10.18605/2175-7275/cereus.v14n3p258-277

ARTIGO ORIGINAL

<< Recebido em: 07/08/2022 Aceito em: 19/07/2022. >>

REVISTA CEREUS ISSN: 2175-7275

Centroid model applied for energy scenarios in regions with limited resources

Modelo centroide aplicado a cenários energéticos em regiões com recursos limitados

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ABSTRACT

The necessity of energy renewal sustained by the use of clean and renewable sources is a worldwide reality, the current efforts that direct these natural resources, increasingly linked to the growth of global energy demand, have a direct impact on the environment. This energy production also has a relevant contribution to the economy and, consequently, to the quality of life of the people present in these production spaces, especially in regions with high levels of social fragility, increasingly present due to the pandemic scenario caused by COVID-19, in this sense, considering the mapping of several economic and social indicators, the study seeks to meet the need to increase energy production in regions with great natural potential but low socio-economic development through a mathematical model based on centroids, identifying optimal location as a parameter for the implementation of renewable power plants in the State of Bahia, aiming to broaden the discussions on the social impacts of these investments and that dialogue with a reality present in several countries around the world.

Keywords: Sustainability. Energy. Economy. Clustering.

RESUMO

A necessidade de renovação energética sustentada pelo uso de fontes limpas e renováveis é uma realidade mundial, os atuais esforços que direcionam esses recursos naturais, cada vez mais atrelados ao crescimento da demanda energética mundial, têm impacto direto no meio ambiente. Essa produção de energia também tem uma contribuição relevante para a economia e, consequentemente, para a qualidade de vida das pessoas presentes nesses espaços de produção, principalmente em regiões com altos níveis de fragilidade social, cada vez mais presente devido ao cenário de pandemia causado pela COVID-19, nesse sentido, considerando o mapeamento de diversos indicadores econômicos e sociais, o estudo busca atender a necessidade de aumentar a produção de energia em regiões com grande potencial natural, mas com baixo desenvolvimento socioeconômico por meio de um modelo matemático baseado em centroides, identificando a localização ótima como parâmetro para a implantação de usinas renováveis no Estado da Bahia, visando ampliar as discussões sobre os impactos sociais desses investimentos e que dialogam com uma realidade presente em diversos países do mundo.

Palavras-chave: Sustentabilidade. Energia. Economia. Agrupamento

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1. INTRODUCTION

The global energy landscape has been showing important changes, with signs that these transformations will keep pace in the coming decades. It is already possible to observe short-term actions that can accelerate the transitions to a clean and renewable energy matrix (Borges et al., 2022).

At the same time, several researches have been carried out with the objective of expanding the existing possibilities in renewable energy sources (Silva et al., 2020); (Murari et al., 2020), and how it - energy - can play an important role in solving the dilemma of increasing energy production capacity, minimizing interference with the environment. However, exceptional circumstances experienced with the COVID-19 pandemic required caution regarding the scenario of the global energy matrix, including those from renewable sources (Cozzi el al., 2020);(Wanner and Wetzel, 2020); (Ijjas, 2021).

Furthermore, recent projections indicate that there will be a 30% growth in global energy demand by 2040, with increased electrification transforming traditional ways of meeting this demand. Clean energy technologies are expected to satisfy around 40% of the predicted growth and solar energy is expected to become the cheapest source of electricity in many countries (Cozzi et al., 2020). Large-scale changes are expected to include rapid deployment and declines. accentuated in the costs of the main renewable energy technologies.

In this context, the benefit of the public policies that directly impact cost, mencioned above, is added. These transformations, observed in the Brazilian market (Nascimento et al., 2018); (Nascimento et al., 2021); (Nascimento et al., 2022); (Murari et al., 2019) on the need for changes aimed at reducing fuel prices, also proves transformations of energy systems in terms of people's quality of life and their importance in terms of public services playing a relevant role in the construction of socioeconomic well-being (Moore and Collins, 2020); (Leal Filho, 2020). On the other hand, the strong assumption of a relationship between prosperity and access to electricity, observed mostly in industrialization countries, Table 1, represents a challenge for societies, since there are still societies in the 21st century that do not enjoy the luxury to have light in their homes (Zahnd and Kimber, 2009).

Table 1. Production and Energy Consumption of the most industrialized countries in 2019.

Rank	Consumption[1]	Production[2]	Manufacturing[3]
1	China 6875.0886	China 123.591	China 28.7%
2	USA 3989.3782	USA 101.437	USA 16.8%
3	India 1229.3877	Russia 64.281	Japan 7.5%
4	Russia 942.8954	Saudi Arabia 27.861	Germany 5.3%
5	Japan 903.6987	Canada 23.517	India 3.1%
6	Canada 552.6221	Australia 18.851	South Korea 3.0%
7	South Korea 539.9822	India 17.785	Italy 2.1%
8	Brazil 533.8517	Indonesia 17.059	France 1.9%
9	Germany 517.3033	Iran 16.085	UK 1.8%
10	France 449.2354	Brazil 12.713	Indonesia 1.6%

Fonte: Adapted from:
[1] Electricity net consumption (billion kWh). Energy Informatiion Administration - EIA
[2] Total energy production (quadrillion Btu). Energy Information Administration - EIA
[3] Global Manufacturing Output (% global). GLOBAL Update

According to the World Bank (2020a), the pandemic scenario caused by COVID 19, linked to the challenges imposed by climate change, should drive the increase in extreme poverty in many countries, including Brazil, which has stood out in a scenario of social vulnerability that increasingly pushes towards social and economic distancing, is what the Global wealth report 2021 produced by Credit Suisse (2021) points out. Among the various highlights, the document notes that in 2020, only 1% (one percent) of the Brazilian population holds 49.6% of all the wealth in Brazil.

As a way to quantify a statistical index that bears his name - Gini Index, in 1912 by the Italian mathematician Conrado Gini, with the objective of establishing a mathematical relationship on existing income inequalities, an index that, according to the World Bank, Table 2, has Brazil among the 15 (fifteen) countries with the worst Gini coefficients (Thomas, Wang and Fan; 2001); (World Bank, 2020b)

Table 2. GINI Index World Bank Estimative.

Rank	Country	Most Recent Year	Most Recent Value
1	South Africa	2014	63.00
2	Namibia	2015	59.10
3	Zambia	2015	57.10
4	Central African Republic	2008	56.20

5	Eswatini	2016	54.60
6	Colombia	2020	54.20
7	Mozambique	2014	54.00
8	Botswana	2015	53.30
9	Angola	2018	51.30
10	St. Lucia	2016	51.20
11	Zimbabwe	2019	50.30
12	Panama	2019	49.80
13	Costa Rica	2020	49.30
14	Congo, Rep.	2011	48.90
15	Brazil	2020	48.90

Fonte: Authors.

Notwithstanding the inequality scenario presented through the Gini index, it is possible to observe, through the Human Development Index (HDI), that the Northeast region of Brazil presents an unfavorable situation, placing, according to the Atlas Brazil ranking, of the 6 (six) last states of Brazil, 5 (five) belong to the Northeast region, they are: Bahia 21°, Sergipe 22°, Piauí 24°, Maranhão 25° and Alagoas 26°.

This social distancing, identified through the Gini and HDI indices, is intensified within a context of social vulnerability when the regions of Brazil are also observed, Figure 1, is what the Atlas of Social Vulnerability of Brazilian Municipalities points out on the Social Vulnerability Index (SVI) in Brazilian macro-regions (IBGE, 2022), which corresponds to a complementary index to the HDI, being constituted by a set of 3 (three) dimensions, they are: Urban Infrastructure; Human Capital and Income and Work.

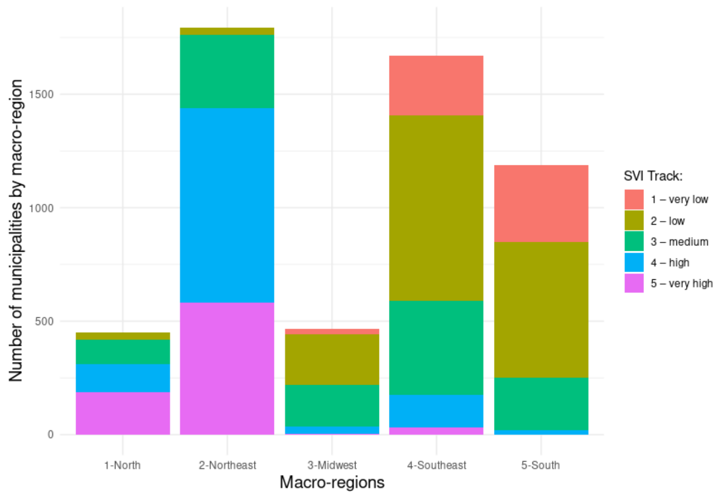

Figure 1. Number of Municipalities by Macro-region and SVI Range in 2010.

The SVI, which is calculated on the average of several indices represented by the dimensions mentioned, in the Northeast has a percentage of 80.1% of municipalities in the two highest ranges of social vulnerability, this region, which represents a conjuncture of social fragility, demands a more human look, which deal with the need for investment aiming at a process of minimizing these distortions.

These unfavorable data presented for the Northeast region contrasts with the entire potential of renewable energy production in the region, especially for Bahia, which according to the National Energy Plan (PNE) 2050 (Ministério de Minas e Energia), corresponds to the second largest producer of wind energy in Brazil, with data obtained from several sources and published in 2013, but which, currently, according to data obtained by the State Government of Bahia (2022a), Bahia has consolidated itself in the leadership not only in the generation of wind energy, as well as in the generation of solar energy throughout the country.

This expansion process provides not only an advance in terms of expanding the energy potential developed in the state and which brings contributions to the entire country, but also a capacity for social transformation resulting from the large number of direct and indirect jobs that can generated with this implementation, which can be evidenced through the figures presented by the Economic Development Secretariat (SDE) of the State of Bahia.

Faced with this divergent reality, considering the territorial dimension existing in a state like Bahia, with territorial realities that diverge within the state itself, but with a territorial division consolidated within the place itself, through a division process defined and presented by the Superintendence of Economic and Social Studies of Bahia known as Territories of Identity, Figure 2, it is suggested the insertion of indicators that dialogue with technical issues of implementation, but also with elements that are inserted within a socioeconomic context that converge to a more human look, through the inclusion of elements that aim to take decision-making process within the energy expansion process suggested by the PNE.

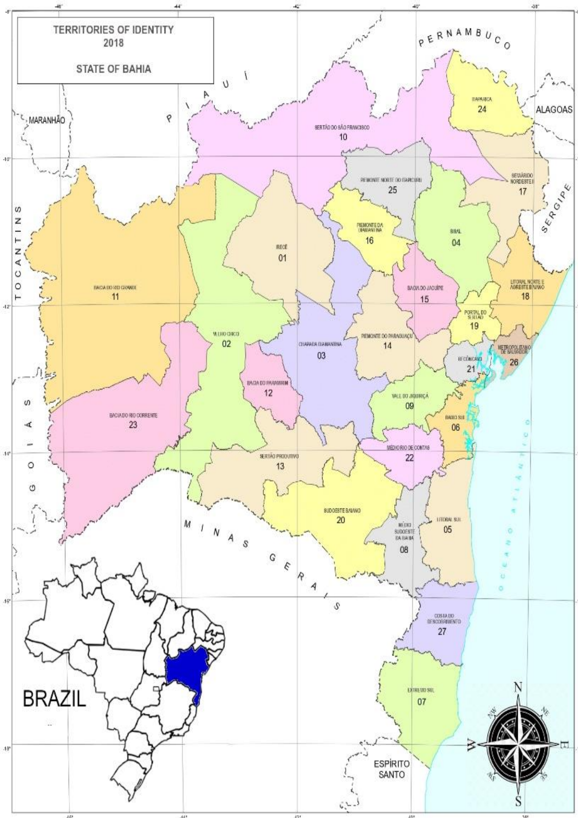

Figure 2. Map of Territories of Identity in the State of Bahia.

This more humanized model, corroborates to reduce the existing socioeconomic disparities in several countries, evidenced by the presented indices, but that can be better observed within an empirical process about the cruel reality that some people are subjected, ranging from lack or precariousness from basic services such as education and health, to inability to access or food precariousness.

In this sense, from the combination of the HDI, Gini and SVI indicators, in Chapter 2, the materials and methods that consolidated the combination of results will be presented, which will complement the criteria for decision-making aiming at the implementation of electric plants in the State of Bahia, considering the socioeconomic elements that affect the improvement in the quality of the social welfare state in the region. In chapter 3, the results obtained through the cut-off lines of the indices that support the research. In chapter 4, the discussions about these results built from a social and economic point of view through the mathematical representations used in the composition of the socioeconomic model and, finally, in chapter 5, the final considerations about the study, pointing out future advances, as well as the directions for other decision-making techniques.

2. MATERIALS AND METHODS

The state of Bahia has a territorial area of 564,760 km^2, this number puts Bahia in similar conditions to countries like France. Such dimensions characterize the need for a model that seeks to meet the different socioeconomic realities characterized by territories of identity, as mentioned above (IBGE, 2022a/b); (Bahia, 2022b).

The mapping carried out through the indicators used (Gini and HDI) on the territories of identity of Bahia, allows us to observe these places from a distance, which leads us to a different look at the evaluation of the territories of identity when comparing these indices (Atlas, 2022)

By establishing a visualization model represented by quadrants, Figure 3, through the average between the worst and the best scenario for both indices, highlighted by the highest Gini indices and the lowest HDI indices of Municipalities (HDI-M), we have a negative highlight for the 2nd quadrant in relation to the Furthermore, this leads to a perspective of worse socioeconomic representation in the region, which leads to a more focused look at the territories of identity that are represented by this specific quadrant.

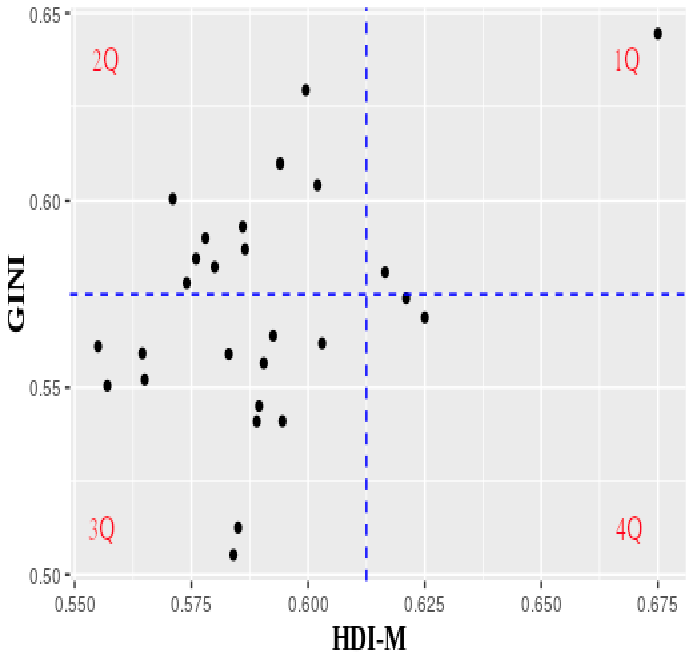

Figure 3. Graph represented by quadrants on the Gini Indices and the HDI-M

It is worth noting that the graphic representation of the relationship between the Gini index and the HDI-M was built on the data obtained from the SEI portal for the Gini index, with the values compiled by territories of identity by the SEI itself, but for the HDI-M, a transposition of the grouping of the value of each municipality in Bahia within its respective territories of identity, thus, the analysis of the boxplot graph, Figure 4, presents the profile of each of the 27 territories of identity, considering the HDI grouping by municipality.

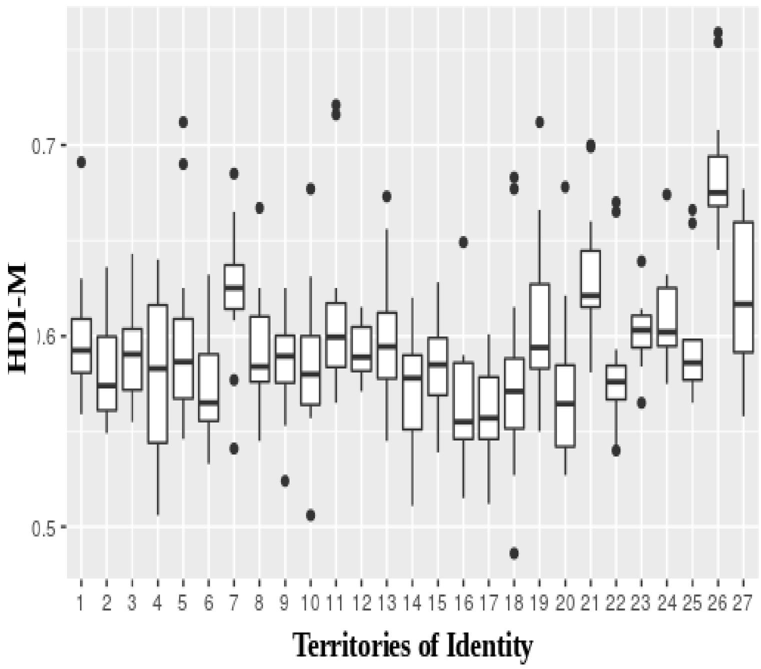

Figure 4. Distribution of HDI-M within the Territories of Identity in the year 2018.

In this grouping relationship, it is possible to identify in the graph a disproportionality over some municipalities, represented by the isolation of the points that do not touch the diagram box but that compose their respective territory of identity. These outliers, whether in a higher or lower form, represented by some municipalities, lead us to an average reflection supported by the need to eliminate these outliers, thus, for the construction of the values that compose the identified elements in the cut-off lines, the calculation of the median of the municipalities was used to obtain the crossing values for their respective territories of identity.

2.1. Territories of Identity Selection Criteria

In view of the crossing of the data presented on the Gini and HDI-M indices acting on the territories of identity inserted in the State of Bahia, considering the financial impact on the municipalities inserted there in the face of socio-economic collapse caused by COVID-

19 pandemic scenario pointed out in the Global wealth report 2021 produced by Credit Suisse, driving the increase in extreme poverty in the world, the indices that stand out most negatively on the defined locus were established.

The state of Bahia, according to the Brazilian Institute of Geography and Statistics (IBGE), has an HDI of 0.660; placing the State within a range of “Average Human Development” and “Low Human Development”, this situation, when applied to the data set of the municipalities that make up its territories of identity, considering the data presented in function of the last census carried out in the year of 2010, it can be seen that only the Metropolitan Territory of Salvador has a higher index than the one indicated in the state (United Nations Development Progamme, 2014).

As a support for the ratification of this reality, when the focus falls on the municipalities present in these territories of identity in the State of Bahia, it is possible to establish a scenario where the reality of several municipalities leads to a condition of “Low Human Development”, with rates below 0.550 ; in contrast to municipalities that are in an interval constituted between a “High Human Development” and “Average Human Development”, with indices that reach 0.759; like the city of Salvador.

Due to this existing social distance, from the same calculation conditions presented to obtain the HDI of the territories of identity of the State of Bahia, through the use of the Median, the limit of 0.5865 was obtained for the calculation of these values as a result of the operation on the total of the values obtained in the HDI of the territories of identity, defining indices equal or smaller in relation to the total HDI-M for the choice of territories of identity of the State, establishing a cut-off ratio for the choice of territories.

Considering the same criteria established for the calculation of the HDI cut-off line, the median of the values was used for the Gini index, consisting of the interval between 0 (zero) and 1 (one), where the lowest values indicate a scenario of perfect distributive equality of income and the highest values as indicative of an unequal income distribution, considering the data collected and already compiled by the SEI.

In view of the presented scenario, values equal to or greater than 0.5688 were established as a result of the operation on the total of values obtained in the definition of the Gini index, defining the choice of territories of identity and establishing a cut-off ratio for the choice of these territories.

2.2. Selection Criteria for the Municipalities of Bahia

From the chosen territories of identity, still considering the existing levels of poverty and social inequalities, the SVI was used, which, according to the Atlas of Social Vulnerability in Brazilian Municipalities (Costa et al., 2015a) “seeks to highlight different indicative situations of exclusion and social vulnerability in the Brazilian territory, in a perspective that goes beyond the identification of poverty understood only as insufficiency of monetary resources”.

The SVI, developed with a set of 16 (sixteen) indicators with the divisions represented by a weight scheme for each item present in the aforementioned dimensions, has in its representation, a “sets of assets, resources or structures, whose access, absence or insufficiency indicate that the standard of living of the families is low, suggesting, in the limit, the non-access and non-observance of social rights” (Costa et al., 2015b).

This construction, which can be further explored in the Atlas of Social Vulnerability in Brazilian Municipalities, considering the weights used on each index and sub-index applied, results in, on the information that points to situations of exclusion and vulnerability, an interval that varies between 0 (zero) and 1 (one), with cuts between 0 and 0.200 for “Very Low Social Vulnerability”; from 0.201 to 0.300 for “Low Social Vulnerability”; from 0.301 to 0.400 for “Average Social Vulnerability”; from 0.401 to 0.500 for “High Social Vulnerability” and, finally, for values above 0.501, it constitutes a scenario of “Very High Social Vulnerability”.

Given the scenario presented, a value greater than to 0.500 was established; which represents the limit of the “Very High” social vulnerability interval, thus generating a cut-off relationship established on this limit for the values obtained in the SVI table (2010) of the municipalities (IPEA, 2022) that were defined in the composition of the territories of identity chosen to be used.

2.3. Cluster Mappings on the Selection of Municipalities Inserted in the Chosen Territories of Identity in the State of Bahia

Considering the capacity for social transformation resulting from the large number of direct and indirect jobs already highlighted by the SDE, but which conflicts with the financial impossibility of providing the implementation of electric plants in all the municipalities that are part of the cutting line, it was used from latitude and longitude elements of these chosen municipalities, a model that would allow serving these chosen locations through centroids that would establish optimal location points on sets of municipalities acting through a clustering model.

This distance relationship, identified by latitude and longitude points, resulted in a mathematical model developed through the K-Means clustering algorithm, which establishes the distances in each cluster. This relationship points to the fact that, after a certain number of clusters, investment in plants in the region is no longer viable, given that the distance between the municipalities and the number of plants in relation to this distance is no longer relevant, since there is no significant change, over the existing distance, for the sum of the distances of the municipalities present in each cluster in relation to its respective centroid.

This graphic representation demands the need to choose an optimal number of clusters, for that, two methods were chosen that point to this amount in order to establish the municipalities that would serve as a basis for the implementation of electric plants, they are:

- Elbow Method: Corresponds to a technique used to identify an optimal number of clusters in a given data set, this technique, according to Kodinariya and Makwana (2013), represents one of the most traditional methods in the search to obtain a optimal amount of cluster (K);
- Silhouette Method: As a complement to the Elbow method in the study, the Silhouette method proposed by Rousseeuw (1987) is used, which considers a widely used representation of the definition of the location of each centroid within its respective cluster. This method, which makes a comparison in relation to the number of clusters used and results in a value that can be used with any distance metric used, supports a choice model that results in the optimal cluster value considering mathematical models for the obtaining the result on the choice of the cluster quantity to be considered.

The graphic use of the two methods to obtain the results is constituted by the need to combine analysis models that could evaluate an intra cluster relationship, represented by the Elbow method, as well as the possibility of expanding this model to a scenario in which these relationships could consider the inter cluster effect on the values found, combining an intra and inter cluster relationship, represented by the Silhouette method, with the objective of analyzing the impact on the values found in each scenario (Chen, Rubin and Cornwall, 2021).

3. RESULTS

The composition on the two cuts obtained, with the Gini index equal to 0.5688 and the HDI equal to 0.5865, resulted in the indication of the territories of identity chosen and represented on the cut lines, Figure 5, acting in a specific space of the graph on quadrant 2, as a result of the worst socioeconomic indicators.

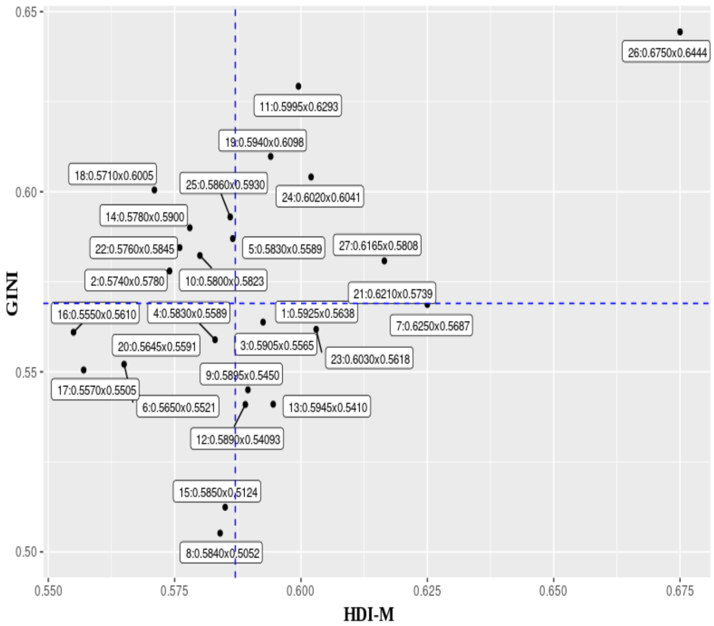

Figure 5. Graph on the cuts obtained for the Gini indices (0.5688) and HDI-M (0.5865) - Territory: IDH-M x GINI.

As a result of this cut-off line that characterizes the worst possible socioeconomic scenario on the territories of identity, considering the limits established in the methodology used, a total of 7 (seven) territories of identity that fit this condition are obtained, they are:

- Velho Chico (Territory 2);
- Litoral Sul (Territory 5);
- Sertao do Sao Francisco (Territory 10);
- Piemonte do Paraguaçu (Territory 14);
- Litoral Norte e Agreste Baiano (Territory 18);
- Médio Rio de Contas (Territory 22);

- Piemonte Norte do Itapicuru (Territory 25).

From the SVI presented in the methodology, which considers the High Social Vulnerability limit as the cut-off line for choosing the municipalities that will be part of the chosen set within their respective territories of identity, it was possible to identify within this set that make up these territories chosen, a total of 40 (forty) municipalities: Acajutiba, Aporá, Apuarema, Aramari, Arataca, Barro Preto, Boa Nova, Boa Vista do Tupim, Campo A. de Lourdes, Campo Formoso, Cardeal da Silva, Carinhanha, Crisópolis, Dario Meira, Filadélfia, Ibiquera, Itajú do Colônia, Itanagra, Itapicuru, Jandaíra, Lajedinho, Macajuba, Malhada, Manoel Vitorino, Mascote, Morpará, Oliveira dos Brejinhos, Pedrão, Pilão Arcado, Piritiba, Rafael Jambeiro, Santa Luzia, Santa Teresinha, São José da Vitória, Sátiro Dias, Serra do Ramalho, Sítio do Mato, Tapiramutá, Ubatã, and Una.

The application of clustering techniques supported by the coordinates of longitude and latitude of these 40 (forty) municipalities produced a clustering model that demands the need to choose an optimal number of clusters (K) in order to identify centroids for the implementation of the plants electrical. The changes in each geometric shape over the topological area, varying over the number of 2 to 7 clusters, produced a clustering model that results in the sum of the distances identified in each cluster, Table 3, a total that gives us makes it possible to observe, within a set of several factors, a sum of the distances that act within each cluster variation.

Table 3. Sum of Distances by Cluster Quantity (K).

K	Sum of distances
2	144.4839
3	63.83009
4	37.47275
5	20.83276
6	16.90524
7	16.57734

Fonte: Authors.

Supported by elbow methods, Figure 6 (a) and silhouette, Figure 6 (b), as a choice factor for an optimal “K”, considering the smallest distance element (Euclidean) over the centroids and their respective municipalities aiming at the installation of electric plants, it is noticed that the application of these methods suggests a value of 5 (five).

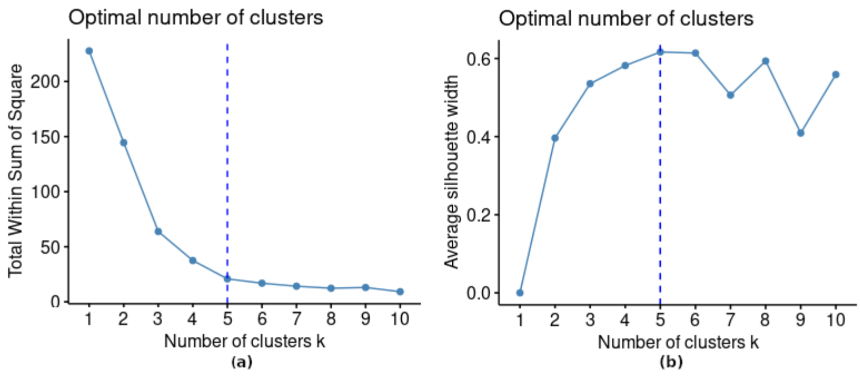

Figure 6. Elbow and Silhouette Method Applied to the Data Set of the Chosen Municipalities.

The clustering techniques presented on the set of data defined from the elements presented, considering the number K of clusters identified by the methods used, obtain a subset of 10, 5, 10, 12 and 3 municipalities on the 5 clusters, totaling the 40 municipalities chosen on the cut-off lines established in the study.

From the identification of latitude and longitude of the value of each centroid found, which represents a specific municipality in the State of Bahia, on the topological model supported by 5 (five) clusters, found through clustering techniques, Google Maps was used, to identify the municipalities that act on these centroids, Table 4, and that may host the implementation of electric power plants aiming at an improvement in the quality of life in the region and its surroundings.

Table 4. Centroids on the respective Municipalities (Google Maps).

Centroid	Territory	Municipal	Latitude	Longitude
1	14	Mundo Novo	-11.97500	-40.3600
2	2	Serra do Ramalho	-13.51800	-43.4940
3	18	Itamira (Apora)	-11.77100	-38.1960
4	5	Ibicarai	-14.79583	-39.6025
5	10	Saldanha (Pilao Arcado)	-10.35333	-42.9300

Fonte: Authors.

The choice based on the mathematical models that resulted in the identification of centroids through the clustering techniques used, represents a total of 5 (five) of the 7 (seven) selected territories, this construction, despite the exclusion of 22 (twenty-two) and

25 (twenty-five), there is a model that caracterizes a relationship of proximity over the chosen territories, Figure 7, abstracting the relationship of territory of identity and considering the factor smaller distance, joining municipalities of nearby territories to centroid that are outside the space identified by their respective identity territory, such as the Ibicaraí, Saldanha and Mundo Novo centroids.

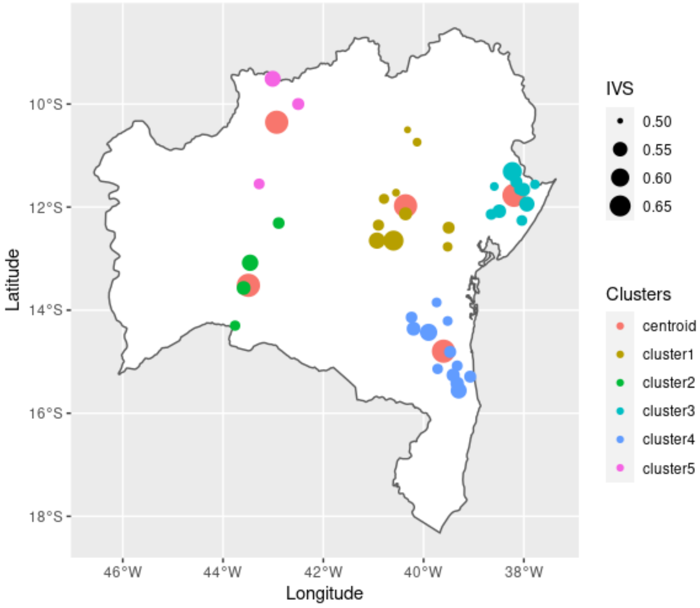

Figure 7. Positioning of municipalities with emphasis on the identification of centroids.

4. DISCUSSIONS

The mathematical path presented in the study constitutes a tool to support decision-making methods, the basis supported by international and local indicators reproduce, within a quantitative aspect, elements that dialogue with the social and economic representation of each region analyzed. The cut found from the numbers presented contrasting with the sustainable energy potential of the region, takes us to a look that transcends the technicality in the installation of electric plants.

The need to use sustainable resources, already evidenced through studies on the social, economic and environmental impacts of renewable energy systems (Akela, Saini and Sharma, 2009), points to a more varied economic activity with positive impacts on the economy in general, thus ensuring, a diversification of revenue but which, in its sustainable local availability, is an element to be considered.

This same study establishes as a criterion for sustainable and economic exploitation villages in remote areas, seeking in the local energy capacity, an improvement in the quality of life and income of the villager through the creation of jobs. This scenario, when compared to regions such as Bahia, demands the use of well-established criteria on distortions that derive from a distance present in the region itself, and which has in the state's capacity for sustainable energy production, a relevant element of social replacement, considering the impacts that an implantation of this nature produces in the regions identified by the controids, as well as in the entire surroundings represented by the clusters identified in the present study.

It is clear that installations of this nature are not limited to an, exclusively, social and economic process. Despite the purposeful limitation of the study, it is possible to observe, through the chosen quantitative route, that the identification of centroids leads to the inclusion of a logical and mathematical consistency on criteria that help decision makers to find social and economic aspects in the modeling of complexity of the relationships that consolidate the stages of a project with these characteristics.

The representation of the sum of the values found in each amount of cluster presented, through the Elbow and Silhouette methods that complement each other within a process of identifying an optimal number of clusters, ratifies a quantitative defined from a perspective that directs to an evaluation of the quality of optimal location points, bringing a model that can be explored not only in terms of physical location, but mainly as an example for a feasibility study of diversification and expansion of plants that can use all the sustainable energy potential of a region, for the construction of a hybrid matrix that considers the specific potential of each region.

These results obtained in the study, when submitted to a social perspective, seek to contribute to a better planning of public and private investments, aiming to meet the need to increase energy production in regions with great natural potential but still with low socio-economic development, optimizing thus, the return on investment considering the social impacts, in addition to the economic ones, and which are based on the need for the production of energy in its fullness.

5. CONCLUSION

The present study aims to broaden the discussions on a need present in several countries, especially Brazil. The unequal distribution of income associated with a scenario of social vulnerability highlighted by international indicators leads to a search that contemplates, within a universal need, discussions that involve a sustainable production of energy, with an impact on the environment, but linked to a context of economic development of regions that demand a more human look and that also contribute to the economic recovery, with impacts on several sectors that support the basic needs of a society, such as: education, health and culture.

Despite the impacts arising from this economic and social distancing being notorious, aggravated and potentiated under the gaze of an empirical reality of the subjects inserted in this context, it is possible to establish, within a mathematical model of measurement of this reality, through the international indices used, a bottleneck on the worst indices used with the objective of adding, within this unequal reality, elements that contribute to a reduction of this inequality, establishing cut lines that do not mean the best scenario of choice but that direct to the worst reality, scientifically proven.

The result of the techniques presented, supported by these indicators, could be used in countries that are placed in a situation of unequal income concentration, such as the Republic of Congo, which has a Gini index equal to that of Brazil, or even, through the use of the HDI, placing countries such as Bolivia (Instituto Brasileiro de Geografia e Estatística), which, in addition to the HDI reality close to that of the analyzed State - Bahia, also has a similar quantitative population.

The use of the SVI, which, as already mentioned, portrays a set of several indicators that expand the discussion on the local reality, constitutes an economic indicator that maps existing social inequalities and that helps to identify distortions, in this sense, other indicators locations can be used to represent cut-off lines, or even, through the compilation of all indicators, as presented in the study, glimpsing places where, effectively, it could represent an advance in public policies that guarantee a better quality of life for this universe needy population.

This model, built from the perspective of economic and social expansion, despite not considering the environmental, logistical, legal and political impacts of an implementation of this nature in the identified locations, could serve as a basis to enhance implementation choices in the identified centroid regions, bringing, as an example, tax incentives for implantations that considered these regions as possible centers for the installation of electric plants.

Furthermore, future studies may expand the investigation on the complexity of the centroids found, with the objective of inserting elements, already mentioned, that are outside the scope of this study. This contribution, although not limited to the energy scope, but envisioning a 30% growth in global energy demand by 2040, intensifies the looks at social inequality present in several countries.

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