Winds of Bahia: an analysis of the socioeconomic impacts of wind farms in Bahia municipalities

Carolina Silva Ribeiro[1]
Roberto Maximiano Pereira[2]
Gilca Garcia de Oliveira[3]

Abstract

The state of Bahia has a significant wind power potential, estimated at 195 GW for a height of 150m, is the leader in the contracting of wind energy in Brazil and has 23 municipalities with projects in implementation. Unlike the other states of the Northeast region, which has a higher incidence of coastal winds, Bahia concentrates its wind potential in the interior, more specifically in the semi-arid region that suffers from a scarcity of rainfall. In this sense, it is questioned how the implementation of wind farms in Bahia municipalities assists in the sustainable development of the semi-arid Bahia? Thus, this work seeks to evaluate the socio-economic impacts of the implementation of wind farms in Bahia municipalities with the advent of wind activity in the State. To do so, it uses the input-output matrix estimated by the Superintendency of Economic and Social Studies of Bahia (SEI) for the year 2015. The analysis will be based on an exploratory study of the impacts of wind activity in the sectors of economic activities inserted in the State of Bahia, through the use of input-output indicators (as a key sector, economic multipliers of employment and production, indices of Rasmussen-Hirschman intersectoral linkages, field of influence and hypothetical extraction of sectors), in order to investigate the creation of jobs and production associated with wind farms and, in turn, the wind energy production chain. The study will show how total production is used and how much direct and indirect jobs have the potential to generate by wind activity and its productive chain. The results of this article will enable us to understand how wind energy can make a significant contribution to the generation of jobs in several rural areas, promoting local and sustainable development.

Keywords: Socio-economic Impacts; Wind farms; Input-output; Sustainable development. Semi-arid region

1. Introduction

With more than 71 thousand km^2 of national territory with wind speeds above 7m/s, mainly in the Northeastern states of the country, Brazil has one of the largest wind potential in the world (BRAZIL, 2012). In the world ranking it is the 8th country in accumulated installed capacity (GWEC, 2018) and has an onshore wind potential greater than 500GW (ABEEÓLICA, 2017).

[1] PhD candidate – Federal University of Bahia – Economic Development Area – Bahia – Brasil, E-mail: minacarol@gmail.com
[2] Research Supervisor of the Intersectorial Relations Study Group and Coordinator of Economic Planning of the Secretariat of Planning of the State of Bahia, E-mail: roberto.pereira@seplan.ba.gov.br
[3] Associeted Profa. Federal University of Bahia – Economic Development Area – Bahia – Brasil, E-mail: gilca.oliveira@gmail.com

The development of wind energy in Brazil is remarkable, from 2009 to 2016 were invested in the wind power sector 32 billion dollars, and of that amount, 5,4 billion dollars were in 2016, which represented 78% of the total invested in energy renewable in the year in question (ABEEÓLICA, 2017).

Regarding the growth of the sources of electric power generation, in 2017, this was led by hydroelectric and wind power sources, which represented 47.86% and 29.62%, respectively (ABEEÓLICA, 2018). In terms of the wind power source, which is the object of this study, it already represents an 8.10% share in the Brazilian electricity matrix, and by the end of 2016 it was 7,12% (ABEEÓLICA, 2018).

In terms of representativeness and supply, the generation verified by the wind power source accounted for 7,44% in the average of all generation injected into the National Interconnected System (SIN), according to ABEEÓLICA (2018). In 2017, the five states with the largest generation were Rio Grande do Norte, Bahia, Rio Grande do Sul, Ceará and Piauí, respectively.

As for the residential supply by the wind power source, in 2017, on average, 22.4 million homes were supplied per month, equivalent to about 67 million inhabitants, that is, in comparative terms, the energy generated by this source was capable of supplying electricity to a population larger than that of the Northeast, which has more than 57 million inhabitants (ABEEOLICA, 2018). As for the installation of new wind farms, in the year in question, the states with the greatest emphasis in the implementation of new ventures were Bahia with 20 and Piauí with 19.

In this context, it can be noted that the states of the Northeast are representative in wind generation, since they concentrate the largest number of wind farms. And in the case of the State of Bahia, this has been a prominent role due to its significant wind power potential, estimated at 195 GW for a height of 150m (BRAZIL, 2015) and for the leadership in contracting wind energy in the country. Bahia has 23 municipalities with projects in implementation and has 182 projects marketed in the energy auctions of the National Electric Energy Agency (ANEEL) and another 52 projects marketed in the free market, totaling 234 (BAHIA, 2018). And, unlike the other states in the Northeast, which has a higher incidence of coastal winds, Bahia concentrates its wind potential in the interior, more specifically in the semi-arid region that suffers from a scarcity of rainfall. Thus, it is questioned how the implementation of wind developments in Bahia municipalities assists in the sustainable development of the semi-arid Bahia?

Therefore, the objective of this work is to evaluate the socioeconomic impacts of the implementation of wind farms in Bahia municipalities with the advent of wind activity in the State. To do so, it uses the input-output matrix estimated by the Superintendency of Economic and Social Studies of Bahia (SEI) for the year 2015. The analysis will be based on an exploratory study of the impacts of wind activity in the sectors of economic activities inserted in the State, through the use of input-output indicators as a key sector, economic multipliers of employment and production, indices of Rasmussen-Hirschman intersectoral linkages, field of influence and hypothetical extraction of sectors, in order to investigate job creation and production associated with wind farms and, in turn, the wind power production chain.

In addition to this introduction, the present study is divided into three more sections. The next section describes the methodology used, as well as the database. In the third section the results are presented and, finally, the fourth section brings the conclusions about the work.

2. Methodology and data

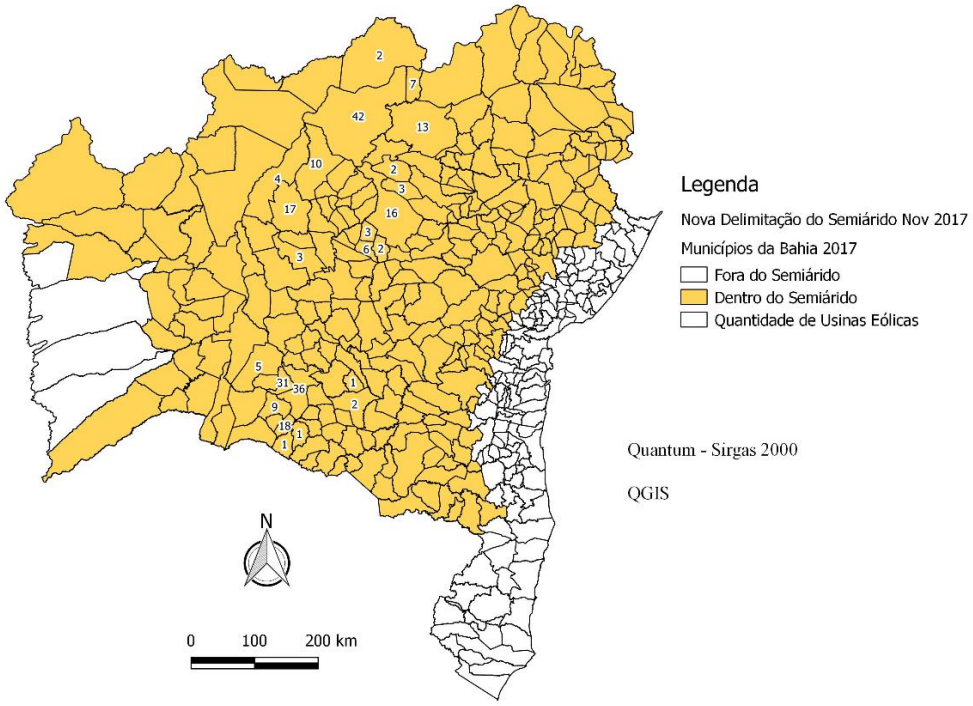
This section presents the methodological aspects of the construction of the Input-Output Matrices (MIP) in and out of the semi-arid Bahia, from the SEI Bahia 2015 matrix, the definitions of the main indicators extracted from the MIP, as well as the origin of the data used.

2.1 Characterization and location of the study area

This study analyzes the Bahian semi-arid (Figure 1), where the municipalities of the seven main areas with potential for wind farms in Bahia (Figure 2) are included: Area 1 - Sobradinho, Sento Sé and Casa Nova; area 2 - Region of the Serras Azul and Açuruá; area 3 - Morro do Chapéu; area 4 - Serra do Estreito; area 5 - Serra do Tombador (Serra de Jacobina); area 6 - Serra do Espinhaço (Caetité / Guanambi / Pindaí); and area 7 - Novo Horizonte, Piatã, Ibitiara and Brotas de Macaúbas mapped in the Bahia Wind Atlas.

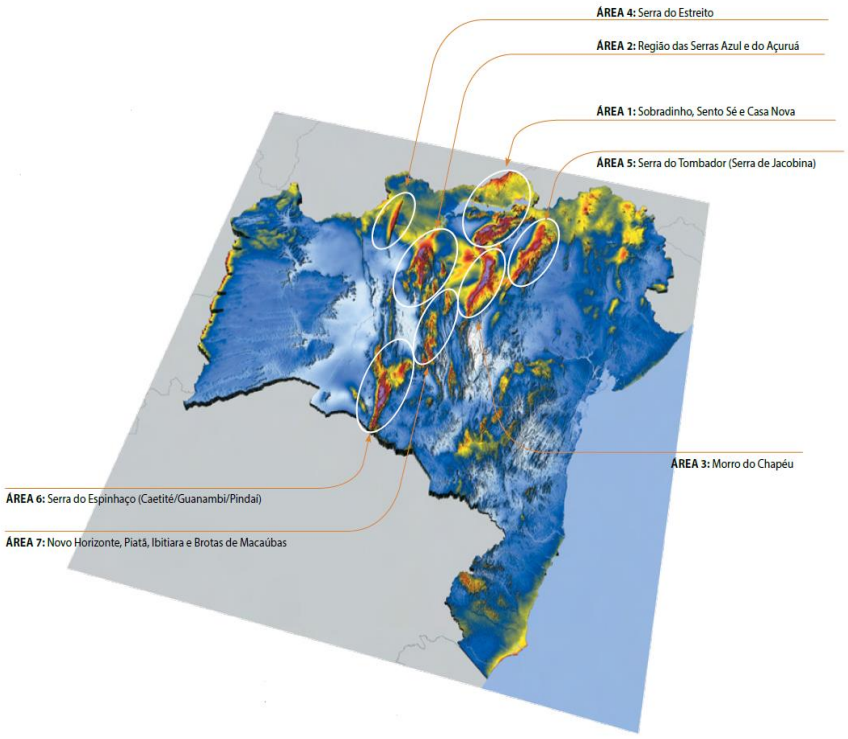
More than 66% of the State of Bahia is within the semi-arid, that is, of the 417 existing municipalities, 279 belong to the region. The semi-arid state of Bahia has an irregular occurrence of rainfall, leading to water scarcity. The majority of the population depends on animal husbandry and agriculture to survive. The region accounted for 51.4% in 2015. However, in terms of the participation of the Gross Domestic Product (GDP) at current prices, the services sector was the most representative with 40, 3%, against 11.4% of the agricultural sector. In 2015, the region produced approximately 33% of the state's GDP.

Figure 1 – New delimitation of the Bahian semi-arid with wind farms



Source: Prepared by the authors based on data from the Northeast Development Superintendency (SUDENE), Superintendency of Economic and Social Studies of Bahia (SEI) and Secretariat of Economic Development of Bahia (SDE), 2018.

Figure 2 – Main promising areas for wind farms in the State of Bahia



Source: CAMARGO-SCHUBERT, 2013.

The wind farms present in the region are located in the municipalities in Figure 1 and listed in Table 1. Wind power in the State has been gaining prominence. There are currently 102 projects in operation (2.526 MW), 71 under construction (1.581 MW) and 61 under construction (1.226 MW) (BAHIA, 2018).

Table 1 – Wind energy projects in Bahia

Municipalities	Company	Investment (R$)	MW	Qtde Power Plant
Bonito - BA	EDF/ENEL	184.436.150,00	40	2
Brotas de Macaúbas - BA	DESENVIX (STATKRAFT)	380.760.000,00	95,2	3
Brumado - BA	ENEL	293.842.200,00	60	2
Caetité - BA	BW GUIRAPÁ/IBERDROLA/RENOVA/RIO ENERGY	2.878.211.500,00	782,7	36
Cafarnaum - BA	ENEL	407.842.400,00	89,9	3
Campo Formoso - BA	ATLANTIC/ENEL	1.417.830.940,00	360	13
Casa Nova - BA	CHESF	251.745.500,00	52	2
Dom Basílio - BA	ENEL	146.921.100,00	30	1
Gentio do Ouro - BA	CER ENERGIA	1.787.791.360,00	416	17
Guanambi - BA	RENOVA	731.342.900,00	182,5	9
Igaporã - BA	ENEL/RENOVA	2.214.776.570,00	541,8	31
Itaguaçu da Bahia - BA	CGEOL	960.770.000,00	280	10
Lício de Almeida - BA	RENOVA	84.211.200,00	21	1
Morro do Chapéu - BA	ENEL/RIO ENERGY/PEC ENERGIA	1.836.266.000,00	452,9	16
Mulungu do Morro - BA	EDF	781.206.120,00	170,6	6
Ourolândia - BA	EDP	257.600.000,00	56	2
Pindaí – BA	BW GUIRAPÁ/GPEXPAN/RENOVA	834.162.740,00	272,8	18
Riacho de Santana - BA	RENOVA	371.288.030,00	94,8	5
Sento Sé - BA	BRENNAND/ENEL/RENOVA/TRACTEBEL	2.709.493.220,00	976,8	42
Sobradinho - BA	GESTAMP	798.098.000,00	188	7
Urandi – BA	RENOVA	72.000.000,00	18	1
Várzea Nova - BA	EDP	386.400.000,00	84	3
Xique-Xique - BA	CER ENERGIA	404.779.880,00	108	4
Grand total		20.191.775.810,00	5373	234

Source: BAHIA, SDE, 2018.

As for the productive chain of wind power in the State, this has been developing and is mostly outside the semi-arid region and is mainly concentrated in the metropolitan region of Salvador, according to Table 2.

Table 2 - Production chain of wind energy in the State

Municipalities	Company	Components and equipment
Camaçari	GE/Alstom	Naceles (wind generator rotor box)
Camaçari	Gamesa	Naceles and engines
Simões Filho	Acciona Windpower	Naceles, shovels and wind towers
Jacobina	Torres Eólicas do Nordeste (TEN)/Andrade Gutirrrez/Alstom	Wind towers
Camaçari	Torrebras	

Source: Prepared by the authors, 2018.

Because of this, the study analyzes the productive chain of both the Bahian economy as a whole and the semi-arid and semi-arid municipalities of the state. However, it focuses on the semi-arid Bahia to verify the impacts of wind activity. Thus, the following are described the methods adopted in the conduction of this work.

2.2 The input-output model

The input-output model, developed by Leontief, has as its fundamental objective to analyze the interdependence between the sectors of an economy. It consists of a system of linear equations, each one representing the distribution of one sector among the others, in the form of inputs, and the final demand, composed of household consumption, government, investment and exports.

The input-output model, summarized below, seeks to account for the contributions of the entire production chain to a given demand (MILLER and BLAIR, 2009). In matrix terms, the intersectoral flow in an economy can be represented by:

$$x = Ax + y \quad (1)$$

Where:

x and y are order columns vectors *(n x 1)*, with values, respectively, of the total production and the final demand of each sector.

A is the matrix of technical coefficients, order *(n x n)*.

Since the final demand is exogenous to the system, it has to be:

$$(I - A)^{-1} = B \quad (2)$$

$$x = By \quad (3)$$

Where:

$B = (I - A)^{-1}$ is the inverse matrix of Leontief or matrix of direct and indirect coefficients, order *(n x n)*, in which the element b_{ij} should be interpreted as the total production of the sector *i* which is required to produce a final sector demand unit *j*.

2.3 Rasmussen-Hirschman linkages indices, key sectors and dispersion index

From the inverse matrix of Leontief, $B = (I - A)^{-1}$, it is possible to measure the linkage of each specific sector to the rest of the economy through the backward and forward effects known as the Rasmussen - Hirschman bonding indices from the works of Rasmussen (1956) and Hirschman (1958). Backward linkage rates quantify how much a particular industry demands from other sectors. The forward linkage indices reveal how much the sector under analysis is demanded by other sectors of the economy. The calculation of these indices is also found in Guilhoto et al. (2010). These indices can be represented as follows:

Backward linkage (backward chaining):

$$U_j = \frac{(\frac{B_{*j}}{n})}{B_*}, \qquad j = 1,2,\dots,n \tag{4}$$

Forward linkage (forward link):

$$U_i = \frac{(\frac{B_{*i}}{n})}{B_*}, \qquad i = 1,2,\dots,n \tag{5}$$

Where:B_* is the average of all elements of B; B_{*j} is the sum of a column j of B; B_{*i} is the sum of a line i of B; *n* is the number of sectors of the economy.

The indices have unit (1) as the reference threshold for interpretation. Thus, if the backward linkage index is greater than 1, it means that the sector under analysis has a strong dependency on the other sectors in the economy in the demand for inputs. If the forward bond ratio is greater than 1, it means that the sector is important in supplying inputs in the economy. In summary, according to Prado (1981), when: $U_j > 1$ the industry has strong backward chaining power; $U_j < 1$ the sector has weak backward linkage; $U_i > 1$ the industry has strong forwarding power; $U_i < 1$ the sector has weak forward chain.

Sectors that have both high values ($U_j > 1\ e\ U_i > 1$) of the Rasmussen-Hirschman indices are considered key sectors for economic growth because they have a strong relationship with other sectors. However, since the values of the bond indices treat a

relationship between averages and these are sensitive to extremes, the dispersion coefficients proposed by Rasmussen are used in conjunction with these indices.

Rasmussen dispersion coeficiente backward:

$$v_{*j} = \frac{\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left[b_{ij} - \frac{1}{n}\sum_{i=1}^{n} b_{ij}\right]^2}}{\frac{1}{n}\sum_{i=1}^{n} b_{ij}}, \qquad i,j = 1,2,\dots,n \tag{6}$$

Rasmussen dispersion coefficient forward:

$$v_{i*} = \frac{\sqrt{\frac{1}{n-1}\sum_{j=1}^{n}\left[b_{ij} - \frac{1}{n}\sum_{j=1}^{n} b_{ij}\right]^2}}{\frac{1}{n}\sum_{j=1}^{n} b_{ij}}, \qquad i,j = 1,2,\dots,n \tag{7}$$

These coefficients reflect a measure of variation or dispersion, verifying the sector's spreading power over the other sectors of the economy. The lower the value of the coefficient, the relation of the sector with other sectors is homogeneous, that is, the power of chaining is more spread. On the other hand, high values indicate a strong link with few sectors. Therefore, the key sectors are those with the linkage indexes higher than one and low values of v_{*j} and v_{i*}.

2.4 *Fields of influence*

Field-of-influence analysis was developed by Sonis and Hewings (1989, 1994) as complementary to Rasmussen-Hirschman binding indices. For, even if they evaluate the importance of the sectors in terms of their impacts on the system as a whole, there is a difficulty in visualizing the main linkages within the economy (GUILHOTO, 2011). Thus, sectors with higher linkage rates, both forward and backward, would be associated with these links.

The concept of fields of influence shows how changes in the direct coefficients are distributed in the economic system, making it possible to determine which relationships between sectors would be more important within the productive process (GUILHOTO, 2011). For more details see Sonis and Hewings (1989, 1994). To obtain the influence fields, the following matrices are considered:

$A = [a_{ij}]$, matrix of direct coefficients;

$E = [\varepsilon_{ij}]$, matrix of incremental variations in direct input coefficients;

$B = (I - A)^{-1} = [b_{ij}]$, Leontief inverse matrix;

$B(\varepsilon) = (I - A - E)^{-1} = [b_{ij}(\varepsilon)]$, Leontief inverse matrix after the changes.

According to Sonis and Hewings (1989, 1994), if there is a small variation and in only one technical coefficient, that is, $\varepsilon_{ij} = \varepsilon, i = i_1, j = j_1 \; e \; \varepsilon_{ij} = 0, i \neq i_1, j \neq j_1$, then, under these conditions, the influence field of this variation will be approximated by the following expression:

$$F(\varepsilon_{ij}) = \frac{[B(\varepsilon_{ij}) - B]}{\varepsilon} \tag{8}$$

where $F(\varepsilon_{ij})$ é na matrix $(n \; x \; n)$ of the coefficient influence field a_{ij}. Thus, in order to identify which technical coefficients have a greater field of influence, a value is associated with each matrix $F(\varepsilon_{ij})$, given by:

$$S_{ij} = \sum_{k=1}^{n} \sum_{l=1}^{n} [f_{kl}(\varepsilon_{ij})]^2 \tag{9}$$

In this way, the highest values of S_{ij} indicate the sectors that have the greatest influence in the economy as a whole. Therefore, it is possible to identify the sectorial relations that promote greater impacts on the economy.

2.5 Hypothetical extraction of sectors

The extraction method proposed by Dietzenbacher et al. (1993) consists of the hypothetical[4] and / or imaginary extraction of a given sector of the input-output structure. Complementing the analysis of the indexes of backward, forward and key sectors, the technique allows identifying sectors important for economic development given their extraction and influence on the level of activity in the economy. Detect these sectors is important in the formulation of economic policies (CABRAL; CABRAL; OLIVEIRA, 2017).

According to Miller and Blair (2009), the objective of the hypothetical extraction method is to quantify how the total output of an economy with n sectors would change (in this case, it would decrease) if a given sector, say that *j-ésimo*, be removed from it. This extraction can occur in three ways: total extraction of the sector (or agent) - columns and rows;

[4] More work using the extraction method can be seen in Perobelli et al. (2010), Haddad, Perobelli and Santos (2012), Perobelli et al. (2015) and Cabral, Cabral and Oliveira (2017).

extraction of the shopping structure (back connection) - extraction of the columns; and extraction of the sales structure (forward link) - extraction of the lines.

The extraction exercise proposed in this study is, firstly, the reduction of the participation of the Electricity, Gas, Water, Sewage and Urban Cleaning sector by 15%, 30%, 50% and then the total extraction of the sector. It was decided to make the total extraction of the sector, column and line, instead of doing separately for the column (extraction only of the purchase structure) or for the line and tested the hypothesis of reduction of the activities in this sector to verify the behavior of other sectors.

The methodological option of using the matrix Q "square" (Q_q) in place of the Technological Matrix to perform the initial calculation process, this matrix is used by Silveira (1993), Pereira (2007) and the Intersectoral Relations Study Group (GERI) of the Federal University of Bahia (UFBA) to make decrease in value, since this is expressed in monetary values. The matrix Q_q is an input matrix in which it considers the market-share hypothesis and can be considered the technological matrix in monetary terms, which improves the partial suppression of production calculations (in monetary values). The matrix Q_q is obtained as follows:

$$Q_q = \left(\left(\widehat{q_p}\right)^{-1} P\right)^t Q \qquad (10)$$

Where P is the production matrix of the Bahian economy, Q is the intermediate consumption matrix and $\left(\widehat{q_p}\right)^{-1}$ is the sum vector, diagonalized and inverted, of each product of the matrix P.

In addition, the application of the method follows all the methodological steps of Miller and Blair (2009) for hypothetical extraction of sectors.

2.6 *Multipliers*

Through the inverse matrix of Leontief (B) it is possible to calculate the multipliers for each sector of the economy. The multipliers allow estimating, from an increase in the final demand, the direct and indirect impact of each sector of the economy on jobs, income, imports, added value, among others (GUILHOTO, 2011). Multipliers help both in the decision-making process of development policies, as in the case of the employment multiplier, and as an indicator of growth, in the case of the production multiplier.

The production multiplier, which indicates how much is produced for each monetary unit spent on final consumption, is defined as:

$$MP_j = \sum_{i=1}^{n} b_{ij} \quad (11)$$

Where MP_j *the production multiplier of the j-th* sector and b_{ij} it's the *ij-th* element of the Leontief inverse matrix.

The employment multiplier indicates the number of jobs created, directly and indirectly, for each direct job created and is defined by the expression:

$$ME_j = \sum_{i=1}^{n} b_{ij}\, e_i \quad (12)$$

where $e_{i=} \frac{E_i}{VBP_i}$ represents the ratio of total employees to the gross value of production in the sector i.

Analogously, we find the income multiplier by the ratio between the value added and the gross value of production, that is:

$$MV_j = \sum_{i=1}^{n} b_{ij}\, v_i \quad (13)$$

what $v_{i=} \frac{VA_i}{VBP_i}$.

2.7 Data

The database that made possible the construction of MIPs for the Bahian economy inside and outside the semi-arid region in 2015 refers to the Bahia 2015 Matrix, elaborated by SEI, based on the TRU 2012, still unpublished and the Intermediate Consumption vectors and the Gross Production Value of the activity sectors for 2015, which, through the RAS methodology modified by Silveira (1993), in the absence of data on intermediate production, it was possible to reach the Bahia 2015 matrix and from this, with proxies of (CNAE) 2.0 of the Annual Social Information Report of the Ministry of Labor and Employment (RAIS / MTE) for 2015, it was possible to extrapolate the matrices for In and Out of the Semi-Arid in Bahia using the the same methodology adopted by Leite (2009) for the construction of regional matrices compatible with RAS modified with the use of regional adjustment tensor.

For the data on impacts, the database of investment intensification protocols of the State of Bahia Economic Development Secretariat (SDE), systematized for the wind sector in this work was used.

4. Results

In this section, the results obtained from the MIPs for the Bahian economy, inside and outside the semi-arid state of Bahia, will be analyzed for the year 2015. However, as the state wind farms are located within the semi-arid region and for comparison purposes, three analyzes of sector indices (linkage and dispersion indices, key sectors and influence field) were initially performed for the economy of Bahia as a whole, one in the semi-arid region of the state and the other out. Later, in the evaluation of the impacts of the wind activity in the sectors of economic activities inserted in the State, analyzes of the hypothetical extraction of sectors, impact multipliers (on production, employment and income) and the impacts of investments in the wind productive chain on production and employment are concentrated only in the semi-arid region of Bahia in order to verify how wind energy helps in the sustainable development of the region.

4.1 Rasmussen-Hirschman linkages indices and dispersion index

Through the Rasmussen-Hirschman linkage coefficients one can understand the sectoral power of the sectors in relation to the average of the economy. The sectors with higher chaining power are those with coefficient values greater than one. In the dispersion indices, the lower the value of the coefficient, the more the sector is related to the many sectors and the high values, indicating a link with few sectors.

Among the sectors of the state that stand out behind (Table 3) are the cultivation of cotton (1,17), the cultivation of soybeans (1,00), food and beverages (1,13), textiles, clothing and leather articles (1,09), pulp, paper, newspapers, magazines and discs (1,10), alcohol and biofuels (1,63), perfumery, hygiene and cleaning (1,35), other non- (1,11), office, electronic, optical and hospital machinery (1,09), electrical machinery and equipment (1,37), automotive industry and vehicle parts (1,40), other transportation equipment (1,38), miscellaneous furniture and industry (1,06) and accommodation and food services (1,01). These have strong back-chaining power since they are above average, that is, they demand a reasonable amount of inputs from other sectors, which also suggests that the dispersion effect would be concentrated in few sectors because they have high values. The sector with the greatest dispersion chain is ethanol and biofuels (1,74).

In the semi-arid the sectors with strong backward linkage (Table 4) are cotton (1,09), forest production (1,01), petroleum refining (1,44), alcohol and biofuels (1,77), products pharmaceuticals (1,10), other non-metallic mineral products (1,31), office, electronic, optical

and hospital machinery (1,03), electrical machinery and equipment (1,33), automotive and vehicle parts (1.19), other transportation equipment (1,72) and miscellaneous furniture and industry (1,31). As in the Bahian economy as a whole, in the semi-arid the alcohol and biofuels sector (1,73) is also the most homogeneous sector.

Outside the semi-arid zone (Table 5), the most demanding sectors of inputs are cotton (1.24), soybean (1,05), food, beverages and tobacco (1,17), textiles, clothing and leather articles (1.31), cellulose, paper, newspapers, magazines and discs (1,13), alcohol and biofuels (1,61), perfumery, hygiene and cleaning (1,33), other nonmetallic mineral products (1,04), office, electronic, optical and hospital machinery (1,10), electrical machinery and equipment (1,38), automotive industry and parts for vehicles (1,41), other transport equipment (1,45), transport, warehousing and postal services (1,07) and accommodation and food services (1,04). Here, according to the dispersion index, the sector that most relates to others is that of other transportation equipment (1,86).

Regarding forward connections (Table 3), the sectors that stand out in the supply of inputs for the economy in Bahia are construction (1.52), financial intermediation and complementary pensions (1,02) and services provided to companies (2,20). In the semi-arid region (Table 4), there is the sector of animal husbandry (1,23), civil construction (2,33), commerce and maintenance and repair services (1,98), transport, warehousing and postal services (1, 91) Housing and food services (1,02), financial intermediation and supplementary pensions (1,56), real estate activities and rentals (1,57) and services provided to businesses (1,41).

Table 3 - Rasmussen-Hirschman linkage indices and dispersion indices, Bahia, 2015

	Sectors of economic activity	Rasmussen-Hirschman Indices		Index dispersion	
		Forward (Ui)	Backward (Uj)	Forward (Vi)	Backward (Vj)
1	Self catering apartments	0,4382	0,7893	5,6839	3,1713
2	Cotton cultivation	0,6203	1,1695	4,1688	2,3281
3	Growing Sugarcane	0,4189	0,7591	5,9469	3,3179
4	Soybean Growing	0,5342	1,0092	4,9019	2,7055
5	Other Temporary Farming	0,5210	0,7376	4,9733	3,4951
6	Orange cultivation	0,4219	0,5170	6,1763	4,9159
7	Coffee Growing	0,4090	0,9015	6,1016	2,8104
8	Other Permanent Crops	0,4291	0,6126	5,9513	4,0966
9	Animal Breeding	0,8632	0,7095	3,0446	3,7197
10	Real Estate Management	1,0002	1,2881	5,4481	4,2055
11	Extraction of Oil and Natural Gas	2,3332	1,0105	1,0579	2,7140
12	Other Extractive Industries	1,3611	1,1529	1,9983	2,5015
13	Food, Beverages and Tobacco	0,9380	1,1369	3,5312	2,9260
14	Textiles, Clothing and Leather Goods	0,7897	1,0980	3,1277	2,3243
15	Pulp, Paper, Newspapers, Magazines and Disks	0,9297	1,1043	2,6501	2,3745
16	Oil Refining	3,9466	1,4731	0,8614	2,6707
17	Alcohol and Biofuels	0,6223	1,6290	4,3764	1,7440
18	Chemicals	3,0794	1,2609	0,8435	2,4114
19	Perfumery, Hygiene and Cleaning	0,4855	1,3489	5,0596	1,8966
20	Pharmaceutical products	0,4534	0,9938	5,3923	2,4809
21	Rubber and Plastic Industry	1,2650	1,2423	2,0311	2,2249
22	Other Non-Metallic Mineral Products	0,7990	1,1111	3,1336	2,3709
23	Metallurgy and Metallurgy	1,7841	1,2590	1,4470	2,2506
24	Maq. Office, Electronics, Optics & Hospitality	0,6931	1,0940	3,5965	2,3528
25	Machinery and Electrical Materials	0,9494	1,3704	2,6862	1,9886
26	Machinery and Equipment and Maintenance	0,8859	0,8238	2,7963	3,0768
27	Automotive Industry and Vehicle Parts	0,7243	1,4000	4,1906	2,2092
28	Other Transport Equipment	0,3845	1,3850	6,6342	1,8445
29	Furniture and Miscellaneous Industries	0,5676	1,0639	4,2842	2,3352
30	Electricity, Gas, Water, Sewer and Urban Cleaning	2,0004	1,0937	1,2147	2,4667
31	Construction	1,5285	0,9161	1,7748	3,1238
32	Trade and Maintenance and Repair Services	0,7399	0,7324	3,3780	3,4294
33	Transport, Storage and Mail	1,0643	1,0212	2,3280	2,6014
34	Accommodation and Food Services	0,6810	1,0131	3,5948	2,4649
35	Information Services	0,9688	0,9046	2,6090	2,8910
36	Financial Intermediation and Prev Complementary	1,0254	0,6744	2,8049	4,3127
37	Real Estate and Rentals	0,8385	0,4556	3,1050	5,6794
38	Business Services	2,2038	0,6756	1,0872	3,8821
39	Pub. Adm., Health and Educ. Pub and Social Security	0,4444	0,6381	5,7322	3,9253
40	Health and Business Education	0,4386	0,7246	6,1548	3,6252
41	Services Provided to Families	0,4188	0,6992	6,0799	3,5580

Source: Prepared by the authors from the Bahia Matrix, 2015.

Table 4 - Rasmussen-Hirschman linkage indices and dispersion indices, semi-arid Bahia, 2015

	Sectors of economic activity	Rasmussen-Hirschman Indices		Index dispersion	
		Forward (Ui)	Backward (Uj)	Forward (Vi)	Backward (Vi)
1	Self catering apartments	0,5242	0,8277	5,4025	3,4262
2	Cotton cultivation	0,9611	1,0874	3,0288	2,7708
3	Growing Sugarcane	0,4407	0,6774	6,5156	4,2052
4	Soybean Growing	0,9212	0,9350	3,2105	3,2264
5	Other Temporary Farming	0,8915	0,7726	3,2913	3,8705
6	Orange cultivation	0,4946	0,5825	5,8233	4,9055
7	Coffee Growing	0,5144	0,8829	5,4799	3,1813
8	Other Permanent Crops	0,6232	0,6185	4,5806	4,6129
9	Animal Breeding	1,2287	0,7445	2,4693	4,1872
10	Real Estate Management	0,5678	1,0123	5,9419	3,3093
11	Extraction of Oil and Natural Gas	-	-	-	-
12	Other Extractive Industries	1,4052	1,4558	2,3990	2,3888
13	Food, Beverages and Tobacco	1,7081	1,1683	2,3417	3,5234
14	Textiles, Clothing and Leather Goods	1,3139	1,1976	2,1811	2,4764
15	Pulp, Paper, Newspapers, Magazines and Disks	0,9884	0,9936	2,8289	2,9221
16	Oil Refining	0,4888	1,4377	6,1622	2,0812
17	Alcohol and Biofuels	0,5227	1,7678	5,8547	1,7340
18	Chemicals	1,5206	1,0258	1,7768	2,8129
19	Perfumery, Hygiene and Cleaning	0,4640	1,4770	6,1751	1,9536
20	Pharmaceutical products	0,4546	1,1043	6,1065	2,5158
21	Rubber and Plastic Industry	1,3436	1,3566	2,2763	2,3453
22	Other Non-Metallic Mineral Products	0,8756	1,3089	3,3860	2,3131
23	Metallurgy and Metallurgy	1,2215	1,4567	2,4191	2,1174
24	Maq. Office, Electronics, Optics & Hospitality	0,4428	1,0349	6,3877	2,7664
25	Machinery and Electrical Materials	0,7997	1,3296	3,5647	2,1875
26	Machinery and Equipment and Maintenance	0,6605	0,8627	4,2353	3,2739
27	Automotive Industry and Vehicle Parts	0,4953	1,1942	5,7395	2,4040
28	Other Transport Equipment	0,4555	1,1726	6,2581	2,4323
29	Furniture and Miscellaneous Industries	0,5580	1,3143	5,0220	2,1313
30	Electricity, Gas, Water, Sewer and Urban Cleaning	2,4184	1,1244	1,1628	2,7537
31	Construction	2,3288	0,9006	1,3982	3,8946
32	Trade and Maintenance and Repair Services	1,9806	0,6552	1,3792	4,5076
33	Transport, Storage and Mail	1,9097	0,8297	1,4731	3,6439
34	Accommodation and Food Services	1,0207	0,9274	2,7413	3,1029
35	Information Services	0,8066	0,9054	3,4864	3,1724
36	Financial Intermediation and Prev Complementary	1,5600	0,7196	2,1318	4,8111
37	Real Estate and Rentals	1,5664	0,5032	1,7757	5,8146
38	Business Services	1,4126	0,6835	1,9439	4,2017
39	Pub. Adm., Health and Educ. Pub and Social Security	0,9213	0,6016	3,0749	4,7833
40	Health and Business Education	0,5929	0,6836	5,5131	4,7571
41	Services Provided to Families	0,5959	0,6667	4,8782	4,3490

Elaborated by the authors from the input-output matrix for the semi-arid Bahia, 2015.

Table 5 - Rasmussen-Hirschman linkage indices and dispersion indices, outside the semi-arid Bahia, 2015

	Sectors of economic activity	Rasmussen-Hirschman Indices		Index dispersion	
		Forward (Ui)	Backward (Uj)	Forwaard (Vi)	Backward (Vj)
1	Self catering apartments	0,431	0,796	5,830	3,208
2	Cotton cultivation	0,496	1,243	5,404	2,323
3	Growing Sugarcane	0,430	0,765	5,838	3,341
4	Soybean Growing	0,445	1,049	5,963	2,684
5	Other Temporary Farming	0,435	0,775	5,769	3,268
6	Orange cultivation	0,421	0,513	6,311	5,000
7	Coffee Growing	0,400	0,943	6,361	2,815
8	Other Permanent Crops	0,409	0,660	6,270	3,837
9	Animal Breeding	0,768	0,731	3,385	3,572
10	Real Estate Management	1,095	1,342	5,298	4,304
11	Extraction of Oil and Natural Gas	2,847	0,961	0,873	2,973
12	Other Extractive Industries	1,206	0,822	2,087	3,350
13	Food, Beverages and Tobacco	0,724	1,174	4,445	2,759
14	Textiles, Clothing and Leather Goods	0,639	1,014	3,841	2,589
15	Pulp, Paper, Newspapers, Magazines and Disks	0,883	1,132	2,826	2,401
16	Oil Refining	4,892	1,448	0,693	2,838
17	Alcohol and Biofuels	0,637	1,610	4,405	1,889
18	Chemicals	3,500	1,270	0,745	2,491
19	Perfumery, Hygiene and Cleaning	0,508	1,335	4,881	2,004
20	Pharmaceutical products	0,463	0,987	5,341	2,556
21	Rubber and Plastic Industry	1,223	1,217	2,099	2,341
22	Other Non-Metallic Mineral Products	0,775	1,039	3,244	2,635
23	Metallurgy and Metallurgy	1,912	1,194	1,356	2,455
24	Maq. Office, Electronics, Optics & Hospitality	0,747	1,100	3,366	2,393
25	Machinery and Electrical Materials	0,958	1,380	2,703	2,067
26	Machinery and Equipment and Maintenance	0,906	0,826	2,770	3,125
27	Automotive Industry and Vehicle Parts	0,763	1,406	4,023	2,260
28	Other Transport Equipment	0,386	1,455	6,806	1,858
29	Furniture and Miscellaneous Industries	0,573	0,994	4,284	2,580
30	Electricity, Gas, Water, Sewer and Urban Cleaning	1,741	1,092	1,410	2,512
31	Construction	1,291	0,929	2,091	3,061
32	Trade and Maintenance and Repair Services	0,546	0,799	4,588	3,138
33	Transport, Storage and Mail	0,889	1,074	2,831	2,575
34	Accommodation and Food Services	0,611	1,041	4,037	2,444
35	Information Services	0,986	0,916	2,604	2,911
36	Financial Intermediation and Prev Complementary	0,896	0,688	3,226	4,187
37	Real Estate and Rentals	0,696	0,461	3,846	5,637
38	Business Services	2,253	0,683	1,082	3,891
39	Pub. Adm., Health and Educ. Pub and Social Security	0,394	0,668	6,541	3,771
40	Health and Business Education	0,427	0,746	6,318	3,498
41	Services Provided to Families	0,398	0,720	6,455	3,471

Source: Elaborated by the authors from the input-output matrix out of the semi-arid Bahia, 2015.

The sectors that have a strong forward chain (Table 5) outside the semi-arid region are petroleum and natural gas extraction (2,85), mining and quarrying (1,206), civil construction (1,29) and business services (2, 25).

4.1.2 Key sectors

The key sectors, those with linkage indexes greater than one, of the Bahian economy for the year 2015 are presented in Table 6. It can be observed that nine sectors are considered key: forest production, oil and natural gas extraction, others petroleum refining, various chemical products, rubber and plastic industry, metallurgy and steel, electricity, gas, sewage and urban cleaning, transportation warehousing and post office. These sectors are important for the State, both as an input demander and as product suppliers.

In the semi-arid region of Bahia, there are seven key sectors (Table 7): others from the extractive industry, food, beverages and tobacco, textiles, clothing and leather goods, various chemical products, rubber and plastic industry, metallurgy and iron and steel, electricity, gas, water, sewage and urban cleaning. Outside the semi-arid region, six key sectors (Table 8) were identified: forest production, petroleum refining, various chemical products, rubber and plastic industry, metallurgy and steel, electricity, gas, water, sewage and urban cleaning.

Table 6 - Key sectors of the economy, Bahia, 2015

Key sectors	Rasmussen-Hirschman Indices		Index dispersion	
	Forward (Ui)	Backward (Uj)	Forward (Vi)	Backward (Vj)
Real Estate Management	1,0002	1,2881	5,4481	4,2055
Extraction of Oil and Natural Gas	2,3332	1,0105	1,0579	2,7140
Other Extractive Industries	1,3611	1,1529	1,9983	2,5015
Oil Refining	3,9466	1,4731	0,8614	2,6707
Chemicals	3,0794	1,2609	0,8435	2,4114
Rubber and Plastic Industry	1,2650	1,2423	2,0311	2,2249
Metallurgy and Metallurgy	1,7841	1,2590	1,4470	2,2506
Electricity, Gas, Water, Sewer and Urban Cleaning	2,0004	1,0937	1,2147	2,4667
Transport, Storage and Mail	1,0643	1,0212	2,3280	2,6014

Source: Prepared by the authors from the Bahia Matrix, 2015.

Table 7 - Key sectors of the economy, semi-arid Bahia, 2015

Key sectors	Rasmussen-Hirschman Indices		Index dispersion	
	Forward (Ui)	Backward (Uj)	Forward (Vi)	Backward (Vj)
Other Extractive Industries	1,4052	1,4558	2,3990	2,3888
Food, Beverages and Tobacco	1,7081	1,1683	2,3417	3,5234
Textiles, Clothing and Leather Goods	1,3139	1,1976	2,1811	2,4764
Chemicals	1,5206	1,0258	1,7768	2,8129
Rubber and Plastic Industry	1,3436	1,3566	2,2763	2,3453
Metallurgy and Metallurgy	1,2215	1,4567	2,4191	2,1174
Electricity, Gas, Water, Sewer and Urban Cleaning	2,4184	1,1244	1,1628	2,7537

Source: Elaborated by the authors from the input-output matrix for the semi-arid Bahia, 2015.

Table 8 - Key sectors of the economy, outside the semi-arid Bahia, 2015

Key sectors	Rasmussen-Hirschman Indices		Index dispersion	
	Forward (Ui)	Backward (Uj)	Forward (Vi)	Backward (Vj)
Real Estate Management	1,095	1,342	5,298	4,304
Oil Refining	4,892	1,448	0,693	2,838
Chemicals	3,500	1,270	0,745	2,491
Rubber and Plastic Industry	1,223	1,217	2,099	2,341
Metallurgy and Metallurgy	1,912	1,194	1,356	2,455
Electricity, Gas, Water, Sewer and Urban Cleaning	1,741	1,092	1,410	2,512

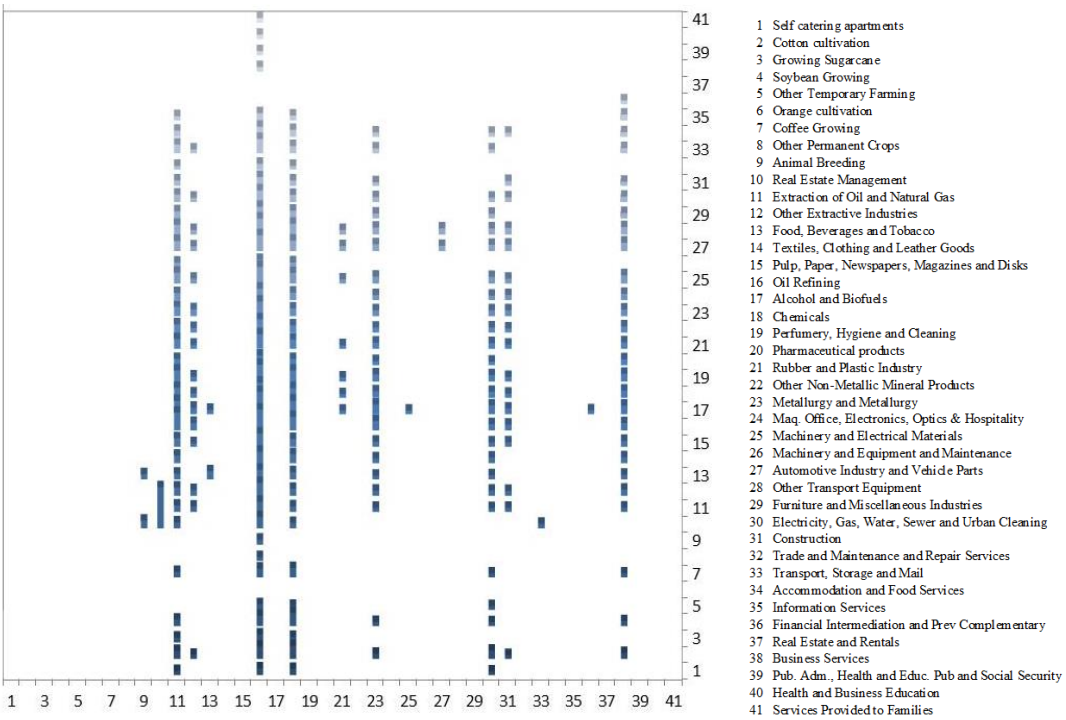
Source: Elaborated by the authors from the input-output matrix out of the semi-arid Bahia, 2015.

The electricity sector, object of this study, is considered key in the three analyzes (Bahia, inside and outside the semi-arid), since it is inserted in practically all economic activities. Thus, this sector exerts a great influence on the other sectors.

4.1.3 Fields of influence

The analysis of the fields of influence complements the linkage indices, showing the most important sectoral relationships that promote the greatest impacts on the economy. In Figures 3, 4 and 5 in the columns we have the optics of the buying sectors and the optical lines of the selling sectors. From the 41 sectors of activity of the economy of Bahia in 2015 (Figure 3), from the point of view of purchasing, the most relevant sectors are 11 - oil and natural gas extraction, 16 - petroleum refining, 18 - various chemical products, 23 - metallurgy and steel, 30 - electricity, gas, water, sewage and urban cleaning and 38 - services provided to companies, however they have little interaction in sales with other sectors, being more demanding.

Figure 3 –Field of influence of Bahia, 2015

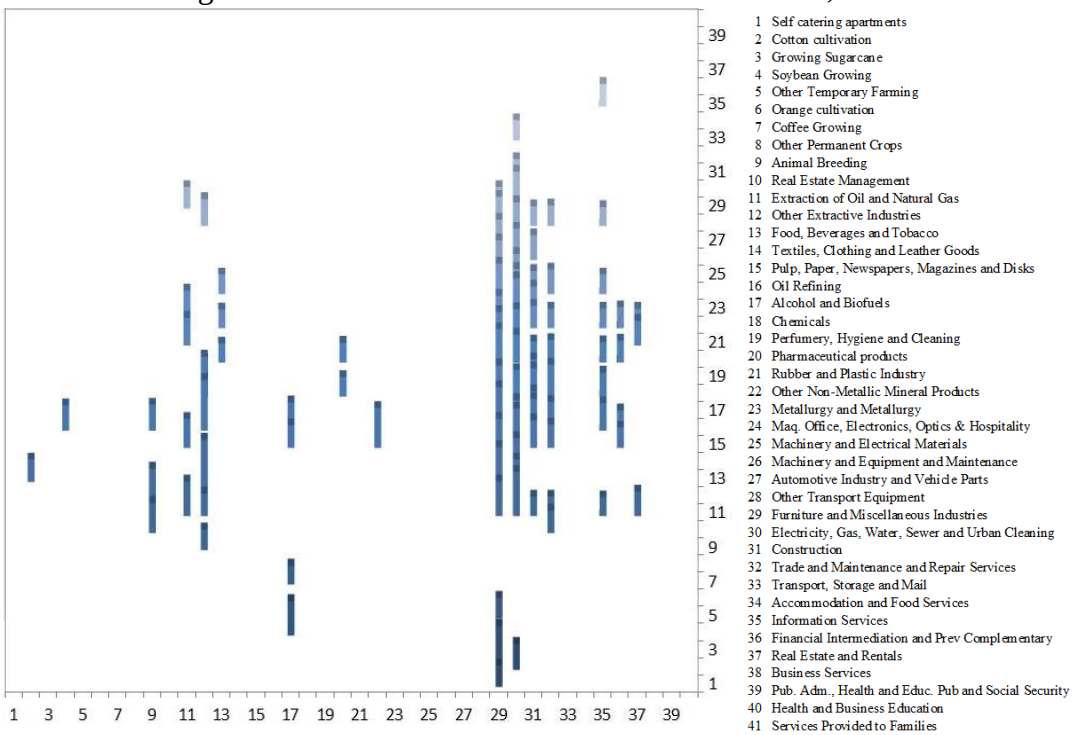


Source: Prepared by the authors from the Bahia Matrix, 2015

Already in the semiarid the field of influence is quite distinct from the state as a whole (Figure 4). The sector 29 - furniture and various industries and the sector 30 - civil construction are the ones that present greater propagating effects on the other sectors. From the perspective of sales there is little interaction.

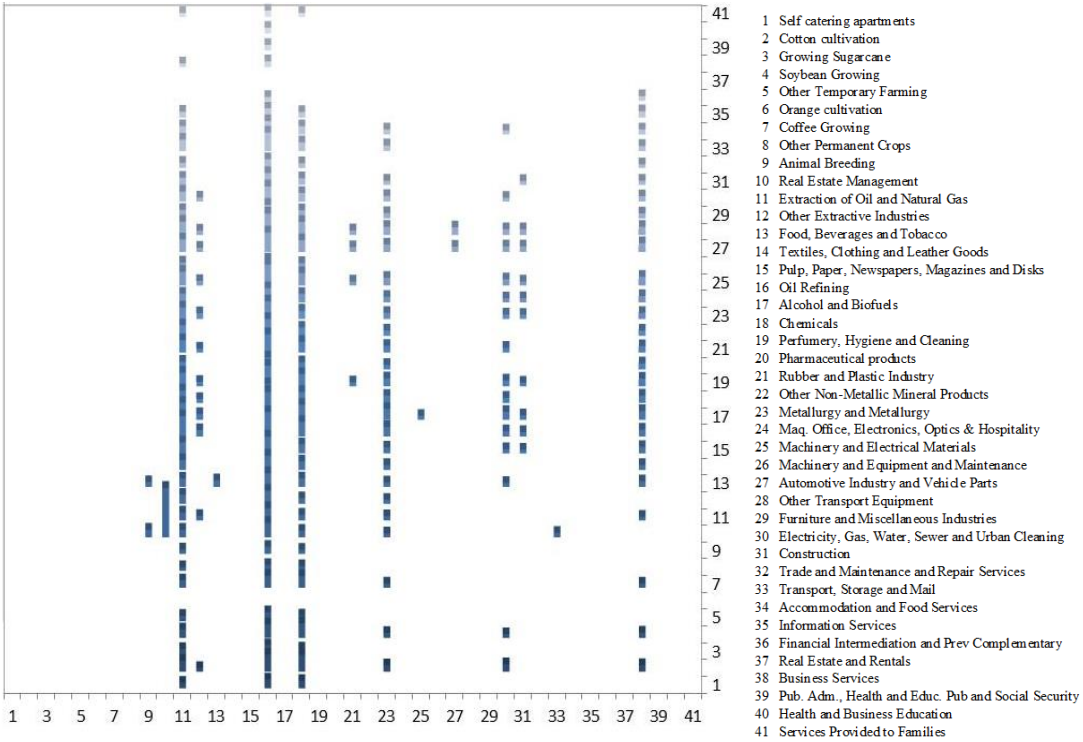
Outside the semi-arid, we have a field of influence closest to the State (Figure 5). In this, the most relevant sectors from the perspective of purchases are: 11 - oil and natural gas extraction, 16 - petroleum refining, 18 - various chemical products, 23 - metallurgy and steel, 30 - electricity, gas, water, sewage and cleaning urban and 38 - business services. Here too there is strong sectoral chaining by demand.

Figure 4 - Field of influence of the semi-arid Bahia, 2015



Source: Elaborated by the authors from the input-output matrix out of the semi-arid Bahia, 2015.

Figure 5 - Field of influence outside the semi-arid state of Bahia, 2015



Source: Elaborated by the authors from the input-output matrix out of the semi-arid Bahia, 2015.

4.1.4 Hypothetical extraction of sectors

As pointed out in the methodology, the hypothetical extraction of sectors in this work was done for the electricity, gas, water, sewage and urban cleaning sectors. First, the sector's share of the economy in the region was reduced by 15%, 30%, 50% and then the total sector extraction (100%). The results of the total negative impacts can be observed in Table 9 on the structure of the matrix for the semi-arid Bahia in the year 2015. It was decided to make the total extraction of the sector, column and line, instead of being done separately for the (extraction only of the purchasing structure) or to the line, to capture the global effects (totals) and tested the hypothesis of a decrease in activities in this sector to verify the behavior of the other sectors in relation to, for example, the effects of changes caused by drought and consequent decrease in hydroelectric power generation.

In order to reduce the electricity, gas, water, sewage and urban cleaning sectors by 15% and 30% and 50%, the behavior of the sectors has similarities and proportionality. The sectors that most feel the effects of a reduction of the in question are: cultivation of cotton, other temporary crops and the cereal sector with the highest percentage losses, which shows in terms of relative losses. In terms of absolute losses, one must observe the size of the gross value of the production of each sector in order to calculate the magnitude of the damage that can be caused in the regional economy.

When the sector of electricity, gas, water, sewage and urban cleaning is fully extracted, the sector that receives the most negative impact is the sector itself, with global impacts of 61% reduction in total activity, taking into account the direct and indirect impacts (totals) in the sector, as can be seen in Table 9.

Table 9 - Hypothetical extraction of the energy sector in the semi-arid Bahia matrix, 2015

	Sectors of economic activity	Total negative impact of the 15% extraction of the Energy sector (in the joint structure of purchases and sales)	Total negative impact of the 30% extraction of the Energy sector (in the joint structure of purchases and sales)	Total negative impact of the 50% extraction of the Energy sector (in the joint structure of purchases and sales)	Total negative impact of the 100% extraction of the Energy sector (in the joint structure of purchases and sales)
1	Self catering apartments	4%	8%	12%	24%
2	Cotton cultivation	6%	13%	21%	40%
3	Growing Sugarcane	1%	2%	4%	7%
4	Soybean Growing	1%	2%	3%	6%
5	Other Temporary Farming	4%	8%	14%	27%
6	Orange cultivation	2%	3%	5%	10%
7	Coffee Growing	2%	4%	6%	12%
8	Other Permanent Crops	1%	2%	4%	8%
9	Animal Breeding	1%	2%	4%	8%
10	Real Estate Management	1%	1%	2%	5%
11	Other Extractive Industries	2%	5%	8%	15%
12	Food, Beverages and Tobacco	1%	2%	3%	6%
13	Textiles, Clothing and Leather Goods	3%	6%	9%	18%
14	Pulp, Paper, Newspapers, Magazines and Disks	1%	3%	5%	9%
15	Oil Refining	2%	3%	5%	10%
16	Alcohol and Biofuels	2%	5%	8%	15%
17	Chemicals	1%	3%	5%	9%
18	Perfumery, Hygiene and Cleaning	2%	4%	7%	13%
19	Pharmaceutical products	1%	3%	4%	8%
20	Rubber and Plastic Industry	3%	5%	8%	16%
21	Other Non-Metallic Mineral Products	3%	6%	10%	19%
22	Metallurgy and Metallurgy	2%	4%	7%	13%
23	Maq. Office, Electronics, Optics & Hospitality	1%	2%	3%	7%
24	Machinery and Electrical Materials	2%	5%	8%	15%
25	Machinery and Equipment and Maintenance	1%	3%	4%	8%
26	Automotive Industry and Vehicle Parts	1%	3%	4%	8%
27	Other Transport Equipment	2%	3%	6%	11%
28	Furniture and Miscellaneous Industries	2%	4%	7%	13%
29	Electricity, Gas, Water, Sewer and Urban Cleaning	1%	2%	4%	61%
30	Construction	1%	2%	4%	7%
31	Trade and Maintenance and Repair Services	1%	2%	3%	6%
32	Transport, Storage and Mail	1%	2%	4%	7%
33	Accommodation and Food Services	1%	3%	5%	9%
34	Information Services	1%	2%	4%	8%
35	Financial Intermediation and Prev Complementary	0%	1%	1%	2%
36	Real Estate and Rentals	0%	1%	1%	2%
37	Business Services	1%	1%	2%	5%
38	Pub. Adm., Health and Educ. Pub and Social Security	1%	1%	2%	5%
39	Health and Business Education	0%	1%	2%	3%
40	Services Provided to Families	1%	2%	2%	5%

Source: Elaborated by the authors from the input-output matrix for the semi-arid Bahia, 2015.

4.1.5 Impact Multipliers

Impact multipliers (Table 10) show the multipliers of production, employment, and income for the 40 sectors of activity in the semi-arid Bahia state for the year 2015. The alcohol and biofuels sector has the largest production multiplier, however, the worst income multiplier due to the fact that in 2015 the Value Added of this sector is negative. For, the costs (intermediate consumption) were higher than the billing (gross value of production), generating not an added value (industry profit), but a negative value (industry loss).

The interpretation here is that for each increase of 1 monetary unit in the final demand of the sector requires 4.06 monetary units of the product of all sectors of the economy of Bahia in 2015. This multiplier shows the direct and indirect effects (total) of the sectors on the total production of the economy. These effects may be due to increases in government spending, or shocks to private investment, or consumption, as an example. The perfumery, hygiene and cleaning sectors have the second largest production multiplier and the metallurgy and steel industry the third, with the greatest impact on the economy of Bahia that year.

In sectors with higher employment multipliers, it can be estimated that for every 1 million monetary units spent on final demand, the number of jobs generated. For purposes of account, it is recommended to deal with whole numbers, since these are jobs, but because they are jobs for monetary values, this conversion can be done when dealing with the results of the impacts. Thus, for the Bahian semi-arid region, in 2015, for every 1 million monetary units in the final demand, the public administration sector has the greatest potential to generate formal jobs in the economy, 134 total jobs (direct and indirect). This is followed by the perfumery, hygiene and cleaning sector that would generate 31 total jobs with the multiplier. Already the sector of furniture and diverse industries with multiplier of 28 total formal jobs in the economy. Employment multipliers differ from the production multipliers, which differ from the income multipliers.

Income multipliers indicate the variation of income over the variation in the final demand component of a given sector. Thus, the sectors of cereal cultivation, the cultivation of other temporary crops and that of machinery and equipment and maintenance in the semi-arid region of Bahia are the ones that are more prominent in this respect, which shows the strength of the agricultural sector in the region for the income generation, as can be seen in Table 10.

Table 10 - Impact multipliers of the semi-arid Bahia, 2015

	Sectors of economic activity	Production		Employment		Income	
		Unit variation - (R$)		Each R $ 1 million in final demand		Unit variation - (R$)	
		MPj	Rank	Mej	Rank	MVj	Rank
1	Self catering apartments	1,90	*28*	8,67	*20*	1,23	*1*
2	Cotton cultivation	2,49	*16*	3,34	*34*	0,83	*27*
3	Growing Sugarcane	1,55	*34*	5,56	*26*	1,08	*10*
4	Soybean Growing	2,14	*21*	1,63	*38*	1,06	*12*
5	Other Temporary Farming	1,77	*29*	3,36	*33*	1,20	*2*
6	Orange cultivation	1,34	*39*	1,38	*40*	1,17	*6*
7	Coffee Growing	2,03	*25*	9,68	*18*	1,14	*7*
8	Other Permanent Crops	1,42	*37*	10,69	*15*	1,13	*8*
9	Animal Breeding	1,71	*30*	7,26	*23*	1,19	*4*
10	Real Estate Management	2,32	*19*	17,91	*9*	0,54	*33*
11	Other Extractive Industries	3,34	*4*	14,35	*11*	0,91	*22*
12	Food, Beverages and Tobacco	2,68	*13*	6,90	*24*	0,55	*31*
13	Textiles, Clothing and Leather Goods	2,75	*10*	27,09	*4*	0,96	*20*
14	Pulp, Paper, Newspapers, Magazines and Disks	2,28	*20*	7,83	*21*	0,74	*28*
15	Oil Refining	3,30	*5*	1,81	*37*	0,32	*37*
16	Alcohol and Biofuels	4,06	*1*	5,12	*29*	- 0,39	*40*
17	Chemicals	2,35	*18*	2,03	*36*	0,47	*35*
18	Perfumery, Hygiene and Cleaning	3,39	*2*	31,13	*2*	0,53	*34*
19	Pharmaceutical products	2,53	*15*	20,50	*7*	1,02	*15*
20	Rubber and Plastic Industry	3,11	*6*	9,28	*19*	0,65	*30*
21	Other Non-Metallic Mineral Products	3,00	*9*	26,84	*5*	0,92	*21*
22	Metallurgy and Metallurgy	3,34	*3*	7,37	*22*	0,55	*32*
23	Maq. Office, Electronics, Optics & Hospitality	2,37	*17*	5,14	*28*	0,72	*29*
24	Machinery and Electrical Materials	3,05	*7*	3,64	*32*	0,24	*39*
25	Machinery and Equipment and Maintenance	1,98	*26*	5,64	*25*	1,19	*3*
26	Automotive Industry and Vehicle Parts	2,74	*11*	12,59	*12*	0,25	*38*
27	Other Transport Equipment	2,69	*12*	3,00	*35*	0,46	*36*
28	Furniture and Miscellaneous Industries	3,01	*8*	28,28	*3*	1,18	*5*
29	Electricity, Gas, Water, Sewer and Urban Cleaning	2,58	*14*	4,17	*30*	0,90	*25*
30	Construction	2,07	*24*	10,13	*16*	1,03	*14*
31	Trade and Maintenance and Repair Services	1,50	*36*	19,31	*8*	1,00	*18*
32	Transport, Storage and Mail	1,90	*27*	10,91	*14*	0,91	*23*
33	Accommodation and Food Services	2,13	*22*	15,52	*10*	0,86	*26*
34	Information Services	2,08	*23*	10,10	*17*	0,90	*24*
35	Financial Intermediation and Prev Complementary	1,65	*31*	3,88	*31*	1,00	*17*
36	Real Estate and Rentals	1,15	*40*	1,38	*39*	1,07	*11*
37	Business Services	1,57	*33*	23,78	*6*	1,12	*9*
38	Pub. Adm., Health and Educ. Pub and Social Security	1,38	*38*	134,37	*1*	1,02	*16*
39	Health and Business Education	1,57	*32*	5,25	*27*	0,97	*19*
40	Services Provided to Families	1,53	*35*	11,46	*13*	1,05	*13*

Source: Elaborated by the authors from the input-output matrix for the semi-arid Bahia, 2015.

4.1.5.1 Impacts of investments in the wind production chain in the semi-arid region of Bahia on production and employment

The investment impacts were obtained from data from the investment intensity protocols captured by SDE. This is a preliminary version of the results that deals with the investments after 2015 and carried out until 2018 and the protocols that have not yet been carried out. The total amount of investments in the wind power chain in the semi-arid region of Bahia is close to 18 billion reais in investment intentions and the generation of approximately 2,000 jobs in these ventures, but in order to obtain the effects along the production chain, input-output for calculating the direct, indirect and total impacts of these investments.

Thus, the results are presented in Tables 11 and 12, respectively, with impacts on production and employment. These results can be interpreted as the total potential of impacts given the proxy of the economic structure built for the semi-arid Bahia in 2015. This is an unprecedented effort as an attempt to measure the economy of the semi-arid Bahia.

Through Table 11, in an initial analysis, an investment of approximately 18 billion reais in the wind power chain has the possibility of generating a total of more than 28 billion reais in direct and indirect impacts on the economy of the Bahian semi-arid region through the matrix that reflects a proxy for the region's economy in the year 2015. What is most striking in the Table are the sectors that receive the most positive impact from these investments, which, in addition to the sectors themselves, civil construction with the possibility of generating direct and indirect impacts which may exceed 2 billion reais, respectively, and the other sector of the extractive industry with the possibility of generating total impacts of more than 2.5 billion reais.

The total impacts on the Bahia semi-arid economy with the investment of approximately 18 billion reais in wind energy has the potential to impact the total production of the region by up to 46 billion reais, which shows a multiplier effect of approximately 2.5 na production, which corroborates with the multipliers calculated in Table 10. They would not receive direct impacts caused by wind investments, 9 sectors of activities, but indirectly all sectors of economic activities in the semi-arid Bahia would receive impacts of the investments predicted, as can be observed in Table 11.

Regarding the possibility of maximum job creation in the economy, given the current structure of the 2015 matrix as a proxy for the Bahia semi-arid economy, the impacts of investments in wind energy planned for the region are capable of generating approximately up to 5,300 formal jobs in the enterprises registered, 1.3 thousand formal jobs in direct impacts and 2 thousand formal jobs in indirect impacts on the economy. This can be seen in Table 12.

Table 11 - Impacts of investments in the wind production chain on production for the semi-arid Bahia, 2015

	Sectors of economic activity	Direct impacts on production- DIPj	Indirect impacts on production - IIPj	Investments in production	Total impacts on production - TIPj
1	Self catering apartments	1,86	44,22	0,00	46,08
2	Cotton cultivation	2,11	297,43	0,00	299,54
3	Growing Sugarcane	0,00	1,15	0,00	1,15
4	Soybean Growing	3,29	238,30	0,00	241,59
5	Other Temporary Farming	2,12	182,42	0,00	184,54
6	Orange cultivation	0,91	28,25	0,00	29,16
7	Coffee Growing	0,40	33,59	0,00	33,99
8	Other Permanent Crops	1,26	83,05	0,00	84,30
9	Animal Breeding	20,67	375,90	0,00	396,57
10	Real Estate Management	1,40	22,56	0,00	23,96
11	Other Extractive Industries	1.443,88	1.265,99	0,00	2.709,87
12	Food, Beverages and Tobacco	0,00	552,39	0,00	552,39
13	Textiles, Clothing and Leather Goods	19,85	765,09	0,00	784,95
14	Pulp, Paper, Newspapers, Magazines and Disks	404,28	475,63	0,00	879,91
15	Oil Refining	5,06	83,82	0,00	88,88
16	Alcohol and Biofuels	0,00	96,30	0,00	96,30
17	Chemicals	235,66	388,40	0,00	624,06
18	Perfumery, Hygiene and Cleaning	0,00	7,44	0,00	7,44
19	Pharmaceutical products	0,00	25,54	0,00	25,54
20	Rubber and Plastic Industry	884,84	670,14	0,00	1.554,98
21	Other Non-Metallic Mineral Products	1.512,39	474,76	0,00	1.987,14
22	Metallurgy and Metallurgy	448,87	549,25	112,00	1.110,12
23	Maq. Office, Electronics, Optics & Hospitality	11,34	5,74	0,00	17,08
24	Machinery and Electrical Materials	283,03	319,96	0,00	602,99
25	Machinery and Equipment and Maintenance	129,10	335,26	0,00	464,36
26	Automotive Industry and Vehicle Parts	0,00	21,42	0,00	21,42
27	Other Transport Equipment	0,00	7,47	0,00	7,47
28	Furniture and Miscellaneous Industries	92,96	102,91	0,00	195,87
29	Electricity, Gas, Water, Sewer and Urban Cleaning	645,13	1.452,77	17.772,17	19.870,07
30	Construction	2.472,83	2.123,95	0,00	4.596,78
31	Trade and Maintenance and Repair Services	67,84	950,00	0,00	1.017,84
32	Transport, Storage and Mail	535,35	918,30	0,00	1.453,65
33	Accommodation and Food Services	644,25	472,77	0,00	1.117,02
34	Information Services	182,38	313,82	0,00	496,20
35	Financial Intermediation and Prev Complementary	668,94	924,72	0,00	1.593,66
36	Real Estate and Rentals	251,12	902,98	0,00	1.154,09
37	Business Services	324,10	1.026,24	0,00	1.350,33
38	Pub. Adm., Health and Educ. Pub and Social Security	97,94	244,15	0,00	342,10
39	Health and Business Education	0,00	61,02	0,00	61,02
40	Services Provided to Families	0,00	92,06	0,00	92,06

Source: Elaborated by the authors from the input-output matrix for the semi-arid Bahia, 2015.

Table 12 - Impacts of investments in the wind power chain on employment for the semi-arid Bahia, 2015

	Sectors of economic activity	Direct Job Impacts - DJIj	Indirect Job Impacts - IJIj	Jobs generated by investments	Total Employment Impacts – TEIj
1	Self catering apartments	1	5	0	6
2	Cotton cultivation	3	40	0	43
3	Growing Sugarcane	0	0	0	0
4	Soybean Growing	5	29	0	34
5	Other Temporary Farming	1	22	0	23
6	Orange cultivation	0	3	0	4
7	Coffee Growing	0	4	0	4
8	Other Permanent Crops	0	10	0	10
9	Animal Breeding	13	46	0	59
10	Real Estate Management	0	3	0	3
11	Other Extractive Industries	200	149	0	348
12	Food, Beverages and Tobacco	0	70	0	70
13	Textiles, Clothing and Leather Goods	28	88	0	115
14	Pulp, Paper, Newspapers, Magazines and Disks	46	55	0	101
15	Oil Refining	1	11	0	11
16	Alcohol and Biofuels	0	12	0	12
17	Chemicals	21	49	0	70
18	Perfumery, Hygiene and Cleaning	0	1	0	1
19	Pharmaceutical products	0	3	0	3
20	Rubber and Plastic Industry	81	76	0	157
21	Other Non-Metallic Mineral Products	138	54	0	192
22	Metallurgy and Metallurgy	50	65	340	454
23	Maq. Office, Electronics, Optics & Hospitality	1	1	0	2
24	Machinery and Electrical Materials	31	38	0	69
25	Machinery and Equipment and Maintenance	13	38	0	51
26	Automotive Industry and Vehicle Parts	0	3	0	3
27	Other Transport Equipment	0	1	0	1
28	Furniture and Miscellaneous Industries	10	12	0	22
29	Electricity, Gas, Water, Sewer and Urban Cleaning	84	169	1.621	1.875
30	Construction	280	248	0	528
31	Trade and Maintenance and Repair Services	33	108	0	141
32	Transport, Storage and Mail	65	105	0	170
33	Accommodation and Food Services	74	54	0	128
34	Information Services	21	36	0	57
35	Financial Intermediation and Prev Complementary	76	106	0	182
36	Real Estate and Rentals	48	103	0	151
37	Business Services	39	119	0	158
38	Pub. Adm., Health and Educ. Pub and Social Security	13	28	0	41
39	Health and Business Education	0	7	0	7
40	Services Provided to Families	0	11	0	11

Source: Elaborated by the authors from the input-output matrix for the semi-arid Bahia, 2015.

Civil construction receives direct and indirect impacts that can be noticed as the largest, in addition to the sectors that generate investments in wind farms. Thus, directly, it is possible that up

to 280 new jobs are created directly by wind investments in the construction sector and 248 new jobs as an indirect impact of these investments. Another fact that calls attention is the steel and metallurgy chain, which, through the mining industry and other nonmetallic minerals and construction sectors, are the sectors most affected by the proposed investments, as can be seen in the Table 12.

5. Conclusion

This work used input-output indicators to evaluate the socioeconomic impacts of the implementation of wind farms in Bahia municipalities with the advent of wind activity in the State, for which the Matrix Bahia 2015 was used to estimate matrices within and outside the semi-arid Bahia. For purposes of conclusion, in this section, the results will be treated in relation to the study region, the semiarid.

The Rasmussen-Hirschman linkage indices revealed that cotton cultivation; forestry production; oil refining; alcohol and biofuels; pharmaceutical products; other non-metallic mineral products; office, electronic, optical and hospital machines; electrical machinery and equipment; automotive industry and vehicle parts; other transport equipment and various furniture and industry are sectors that have strong backward linkages, that is, they reasonably demand a quantity of inputs from other sectors. The alcohol and biofuels sector, due to its relatively low dispersion effect, is the most homogeneous sector in the region.

With regard to the forward link index, the sectors that deserve attention in the supply of inputs are: animal husbandry; construction; trade and maintenance and repair services; transport; storage and post office; accommodation and food services; financial intermediation and supplementary pension; real estate activities and rentals; and business services.

Seven key sectors were identified in the Bahian semi-arid region: others from the extractive industry; food, beverages and tobacco; textiles, clothing and leather articles; various chemical products; rubber and plastic industry; metallurgy and metallurgy; electricity, gas, water, sewage and urban cleaning. These sectors, according to the estimates of this work, are of great importance for the region due to its impacts in the other sectors. And, policies that aim at sustainable development in the region should consider intersectoral linkages. It is interesting to note that the electricity, gas, water, sewage and urban cleaning sector is a key sector in the region of study. In turn, the deployment of wind farms in the semi-arid region can be a strategic target.

Through the fields of influence, it was possible to know the most important links of the semiarid productive structure, especially the sector 29 - furniture and various industries and the sector 30 - civil construction as those that have the greatest propagating effects on the other sectors,

for the (in the columns), that is, on the demand side. From the perspective of sales there is little interaction.

As for the hypothetical extraction of sectors, another measure of semi-arid productive integration in the extraction of the electricity, gas, water, sewage and urban cleaning sectors was first extracted from the region's economy by 15%, 30%, 50 %, and then totally at 100%. It was found that the sectors that feel the effects of a reduction of 15% and 30% and 50% are: cotton cultivation, other temporary crops and cereals with the highest percentage losses in terms of relative losses. The sector most sensitive to the total extraction of the electricity, gas, water, sewage and urban cleaning sector is the sector itself, with global impacts of 61% reduction in total activity, taking into account the direct and indirect (total) impacts on the sector.

The results of the production multipliers show that the ethanol and biofuels sector stands out most, showing that for each increase of 1 monetary unit in the final demand of the sector, 4.06 monetary units of the product of all sectors of the economy baiana On the other hand, the perfumery, hygiene and cleaning sectors and the metallurgy and steel industry presented the second and third places, respectively. In the sectors with the highest employment multipliers, for every 1 million monetary units in the final demand, the public administration sector has the greatest potential to generate formal jobs in the economy, 134 total jobs (direct and indirect). This is followed by the perfumery, hygiene and cleaning sector which would generate 31 total jobs and by the furniture and various industries sector with 28 total formal jobs in the economy. Already in the income multipliers the sectors of cereal cultivation, the cultivation of other temporary crops and that of machinery and equipment and maintenance, in the semi-arid region of Bahia, are the ones that are more prominent. This shows the weight of the agricultural sector in the region for income generation.

The impacts of investments in the production chain of the semiarid wind sector on production and employment were estimated based on data from the investment intensity protocols captured by SDE after 2015 and carried out until 2018, in addition to the unrealized protocols. The results show that in an initial analysis, an investment of approximately 18 billion reais in the wind power chain has the potential to generate a total of more than 28 billion reais in direct and indirect impacts on the Bahian semi-arid economy through the matrix that reflects the economy of the region. The sectors that receive the most impacts from these investments are the construction industry and the other sector of the extractive industry. In production the impact of the initial investment is 46 billion reais. For the generation of jobs, the impacts of the planned wind energy investments can lead to the creation of approximately 5,300 formal jobs in the economy, with approximately 2 thousand formal jobs in the enterprises registered, 1.3 thousand formal jobs in impacts and formal jobs in indirect impacts on the economy.

From the above, since a great part of the Bahian wind potential is mapped in the semi-arid, the implementation of wind power ventures is characterized as a means to bring sustainable development to the semi-arid Bahia, through clean and renewable energy. Thus, the policy-maker in the decision-making process must be aware of the goal that he wishes to achieve. If the economic growth of the region is desired, the key sectors identified in this study should be the focus of the policy. On the other hand, if you wish to foster development, you should look at the multipliers of employment and income, but if you are looking for a growth indicator, the production multiplier would be more appropriate. In this sense, when investigating socioeconomic impacts in the municipalities of Bahia, the present article contributes with the agents involved in the decision making process for the elaboration of policies aimed at the social and economic development of the semi-arid region.

References

ASSOCIAÇÃO BRASILEIRA DE ENERGIA EÓLICA (ABEEÓLICA). **Energia eólica: panorama atual e futuro.** Fórum Nacional Eólico. Natal-RN. 2017.

ASSOCIAÇÃO BRASILEIRA DE ENERGIA EÓLICA (ABEEÓLICA). **Boletim anual de geração eólica 2017.** 2018. Disponível em: < http://www.abeeolica.org.br/>. Acesso em: 17 fev. 2018.

BAHIA. Secretaria de Desenvolvimento Econômico (SDE). **Energias Renováveis – Energia Eólica**. 2018. Disponível em: < http://www.sde.ba.gov.br/Pagina.aspx?pagina=energia>. Acesso em: 10 fev. 2018.

BRASIL. Ministério do Desenvolvimento, Indústria e Comércio Exterior (MDIC). Rede Nacional de Informações sobre o Investimento (RENAI). **Energia Eólica**. 2012. Disponível em: <http://investimentos.mdic.gov.br/public/arquivo/arq1345555081.pdf>. Acesso em: 14 dez. 2017.

BRASIL. Ministério do Desenvolvimento, Indústria e Comércio Exterior (MDIC). Rede Nacional de Informações sobre o Investimento (RENAI). **Energia eólica: um novo ciclo de desenvolvimento.** Panorama Setorial: Energia Renováveis – Eólica. 2015. Disponível em: <http://investimentos.desenvolvimento.gov.br/public/arquivo/arq1447102123.pdf>. Acesso em: 20 nov. 2017.

CABRAL, J. A.; CABRAL, M. V. F.; OLIVEIRA, D. R. Análise do conteúdo tecnológico das exportações brasileiras sob a lógica estruturalista-kaldoriana. **Nova Economia,** v.27, n. 2, p. 157-184, 2017.

CAMARGO-SCHUBERT. **Atlas eólico: Bahia.** 2013.

DIETZENBACHER, E.; VAN DER LINDEN, J. A.; STEENGE, A. E. The regional extraction method: EC input-output comparisons. **Economic Systems Research**, v. 5, n. 2, p. 185-207, 1993.

GLOBAL WIND ENERGY COUNCIL (GWEC). **Global Wind Statistics 2017**. 2018. Disponível em:< http://gwec.net/wp-content/uploads/vip/GWEC_PRstats2017_EN-003_FINAL.pdf>. Acesso em: 17 fev. 2018.

GUILHOTO, J. J. M. **Input – Output Analysis: Theory and Foundations.** Departamento de Economia. FEA-USP. 2011. Disponível em: http://mpra.ub.uni-muenchen.de/32566/. Acesso em: 30 out. 2017.

GUILHOTO, J. J. M.; AZZONI, C. R.; ICHIHARA, S. M.; KADOTA, D. K.; HADDAD, E. A. **Matriz de Insumo-Produto do Nordeste e Estados: Metodologia e Resultados**. Fortaleza: Banco do Nordeste do Brasil, 2010.

HIRSCHMAN, A.O. **The Strategy of Economic Development**. New Haven: Yale University Press. 1958.

LEITE, A.P.V. **Uma metodologia para construção de matrizes regionais compatíveis - o RAS modificado agregado: uma aplicação para as grandes regiões do Brasil em 2006**. 2009. 91 f. Dissertação (Mestrado em Economia) – Faculdade de Ciências Econômicas, Universidade Federal da Bahia, Salvador, 2009.

MILLER, R.E.; P.D. BLAIR. **Input-Output Analysis: Foundations and Extensions.** 2ª Edição. Cambrige: Cambridge University Press. 2009.

PEREIRA, R. M. **Aspectos econômicos dos modelos de cobrança da água pelo lançamento de efluentes: a bacia hidrográfica do rio Paraíba do Sul.** 2007. 227f. Dissertação (Mestrado em Economia) – Curso de Mestrado em Economia, UFBA, Salvador, 2007.

PRADO, E. F. S. **Estrutura tecnológica e desenvolvimento regional**. São Paulo: IPE/USP, 1981. 230 p.

RASMUSSEN, P. **Studies in Intersectoral Relations**. Amsterdam: North Holland. 1956.

SILVEIRA, A. H. P. Uma variante do método biproporcional para a estimativa de matrizes de relações intersetoriais na ausência de dados sobre produção intermediária. In: CONGRESSO NACIONAL DE ECONOMIA,15, 1993, Belo Horizonte. **Anais**... Belo Horizonte: ANPEC, 1993.

SONIS, M.; HEWINGS, G.J.D. Error and Sensitivity Input-Output Analysis: a New Approach. In: R.E. Miller, K.R. Polenske e A.Z. Rose (eds.) **Frontiers of Input-Output Analysis**. New York, Oxford University Press. 1989.

SONIS, M.; HEWINGS, G.J.D. **Fields of Influence in Input-Output Systems**. University of Illinois, Regional Economics Applications Laboratory, 1994.