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Research Article

Energy Consumption and Regional Development in the Matopiba Region Between 2000 and 2020

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ABSTRACT

The region called the acronym Matopiba is an area composed of part of the states of Maranhão, Tocantins, Piaui, and Bahia. Agricultural production in the region is marked by large harvests of grains, especially soybeans, corn, and cotton. Considering that electricity is a vital development infrastructure, the present study analyzed the electricity consumption in the Matopiba region located in the state of Piauí was related to the total GDP (GDP), agriculture GDP (AGDP), and human development index (HDI) between the years 2000 to 2020. The results showed that in 2000 there was a strong positive correlation between GDP and AGDP (0.92), a moderate positive correlation between GDP and energy consumption (0.60), as well as AGDP and electricity consumption (0.67). Results indicated a low negative correlation between the HDI and the other variables. In 2020, the results indicated a strong positive correlation between GDP and AGDP (0.83), and a high positive correlation between GDP and energy consumption (0.83), while AGDP showed a low positive correlation with the consumption of electricity (0.46). The HDI, on the other hand, showed a low negative correlation with AGDP and a low positive correlation with GDP. On the other hand, it showed a moderate positive correlation with electricity consumption. It was also verified that there was a substantial rise in the HDI in the municipalities studied between 2000 and 2020, an increase in the region's GDP and AGDP, and electricity consumption in the period studied. Therefore, we concluded that the increase in the electricity consumed in the region in the last 20 years is a positive indicator of Matopiba's regional development.

Keywords: infrastructure, economic development, social development

INTRODUCTION

The region called the acronym Matopiba is an area composed of part of the states of Maranhão, Tocantins, Piaui, and Bahia. Compared to the tight areas of the country's center-south, the flat topography and the low land cost led some enterprising rural producers to invest in the then-new agricultural frontier. The expansion took place over cerrado areas, especially underused pastures, and was only possible due to the availability of technologies to make planting possible under local conditions (EMBRAPA, 2018b). Agricultural production in the region is marked by large harvests of grains, especially soybeans, corn, and cotton (Buainain et al., 2018). Adding to the entire expansion area, the local harvest of soybeans and corn was almost 15 million tons in 2018, equivalent to about 10% of national production (EMBRAPA, 2014, 2018a). The region's rural areas also make room for fruits, roots and tubers, forest species, and livestock. The Matopiba area in the state of Piauí encompasses Southwest Piauiense, covering the microregions of Alto Parnaíba Piauiense, Bertolínia, and Alto Médio Gurgéia (Pereira et al., 2018).

Gross domestic product (GDP) is the sum of all final goods and services produced by a country, state, or city, usually in a year. It is an economic indicator related to the economic activity of a place during a specific period. The GDP represents the place's economic dynamics, indicating the economy's possible growth. The agriculture GDP (AGDP) corresponds to the sum of all final goods and services associated with agricultural production. Usually, the data on GDP is reported as development. However, development is a political construction of society characterized by improved quality of life, technological advancement, improvement of institutions, and evolution of social indicators (Saab et al., 2021). Therefore, the development concept goes beyond definitions restricted to economic growth and must involve aspects related to social and human dimensions. The human development approach considers that economic growth alone is insufficient to explain countries' progress (Bilbao-Ubillos, 2013). Progress stems from a process of political, economic, and social

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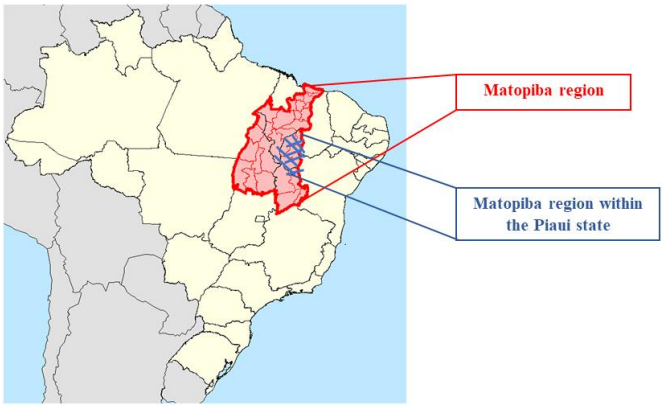

Figure 1. The region of Matopiba is delimited on the map of Brazil (EMBRAPA, 2014)

transformation, where growth is just one of these areas and, in isolation, will consist of superficial development.

Human development index (HDI) is an important indicator to support the direction of public policies. Created in the mid-1990s by the United Nations, HDI aims to verify the degree of development of countries, regions, states, and municipalities based on pre-established performance indicators related to health, education, and income (UNDP, 2010). Thus, from the diffusion of the use of the HDI, public authorities were able to guide public policies in order to seek development not only through an increase in wealth but also through improvement in the levels of health, medical services, education, conditions of work, rights, freedoms, family relationships and infrastructure (Mattei et al., 2018).

The dissemination of HDI use and its application in public policies has enabled the identification of determining factors for increasing the quality of life of populations. Saab et al. (2021) studied the factors that influence the HDI of Brazilian municipalities. The results indicated that the conditions of electric energy, population size, location, income, and sanitation proved to be factors that explain the HDI. However, according to Melo et al. (2020), between 1999 and 2011, there was a retraction in residential energy consumption in Brazil. Despite this retraction, HDI increased in the same period indicating that the quality of life is associated with electricity consumption in the studied period. The consumption of electric energy in the residential sector has different habits, which can vary according to the priorities in each region. The results obtained by Scaramucci et al. (2006) show, in a way, that the supply of electricity has not only energy-ensured living advantages but also provides economic benefits. Barbosa and dos Santos (2020) studied the causal relationship between Brazil's electricity consumption and real GDP. The results indicated that factors associated with the restriction of electricity consumption, such as the lack of investments in the infrastructure of the electricity sector and inadequate policies, can influence, in the long term, the growth of the Brazilian economy.

Electricity plays a decisive role in regional development, and its proper use can increase the productivity of production factors (capital and labor) and promote quality of life. Within this scenario, the present study analyzed the interrelations between GDP, AGDP, HDI, and electricity consumption in the Matopiba region, inserted in Piauí, between 2000 to 2020. The research questions are, as follows:

1. Is the electricity consumption related to the region's development?
2. Can we use the electric energy consumption to describe the region's development with the energy consumption?

METHODOLOGY

Data were collected on GDP, AGDP, HDI, and electricity consumption in 14 municipalities between 2000 and 2020 in the Matopiba region of Piauí (**Figure 1**). The data were collected from primary online databases (IBGE, 2020; IEA, 2020; IEA-SAA, 2020; UNDP, 2010) and organized for processing.

Multiple linear regression was applied to explain the relationship between a dependent variable and two or more independent variables. In this case, the dependent variable (Y) was considered electricity consumption, while the independent variables (X_n) were GDP (R$, X_1), agribusiness GDP (R$, X_2), and HDI (X_3). Multiple linear regression can be expressed as:

$$Y=a+b_1X_1+b_2X_2+\cdots+b_nX_n, \quad (1)$$

where a is a starting point constant analogous to the intercept in a simple two-variable regression, and b_1, b_2, and ... b_n are the nonstandard regression weights for X_1, X_2, and X_n analogous to the slope of two regression variables (Lowry, 2021).

Correlations between the variables were evaluated to understand how the dependent variables behaved concerning energy consumption. For the correlation values, the following were considered: ±0.9 indicates a very strong correlation. Between 0.7 and 0.9, positive or negative, indicates a strong correlation. Between 0.5 and 0.7, positive or negative, indicates a moderate correlation; below 0.5, it is a low correlation (Ingram, 1974).

The online software Vassarstatst (Lowry, 2021) was used to perform the calculations.

RESULTS AND DISCUSSION

Figure 2 shows the variation in the studied GDP, AGDP, HDI, and electricity consumption between 2000 and 2020 for the studied municipalities. It is noted that there was an increase of about 35% in HDI values in 20 years, while the GDP and the AGDP, which were almost imperceptible in 2000, became significant in 2020. Electricity consumption also increased significantly in the period.

Table 1 indicates the correlation matrix between the variables studied in 2000. The value of a=34325.78, b_1=-0.02 and b_2=0.07, for r^2=0.60, with a p-value= 0.0004. Note that in 2000 (**Table 1**), there was a strong positive correlation between GDP and AGDP (0.92), a moderate positive correlation between GDP and energy consumption (0.60), as well as AGDP and electricity consumption (0.67). There was a low negative correlation between the HDI and the other variables.

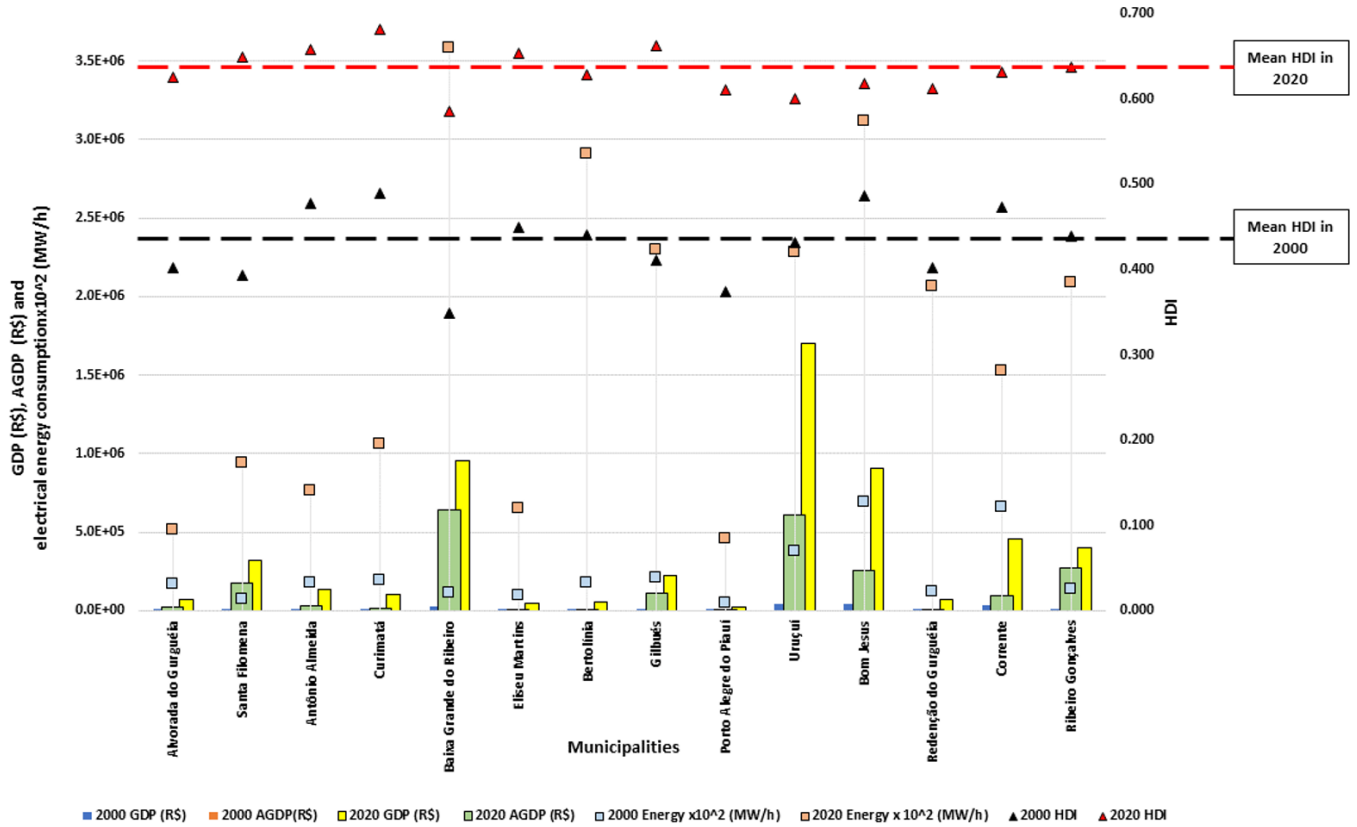

Figure 2. Variation in the values of GDP, AGDP, HDI, and electricity consumption in the years 2000 and 2020 in 14 municipalities in the Matopiba region included in the state of Piauí

Table 1. Correlation matrix of the variables studied in 2000

	GDP	AGDP	HDI	EC
GDP	1	0.92	-0.45	0.60
AGDP	0.92	1	-0.22	0.67
HDI	-0.45	-0.22	1	-0.35
EC	0.60	0.67	-0.35	1

Note. EC: Electricity consumption

Table 2. Correlation matrix of the variables studied in 2020

	GDP	AGDP	HDI	EC
GDP	1	0.83	0.24	0.83
AGDP	0.83	1	-0.08	0.46
HDI	0.24	-0.08	1	0.54
EC	0.83	0.46	0.54	1

Note. EC: Electricity consumption

Table 2 indicares the correlation matrix between the studied variables in 2020. The value of a=-2704.71, b_1=0.19, and b_2=-0.25, for r^2=0.90, and a p-value=0.0001.

In 2020 (**Table 2**), there was a strong positive correlation between GDP and AGDP (0.83), a high positive correlation between GDP and energy consumption (0.83), while AGDP showed a low positive correlation with electricity consumption (0.46). The HDI, in contrast, showed a low negative correlation with AGDP and a low positive correlation with GDP. On the other hand, it showed a moderate positive correlation with electricity consumption. The high positive correlation between GDP and energy consumption indicates the economic region economic dynamics of the region up to 2020. Between 2010 and 2020, there was an infrastructure investment in a substation in the micro-region of Uruçui (500 KV) encompassing the municipalities of Ribeiro Gonçalves, Baixa Grande do Ribeiro, and Uruçui). GDP data in 2020 was affected by the COVID-19 pandemic; HDI increased for most municipalities in the region from 2000 to 2020. Also, energy consumption increased during the period.

This region is highly demanded with the growth in demand for food and other products from the agricultural and forestry environment (Macedo et al., 2012). It will be demanded from other sectors for its growth. Although the increase in electricity use in agricultural production is seasonal, it relates to the dry season when there is an increase in the irrigation systems, and the overall electricity consumption increases consistently during the period (**Figure 1**). Such a scenario might indicate the urban population's energy demand that grew in the cities surrounding the agricultural production area related to manufacturing, services, and commerce. Suela et al. (2021) studied the economic dynamics between the Matopiba regions and the other regions of Brazil. The authors concluded that the sectors of Matopiba, despite having lower production multipliers compared to other Brazilian regions, have the highest rates of investment spillover to other regions, thus presenting a higher capacity to boost national industry than any other region of the model. At the same time, the final demand in the main agricultural sectors of the Matopiba region presented a great perspective of growth in the whole model. In Matopiba, the economic sectors related to agricultural production indicate a high demand for inputs from the other economic sectors (EMBRAPA, 2018a).

Mattei et al. (2018) analyzed the functional relationships between Brazilian socio-economic variables and human

development. The authors found that health care, employment, population, longevity, income, and deaths from ill-defined causes impact HDI in Brazil. While Saab et al. (2021) identified that health and education expenditures have a strong influence on HDI of Brazilian municipalities. In the present study, electricity consumption had a low correlation with HDI in 2000; however, the correlation increased to a moderate positive in 2020. Fadilah et al. (2018) and Ijaz (2018) reinforce the importance of infrastructure, including energy, as a crucial investment to achieve better adequate levels of human development. In the present study (**Figure 1**), it is noted that HDI increased significantly between 2000 and 2020 as it also increased the consumption of electricity, probably driven by the growth of agriculture in the region since GDP and agricultural production also evolved positively during the period. Although the COVID-19 pandemic affected the economy in the urban areas, it did not show in the 2020 HDI data, especially when compared to the 2000 database.

According to Martins (2002), the analysis of socio-economic changes in a region, based on data on electricity consumption, has advantages concerning other socio-economic indicators available in Brazilian statistics. First, it can capture the informal economy, which is known to have difficulties securing by available indicators, such as value-added and tax collected. Second, objective information can be collected directly from meters. The results of the current study indicate a high positive correlation between GDP and energy consumption in 2020 (0.83), while AGDP showed a low positive correlation with electricity consumption (0.46). Considering the increase in HDI in 2020 compared to 2000, we can infer that electricity consumption is associated with Matopiba's regional development.

CONCLUSION

The electricity consumption was highly related to the region's development, and there was also an increase in the region's GDP and AGDP and electricity consumption in the period studied. Between 2000 and 2020, the correlation between GDP and electricity consumption grew by around 25%, while the correlation between the HDI and energy consumption grew by around 150%. We can infer that electric energy consumption can describe the region's development according to the results, pointing out the importance of investing in this infrastructure in the region.

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Ethics approval and consent to participate: Not applicable.

Availability of data and materials: All data generated or analyzed during this study are available for sharing when appropriate request is directed to corresponding author.

REFERENCES

Barbosa, P. A. M. and dos Santos, V. F. (2020). Cointegração e causalidade entre consumo de energia elétrica e pib na região sudeste do Brasil [Cointegration and causality between electricity consumption and GDP in southeastern Brazil]. *Revista Estudo & Debate* [*Study & Debate Magazine*], 27(3), 104-118. https://doi.org/10.22410/issn.1983-036X.v27i3a2020.2518

Bilbao-Ubillos, J. (2013). Another approach to measuring human development: The composite dynamic human development index. *Social Indicators Research*, 111(2), 473-484. https://doi.org/10.1007/s11205-012-0015-y

Buainain, A. M., Garcia, J. R. and Vieira Filho, J. E. R. (2018). A economia agropecuária do Matopiba [The agricultural economy of Matopiba]. *Estudos Sociedade e Agricultura* [*Society and Agriculture Studies*], 26(2), 376-401. https://doi.org/10.36920/esa-v26n2-6

EMBRAPA. (2014). Delimitação para o MATOPIBA proposta pelo Grupo de Inteligência Territorial Estratégica da Embrapa [Delimitation for MATOPIBA proposed by Embrapa's Strategic Territorial Intelligence Group]. *Empresa Brasileira de Pesquisa Agropecuária* [*Brazilian Agricultural Research Corporation*]. Available at: https://commons.wikimedia.org/wiki/File:Delimitacaomatopibagite.png

EMBRAPA. (2018a). Visão 2030: O futuro da agricultura Brasileira [Vision 2030: The future of Brazilian agriculture]. *Empresa Brasileira de Pesquisa Agropecuária* [*Brazilian Agricultural Research Corporation*]. Available at: https://www.embrapa.br/visao/o-futuro-da-agricultura-brasileira

EMBRAPA. (2018b). Matopiba. *Empresa Brasileira de Pesquisa Agropecuária* [*Brazilian Agricultural Research Corporation*]. Available at: https://www.embrapa.br/tema-matopiba/sobre-o-tema

Fadilah, A., Ananda, C. F. and Kaluge, D. (2018). A panel approach: How does government expenditure influence human development index? *Jurnal Ekonomi Dan Studi Pembangunan* [*Journal of Economics and Development Studies*], 10(2), 130-139.

IBGE. (2020). PIB por município [GDP by municipality]. *Instituto Brasileiro de Geografia e Estatística* [*Brazilian Institute of Geography and Statistics*]. Available at: https://www.ibge.gov.br/estatisticas/economicas/contas-nacionais/9088-produto-interno-bruto-dos-municipios.html?=&t=pib-por-municipio

IEA. (2020a). Key world energy statistics. *International Energy Agency*. Available at: https://www.iea.org/reports/key-world-energy-statistics-2020

IEA-SAA. (2020b). Análises e indicadores do agronegócio [Agribusiness analysis and indicators]. *Instituto de Economia Agrícola-Secretaria de Agricultura e Abastecimento* [*Institute of Agricultural Economics-Secretariat of Agriculture and Supply*]. Available at: http://www.iea.sp.gov.br/out/artigosaia2.php?codTipo=2

Ijaz, M. (2018). Does poverty reduction cause economic development? *Sukkur IBA Journal of Economics and Finance*, 2(1), 36. https://doi.org/10.30537/sijef.v2i1.200

Ingram, J. A. (1974). *Introductory statistics*. Menlo Park, CA, USA: Cummings Publishing Co.

Lowry, R. (2021). Concepts and applications of inferential statistics. *vassarstats.net*. Available at: http://vassarstats.net/index.html

Macedo, M. N., Defries R. S., Morton D. C., Stickler C. M., Galford G. L. and Shimabukuro, Y. E. (2012). Decoupling of deforestation and soy production in the southern Amazon during the late 2000s. *PNAS*, 109(4), 1341-1346. https://doi.org/10.1073/pnas.1111374109

Martins, C. D. M. (2002). *Consumo de energia elétrica e desenvolvimento sócio-econômico nas regiões de Botucatu e Avaré* [*Electricity consumption and socio-economic development in the regions of Botucatu and Avaré*] [PhD dissertation, Universidade Estadual Paulista].

Mattei, T. F., Bezerra, F. M. and Mello, G. R. de. (2018). Despesas públicas e o nível de desenvolvimento humano dos estados brasileiros: Uma análise do IDHM 2000 e 2010 [Public expenditures and the level of human development of Brazilian states: An analysis of the HDI 2000 and 2010]. *RACE–Revista de Administração, Contabilidade e Economia* [*RACE–Journal of Administration, Accounting and Economics*], 17(1), 29. https://doi.org/10.18593/race.v17i1.10296

Melo, A. P. S., Lima, F. F., Ramos, J. E. S. and Da Costa Borba, M. (2020). Admissibilidade da relação do consumo de energia residencial e o indice de desenvolvimento humano no Brasil no período de 1970 a 2011 [Admissibility of the relationship between residential energy consumption and the human development index in Brazil from 1970 to 2011]. *Revista Ciências Sociais em Perspectiva* [*Journal of Social Sciences in Perspective*], 19(36), 88-a. https://doi.org/10.48075/revistacsp.v19i36.22567

Pereira, C. N., Porcionato, G. L. and Castro, N. (2018). Aspectos socioeconômicos da região do MATOPIBA [Socioeconomic aspects of the MATOPIBA region]. *Boletim Regional, Urbano e Ambiental do IPEA* [*IPEA Regional, Urban and Environmental Bulletin*], 18, 47-60.

Saab, F., Dias, F. O., Lopes, A. V. and Ramalho, P. I. S. (2021). Políticas públicas e desenvolvimento humano: Fatores que impactam o IDH em municípios brasileiros [Public policies and human development: Factors that impact the HDI in Brazilian municipalities]. *RACE-Revista de Administração, Contabilidade e Economia* [*RACE-Journal of Administration, Accounting and Economics*], 20(2), 209-230. https://doi.org/10.18593/race.23354

Scaramucci, J. A., Perin, C., Pulino, P., Bordoni, O. F. J. G., da Cunha, M. P. and Cortez, L. A. B. (2006). Energy from sugarcane bagasse under electricity rationing in Brazil: A computable general equilibrium model. *Energy Policy*, 34(9), 986-992. https://doi.org/10.1016/j.enpol.2004.08.052

Suela, A. G. L., Suela, G. L., Botelho, L. S. and Trotter, I. M. (2021). Economic impact analysis and sectorial relations between MATOPIBA and the rest of Brazil: An input-output approach. *Encontro Internacional de Gestão, Desenvolvimento e Inovação (EIGEDIN)* [*International Meeting on Management, Development and Innovation (EIGEDIN)*], 5(1). https://doi.org/1048075/igepec.v26i1.27994

UNDP. (2010). Relatório de desenvolvimento humano [Human development report]. *United Nations Development Program*. Available at: https://www.undp.org/content/dam/brazil/docs/RelatoriosDesenvolvimento/undp-br-PNUD_HDR_2010.pdf