with loose animals in the lot. Drtca = total number of households in the rural cluster which raise animals.	Identify the houses which raise animals loose in the lot, as the animals may have access to supplying sources, and possibly contaminate those	Created
Destination of excreta in the yard (Ideq)	Excrements left on the yard, thrown into surface sources and/or near springs, thrown untreated into the soil, used as manure without treatment, among others	Ideq = $\frac{Dreq}{Drtca}$	Dreq= number of households in the rural cluster with inadequate destination for the animal excreta in the yard. Drtca = total number of households in the rural cluster which raise animals.	Identify the households with adequate destination to the animal excreta in the yard, as the destination might be inadequate to the population, exposed to vectors, helminths, bactéria, among others	Created

Source: Drafted by the authors.

Note: Inadequate destination for fecal waters = Idaf; Destination of excreta in the yard = Ideq; Livestock farming of exclusively loose animals or animals loose and in confining structures within the lot = Ica; Destination of grey waters = Idac; Inadequate conditions of infrastructure for the destination of fecal waters = Iiaf

Periódico Eletrônico
Fórum Ambiental da Alta Paulista
ISSN 1980-0827 – Volume 18, número 3, 2022

Appendix 3 – Indicator of solid waste management and its sub-indicators used to compose the ISS_{Rural} with formulae, score, description and purpose

Solid Waste Management: I_{MRS} = 0,287 Idrsn + 0,109 Idrp + 0,055 Idri + 0,043 Idpb + 0,264 Idrss + 0,165 Idra + 0,077 Idro

Goal I_{MRS}: Evaluate the healt risk due to the risk factors of the sub-indicators of solid waste management.

Sub-indicator	Risk Factor (inadequate)	Formula	Description	General Goal	Origin
Inadequate destination of non-separated solid waste in households (Idrsn)	Burned, thrown at the margins or into water bodies, thrown at empty lots or into bushes, left in the yard, buried or thrown into deactivated solid residue cesspool	Idrsn = $\frac{Drsn}{Drtsn}$	Drsn= Number of households in the rural cluster with inadequate destination for non-separated solid waste. Drtsn = Total number of households in the rural cluster which do not separate solid waste.	Quantify the rural households which burn, bury, throw into the bushes, empty lot or river margins the non-separated solid residues, determining populations potentially exposed to odors, vectors, venomous animals, among others	Criado
Inadequate destination of tires separated in households (Idrp)		Iqrp = $\frac{Drrp}{Drtrp}$	Drrp= Number of households in the rural cluster with inadequate destination for tire residues Drtrp = Total number of households in the rural cluster which produce tires.	Quantify the rural households which burn, bury, throw into the bushes, empty lot or river margins the tires, determining populations potentially exposed to odors, vectors, venomous animals, among others	Created
Inadequate destination of infectious residues separated in households (band-aid, adhesive tape, needles, syringes, curatives) (Idri)		Idri = $\frac{Drri}{Drtri}$	Drri= Number of households in the rural cluster with inadequate destination for infectious residues Drtri = Total number of households in the rural cluster which produce and separate infectious residues.	Quantify the rural households which burn the infectious residues, determining populations potentially exposed to odors, vectors, venomous animals, among others	Created
Inadequate destination of battery waste separated in households (Idpb)	Burned, thrown at the margins or into water bodies, thrown at empty lots or into bushes, left in the yard, buried or thrown into deactivated solid residue cesspool	Idpb = $\frac{Drpb}{Drtpb}$	Drpb= Number of households in the rural cluster with inadequate destination for battery residues. Drtpb = Total number of households in the rural cluster which produce and separate battery residues.	Quantify the rural households which burn, bury, throw into the bushes, empty lot or river margins the battery residues, determining populations potentially exposed to odors, vectors, venomous animals, among others	Created
Inadequate destination of dry waste separated in the households (Idrss)		Idrss = $\frac{Drrs}{Drts}$	Drrs= Number of households in the rural cluster with inadequate destination for dry residues. Drts = Total number of households in the rural cluster which separate solid residues.	Quantify the rural households which burn, bury, throw into the bushes, empty lot or river margins the separated dry residues, determining populations potentially exposed to odors, vectors, venomous animals, among others	Created
Inadequate destination of household separated organic waste (Idro)	Burned, thrown at the margins or into water bodies, thrown at empty lots or into bushes, left in the yard, buried or thrown into deactivated solid residue cesspool	Idro = $\frac{Drro}{Drto}$	Drro= Number of households in the rural cluster with inadequate destination for organic residues. Drto = Total number of households in the rural cluster which organic residues.	Quantify the rural households which burn, bury, throw into the bushes, empty lot or river margins the agrochemicals packaging, determining populations potentially exposed to odors, vectors, venomous animals, among others	Created
Inadequate destination of separated agrochemical packaging residue (Idra)		Idra = $\frac{Drra}{Drtra}$	Drra= Number of households in the rural cluster with inadequate destination for agrochemicals packaging residues. Drtra = Total number of households in the rural cluster which use agrochemicals.	Quantify the rural households which burn the agrochemicals packaging, determining populations potentially exposed to odors, vectors, venomous animals, among others	Created

Source: Drafted by the authors.

Note: Inadequate destination of dry waste separated in the households = Idrss; Inadequate destination of separated agrochemical packaging residue = Idra; Inadequate destination of household separated organic waste = Idro; Inadequate destination of tires separated in households = Idrp; Inadequate destination of battery waste separated in households = Idpb; Inadequate destination of non-separated solid waste in households = Idrsn; Inadequate destination of infectious residues separated in households (band-aid, adhesive tape, needles, syringes, curatives) = Idri

Appendix 4 – Indicator of Rainwater management and draining and its sub-indicators used to compose the ISS_{Rural} with formulae, score, description and purpose

Indictdor of Rainwater Management: I_{MAPP} = 0,204 Idvia + 0,123 Ices + 0,198 Ipce + 0,319 Ioia + 0,156 Iel

Goal I_{MAPP}: Evaluate the healt risk due to the risk factors of the sub-indicators of Rainwater management and draining devices.

Sub-indicator	Risk Factor (Inadequate)	Formula	Description	General Goal	Origin
Difficulty or impossibility of utilization of the roads of access to the studied area (Idvia)	Difficulty to use access roads to the community, be it in the dry or rainy seasons	Idvia = $\frac{Drdvia}{Drt}$	Drdvia= Number of households in the rural cluster which have shown difficulty towards roads of access to the rural area in the last five years. Drt = total number of households in the rural cluster.	Quantify the rural households which presented some difficulty in using the roads of access to their houses in the rainy season	Braga, Bezerra and Scalize (2022)
Inadequate surface outflow control in the lot (Ices)	Absence of device in the lot for the destination of rainwater	Ices = $\frac{Drces}{Drt}$	Drces= Number of households in the rural cluster without devices for the control of exceeding surface outflow in the peridomicile, as level curve, channel or gutter, or others. Drt = total number of households in the rural cluster.	Quantify the rural households with devices to control exceeding surface outflow	Braga, Bezerra and Scalize (2022)
Absence of constructive aspects of household protection against rainwater torrent (Ipce)	Dwelling built at the same level or below the terrain level	Ipce = $\frac{Drpce}{Drt}$	Drpce= Number of households in the rural cluster built below or at the same level of the terrain. Drt = total number of households in the rural cluster.	Quantify the rural households built below or at the same level of the terrain	Created
Occurrence of flooding or inundation in the lot (Ioia)	Flooding or inundation in the lot and/or household	Ioia = Droia/Drt	Droia= Number of households in the rural cluster with occurrence of inundation and flooding in the lot in the last five years. Drt = total number of households in the rural cluster.	Quantify the rural households without reports of inundation and flooding	Braga, Bezerra and Scalize (2022)
Erosions in the lot (Iel)	Existence of erosions or erosive processes	Iel = Drel/Drt	Drel= Number of households in the rural cluster which present erosions. Drt = total number of households in the rural cluster.	Quantify the rural households which present erosions	Braga, Bezerra and Scalize (2022)

Source: Drafted by the authors.

Note: Absence of constructive aspects of household protection against rainwater torrent = Ipce; Difficulty or impossibility of utilization of the roads of access to the studied area = Idvia; Inadequate surface outflow control in the lot = Ices; Erosions in the lot = Iel; Occurrence of flooding or inundation in the lot = Ioia.

Appendix 5 – Indicator of habitability and its sub-indicators used to compose the ISS_{Rural} with formulae, score, description and purpose

Indicator of Habitability: I_H = 0,201 Ieb + 0,128 Ici + 0,085 Idhf + 0,200 Icfh + 0,125 Idhfc + 0,103 Icqv + 0,158 Ipv

Goal I_H: Evaluate the health risk due to the risk factors of the sub-indicators of habitability concerning house and yard conditions.

Sub-indicator	Risk Factor (Inadequate)	Formula	Description	General Goal	Origin
Bathroom situation (Ieb)	Household without bathroom or bathroom did not have the basic plumbing installations (toilet seat, washbasin and shower)	Ieb = $\frac{Drab}{Drt}$	Drab= Number of households in the rural cluster which do not have a bathroom or plumbing installations. Drt = total number of households in the rural cluster.	Quantify the rural households without internal or external bathrooms	Created
Households without internal pipelines (Ici)	Households without internal pipelines or with pipelines, leakage and wrapped, rubber, among others	Ici = $\frac{Drci}{Drt}$	Drci= Number of households in the rural cluster without internal pipelines. Drt = total number of households in the rural cluster.	Quantify the rural households without internal pipelines to determine the ease of access to water, besides associating the lack of channeling with water withdrawal from the sources of dug shallow wells, Rainwater collection cisterns, springs, mine or water fountain, river, creek or dam with a bucket	Created
Inadequate distance between the household and the cesspool (Idhf)	Household with distance below 1,5m from the cesspool, terrain limits, sinkholes, seepage ditch and/or 3,0m of trees and any point of the water supplying network	Idhf = $\frac{Drdhc}{Drtf}$	Drdhc= Number of households in the rural cluster with distance shorter than 1,5m between other households and cesspits. Drtf = total number of households in the rural cluster which uses sceptic tank.	Quantify the rural households with distances below the recommended, as they can contaminate the potable water and cause illness due to the odor Quantificar os domicílios rurais com distâncias inferiores ao recomendado, pois podem contaminar a água de consumo e causar mal-estar devido ao odor	Created
Inadequate physical internal conditions of the households (Icfh)	Dwelling with walls made of adobe, wattle, straw, tarp, metal foil, with existing cracks, dirt floor, wood, straw or tarp roof	Icfh = $\frac{Drcfh}{Drt}$	Drcfh= Number of households in the rural cluster with walls built with non-painted plaster, adobe, with cracks, dirt floor, wood, straw roof, etc. Drt = total number of households in the rural cluster.	Quantify the rural households with dwelling structure favorable to the proliferation of vectors, rodents and venomous animals	Created
Inadequate distance between households and sources of contamination in the peridomicile (Idhfc)	Dwelling with distances below 200m from pig sty, corral, storages, chicken coops, barns or other sources which serve as breeding spots for the *Trypanosoma cruzi*	Idhfc = $\frac{Drdhfc}{Drt}$	Drdhfc = Number of households in the rural cluster with distance shorter than 200m from the contamination sources (chicken coop, pig sty, barn, woodpiles or storages) which can be used by triatominae so that those can thrive and feed, besides animals such as cats, dogs, armadillos, monkeys, deer etc., which serve as food for triatominae which host the *Trypanosoma cruzi* parasite, who causes the Chagas disease. Drt = total number of households in the rural cluster.	Quantify the rural households with distance below 200m from the sources of contamination which may serve as *habitat* for the kissing bug	Created
Inadequate condition of yards in relation to the source of vectors (Icqv)	Presence of residues spread throughout the yard which may accumulate water and attract vectors or containers such as plant vases or tree ferns, jerry cans, troughs, among others, which may store water (with or without vectors), watering livestock, water reservoirs, cisterns, wells with larvae	Icqv = $\frac{Dramar}{Drt}$	Dramar= Number of households in the rural cluster without proper management of water-storing containers. Drt = total number of households in the rural cluster.	Identify the need for good practice programs related to the management of containers which store water, that can become vector breeding spots	Created
Presence of vectors and animals related to basic sanitation (Ipv)	Report of the presence of rats, flies, cockroaches, *Aedes aegypti*, kissing bugs, pigeons, scorpions, ticks, fleas, mosquitoes, aphids, centipedes, among others Relato de presença de ratos, moscas, baratas, *Aedes aegypti*, barbeiro, pombo, escorpião, carrapato, pulga, mosquito, pulgão, lacraia, entre outros	Ipv = $\frac{Drva}{Drt}$	Drva= Number of households in the rural cluster which have reported the presence of rats, flies, cockroaches, *Aedes aegypti, kissing bug, pigeon, scorpion, tick, flea, mosquito, etc.* Drt = total number of households in the rural cluster.	Identify the need for good practice programs related to the management of residues that attract vectors, venomous animals, among others	Created

Source: Drafted by the authors.

Note: Presence of vectors and animals related to basic sanitation = Ipv; Inadequate distance between households and sources of contamination in the peridomicile = Idhfc; Inadequate condition of yards in relation to the source of vectors = Icqv; Bathroom situation = Ieb; Inadequate physical internal conditions of the households = Icfh; Households without internal pipelines = Ici; Inadequate distance between the household and the cesspool = Idhf

Periódico Eletrônico
Fórum Ambiental da Alta Paulista
ISSN 1980-0827 – Volume 18, número 3, 2022

Appendix 6 – Indicator of health and its sub-indicators used to compose the ISS_{Rural} with formulae, score, description and purpose

Indicator of Health: I_S = 0,140 Ilm + 0,160 Idd + 0,150 Iva + 0,060 Ive + 0,070 Ivl + 0,060 Iot + 0,180 Iov + 0,080 Idch + 0,100 Iss

Goal I_S: Evaluate the healt risk due to the risk factors of the sub-indicators of the health conditions.

Sub-indicator	Risk Factor (Inadequate)	Formula	Description	General Goal	Origin
Inadequate hand washing (Ilm)	No adequate hand sanitizing (water and soap or alcohol) before meals and its preparation, and after bathroom use	$Ilm = \left(\left(\frac{Drmr}{Drt}\right) + \left(\frac{Drmb}{Drt}\right)\right)$	Drmr = Number of households in the rural cluster which reported not having washed hands or not doing it adequately (water + soap) before meals. Drmb = Number of households in the rural cluster which reported not doing proper hand hygiene after using the bathroom. Drt = total number of households in the rural cluster.	Identify the need for good practice programs of self-care related to hygiene and sanitation	Braga, Bezerra and Scalize (2022)
Prevalence of diarrheic diseases (Idd)	Diarrhea episode lasting over a day, with the necessity of using medicine or was stopped from performing daily activities	$Idd = \frac{Drdd}{Drt}$	Drdd = Number of households in the rural cluster reporting the occurrence of diarrheaDrt = total number of households in the rural cluster.	Quantify the number of inhabitants which had diarrhea episodes, possibly being correlated to the absence of good sanitation and hygiene practices	Braga, Bezerra and Scalize (2022)
Prevalence of diseases transmitted by the *Aedes aegypti* (Iva)	Inhabitant diagnosed with dengue, zika, chikungunya, mayaro, yellow fever, malaria, Schistosomiasis, leptospirosis and/or toxoplasmosis	$Iva = \frac{Drvd}{Drt}$	Hrda = Number of households in the rural cluster with one dweller diagnosed with dengue, zika, chikungunya, mayaro, yellow fever, malaria. Drt = total number of households in the rural cluster.	Quantify the number of households in which the inhabitants were diagnosed with dengue, zika, chikungunya or yellow fever	Braga, Bezerra and Scalize (2022)
Prevalence of Schistosomiasis (Ive)		$Ive = \frac{Drve}{Drt}$	Drve = Number of households in the rural cluster with individual tested positive for *Schistossoma* eggs. Drt = total number of households in the rural cluster.	Quantify the number of households in which the inhabitants were diagnosed with Schistosomiasis	Adapted from Braga, Bezerra and Scalize (2022)
Auto-referred prevalence of leptospirosis (Ivl)		$Ivl = \frac{Drvl}{Drt}$	Drvl = Number of households *in* the rural cluster auto-referred with leptospirosis Drt = total number of households in the rural cluster.	Quantify the number of households in which the inhabitants reported having leptospirosis	Braga, Bezerra and Scalize (2022)
Prevalence of toxoplasmosis (Iot)		$Iot = \frac{Drdt}{Drt}$	Drdt = Number of households in the rural cluster diagnosed with toxoplasmosis. Drt = total number of households in the rural cluster.	Quantify the number of households in which the inhabitants had or reported having toxoplasmosis, possibly being correlated to the absence of good sanitation practices in the presence of cats	Braga, Bezerra and Scalize (2022)
Prevalence of infections by nematodes, tapeworms and protozoans (Iov)	In case that one or more inhabitants of the same house report the possibility or were diagnosed with toxoplasmosis, Chagas or nematodes, tapeworms or protozoans which can be correlated to the absence of good sanitation practices, bad eating habits and hand sanitizing, such as: Ascariasis, Echinococcosis, Taeniasis, Amoebiasis, Cryptosporidiosis, Giardiasis, Cystoisosporiasis, Leishmaniasis, Lymphatic Filariasis, Hookworms, among others	$Iov = \frac{Drtv}{Drt}$	Drtv = Number of households in the rural cluster with individuals tested positive for nematodes, tapeworms and protozoans. Drt = total number of households in the rural cluster.	Quantify the number of households in which the inhabitants reported or tested positive for nematodes, tapeworms and protozoans	Created
Prevalence of Chagas disease (Idch)		$Idch = \frac{Dch}{Drt}$	Dch = Number of households in the rural cluster which reported having Chagas disease.	Quantify the number of households In which the inhabitants reported having or had Chagas	Created
Health services (Iss)	If the community has no health unit or the inhabitants have no easy access to it, or the health units are not covered by basic health attention professionals (community or endemic agentes)	Iss = Criterion	Health in the rural cluster (S), criterion: the rural cluster is covered by health center (clinic or community agents) = 0; the rural cluster is not covered by public health service = 1	Identify the need for the implementation of mandatory public	Braga, Bezerra and Scalize (2022)

Source: Drafted by the authors.

Note: Prevalence of infections by nematodes, tapeworms and protozoans = Iov; Inadequate hand washing = Ilm; Prevalence of toxoplasmosis = Iot; Prevalence of diseases transmitted by the *Aedes aegypti* = Iva; Prevalence of diarrheic diseases = Idd; Prevalence of Chagas disease = Idc; Prevalence of Schistosomiasis = Ive; Auto-referred prevalence of leptospirosis = Ivl; health services = Iss.