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## TAILINGS CONTAINMENT DAMS IN THE SOUTHEASTERN OF STATE OF PARA-BRAZIL: AN ANALYSIS BASED ON THE CURRENT MODEL OF SUSTAINABLE DEVELOPMENT OF THE UN

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### ABSTRACT

The mesoregion of southeastern of Pará State, in Brazil, made up of 39 municipalities, is of great relevance under the prism of several aspects, such as economic, social and territorial. For example, according to Brandão, Castro and Neto (2017), the Gross Domestic Product (GDP) of this mesoregion, which is part of a Brazilian state, is similar to the GDP of the states of Rio Grande do Norte and Paraíba. Due to the importance and the mineral vocation of this mesoregion, it is observed that it contains around 56% of the mining waste containment dams in the state of Pará, according to data from DNPM (2016). This leads to a focus on sustainable development. The beginning of this theme dates back to the 1980s. This article will focus on 2015, when the 2030 Agenda for Sustainable Development emerged. The Objectives of Sustainable Development (ODS) can be related to the theme of dam safety and conclude that the adoption of the practice of dam safety is a way of contributing to sustainable development along the lines of the United Nation (UN). Thus, the following question arises that will guide this article: how are the mining tailings containment dams in the southeast meso region of Pará in relation to the UN sustainable development assistance prescribed through these ODS?

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### INTRODUCTION

containment dams are common structures in mining, according to the latest Dams Safety Report - RSB (ANA, 2017) with data computed up to December 31, 2016, Brazil has about 839 mining tailings containment dams and according to the mining dams classification of ANM (DNPM, 2016) in the state of Pará there are 98 registered. Based on this expressive quantity of retention dams and the concern to find ways of development that work with the environmental idea, this article will adopt the idea of sustainable development. Therefore, the first problem to be discussed will be the definition of the concept of sustainable development. The concept of sustainable development will be based on the culmination of the creation of the Sustainable Development Objectives for the 2030 Agenda for Sustainable Development, defined by the UN in 2015.

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In this sense, it is observed that there is a possibility of a relationship between these 17 Objectives and thematic of security of dams. This is the second point that will be discussed in the article. The third issue that will be dealt with will be the relevance of law 12.334 / 2010 (BRAZIL, 2010) for dam safety and even for sustainable development in accordance with UN standards. This relationship may seem distant, but it is closer and so strong that a dependency is created when it addresses the sustainable development applied in the mineral sector, considering as main mediator of this interaction of the government through its legal framework. Finally, a brief discursive analysis of how the southeastern mesoregion of the state of Pará is developing along the lines of sustainable development proclaimed by the UN will be elaborated. It is known that this mesoregion is relevant for the local, regional and national economy and society, especially the study by Brandão, Castro and Neto (2017), who pointed out that the GDP of this mesoregion is similar to the Brazilian states of Rio Grande do Sul North and Paraíba. It is hoped that this brief analysis may foster a clearer understanding of the

insertion of the southeast of the state of Pará into the sustainable development parameters praised by the UN, when referenced by the theme of safety of tailings dams.

## MATERIALS AND METHODS

**Study area:** According to Brandão, Castro and Neto (2017) southeastern Pará is one of the mesoregions of the state of Pará, consisting of 39 municipalities and an area of more than 297 thousand square kilometers, corresponding to a larger territory, for example, that of the state of São Paulo, whose area is 248.2 thousand square kilometers. This region is being very important for the development of the state of Pará and Brazil. As shown below, you already have good indicators that demonstrate your high level of growth in many ways.

*The mesoregion has drawn attention to the great socio-economic dynamism and deep transformations in the socio-productive base. It had a population estimated in July 2014 of R \$ 1.8 million (IBGE, 2014a), which corresponds to 22.2% of the population of the state of Pará; a gross domestic product (GDP) in 2012 of R \$ 37.5 billion (IBGE, 2014b), equivalent to 41% of Pará's GDP (noting that its state participation was 12.3% in 1980) and 0.9% of Brazil's GDP (a contribution similar to that of the states of Rio Grande do Norte and Paraíba and higher than Alagoas, Sergipe, Piauí, Rondônia, Tocantins, Amapá, Acre and Roraima); and accounts for 59.4% of Paraguayan exports. (Brandão, Castro and Neto, 2017, pp.128)*

**Concept of tailings dams:** Dams are structures that can be used for various purposes such as water damming, irrigation, electric power generation among other purposes. There is in the literature a research of Schnitter (1994) that works the history of the dams. In this research, he cites the Sadd El-Kafara dam, located in ancient Egypt, as the oldest recorded in the world, almost five thousand years old. In the same way that the design of the use of dams for multiple uses is old, so is mining activity. And over time, the mining methods were being improved, allowing a greater volume withdrawal of material and gradually allowing the exploration of areas with lower mineral content. However, along with this process came more waste and this waste has impacted the environment.

As highlighted by Mello and Piasentin (2011), the waste generated has long been discarded in nature, in water courses or launched on adjacent land, forming deposits without any concern of organization or environmental impact. Thus, through the evolution of mining and its techniques for tailings disposal, it is necessary to define a clear and objective concept of tailings containment dams for the purposes of this work. For this purpose, we will adopt the concept proposed by DNPM, expressed in Administrative Rule No. 416 (DNPM, 2012). This definition is generalist, but reflects the types of structures that exist in the Brazilian context for the purpose of reject containment and which are the target of the actions of public oversight agencies.

*Mining dams: they are barrages, dams, reservoirs, exhausted cavas located within the granted area or easement area, used for containment, accumulation or decantation of mining tailings, discharge of sediments from mining activities, with or without associated water catchment, comprising the structure of the bus and its associated structures. (DNPM, 2012)*

**Information on mining tailings containment dams:** The data were extracted from the dams safety reports, from 2011 to 2018, of the national dams registry prepared by the National Mining Agency and the Federal Law 12,334 of 2010.

**Statistical analysis:** The data of dams inserted in the national dams registry in the state of Pará-Brazil, were submitted to simplified statistical analysis to obtain a graph, as well as other information. For this task was used Microsoft® Office Excel 2016.

**Flowcharts:** The data for the assembly of the relationship flow chart of the ODS with the safety theme of waste containment dams were worked on CmapTools 6.02 software.

## RESULTS AND DISCUSSION

**Sustainable development:** The theme of sustainable development is relatively recent, the term first appeared in the document entitled Our Common Future, issued in 1987 within the framework of the work of the World Commission on Environment and Development and as highlighted by Nascimento (2012). To reconcile the preservation of the environment with economic development, whose port of arrival was called Sustainable Development. From this infamous document, also entitled Brundtland report, still Nascimento (2012) emphasizes that the definition emerged that became classic and object of great world debate. This definition, as transcribed below, presents the development linked to the environment and society in such a way that creates an interdependence between them.

*Sustainable development is one that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains two main concepts: the concept of 'needs', in particular the essential needs of the world's poor, for which absolute priority must be given; and the idea of limitations imposed by the state of technology and social organization on the ability of the environment to meet present and future needs. (WCED, 1987, pp. 41)*

Therefore, as Sing and Köhler (2010) points out, the discourses on sustainable development were taken to the United Nations Conference on Environment and Development held in 1992 in Rio de Janeiro and after that period the subject fell into disillusionment and skepticism, allowing that many criticisms arose, especially in the sense that the term was becoming more a slogan than a theoretical concept that guides uniform development. Nonetheless, the same authors acknowledge that issues related to ecology, the environment, and natural resource management are increasingly recognized by development scholars in the search for a just world and open the way towards the great potential to improve the conceptual solidity and the methodological ideas that can be advantageous for the studies related to this subject. Another point of view that can be seen, is expressed in the work of Freitas, Nélsis e Nunes (2012) that critically analyzed the concept of sustainable development issued in the Brundtland report and reached the conclusion that is consistent with the harmonization of a trans-pact without theoretical formulation needed to address the issue of environmental sustainability. However, the authors agree that the concept of sustainable development is a process that is under construction and corroborate that the denial of the term sustainable development requires theoretical efforts to conceptualize a term compatible

with Marxist longings. Thus, it is evident that Freitas, Nélsis eNunes (2012) consider the process of constructing the concept of sustainable development as relevant and does not extirpate the importance of this term. In order to seek a more up-to-date understanding of sustainable development, we reinforce the discourse of Nascimento (2012) that highlights that amid the debate in the media, a consensus emerged that sustainable development is essentially composed of three dimensions, yet many authors consider the relevance of several other dimensions.

Focusing within the United Nations, the idea of the three dimensions of sustainable development became clearer when at around 2002 gone, the document entitled the Johannesburg Declaration on Sustainable Development (WSSD, 2002) said that the countries that met (local, national, regional and global) the collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development: economic development; social development and environmental protection. This vision expressed in the Declaration helped and strengthened the implementation of the importance of the tri-modal focus on sustainable development.

Sustainable Development Agenda, which contains 17 Sustainable Development Objectives (ODS). Accordingly, according to ONU (2016), these ODS are integrated and indivisible, and blend, in a balanced way, the three dimensions of sustainable development: economic, social and environmental. Thus, the intention of the United Nations is to strengthen this tri-modal vision of sustainable development that has been established since the beginning of 2002 and for that purpose developed in the period of 2015 these 17 ODS, as expressed in table 1 and representing according to the ONU (2016), an ambitious set that goes beyond the 17 objectives, unfolding in 169 defined goals and developed through a broad dialogue considered unprecedented among UN member states, local authorities, civil society, private sector and other interested parties.

**Relation of ODS to the safety of retention dams:** After a brief explanation about the definition of retention dams and later a brief study on the concept of sustainable development, in this topic we aim to show the relationship of ODS to the safety of retention dams. Among the 17 ODS, it was possible to identify a relationship with 13 of them that are connected with the

**Table 1. Sustainable Development Objectives - Adapted from ONU (2016)**

ODS - OBJECTIVES OF SUSTAINABLE DEVELOPMENT		
ODS-1	Poverty Eradication	End poverty in all its forms, everywhere
ODS-2	Zero Hunger and Sustainable Agriculture	End hunger, achieve food security and improve nutrition, and promote sustainable agriculture
ODS-3	Health and wellness	Ensure a healthy life and promote well-being for all, in all ages
ODS-4	Quality education	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
ODS-5	Gender equality	Achieve gender equality and empower all women and girls
ODS-6	Drinking Water and Sanitation	Ensure the availability and sustainable management of water and sanitation for all
ODS-7	Clean and affordable energy	Ensure reliable, sustainable, modern and affordable access to energy for all
ODS-8	Decent Work and Economic Growth	Promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
ODS-9	Industry, Innovation and Infrastructure	Build resilient infrastructures, promote inclusive and sustainable industrialization and foster innovation
ODS-10	Reducing Inequalities	Reduce inequality within and between countries
ODS-11	Sustainable Cities and Communities	Making Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable
ODS-12	Responsible consumption and production	Ensure sustainable production and consumption patterns
ODS-13	Action Against Global Climate Change	Take urgent action to combat climate change and its impacts
ODS-14	Water in Life	Conservation and sustainable use of oceans, seas and marine resources for sustainable development
ODS-15	Earth Life	Protecting, restoring and promoting the sustainable use of terrestrial ecosystems, sustainably managing forests, combating desertification, halting and reversing land degradation and halting biodiversity loss
ODS-16	Peace, Justice and Effective Institutions	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
ODS-17	Partnerships and Means of Implementation	Strengthen the means of implementation and revitalize the global partnership for sustainable development

As expressed by Nascimento (2012), the focus on the three dimensions occurs in the following sense: in the first, the economic dimension is proposed as the increase of efficiency of production and consumption with increasing economy of natural resources; in the second dimension, the social approach presupposes that a sustainable society must allow all citizens to have the minimum necessary for a decent life and that no member should absorb goods, natural resources and energy that are harmful to others; Finally, in the third one, we address the environmental dimension that has in its essence the guiding principle that production and consumption occur in a way that ensures that ecosystems can maintain their self-repair or capacity for resilience. Nascimento (2012) highlights other dimensions of sustainable development, but will not be mentioned in this work, since this approach will follow the UN's understanding, in particular, what was developed at the United Nations Summit on Sustainable Development in 2015 and attended by 193 countries that adopted the 2030

safety of dam retention dams. This relationship occurs directly and / or indirectly, as shown in Figure 1. It can be observed, according to figure 1, that the safety of retention dams is closely related to the ODS and when conditions for their implementation in the mining field are not met, several damages to sustainable development can occur through its numerous consequences related to collapse of a structure, either in an overflow, rupture among other mechanisms. Finally, it is worth noting that the Brazilian legislation establishing the National Dams Security Policy is based on the fact that the safety of a dam directly influences its sustainability and the extent of its potential social and environmental effects. This foundation demonstrates how this policy is related to sustainable development when put into practice. That is, we can consider the following premise, if a mining company that owns tailings dams adopts the PNSB, then it is already contributing with a portion to obtain a Sustainable Development in the way touted UN.

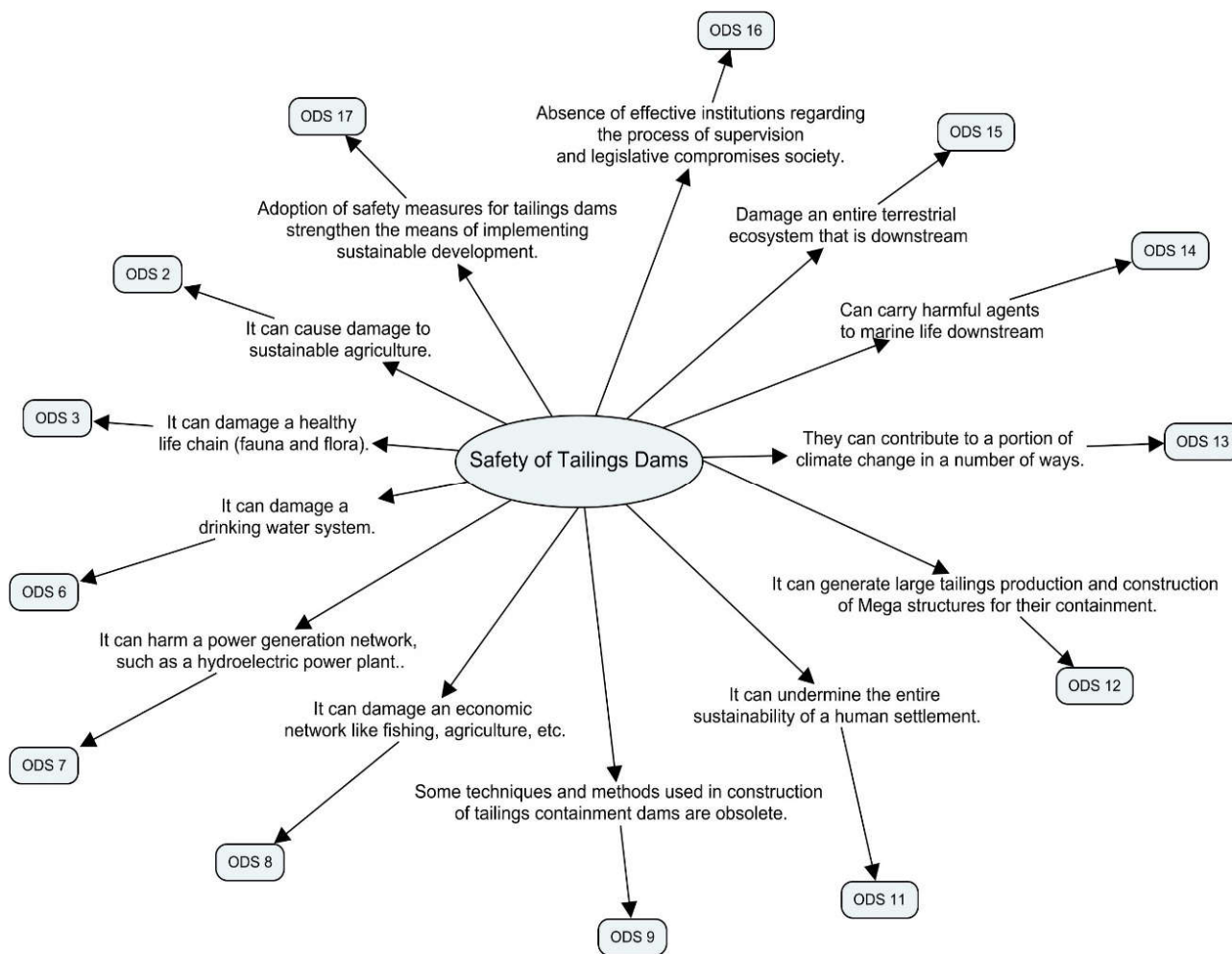


Figure 1. Relation flow diagram of ODS with the theme of safety of retention dams

Table 1. Instruments of the PNSB - Adapted from BRAZIL (2010)

PNSB instruments	
1	System of classification of dams by Category of Risk and by Associated Potential Damage;
2	DamSafetyPlan (PSB);
3	National Information System on Dam Safety (SNISB);
4	National Information System on the Environment (SINIMA);
5	Federal Technical Register of Environmental Defense Activities and Instruments;
6	Federal Technical Register of Potentially Polluting Activities or Users of Environmental Resources;
7	DamsSafety Report.

**A relevância da PNSB para o atendimento dos ODS e consequentemente do desenvolvimento sustentável:**

According to the ONU (2016), national governments have a strong role to play in meeting Agenda 2030 for Sustainable Development, and it is emphasized that this is concretely achieved through the creation of a strong commitment to provide adequate legal and institutional frameworks, as well as financial capacity. In this sense, it should be noted that since 2010, the Brazilian government and Brazilian society have made great progress in dam safety at the national level, and consequently this is contributing considerably to the progress of the Sustainable Development Agenda 2030, as regards the part of Brazil related to the implementation of a policy for the safety of retaining dams. In fact, it should be pointed out that this law precedes the establishment of ODS, but it is very important, since it indicates concrete practices to implement, evaluate and control the safety of retention dams. Thus, in short, in 2010 enters into force the federal law 12.334. It establishes the National Dams Safety Policy (PNSB) and creates the National Information System on Dams Safety.

This law covers dams intended for the accumulation of water for any use, the final or temporary disposal of tailings and the accumulation of industrial waste. For a dam to be inserted in this policy, it must have at least one of the four criteria: Height of the mass, counted from the lowest point of the foundation to the crest, greater than or equal to 15 m (fifteen meters); Total capacity of the reservoir greater than or equal to 3,000,000 m³ (three million cubic meters); Reservoir containing hazardous waste according to applicable technical standards; Category of potential damage associated, medium or high, in economic, social, environmental or loss of human life. One of the most important elements of this regulation are the seven PNSB instruments, which are mentioned in table 2. These instruments are fundamental to reach the several objectives of this legislation, among them, they are mentioned: To guarantee the observance of dam safety standards in order to reduce the possibility of an accident and its consequences; and foster a culture of dam safety and risk management. The creation of this legislation represents a relevant landmark for the security of dams in Brazil. According to Mello and Piasentin. (2011),

this law was the fruit of more than 30 years of work involving professionals of renowned knowledge and entities concerned with this subject, such as CBDB (Brazilian Dam Committee), ABMS (Brazilian Association of Soil Mechanics and Geotechnical Engineering) and others. Finally, it can be concluded as a valuable conclusion that the adoption of the PNSB by the mining companies is an important step towards the implementation of a concrete safety practice of retention dams, especially as far as mining companies are concerned, and this allows a contribution to meeting Agenda 2030 for Sustainable Development. However, there is a gap in Brazilian legislation. What happens to dams that are less than 15 meters high, a reservoir with a capacity of less than 3 million cubic meters, do not contain hazardous waste and / or that present low associated potential damage? Should I ignore safety at dams under these conditions?

In fact, Brazilian legislation establishes a gap for mining companies by creating these four criteria for inclusion in the PNSB, since it failed to standardize a framework that would allow the framing of retention dams that do not conform to the PNSB criteria.

Based on this reality, the question arises: How is the panorama of retention dams in southeastern Pará State regarding the adoption of PNSB?

**Brief overview of retention dams in the Southeast of Pará-Brazil:** In this context, it is important to highlight that according to ANA (2017), the National Mining Agency was able to register all mining dams on its responsibility. Thus, it is clearly defined that the southeastern mesoregion of the state of Pará presents all of its retention dams classified by DNPM. However, not all dams were entered in the PNSB. According to information extracted from the last classification of mining dams (DNPM, 2016), there are 55 mining waste containment dams in this mesoregion, being only 31 dams that are included in the PNSB, the others are not inserted because they do not meet some of the four criteria for inclusion in the PNSB. Thus, as shown in figure 2, approximately 44% of the total retention dams of mining tailings in the southeastern mesoregion of Pará are not included in the PNSB. This fact raises the concern in the following sense, how are dam safety policies being established for these 24 dams in southeastern Pará, since they are not suitable for PNSB?

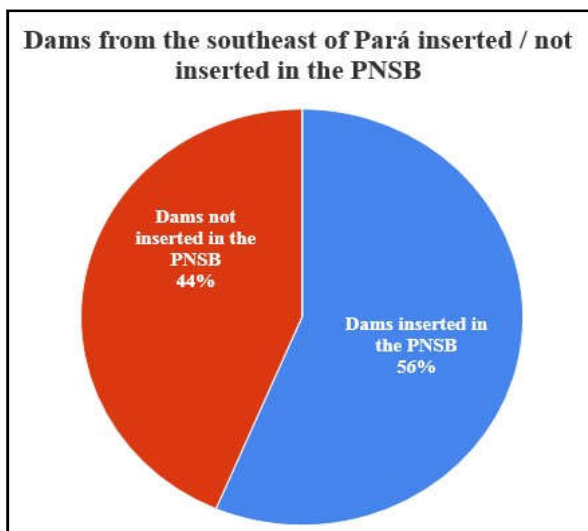


Figure 2. Graph of the percentage relation of dams inserted in the National Policy of Security of Dams

## Conclusion

Mining tailings containment dams are structures relevant to the mining process. They show an evolution in the tailings disposal process. As Mello and Piasentin (2011) pointed out, for a long time the tailings of mining were highlighted without any kind of environmental concern. The development of the rebar bus method provided environmental advantages such as the organization of the tailings at a predefined location and with a planned structure that is in keeping with the need for storage. Based on this and the need to look for ways of development, the work is proposed based on the concept of sustainable development and its relation with the theme of dam safety. In this article, some definitions on sustainable development were addressed, but it was decided to adopt the definition constructed by the UN throughout the 1980s, 1990s, 2000s and 2010s. The year 2015, presented a milestone for the theme of sustainable development advocated by the UN. This year, it became clear that this Organization addressed sustainable development in a more practical way, through the creation of the Sustainable Development Objectives (ODS). These 17 ODSs can be related to the safety of dams in at least 13 of them. In Brazil, the main indicator for the verification of the safety of dams is the inclusion of the miners in the PNSB. The PNSB's practice by the mining companies and the control and control of this process by the government, makes it possible to conclude that both the government and the mining companies included in the PNSB are involved with a share of the ODS contribution to the Sustainable Development Agenda 2030.

However, the government creates a gap in the PNSB when it establishes the four criteria for inclusion in this policy, since it does not develop a mechanism to fit dams that do not meet these criteria. Based on this, we focused the study on the mesoregion of southeastern Pará, composed of 39 municipalities and of great relevance for the national market, as highlighted by Brandão, Castro and Neto (2017). This meso-region can be seriously undermined by the gap created by law 12334/2010. In addition, it is not contributing fully to the ODS and observing because this focus is failing to contribute to a sustainable development effectiveness, since there is no way to determine the type of dam safety policy that the miners included in the gap adopt. Thus, according to figure 2, 44% of the dams in southeastern Pará belong to this gap of law 12334/2010. This fact is detrimental to the compliance with the Agenda 2030 of the Sustainable Development established by the UN, since it does not contribute with ODS. Therefore, it is believed that it is up to the government to provide an adequate solution to this gap.

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