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CHAPTER 25

Interfaces of Transformative Innovation Policies, Socio-environmental Justice and Circular Economy: a focus on the Brazilian Semiarid Region

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Abstract

Transformative Innovation Policies (TIPs) represent a novel approach that links innovation with societal and environmental challenges during the transition towards low-carbon systems. This framework illuminates the interplay between political dynamics and socio-environmental equity, especially in regions marked by resource scarcity and unequal distribution. A prime example is Brazilian semi-arid area, characterized by resource limitations leading to unhealthy practices like using hazardous firewood for cooking. The Biodigestor Sertanejo Program, a result of collaboration among the Brazilian Government, the UN's International Fund for Agricultural Development (IFAD), and the Global Environment Facility (GEF), has been operational since 2008 to promote sustainable production in this region. This research focuses on this initiative, leveraging TIPs, social/environmental justice, and circular economy literature to analyse policy documents. Through assessing intervention goals and project execution data, the study aims to gauge the efficacy of the program in providing technological innovation access, fostering stakeholder engagement, and ensuring a socially and environmentally equitable transition.

Keywords: Transformative Innovation Policies; Justice; Circular Economy, Sertanejo Biodigestor Program

The Chapter addresses the issue of inadequate access to essential resources in the Brazilian semi-arid region, causing precarious living conditions. TIPs are proposed to connect innovation with social and environmental challenges, aiming for an equitable transition to sustainable low-carbon systems within the framework of CE.

25.1 Introduction

In recent years, the circular economy (CE) concept has gained popularity as an effective way to reduce the harmful impact of linear economic models on the environment (Stahel, 2016, Kirchherr et al., 2017; Geissdoerfer et al., 2017). However, although the CE model is widely considered to be a response to ecological issues, some have pointed out its failure to consider the social consequences of this model (Padilla-Rivera et al., 2021). The social implications of CE models have received insufficient attention, perhaps due to a lack of conceptual clarity (Mies

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and Gold, 2021). This indicates that there is an emphasis on the productive aspects of the economy, which has given rise to many criticisms of the CE model (Kopnina, 2019; Temesgen et al., 2021). The CE has great potential to address environmental concerns, but is sometimes negligent in the social pillar (Blomsma & Brennan, 2017). Thus, it is necessary to develop discussions committed to evaluating the social ramifications of the CE model that addresses social challenges. Against this background, the research is framed within the multidimensional framework proposed by the JUST2CE project, emphasizing the need for a comprehensive evaluation of the CE transition. The framework comprises four key dimensions: framing, vulnerability, distribution, and learning. Framing involves understanding how different actors interpret and shape the CE transition, while vulnerability delves into the social and epistemic injustices present within CE discourse. Distribution examines the geographic and social inequalities associated with CE policies, while learning emphasizes the importance of participatory approaches and reflexivity in knowledge production. These dimensions are interconnected, promoting a holistic understanding of the complexities of the CE transition. The framework encourages a critical examination of power dynamics, marginalized voices, and global inequalities within the context of the CE implementation. Inserted in the CE dynamics is biogas. Biogas production is an excellent approach that helps reduce waste and mitigate greenhouse gas emissions, showing the use of a CE model (Wang et al., 2021). In the Brazilian scenario, CE is seen very positively in contexts of scarce resources, as is the case of the Semiarid Region. It is a region that faces serious socioeconomic difficulties, such as poverty, limited economic diversity and lack of access to safe ways of cooking. These challenges significantly limit income generation and employment prospects for communities in the region (IPEA, 2019). Biogas has been seen as an alternative to face the environmental, social and economic challenges that developing regions are subject to (Diouf & Miezán, 2019). Committed to contributing to this problem, the Sertanejo Biodigestor Program seeks to promote this form of energy as a solution to social issues in the Brazilian semi-arid region. This biogas promotion policy serves as an excellent approach to a CE, since, through the use of biodigester technology, rural organic waste is treated for the production of cooking gas and fertilizers (Silva & Correia, 2020).

This research aims to evaluate the effectiveness of the Sertanejo Biodigestor Program in promoting access to technological innovation, with attention to the dimensions of distribution, participation and recognition of EJ (EJ). Thus, this study seeks answers to the following research question: *How can the Sertanejo Biodigestor Program be evaluated in relation to its strengths and weaknesses considering the dimensions of distribution, participation and recognition of Environmental Justice?* By analysing the connection between energy justice and transformative innovation policies from a case study, this research can help public policies and initiatives committed to ensuring an equitable and sustainable transformation in rural areas. By pointing out the challenges and opportunities of this policy, this study also sheds light on the prospects for promoting social and EJ in the promotion of biogas in a context marked by major environmental, economic and social problems.

25.2 Literature review

25.2.1 EJ and its dimensions

The distribution of natural resources has been widely discussed in recent years, as it relates to the production or intensification of inequalities. The displacement of environmentally harmful activities in GS regions and the

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resulting "ecological debt" has triggered significant environmental distribution conflicts as highlighted by EJ advocates and scholars (Hornborg and Martinez-Alier, 2016; Martinez-Alier, 2021; Scheidel et al., 2018). These disparities necessitate acknowledgment and response within the frameworks of CE underscoring the importance of addressing global structural asymmetries. Apart from the geographical allocation of burdens and benefits, the concept of "justice" entails ensuring equitable access to resources and opportunities to rectify inequalities and vulnerability (Barca, 2020). Committed to discussing these disparities, EJ has increasingly approached complex dimensions of the social sphere (El Amrani, 2021; Lessmann & Steinkraus, 2019). The focus of EJ, in general, is on highlighting the environmental burden and lack of access to decision-making of economically, socially and politically marginalized communities (Pellow, 2021). In view of this, EJ is indicated as a promising approach to investigate aspects related to the development of the CE, with emphasis on the social dimension of these processes (Menton et al., 2020). Sustainable Development (SD) is increasingly linked to EJ (Schlosberg et al., 2019). Social justice, economic well-being and environmental management are interdependent dimensions so the EJ and the SD act from this discussion in the direction of revealing problems and finding solutions for the unequal distribution of natural resources and for the way in which this dynamic generates social marginalization in the context of environmental exploitation (Pellow, 2021). The questions mentioned above arise from the recognition that if not handled fairly, transitions towards sustainability (considering all dimensions) have the potential to impose unwarranted challenges on workers and their communities, potentially resulting in resistance that could impede the successful execution of required actions. From this standpoint, the concept of a "just transition," originating from the labor movement, takes on significant importance. Brian Kohler, a Canadian labor member, encapsulated this concept back in 1966 when he asserted, "*The real choice is not jobs or the environment. It is both or neither.*" This statement succinctly captures the essence of the just transition idea, which remains highly relevant in our current era marked by profound political polarization and the tension between employment and environmental concerns (Eisenberg, 2019).

Schlosberg's EJ theory (2004) contributes to the reflection on this theme, as it identifies three key issues to be observed: *distribution*, *participation*, and *recognition*. *Distribution* refers to the allocation of material goods and rights/duties among the members of society. *Participation* is related to decision-making, referring mainly to understanding how opportunities for participation by communities and individuals are made possible to demand EJ and equity in the distribution of environmental impacts. Finally, *recognition* refers to the inclusion of all subgroups in a society in any attempt at development and the explanation of how the most privileged groups achieved this status and why. Furthermore, it involves valuing cultural diversity and respecting the unique perspectives and experiences of affected communities. Schlosberg's structure (2004) can help answer the main criticisms of CE pointed out by the current literature. By bringing EJ into CE policies, weaker groups, such as precarious workers, would engage in the social and economic policies to be applied and the subgroups of a society, which should be included in any attempt at development. Known as the tripartite EJ framework, this theory provides a holistic and intersectional approach to understanding and addressing issues of EJ. Thus, it is recognized that EJ is not restricted to the distribution of environmental risks and benefits, but also involves complex issues of recognition and participation, essential to ensure equitable and sustainable environmental outcomes for all. By including EJ in CE policies, it is possible for policies to walk in fairer, more equitable and sustainable ways in relation to their impacts on people and communities. Thus, EJ is also increasingly linked to SD principles, as the social dimension is critical to ensure that a society is sustainable in environmental and economic terms.

25.2.2 Transformative Innovation Policies (TIPs) and their interfaces towards EJ and CE

The search for EJ has been one of the main demands of civil society, especially those communities that disproportionately suffer the negative effects of environmental imbalance (Liotta et al., 2020). In this context, it is important to understand how political and economic paradigms relate to the issue of EJ and how innovation policies can contribute to a more inclusive and sustainable approach. The political paradigm of TIPs has proven to be an alternative to deal with the current crises, by connecting innovation with social challenges and transformative changes, opening a new discursive space for discussions and policy advances (Diercks et al., 2019). The emphasis on the interactive nature of innovation allows bringing together different parts of the system for the development of innovation, including companies, cities, communities and organizations that can contribute to sustainable transitions (Geels, 2020). TIPs also aim to address failures in policy coordination and reflexivity that often impede the effectiveness of innovation policies. Failure to coordinate policies refers to the inability to horizontally coordinate policies in different domains, such as environmental policies, fiscal policies, economic, social and employment policies, which can generate inequalities and negative impacts on vulnerable communities (Akon-Yamga et al., 2021). These discussions point out that EJ involves social issues that must be included in the political agendas of innovation and technology. This means ensuring that innovation policies are inclusive and consider the needs of historically marginalized communities and social groups. Furthermore, it is important to consider that technological solutions are not enough to address issues of EJ. As Bullard (2021) points out, EJ requires a holistic and interdisciplinary approach that considers the social, cultural and political dimensions of environmental problems. This implies listening to and involving affected communities in political decisions and the construction of sustainable and inclusive solutions. The emergence of this new political paradigm, focused on connecting innovation with social and environmental challenges, points to the need for new solutions to deal with the current crises and for a more inclusive policy that involves different actors and considers different dimensions. In this context, the TIPs approach seeks to address flaws such as directionality, policy coordination, articulation of reflexivity and geographic dimensions, seeking to promote a transition to more sustainable practices. TIPs propose an innovative approach to deal with social and environmental challenges, through the connection between innovation and transformative changes. TIPs consider innovation as an interactive and social process, involving different stakeholders, including companies, cities, communities and organizations. TIPs thus aim to create an environment conducive to innovation and systemic changes that can lead to sustainable and inclusive transitions (Schot & Kanger, 2018). It is important to remember that this approach argues that an emphasis on the interactive nature of innovation allows the connection between different parts of the system for the development of innovation (Geels, 2020; Diercks et al., 2019). The approach of the TIPs is important for the discussion on EJ, since it considers the inclusion of different actors and the concern with the social and environmental dimensions in the innovation policy.

In this study, we examine TIPs and their role in disseminating this technology as a strategy to drive and enhance the adoption of biogas technology in Brazil. Therefore, by adopting the perspective of TIPs to analyze this case, we recognize that this initiative goes beyond simple technology promotion but encompasses systemic changes, addressing economic, institutional, and social challenges to drive the adoption and positive impacts of biogas technology in small rural properties in the Brazilian semiarid region.

25.3 Materials and Methods

In this section, the methodological aspects related to the analysis of the Sertanejo Biodigester Program will be presented from the participation, recognition and distribution dimensions of Schlosberg's theory (2004) on EJ.

25.3.1 Case Study

The Biodigester Sertanejo Program is a social initiative that aims to contribute to the sustainable development of the Brazilian semi-arid region (Carvalho & Lago, 2020). Although the first biodigesters of the Program were delivered in 2009, this social technology has reached a larger number of families in recent years, through a biogas production system from rural waste, used as a source of energy to cook food and as a fertilizer that spread throughout Brazil. The Program is part of a larger project known as Dom Helder Câmara. The project is funded by the International Foundation for Agricultural Development (FIDA) and the Brazilian government, the initiative developed actions with around 54,000 families from 913 municipalities that live in the Brazilian semi-arid region by offering technical assistance and social promotion, coordinating and implementing actions that seek to training to improve income and promoting economic, social and organizational autonomy (Barros et al., 2020).

Figure 25.1 show that the low-cost sertanejo biodigester is a simple system that uses the anaerobic decomposition of organic waste to produce biogas. Approximately 2,000 biodigesters have already been constructed, and additional projects are in progress to further disseminate this technology in the region, thousands of people to benefit from it. Installed close to sources of organic waste, such as animal manure and food waste, the technology consists of an excavated pit lined with impermeable materials. It consists of four boxes: inlet box, fermentation box, gas storage tank and outlet box. Organic waste is added through an inlet and undergoes anaerobic fermentation inside the biodigester, resulting in the production of biogas, which is used by households for cooking, while its effluent can be used as organic fertilizer (Mattos & Farias, 2011).



Figure 25.1 Sertanejo biodigester built in the Brazilian semi-arid region. Source: Mattos & Farias (2011)

The socioeconomic vulnerability of the rural population in the northeastern semi-arid region has intensified due to successive increases in the value of cooking gas derived from oil. For these reasons, the population has more frequently used firewood and/or charcoal to cook food, even though this practice involves serious risks to the health and safety of these communities (Gioda, 2019). The Biodigester Sertanejo Program is, therefore, one of the

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social technologies supported by the Dom Helder Câmara Project that contributes to the generation of clean and renewable energy in rural communities in the semi-arid region, reducing dependence on fossil fuels and improving the quality of life of local families (Barros et al., 2020).

The Biodigestor Sertanejo was implemented in several communities in the Brazilian semi-arid region with the aim of contributing to improving people's quality of life and preserving the environment (Calgaro Neto & Souza de Oliveira, 2022). The semi-arid region is characterized by long periods of drought, scarcity of water resources and low soil fertility. These conditions make food production difficult and make the lives of residents of the region quite challenging (Silva et al., 2019). The Brazilian semiarid occupies 12% of the national territory and is home to around 28 million inhabitants divided between urban (62%) and rural (38%) areas (**Figure 25.2**). Therefore, it is one of the most populated semi-arid regions in the world (INSA, 2022). Almost 80% of all rural establishments present in the Brazilian semi-arid region are characterized as family farming, which corresponds to 37.1% of the segment in Brazil (IBGE, 2017). More than half (59.1%) of Brazilians living in extreme poverty live in this region, which also has lower human development indices, which take into account indicators of longevity, education and income (SUDENE, 2021).

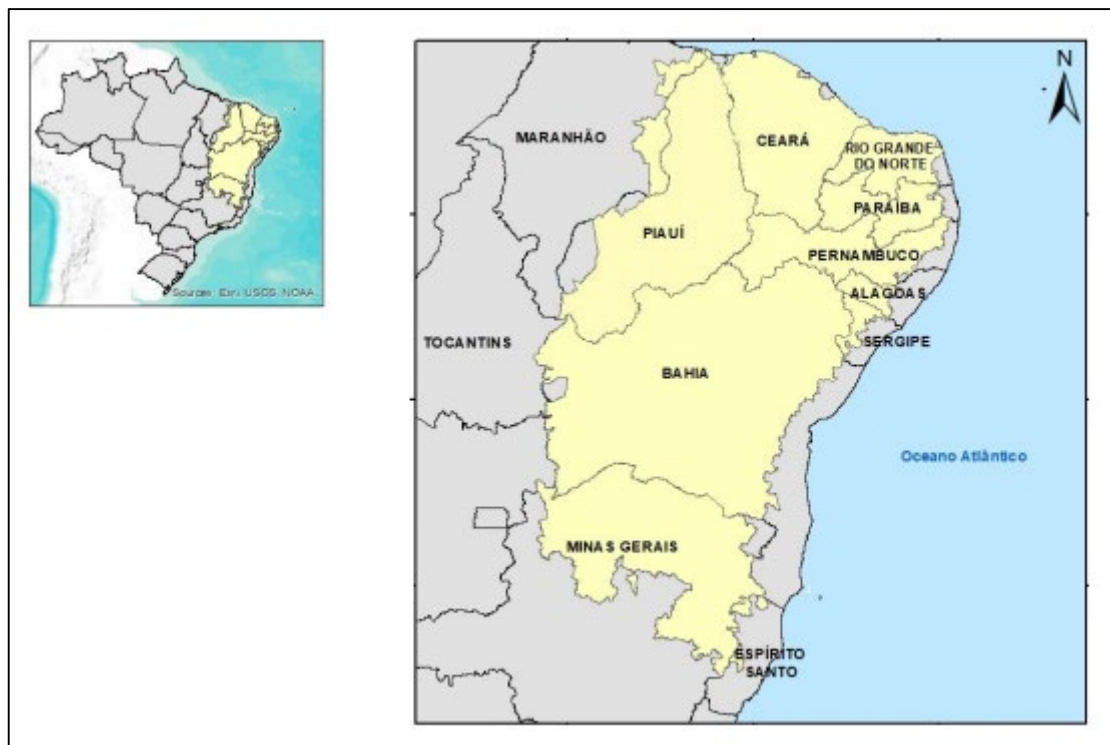


Figure 25.2 Brazilian Semiarid Map. Source: SUDENE (2021)

The municipalities that make up the Brazilian semi-arid region have a hot and dry climate and an economy based mainly on family farming (Bezerra et al., 2020). The Sertanejo Biodigestor Program was applied in rural communities in the Brazilian semi-arid region due to the challenges faced by the region. Geographic characteristics and difficulties in accessing clean and renewable energy sources are some of the main problems that rural communities in the semi-arid region have to live with. For this reason, policy makers saw the Sertanejo Biodigestor Project as a viable and sustainable alternative for generating clean and renewable energy, which can be produced from rural waste, resources that are abundant on family farms.

In addition, 75% of rural households in the region do not have an adequate treatment or disposal system for sewage which, in general, is dumped into rudimentary pits, ditches, or directly into the ground, or into streams, rivers or lakes (IBGE, 2017). These problems represent a serious public health and environmental problem, since improperly treated sewage can contaminate the soil, groundwater, rivers and lakes, in addition to increasing the risk of diseases.

25.3.2 Data collection and analysis

In our exploratory study, we used a qualitative data analysis approach through a case study to reach an understanding of the weaknesses and strengths of the initiative characterized by the Sertanejo Biodigestor Program based on the dimensions of Schlosberg's (2004) tripartite approach to EJ. We compiled relevant literature and examined published documents, including scientific articles, reports, theses and dissertations, video content from social networks, and materials produced by the government, civil society organizations, and the media about the Program's work. Data were categorized with specific descriptions and active searches were carried out for strengths and weaknesses, experiences, stakeholders, policy decisions and important events that related to the

Program. This process involved several detailed readings of the texts to identify themes based on Schlosberg's (2004) conceptual framework for EJ.

Based on what the author proposes about approaching the dimensions of recognition, distribution and participation, we seek to understand how politics seeks to intervene in these questions of justice. Using EJ's tripartite structure, we defined categories of analysis based on Schlosberg's (2004) proposal in a systematic and organized way through the elaboration of a matrix (see **Table 25.1**) that relates the criteria to the dimensions of recognition, distribution and participation.

Table 25.1 Analysis dimensions based on Schlosberg's criteria (2004)

Dimension	Aspects analyzed
Participation	<ol style="list-style-type: none"> 1. Involvement and active participation of local residents in the program implementation process. 2. Conducting training and technical assistance actions for local communities. 3. Existence of reports of positive impacts on the quality of life of local residents arising from the implementation of the program.
Recognition	<ol style="list-style-type: none"> 4. Respect and appreciation of local culture and traditions by the Sertanejo Biodigestor Program. 5. Existence of dialogue and negotiation with local communities to identify their needs and demands. 6. Consideration of local residents as partners in the program implementation process.
Distribution	<ol style="list-style-type: none"> 1. Promotion of equitable distribution of benefits generated by the program. 2. Fair and equitable distribution of benefits generated by the program among local communities. 3. Seeks to reduce socioeconomic inequalities and promote sustainable development in the region.

Source: The authors based on Schlosberg (2004)

We chose papers based on their alignment with our research objective. Searches in the databases took place on 04/05/2023. We searched for the terms "Biodigestor Sertanejo and Semiárido" and "Biodigestor Sertanejo and

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Semiárido" (in order to gather texts written both in Portuguese and in English) in the Scopus, Web of Science, Google Scholar and Periódicos Capes databases to raise academic publications that explored dimensions of this policy. In order to access news published by the media and by civil society organizations, a more extensive search was carried out in the Google search engine with the filter "news", from the same term. We also searched for content published on the Government of Brazil website to access policy documents. We also conducted a survey on the YouTube social network, where civil society organizations, government and universities produced videos with content about the Program.

We did not make time restrictions in our searches and we chose to consider documents published since the beginning of the Program's activities. We included 19 documents (9 academic studies and 10 documents from civil society organizations) during the analysis, using the Snowball technique, as recommended by Biernaki and Wandorf (1981), due to the potential that these texts had to support the study.

In the end, we obtained a result of 159 documents, however some exclusions were made, either due to identified repetitions (12) or because the contributions were not useful for our investigation (64). Our content analysis, therefore, was performed from 95 documents. Information on searches is systematized in **Table 25.2**.

Table 25.2 Search mechanisms and number of documents

Document source	Amount	Excluded	Total
Academic studies			
Web of Science	1	0	1
Scopus	0	0	0
Capes periodicals	3	1	0
Google Scholar	40	9	31
Added by the snowball technique	9	0	15
Repeated	-	12	0
News, Reports and Videos			
Google search engine	36	12	28
Videos	15	7	8
Government Website	45	23	22
Added by the snowball technique	10	0	10
Total partial	96	42	54
Total	159	64	95

Source: authors'elaboration

Documentary research based on the analysis matrix that considered Schlosberg's tripartite structure provided important subsidies for the analysis of the Sertanejo Biodigestor Project. The adoption of systematic and organized criteria presented in Table 1 allowed a more rigorous and reliable analysis of the social impacts in which the project intends to intervene.

25.4 Results and discussions

In this section, we present the results and discussions of the documentary analysis carried out on the Sertanejo Biodigestor Program, from the perspective of EJ. By evaluating the dimensions of participation, distribution and recognition, we seek to understand how the program has been implemented and what socio-environmental impacts have been generated for farming families in the Brazilian semi-arid region.

25.4.1 Scientific literature

In this analysis, we evaluate the participation, recognition and distribution of the Program's actions explored in the academic literature published in the searched databases. The literature review pointed out that one of the fundamental criteria for the success of a community program is the participation and active involvement of local residents. Regarding the Sertanejo Biodigestor Program, several articles highlight the involvement of the community in the implementation of actions (De Souza et al., 2021) in which initiatives were identified that enabled a participatory process of building the program. Queiroz (2015) and Barros et al. (2021) explore the mobilization of community leaders and local associations with the implementation of the Program, which contributed to the dissemination of technologies and the training of residents. In addition, another important criterion is the carrying out of training and technical assistance actions for local communities. In this regard, several studies point to the importance of the qualifications and training offered by the Sertanejo Biodigestor Program. For example, the study by Gama et al. (2018) highlights that technical training was fundamental for the autonomy of communities in the management of biodigestors, in addition to generating income and improving the quality of life of residents Silva and Correia, 2020; Barros et al., 2021). Finally, another important criterion is the existence of reports of positive

impacts on the quality of life of local residents resulting from the implementation of the Program. Several articles highlight the benefits generated by the Sertanejo Biodigestor Program, such as reducing environmental impacts, improving public health and generating employment and income (Bezerra et al, 2020; Santos, 2023; Salzer, 2018 and Gama, 2018). The recognition and appreciation of local culture and traditions are fundamental aspects for the success of community programs. Gama (2018) highlighted the importance of considering the local culture. As for the criterion characterized by the existence of dialogue and negotiation with local communities to identify their needs and demands, in the academic studies analyzed, reports of dialogue actions with local communities to understand their needs and demands before the implementation of the Program were not identified, only during the implantation of the biodigester and after. This proves to be a bottleneck for the initiative, as knowledge of the needs of communities in terms of waste treatment and the choice of the most appropriate technologies for each location is important for the effectiveness of the policy. Equitable distribution of benefits generated by the program is an important criterion for ensuring social justice and promoting sustainable development in the region. Several studies highlight the importance of promoting the equitable distribution of benefits generated by the program, as pointed out by Barros et. al (2020) and Calgaro Neto & Souza de Oliveira (2022) when highlighting that the Biodigestor Sertanejo Program contributes to the social inclusion of the community. In addition, these studies indicated that the implementation of the program promoted the reduction of environmental impacts, improvements in public health and in the quality of life of local residents. In general, it is possible to state that the analyzed literature also highlighted that the Sertanejo Biodigestor Program promoted actions in the dimensions of participation, distribution and recognition.

25.4.2 Analysis of news, reports and videos

Based on the analyzes carried out on the news published about the Biodigestor Sertanejo Program, it is possible to verify that the dimension of recognition of the JE has been contemplated in a significant way. The news, in general, highlight the importance of the program for the generation of clean energy and organic fertilizer in rural

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communities in the Brazilian semi-arid region, highlighting the adaptation of technology to local conditions and sertaneja culture (Renova Semiárido, 2020; Aberje, 2018). However, regarding the dimension of participation, the news has some limitations, as had already been observed in the analysis of academic productions. Although the documents highlight that farmers contributed to the construction and operation of biodigesters (IFRN, 2013 FBB, 2015, UFPB, 2022), none mentioned community participation in the decision-making process, nor in defining the best technology or choosing of the criteria that determined who would benefit from the Program. This may indicate a limitation in the engagement of different sectors of the community and compromise the sustainability and effectiveness of the program. Regarding the distribution dimension, the news presents some challenges. Although they all highlight the economic and environmental benefits of technology for rural communities in the Brazilian semi-arid region, no mention was made of the measures adopted to ensure the equitable distribution of environmental and social benefits and burdens among the different social groups involved. This limitation may indicate the need to improve the policy for distributing the benefits generated by the program. Schlosberg (2004) points out that a common problem in many rural communities is the lack of recognition of traditional knowledge and practices in relation to agriculture and environmental management. This was a positive point observed during the content analysis of the documents, there is mention of initiatives related to the Program that seek to value and strengthen these practices, including meetings of farmers that promote the exchange of experiences between different rural communities. Regarding the dimension of participation, another common problem in many rural communities is the lack of effective engagement in decision-making processes related to the management of natural resources and the implementation of public policies. Several analyzed texts mention projects and initiatives that seek to increase the participation of rural communities in these areas such as water management actions carried out, including by women in the region (Governo de Sergipe, 2021).

In addition to news, various actions and dimensions of the Program were explored through content published by the government and civil society organizations, either through reports, opinions or through content published on the YouTube social network. Analysis of these documents provided important information about how the program is being implemented and what its implications are for EJ. The analysis of the Biodigestor Sertanejo videos identified three recurring themes: i) the collaboration between rural producers and the program team, ii) the reduction of poverty and iii) the contribution to sustainable rural development, and the installation and maintenance of biodigestors by rural producers. These documents showed that the collaboration between rural producers and the Biodigestor Sertanejo team is crucial to the success of the program, but that it is not always possible to make this interaction viable (Diaconia, 2016; LATACS TV, 2021).

There are videos that point out that rural producers are encouraged to collaborate with the program, either through the installation of biodigestors or by publicizing the program to other rural producers, a concern that converges with the distributive dimension of JA, which seeks equity in the distribution of environmental benefits and respective risks (Diaconia, 2014; Experimentador do Sertão, 2022). In this sense, the dimensions of the EJ can be seen as useful analytical tools to assess whether a sustainable development project or program is fair or not.

Analyzing these dimensions can help identify whether environmental benefits and costs are equitably distributed across different social groups, whether there is adequate participation and inclusion of affected communities in environmental decisions, and whether cultural identities are valued and recognized. In the case of the Sertanejo Biodigestor Program, the distribution of benefits is highlighted in several analyzed documents. In addition, the documents point out that the savings provided by the use of biodigestors generated extra income for the family, including cases in which families began to receive extra income from the sale of food products provided by the

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ease of access to gas for cooking or commercialization. of organic fertilizers produced by the biodigester on its own properties.

The reduction of cooking gas costs and the production of biofertilizers were pointed out as the greatest benefits of the program (Diaconia, 2016). Although the analyzed documents demonstrate distributional and participation concerns, there is little evidence of concern with the recognition dimension. This can be attributed to the limited nature of these documents, which generally focus on technical and practical aspects. However, the lack of attention to the recognition dimension is problematic because it neglects the cultural and social aspects of the communities involved in the program.

25.4.3 Strengths and Weaknesses of the Sertanejo Biodigester Program in terms of TIPs

The Biodigester Sertanejo Program has contributed to the promotion of sustainable technologies in the Brazilian semi-arid region, with the main objective of producing renewable energy and reducing the environmental impacts caused by the use of fossil fuels. However, like any program or public policy, Biodigester Sertanejo has strengths

and weaknesses that must be considered when assessing its impact on the communities and social groups involved. In the distribution dimension, we observe how the analyzed documents seek to present a positive image of biodigesters, emphasizing their environmental and economic benefits. However, there is no critical reflection on the limitations and challenges of using biodigesters, such as obstacles to the need for technical and financial training of farmers and dependence on transport and logistics infrastructure for the use of biogas. There also does not seem to be an effective concern with cases in which the family stops using the biodigester. The analyzes allow us to perceive a constant movement of ratification of the positive side of the Program and the way in which the initiative can contribute to the reduction of energy and input costs, with emphasis on the potential economic benefits for farmers. However, there is no critical reflection on how the use of biodigesters can reinforce farmers' dependence on institutions or companies that provide technologies for biogas production, for example, or on specialized technical assistance to operate. This dimension of Schlosberg's model is a point of attention, since, even if social technologies are important to ensure that aspects of justice are observed, they can maintain the unequal distribution of power and resources between different social groups. Power is a crucial aspect of EJ, as marginalized communities are often relegated to opportunities to participate in decision-making processes that directly affect their own lives. In the case of the Sertanejo Biodigester Program, it is important to examine in future research whether these power relations are producing or maintaining injustices. The videos and news reviewed often feature technical experts explaining biodigester technology and how it works. While this information is important, it is also important to ensure that the voices of project-affected communities are heard and that they have a say in how the project is implemented. In general, although the full participation of the community in the stages that precede the implementation of the Project has not been identified, the active participation of local residents in the process of implanting the biodigester, carrying out training actions and technical assistance for local communities were identified in reports of positive impacts on the quality of life of farmers and demonstrate the Program's commitment to promoting sustainable development in the region. The analysis of the documents pointed out that the events in which the appreciation of the local culture is mentioned is not enough to guarantee the full approach of the dimension of recognition of the JE. The posture of the government and the organizations involved in relation to the dimension of recognition of the EJ could be more robust, for example, in proposing

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broader partnerships with local cultural groups. The continuity of the program should consider maintaining these relationships and promoting the equitable distribution of benefits to local communities, thus ensuring its long-term sustainability. Finally, it is necessary to highlight the importance of cooperation between different actors and institutions involved in the program, including civil society organizations, universities, research institutions and government agencies. Collaboration between these different actors can contribute to identifying innovative solutions and improving the program, in addition to strengthening the articulation and support network for male and female farmers.

25.5 Conclusions

The Biodigestor Sertanejo Program is an important initiative in the search for sustainable solutions for the environmental and social problems of the Brazilian semi-arid region. By providing an alternative for producing clean energy from organic waste, the program promotes EJ by acting directly to reduce the negative environmental

impact and improve the living conditions of rural populations. The Sertanejo Biodigestor Program has made efforts to involve farmers and their families in the process of implementing biodigestors, promoting training and offering technical assistance. However, there are still limitations on how farmers' participation is effectively incorporated into the program, especially in terms of decision-making and priority setting, that is, in the steps that precede technology deployment. It was identified that the program has the potential to contribute to the reduction of socioeconomic inequalities in the region, providing a source of renewable energy and financial savings for family farmers. However, there is a need to assess more broadly how the program is being distributed geographically and across different socioeconomic or gender and racial groups to ensure that inequalities are not perpetuated or even exacerbated. Finally, in the recognition dimension, the program demonstrates a limitation in recognizing and valuing cultural diversity and the identities of the communities involved. A greater effort is needed to ensure that the approaches adopted in the program are sensitive to cultural differences and respect local specificities, so that the program is truly inclusive and sustainable. Thus, it is important that the Sertanejo Biodigestor Program promote more robust actions to strengthen the recognition dimension, through consultation and involvement of local communities in the design and implementation of the program, valuing their traditional practices and knowledge, and promoting gender equity. and social inclusion. Only then will it be possible to ensure that the program is effectively transformative and sustainable in the long term. An important limitation of this study to be mentioned is that the documents may not have been able to provide an in-depth understanding about the Program, due to its scope and complexity. At the same time that this is imposed as a limitation, it also reinforces the recommendation for future research that strives to expand this study, for example, through interviews, so that other points of view are explored in the context of this policy.

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