



Spatial analysis of sustainable development goals: A correlation between socioeconomic variables and electricity use

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ABSTRACT

It is believed that the environment is largely susceptible to changes in human behavior and the constant advances in using new technologies. Different challenges with regard to housing, basic services, food, health, education, and natural resources must be overcome as it is expected an urban population growth in the upcoming decades. Thereby, a proposal has been formulated herein with the aim of understanding the correlation between a group of socioeconomic and environmental variables that tend to represent how cities of a metropolitan region in Brazil behave towards the duality of social development and electricity use. For such a purpose, a spatial econometric analysis has been conducted on sets of variables that are associated with sustainable development goals (SDGs) established to understand social vulnerabilities, economy, electricity use, health and population. The Euclidean distance has been used on standardized variables for the 39 cities in the Metropolitan Region of Paraíba Valley and North Coast as an alternative to that suggested by spatial econometrics. The region under study presents hub cities whose economies are mainly based on industry, trade and services. The results show good consistency and reveal the correlation between SDGs as regards care for vulnerable people, mainly women, children and the elderly.

1. Introduction

Identifying a sustainable human act suggests a reflection of the past habits and desires in order to enable new technologies to be offered and meet the basic demands in various poor regions of the world, meeting the expectations of the Sustainable Development Goals (SDG)¹ suggested by the United Nations, mainly in meeting the wishes of future generations [1]. For this reflection, the duality 'man-nature' must be understood as essential for the understanding of sustainable human acts, showing their choices in the places where they live.

Since the discovery of fire, humanity has been exploiting much more than what nature can offer, thus rendering less than it should to restore its conditions before the aforementioned rampant exploitation of resources. According to [2], reinventing human thought (and/or behavior) is enough for a minimally significant change in current conditions to provide better expectations for future generations.

Human behavior has been adaptable along many years, and changeable under pressure of both natural resource consumption and energy use for producing and using materials and technology. As an example to represent changes in human behavior [3], argue that the relationships between energy consumption, the economy and human well-being can differentiate less developed countries from other more affluent ones, and this may be perceived by the improvement of indicators such as life expectancy, infant mortality and economic development. Such relationship occurs effectively when the interconnection between these areas is perceived - this is a very vague concept of the quality of life of citizens who hardly ever discuss the possibility of any kind of environmental gains to serve future generations.

As regards sustainability of cities, there are different challenges to be overcome concerning urban population growth, which is expected to double in 2050 if compared to the current situation. Among these challenges, there are housing, infrastructure, basic services, food

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¹ 1-No poverty; 2-Zero hunger; 3-Good health and well-being; 4- Quality education; 5-Gender equality; 6-Clean water and sanitation; 7-Affordable and clean energy; 8-Decent work and economic growth; 9-Industry, innovation and infrastructure; 10-Reduced inequalities; 12-Responsible consumption and production; 13-Climate action; 14-Life below water; 15-Life on land; 16-Peace, justice and strong institutions; 17-Partnerships for the goals.

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security, health, education, decent work and natural resources [4].

It is believed that much of the environment is susceptible to changes in human behavior and the constant advances in using new technologies [5]. understand that the sustainability will be achieved if smart energy technologies are possible, energetically safe, environmentally benign, economically feasible, commercially viable, socially acceptable, integrative and reliable. Thus, Malthus's theory, which indicates that environmental damage is caused by arrangements formed by population growth, overshadows human capacity to produce (food, among other resources), thus it is not going not be worked on herein. Instead, Boserup's theory has been used [6] by which it is understood that there is a great opportunity for technological innovation when population growth is considered to be fast, especially the one in urban areas.

Global challenges have been partly overcome, but there is still a wide range of non-serviced communities, among other issues, by modern energy technologies (mainly cleaner and renewable energy technologies such as photovoltaic and wind power), which makes them coexist with rudimentary energy conditions. Rudimentary energy conditions are described by the undesirable sources – based on coal, petroleum products and other poor sources of energy, which are never renewable and very polluting –, without minimum conditions for thermal comfort, cooking or even basic sanitary conditions. According to [4], around 10% of the world's population still lives under poor sanitary conditions, and one third do not have access to electricity.

If the sustainability issue is underpinned by access to modern energy technologies (preferably less polluting and technically more efficient), then the majority of women, children and the elderly are left out of it. Mercilessly, any group that does not contribute minimally to the consumer market is excluded from having access to these technologies (this corresponds to the 'technological threshold' approach for energy poverty described by [7]). Socioeconomic indicators have not fully portrayed the existence of these groups as elements of change in the process of consumption of goods and services, and therefore their expectations of using modern energy technologies are not (or are partially) met. This fact, however, must be taken into account by government agencies, given that they can indirectly influence future choices of types of consumption and growth perception, even though they are consumers who offer a very small economic contribution to the new energy technology market.

It is routinely perceived that women, their children and elderly people consistently are a large portion of the population, which is vulnerable to various essential services to human activity. This same area coexists under unfavorable working conditions, precarious basic health care and sanitary services. This has occurred in several countries of the world on all continents, from the least to the most developed.

In cities that make up the Metropolitan Region of Paraíba Valley and Northern Coast (MRPVNC), socioeconomic aspects have contributed more effectively to the duality man-environment. It is located in eastern São Paulo state and between the strongest economies in Brazil (São Paulo and Rio de Janeiro) and surrounded by Mantiqueira and Serra do Mar Mountains, MRPVNC presents a socioeconomic development characteristic by the Paraíba do Sul River, which crosses the whole region. This is a historically relevant region for Brazil, since there were the main agricultural and livestock riches of the early 19th century - however, in the beginning of the 20th century, driven by the newly installed industry in the State of São Paulo, social and economic issues have changed dramatically [8]. characterized the MRPVNC as for its development according to Gross Domestic Product (GDP) and Human Development Index (HDI), which identifies that cities by the Paraíba do Sul River have been favored due to development characteristics, thus being closer to what is expected from a region to meet the targets of the Millennium Development Goals (and, consequently, SDGs). On the other hand, less developed cities located both in the surroundings of Serra da Mantiqueira and around Serra do Mar, coexist in particular conditions of lower GDP and HDI, which means that the nexus health-economics-education is underprivileged in cities belonging to these

mountainous areas.

This article aims to present interactions between MRPVNC cities in the context of SDGs, particularly the existing correlations between socioeconomic characteristics and electricity use. For this, the studied variables collected from a public database were correlated to the 17 SDGs as classified by the UN, with a strong correlation with the first 12 SDGs for the present analysis. Its conceptual framework is based on the spatial econometric analysis from which distances between studied variables, initially considered strongly correlated with each other, are calculated. From this analysis, it is sought to understand the current social, economic and energy conditions of RMVPLN correlated to SDGs.

2. Literature review

In order to be exclusively dedicated to a city's economic growth, a decision-maker must understand the small but important contributions of choices made by individuals. From the point of view of energy supply and demand, each small contribution allows individuals to significantly and positively affect the characteristics of a sustainable life that protects and frees people who are vulnerable to modern energy technologies in small and large regions [9]. emphasize that the social and technological dimensions are essential for the sustainability, but the availability of the necessary resources at the level of technological infrastructure is limiting for some groups of people. Among these groups, it can be highlighted the social vulnerability faced by low per capita income people that demands for modern and clean energy (e.g. photovoltaics) but need greater financial support for that.

The protection stated herein concerns the way in which technology is offered to a group of individuals or cities in the face of an urbanization process. This is reflected in mechanisms (from the simplest to the most sophisticated) that can be associated with the development of cities, even though such mechanisms are associated with behavioral changes and new paths to a culture that has already been fostered by a population. One example is the challenge posed to China to meet sustainable development aspirations in the face of an intense urbanization process over the past 30 years, in contrast with the proposed reduction of energy consumption suggested by the systematization of energy efficiency in industrial processes [10,11].

On the other hand, technological liberation of a population refers to offering an opportunity to use less expensive technologies or mechanisms, which lead to a disconnection from the usual way of consuming energy, such as using electricity to cook food (by using a microwave oven), which can be replaced by the use of LPG or biogas (e.g. from biomass).

In addition to protection and technological liberation, there is flexibility whose main result is an opportunity for each individual to independently choose the extent to which they use these technologies as time elapses. As regards using energy technologies [12], define flexibility as energy users who are able to choose how, when or where energy is demanded, moreover [13], indicate that it is also the ability to increase or decrease its use over a given period of time [14]. supports the idea that individual flexibility depends on collective proposals in systems that allow and restrict these choices and there is a dependence on decisions associated with energy services being provided.

With respect to exclusively cultural aspects, it is believed that a simplified comparison of the degree to which each individual contributes to society, i.e. to understand the essence of a group of individuals and their cultures, it is necessary to experience it directly [15]. Thus, the same authors infer that there is no way to predict that individuals who work in different areas of expertise perform or engage in their tasks in the same way, which allows discussing technological flexibility. This thought contributes to the idea that one should not accept a simplified behavioral change that includes all kinds of cultures into the same set of intentions.

As regards a sustainable use of resources that contributes towards clean and accessible energy transformation to all, one must understand

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