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Indicators to the Consumption of Electric Energy and Agriculture Cattle Farming Production for the Elaboration of Clusters with Cities of the State of São Paulo, Brazil

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Abstract: The issue in this matter is that rules for use of electricity in rural areas are limited to the provision of inputs. Adopting guidelines to consider managed sub regions can generate poor results. The focus of this study was to present parameters for indicators of electric energy and agricultural production to allow the formation of city groups in Sao Paulo State, Brazil, with similar electric energy consumption and rural agricultural production. The methodology was the development of indicators that characterize the electric energy consumption/agricultural production and the preparation of groups using indicators with ward of statistical method of groups. The main conclusions were the formation of six homogeneous groups with similar characteristics regarding agricultural production/consumption of electricity. The application of these groups in cities with similar characteristics would produce more satisfactory results than the division of administrative Rural Development Offices (RDO).

Key words: Clusters, indicators, productive energy.

1. Introduction

The economic development of society is a strong target of government. For this purpose, many strategies have been planned by the Brazilian government considering current policies and directed by international organizations. Among these rules, authors can highlight the suggested in 1940 by Economic Commission for Latin America and the Caribbean (ECLAC), which emphasized industrialization which was the main premise of a country as a fundamental factor for development [1]. Urban concentration is indispensable to this model to become truthful. The development standard that considers fundamental urbanization has resulted in the rural exodus. However, this exodus did not occur because the cities functioned as an attractive force for rural residents with better living conditions, urban infrastructure and employment opportunities, but also as a reflection of technological and industrial development activities farming to laborsaving. The expansion of rural and non-agricultural (RNA) activities is an important component of the current stage of development in the rural economy. It has created new job opportunities for the resident population in the field and alternatives to achieve superior gains compared to agricultural activities, constituting a growing share of rural incomes. This phenomenon, although further researched in developed countries, can also be observed in countries under development [2].

The rural electrification represents a condition for

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development of rural areas contributing to non-agricultural rural activities, though simple electrification does not guarantee long-awaited development, because there are multiple other factors and interrelated factors. Therefore, there are controversies to be discussed and clarified [3]. In a broader concept [4], besides being fundamental to the promotion of development, electric power also serves as a promoter of other terms of social inclusion policies, which has a strategic character and its access is a common right for all citizens. Consequently, rural electrification is a process that helps to minimize social differences.

The public policy of Sao Paulo State follows the division of administrative areas of the Rural Development Offices (RDO), created from the Decree. 41559 of January 1, 1997 which provides for the administrative structure of the Integral and Technical Assistance Coordination (ITAC), of the Department of Agriculture and Supply of Sao Paulo State [5]. This division follows principles of adjacent municipalities that, if in the opinion of the farmer, understand that assistance can be effective, in terms of parameters of electrical energy consumption in rural areas and can be a measurement allocative inefficient.

The regular issue regarding public policy is the use of electricity in rural areas limited to the provision of inputs. The particular characteristic of each city needs to be observed, because in some regions there are many people with the same electric connection, and in the other side, people are fully satisfied with the input, due to a low application of electric energy. The hypothesis raised is there are no parameters and indicators that assist in the implementation of public policies and private, making them efficient through the decisions taken.

The aim of this study was to present parameters for indicators of energy and agricultural production to allow the formation of city groups in Sao Paulo State with rural similar electric power consumption and the same characteristics of the agricultural production.

2. Materials and Methods

2.1 Materials

The study area includes all cities in Sao Paulo State that meet the initial criteria to own agricultural production, or Gross National Product (GNP) of agricultural and rural population. The first criterion is justified by the purpose of characterizing the consumption of electricity for productive agricultural activity or not. The second criterion emerged by hypothesis that the city only can be used as habitation. Following these criteria, the authors selected 606 of the 645 cities in the State. The data used were for the period from 2001 to 2008, considering energetic variables and productive variables. This period was the latest that could achieve the limitations imposed by electric energy suppliers in the State, considering the latest information under strategic point of view.

The data of the agricultural production of the cities are obtained in the Database of Agricultural Economics Research Institute of Sao Paulo State [6], in the period from 2001 to 2008. The 62 agricultural products used in this work were the same used by the IEA for the calculation of the gross value of agricultural production in Sao Paulo State.

The products were as follows (Portuguese language in parenthesis): avocado, pineapple, dehydrated pumpkin, zucchini, lettuce, cotton, peanut (amendoim da seca and amendoim das águas), rice (arroz de sequeiro, arroz de várzea and arroz irrigado), banana, potato (batata da seca, batata das águas, batata de inverno, batata doce), beet, silkworm, cattle, coffee, sugarcane, persimmon, onion (cebola de muda and cebola de soqueira), carrot, bean (feijão da seca, feijão das águas, feijão de inverno irrigado, feijão de inverno sem irrigação), figfruit (figo para mesa), chickens (frangos and galinhas para ovos), guava (goiaba para indústria and goiaba para mesa), orange, milk (classified as B type and C type), lime, cassavaroot (mandioca para indústria and mandioca para mesa), mango fruit, passion fruit, watermelon, tangerine, corn, murcott, peach, capsicum, ponkan fruit, cabbage, rubber tree, soybean, grain sorghum (sorgo granífero da seca and sorgo granífero das águas), pigs, tomato (tomate envarado and tomate rasteiro), wheat, and grape (uva comum para mesa and uva fina para mesa).

The prices were collected from the average values in Sao Paulo State [6], between 2001 and 2008, updated by the Consumer Price Full Index-CPFI [7] until December 2008. The CPFI was chosen as the official inflation index used by the Central Bank of Brazil. The production value of each city was calculated with the updated prices. Data were collected on the electric power of cities, by special request to all electric energy suppliers in Sao Paulo State, in Table 1.

Information: electricity consumption in kWh units, in residential and rural areas, and the respective quantities of connections among the cities. Remark: the electric energy supplier classifies consumer unit according to the activity carried on in it, as ANEEL Resolution 456 of November 29, 2000 (ANEEL is the Electric Energy National Agency, or Agencia Nacional de Energia Elétrica, in Portuguese language). The industries located in rural areas are classified as industrial consumer, and the separation of energy used for irrigation has not been observed by all electric energy suppliers since 1998. Thereby, the subgroup B2 was considered as rural consumers, which include: rural, rural electrification cooperative and public service for irrigation.

Table 1 Electricity supply companies in Sao Paulo State.

No.	Company name
1	Bandeirante Energia S.A.
2	Caiuá-Serviços de Eletricidade S.A.
3	Companhia Jaguari de Energia
4	Companhia Luz e Força Mococa
5	Companhia Luz e Força Santa Cruz
6	Companhia Nacional de Energia Elétrica
7	Companhia Paulista de Energia Elétrica
8	Companhia Sul Paulista de Energia Elétrica
9	Cpfl-Companhia Paulista de Força E Luz
10	Companhia Piratininga de Força E Luz
11	Elektro-Eletricidade e Serviços S.A.
12	Eletropaulo Metropolitana-Eletricidade de Sao Paulo S.A.
13	Empresa Bragantina S.A.
14	Empresa de Eletricidade Vale Paranapanema S.A.

Information about the list of rural and urban residents, as well as the profile of the cities, was obtained through the Foundation's State System of Data Analysis [8].

2.2 Methods

The original data correspond to the period from 2001 to 2008, were transformed into variables of the arithmetic average of the period. The following description is related to these variables calculated for all 606 cities of the study:

RIPEP: Rural Indicator of the Proportion of Electricity Production. It represents the proportion of electricity production in total electricity consumed, considering rural residential uses similar to an urban per capita. It is obtained by dividing the RIEEP by Consumption of Urban Residentia (CUR) as shown in the Eq. 1.

(1) For positive values of RIPEP: the answer will be the proportion of electric energy for productive activities above the minimum intended for residential uses. The multiplication of positive indicator by the Consumption for Each Rural Inhabitant (CERI) results in surplus value of rural electricity consumption per capita in the city (kWh), compared to the expected, in other words, how much each inhabitant consumes.

$$RIPEP = \frac{RIEEP}{CUR} \tag{1}$$

(2) For negative values of RIPEP: the answer will be the proportion of electricity below what is expected of residential consumption per capita in rural areas. It indicates the absence of energy use for productive purpose sand under-utilization of available energy for residential purposes. This indicator shows a deficit of electricity rural consumption per capita, compared to that expected, in other words, how much the urban inhabitant consumes, according to it is explained in the item #3, as follow.

(3) If the RIPEP is zero: in this situation the average urban per capita equaled to the average rural consumption per capita. The existence of electricity for productive purposes was not detected by the indicator (Source of the preparation of this indicator: this research).

CERI (kWh): annual average electricity Consumption for Each Rural Inhabitant. It is calculated by dividing the total rural consumption of electricity by the number of rural inhabitants in the city. This indicator measures different levels of consumption among the cities (Source of preparation of this indicator: all electric energy suppliers and SEADE Foundation).

RIEEP (kWh): Rural Indicator of Electric Energy Productive per capita. It is obtained by the difference between the rural average CERI and the average CUR per capita. It is represented by Eq. 2.

$$RIEEP = CERI - CUR \qquad (2)$$

The preparation of this indicator assumes that rural average consumption per capita is equal to the urban consumption per capita. The lower income of rural resident compared to urban justifies a discount of rural consumption, however there are energy costs in rural areas, not observed in the urban area, such as water pumping, use of equipment for grass smashing and others. The purpose of this indicator is to track the use of productive energy, to match the urban and rural consumption, and it offers (kWh) a security to affirm use of electricity for productive purposes. This variable value can be positive or negative.

If the RIEEP is positive, indicating how much (kWh) the rural average consumption of electricity is beyond the residential use per capita. Therefore, it is a surplus of electric energy use for productive purposes.

If the RIEEP is negative: it indicates how much (kWh) the rural average consumption of electricity per capita is below urban average, resulting in a deficit use of electric energy for productive purposes. (Source of preparation of this indicator: all electric energy suppliers and SEADE Foundation).

Rural Connection (RC) (u): number of people who use the same rural electric energy connection. This value is obtained by dividing the number of rural residents by the number of electricity connections in a conventional system of energy distribution. This indicator allows evaluating the quality of energy supply (also called electric support) in the city (Source of preparation of this indicator: all electric energy suppliers and SEADE Foundation).

APGV (R$-Brazilian currency): Agricultural Production Gross Value per inhabitant. This value is obtained by dividing the rural production gross value of the city by the number of rural inhabitants in the city. This index follows a method [9], adapted for only one city: This indicator represents the average of the gross value of production in Real (Brazil’s currency) per rural inhabitant. Authors used a rate per inhabitant in order to explain that the difference in production among cities reaches a common indicator among them and the indicators of electric energy. The intensiveness in the use of workforce and use of hardware has main influence on this indicator, as well as the type of productive activity. However, as intended to establish parameters for city groups with the same energetic characteristics and similar production, the reduction of the activities in a per capita indicator can achieve the purpose of comparison (Source of preparation of this indicator: IEA and SEADE Foundation).

CUR (kWh): average annual consumption of urban electricity per capita. It is calculated by dividing the total urban consumption of electricity by the number of urban inhabitants in the city (Source of preparation of this indicator: all the electric energy suppliers and SEADE foundation).

2.2.1 Working with the Variables

After the definitions of the variables to be used for each city (RIPEP, CERI, RIEEP, RC, APGV, CUR) proceeded to begin analysis in the main components and in the defined groups. These six variables were chosen for their importance to have as a common element: the number of inhabitants.

The main components [10] are a statistical technique which linearly transforms a set of *P* variables in a smaller set (k) of uncorrelated variables, which explains a significant portion of the information of the original set. For this analysis does not need any assumption about the shape of the multivariate distribution of these variables, it may be normal or not, and even this does not occur, the results are satisfactory [11].

Based on the scores obtained in the main components of each city, the method becomes in a cluster analysis in order to detect the cities with similar standards for the variables evaluated. This multivariate analytical technique is to develop meaningful subgroups of individuals or objects mutually exclusive based on the similarities of the variables [12]. Among the various clustering methods, ward method was chosen to minimize the differences within groups and to avoid problems with chaining of the observations found in the method of individual connection.

The use of these techniques resulted in the formation of clusters. For a visual comparison of the trend of variable energy and production (RIPEP, CERI, RIEEP, RC, APGV and CUR) in each group, Table 2 is presented with all the parameters of clusters formed with the arithmetic average, maximum value, minimum value and standard deviation (Std. D.).

3. Results and Discussion

The cluster analysis allowed to detect cities with similar standards for the variables evaluated. It was decided, following consideration of the dendrogram, establishment of six groups or clusters (the dendrogram is omitted due to lack of clarity of the chart considering the high number of cities) amounting

Table 2 Indicators and parameters for the variables of electrical energy and agricultural production by grouping formed in the cities of Sao Paulo State.

Cluster	Parameter	RIPEP	CERI (kWh)	RIEEP (kWh)	RC (u)	APGV (R$)	CUR (kWh)
CL1 8 Cities	Average	19.5	10,782.7	10,254.3	6.33	83,358.39	528.3
	Maximum	24.9	13,049.1	12,544.6	23.18	148,841.23	605.4
	Minimum	13.4	8,698.3	8,092.9	2.55	35,175.37	455,6
	Std. D.	4.7	1,713.8	1,712.9	6.44	39,139.21	44.0
CL2 39 Cities	Average	8.5	4,592.2	4,090.0	6.89	58,842.08	502.3
	Maximum	24.5	8,004.8	7,521.7	78.60	137,828.57	608.7
	Minimum	3.2	2,057.2	1,574.7	1.94	2,143.45	261.5
	Std. D.	9.0	1,491.5	1,498.8	12.17	32,809.47	72.8
CL3 190 Cities	Average	2.9	2,081.4	1,548.6	5.42	36,977.92	532.8
	Maximum	8.1	4,338.4	3,700.4	37.57	103,034.97	866.3
	Minimum	0.4	634.9	165.6	1.43	3,604.26	376.6
	Std. D.	1.2	646.9	627.2	4.60	16,649.27	82.4
CL4 275 Cities	Average	1.1	1,111.4	573.1	6.72	16,137.98	538.3
	Maximum	5.5	2,251.2	1,906.1	53.82	66,651.85	1007.2
	Minimum	-0.3	333.5	-191.6	1.95	650.14	314.3
	Std. D.	0.7	334.6	322.0	5.19	9,435.71	112.5
CL5 73 Cities	Average	-0.48	331.6	-327.1	23.16	3,656.46	658.7
	Maximum	0.23	809.3	101.6	71.91	18,999.81	1,312.9
	Minimum	-0.90	65.7	-1,121.6	5.28	207.05	330.5
	Std. D.	0.26	180.5	242.6	14.99	3,724.87	175.5
CL6 17 Cities	Average	-0.82	125.3	-570.7	121.28	1,677.11	696.1
	Maximum	0.41	1,152.5	335.5	387.29	17,297.94	1,522.8
	Minimum	-0.98	15.7	-1,488.2	31.72	16.79	375.1
	Std. D.	0.32	261.1	374.9	79.28	3,933.02	291.2

to 602 cities. Four additional cities in the State do not fit in any group, as follows: Aluminio, Holambra, Sao Paulo and Taquaral. These cities have values (outliers) for one or more variables that would justify their individualized analysis, in other words, each one of them would be a group.

Groups formed by the indicator parameters are the result of the combination of all variables. For this reason a city fit for a particular group is closer to a particular combination. Observing the average value of each variable in each cluster can be seen and these values are decreasing for the variables—RIPEP, CERI, RIEEP, and APGV.

Table 2 shows the parameters of the studied variables. The first group (CL1) is composed by eight cities with the largest use of electric energy for productive activities, about 10,254.70 kWh annually. The electric energy for productive activities corresponds 19.5 times higher than spent on electricity for residential use, as can be seen in RIPEP.

The index for CL2 is 8.5 times (4,090.00 kWh) decreased to 2.9 in CL3 (1,548.62 kWh) and 1.1 in AG4 (573.09 kWh) until reaching negative values in CL5 (-327.08 kWh) and CL6 (-570.77 kWh). Therefore, we can affirm the existence of electric energy for productive purposes in groups 1, 2, 3 and 4. In group 5 there is a negative RIPEP of 0.48, in other words, indicating the energy consumed in cities is average 48% lower than the minimum for residential use. The same occurs in group 6 with negative index of 0.82.

The presence of electrical energy consumption for production purposes can be an indicator of non-agricultural rural activities (RNA). Increasing the general level of education of the rural population in countries under development is a crucial factor for the expansion of more productive activities RNA [13]. The educational performance is an important variable to install activities of processing and marketing of food, focusing the success of non-agricultural enterprises and to obtain jobs with higher earnings [1]. Previously, these enterprises were dedicated only to produce primary or basic goods.

Negative consumption values of electric energy for productive purposes occur in the groups 5 and 6. They present a high ratio of inhabitants per electric energy connection. We can see a variation of 5.42 to 6.33 inhabitants per electric connection in groups 1, 2, 3 and 4, but in groups 5 and 6, the values are 23.16 and 121.28 inhabitants per electric energy connection respectively. The electrical support is still poor in the cities of these groups. This deficiency associated with consumption below the urban average electric energy consumption per capita indicates the use of rural area for leisure activities such as cottage and the beach, it stands out in groups 5 and 6, the metropolitan region of Sao Paulo and the Paulista Coast (cities near Sao Paulo City in the sea side of the Sao Paulo State).

Remark: the groups have a descending order in electric energy consumption. The highest consumption occurs in the group 1 decreasing to the group 4, and becomes negative in the groups 5 and 6. Concomitantly we observe a decrease in the gross value of city production per inhabitant. That agricultural production requires non-agricultural goods and services and it attracts investment to expand the local agriculture industry as trade in inputs, services transportation, mechanical repairs and rural plants. Therefore, the dynamic agriculture attracts non-agricultural activities [14].

In Fig. 1 it can be seen that the standard of CUR maintains stable ranging in average, 502 kWh to 696 kWh for the six groups. The CUR is a reference to calculate RIEEP. The indicator is more reliable due to this stability.

To increase the electric energy consumption in the rural groups 5 and 6 until reaching the city level would suggest a change in the use of rural areas. This change would indicate an increase of agricultural production, according to the APGV decrease from the first to the group 6, from R$83,358.39 to R$1,677.11 (Brazilian Real) and the decreased CERI

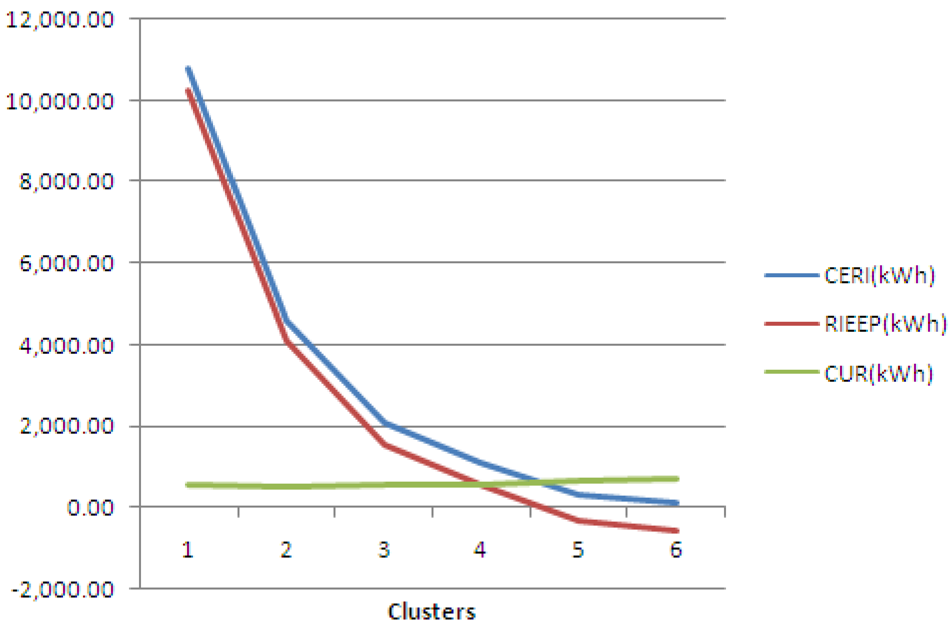

Fig. 1 Indicators of rural electric energy consumption (kWh).

from 10,782.70 kWh to 125.32 kWh annually. Thus, the observation in these groups 5 and 6 is that houses are not used as permanent residences, but eventually used as residences.

Most cities in the State have productive use of electric energy and proper electrical support in rural areas in groups 1, 2, 3 and 4. The increased use of electricity in non-agricultural activities can be an option to increase income generation; however, there are most non-agricultural activities related to agricultural activities.

4. Conclusions

The preparation of indicators to give an overview in the situation of the electric energy consumption of rural and agricultural production has enabled us to draw up groups of cities with homogeneous characteristics regarding the consumption of electricity and rural agricultural production. The State Division in Rural Development Offices (RDO) areas, which follows the principles of adjacent cities, presented very dispersing parameters and their average values clearly demonstrate differences among groups of cities. It allows us to conclude that public policies considering adjacent areas may provide unsatisfactory results for rural electrification.

The use of groups of adjacent cities or not, with similar characteristics, would produce more satisfactory results in the policy of rural electrification.

The electric energy works as vector of development, considering that: as the smaller is the rural indicator of productivity energy, the more distant is the minimum expected consumption for electric energy per capita is. The indicator values of rural productive electric energy per capita presented decrease concomitantly with the value of agricultural production per capita, demonstrating the existence of a dynamic between agricultural production and the presence of non-agricultural activities.

In this way, it can be concluded that indicators of electric energy consumption for productive activities can be used as a reference to detect: the way that rural area is using, in other words, as a permanent residence or sporadic, if there is also presence of non-agricultural activities. This indicator allows this detection without need to conduct a census, assisting in policy for rural development. Other studies should be made to complement this one and to assist decision-making of public and private agencies.

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