REVISTA BRASILEIRA DE PESQUISA EM TURISMO
BRAZILIAN JOURNAL OF TOURISM RESEARCH
e-ISSN 1982-6125

Papers

Contribution of accommodation facilities to direct emissions of carbon dioxide (CO_2) in the city of Parnaíba (Piauí State, Brazil)

Contribuição dos meios de hospedagem para as emissões diretas de dióxido de carbono (CO_2) na cidade de Parnaíba (Piauí, Brasil)

Contribución de los medios de alojamento para emisiones directas de dióxido de carbono (CO_2) en la ciudad de Parnaíba (Piauí, Brasil)

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Keywords:

Greenhouse gases;
Sustainability;
Hotel sector.

Abstract

Climate change caused by the increase in greenhouse gas (GHG) emissions, especially carbon dioxide (CO_2), will directly and indirectly affect all human activities, mainly those that are closely dependent on natural factors, such as tourism. In this context, it is necessary to expand scientific knowledge about global and sectoral emissions (transport, accommodation facilities, etc.) from tourism. Thus, this article examined the direct emissions of CO_2 of accommodation facilities in the city of Parnaíba (PI), and its contribution to local emissions from tourism. Therefore, it was based on the characterization of the emission sources in the accommodation sector, being selected the categories of energy, cooking gas, and water consumption, and the production of solid waste, with emphasis on WTTC and ITP guidelines (2016), and on the conversion values proposed by DEFRA (2012). The results indicated that CO_2 emissions per capita were similar to the world average for domestic visitors in developing countries, i.e. 4.01 kg/CO_2, and the main contributor was energy consumption, accounting for 94.7% of emissions. In addition, the possibilities of reducing such emissions were listed with managerial, technological, and educational measures in the daily hospitality activities.

Palavras-chave:

Gases de Efeito Estufa;
Sustentabilidade;
Hotelaria.

Resumo

As mudanças climáticas causadas pelo aumento das emissões de gases do efeito estufa (GEE), principalmente o dióxido de carbono (CO_2), afetarão direta e indiretamente todas as atividades humanas, sobretudo aquelas que possuem estreita dependência dos fatores naturais, como o turismo. Nesse quadro, faz-se necessário ampliar o conhecimento científico sobre as emissões globais e setoriais (transportes, meios de hospedagem, etc.) do turismo. Assim, este artigo analisou as emissões diretas de CO_2 dos meios de hospedagem da cidade de Parnaíba (PI) e sua contribuição para as emissões locais do turismo. Para tanto, baseou-se na caracterização das fontes de emissão no setor de hospedagem, sendo selecionadas as categorias consumos de energia, gás e de água, além da produção de resíduos sólidos, com ênfase no manual do WTTC e ITP (2016) e nos valores de conversão propostos pelo DEFRA (2012). Os resultados indicaram que as emissões per capita de CO_2 foram similares a média mundial para visitantes domésticos em países em desenvolvimento, isto é 4,01

kg/CO_2, e o principal contribuinte foi o consumo de energia, respondendo por 94,7% das emissões. Ademais, elencou-se as possibilidades de reduzir tais emissões com medidas gerenciais, tecnológicas e educativas no cotidiano das atividades de hospedagem.

Palabras clave:

Gases del efecto invernadero;
Sostenibilidad;
Sector hotelero.

Peer-reviewed article.
Received in: 05/03/2020.
Approved in: 14/05/2020.
Editor:
Glauber Eduardo de Oliveira Santos.

Resumen

Los cambios climáticos ocasionados por el aumento de las emisiones de gases del efecto invernadero (GEI), principalmente el dióxido de carbono (CO_2), afectarán directa e indirectamente a todas las actividades humanas, sobre todo a aquellas que presentan una dependencia estrecha de los factores naturales, como el turismo. En este contexto, es necesario ampliar el conocimiento científico sobre las emisiones globales y sectoriales (transporte, medios de alojamiento, etc.) del turismo. De ahí que en este artículo se analizaran las emisiones directas de CO_2 de los medios de alojamiento de la ciudad de Parnaíba (PI) y su contribución a las emisiones locales del turismo. Por lo tanto, se basó en la caracterización de las fuentes de emisión en el sector de alojamiento, seleccionando las categorías de consumo de energía, gas y agua, y la producción de residuos sólidos, con enfásis en el manual WTTC e ITP (2016), y en los valores de conversión propuestos por DEFRA (2012) . Los resultados indicaron que las emisiones per cápita de CO_2 fueron similares al promedio mundial para visitantes nacionales en los países en desarrollo, es decir, 4.01 kg / CO_2, y el principal contribuyente fue el consumo de energía, que representa el 94.7% de las emisiones. Además, se incluyeron las posibilidades de reducir tales emisiones con medidas generales, tecnológicas y educativas de las actividades diarias de alojamento.

How to cite: Melo, R. S.; Braga, S. S.; Lins, R. P. M. (2021). Contribution of accommodation facilites to direct emissions of carbono dioxide (CO_2) in the city of Parnaíba (Piauí State, Brazil). *Revista Brasileira de Pesquisa em Turismo, São Paulo,* 15 (2), 1968, May./Aug. http://dx.doi.org/10.7784/rbtur.v15i2.1968

Open data: http://dx.doi.org/10.17632/z9swc8fd55.1

1 INTRODUCTION

It should be noted that tourism is an activity capable of boosting local economies, contributing to the conservation of natural and cultural heritage, and improving the quality of life of the receiving centers. While promoting such benefits, when not planned and managed on a sustainable basis, it can compromise the ecological stability of ecosystems and promote changes in the social and cultural patterns of local communities (Beni, 2007; Cooper, Fletcher, Fyall, Gilbert, & Wanhill, 2007; Hall, 2004).

In this context, a new threat to the sustainability of tourist destinations emerges: the climate changes caused by global warming, since, according to Becken (2013) and the World Tourism Organization - UNWTO (UNWTO, 2009; 2008), this phenomenon can affect travel flows, the tourism production chain, and the tourists' decisions in choosing the destinations they want to visit. The loss of biodiversity, changes in climate regimes, sea level rise, disappearance of islands, are examples of negative impacts for tourism, as the sector uses them as attractions.

Tourism plays two roles in this climate crisis, on the one hand as suffering from these evils, as the activity will suffer severe impacts from the effects of changes; on the other, as a contributor to direct and indirect greenhouse gas (GHG) emissions, especially carbon dioxide (CO_2), which intensify the processes that promote damage to the global climate (Sun, Lenzen, & Liu, 2019; Becken, 2019; 2013). Scott, Hall and Gössling (2019) indicate that tourism is an extremely vulnerable activity to climate change and point out the importance of expanding scientific research in developing countries to understand the causes and consequences of the relationship between tourism and climate change, as there are regional knowledge gaps. UNWTO (2008) highlighted that the greatest challenge to tourism sustainability in the 21st century will be climate change.

Lenzen, Sun, Faturay, Ting, Geschke and Malik (2018) estimated that CO_2 emissions from tourism, including transport, shopping, food, accommodation, and other activities, accounted for about 8% of global CO_2 emissions, thus totaling at 4.5 $GtCO_2e$ the carbon footprint of global tourism. Among all tourism sectors, according to the UNWTO and ITF (2019), transport is considered to be the most polluting, accounting for ¾ of total emissions by tourism, with emphasis on airfare as the biggest contributor. Emissions from accommodation facilities were estimated at 21% of the global amount of tourism (UNWTO, 2008).

In the research on direct and indirect CO_2 emissions in lodging facilities, the studies conducted by Abeydeera and Karunasena (2019), Huang, Wang and Wang (2015), Lai, Yik, and Man (2012), Tsai, Tsang, and Cheng stand out (2012), Teng, Horng, Hu, Chien and Shen (2012), Chan (2012), Filimonau, Grosbois and Fennell (2011), Dickinson, Robbins, and Huijbregts (2011), Rosselló-Batle, Moià, Cladera, and Martínez (2010), and Taylor, Peacock, Banfill, and Shao (2010), pointed out the relevance of the analysis of these emissions for the understanding of the global and local tourist emissions picture and listed knowledge gaps that need to be studied to expand knowledge on this topic. In developing countries such research is scarce, especially in South America, as reported by several authors (Scott, Hall, & Gössling, 2019).

In accordance with Filimonau, Dickinson, Robbins and Huijbregts (2011), there is a prevalence of investigations carried out notably on the European and Asian continents, thus requiring a geographic expansion of studies to understand the carbon footprint of lodging facilities and thereby contribute to the evolution of scientific knowledge about the global contribution of GHG emissions in that sector. Using this framework, the present study examined the contribution of accommodation facilities in the city of Parnaíba (PI) to direct CO_2 emissions, based on the categories of energy, water, and cooking gas consumption and the production of solid waste, as well as listing mitigating measures to align the sector's development with management challenges in times of climate crisis.

The methodological approach of this research was based on the use of structured interviews with the managers of the investigated accommodation facilities to characterize the variables intended to compose the picture of local CO_2 emissions. After the data collection, the information was analyzed with emphasis on manuals from the World Travel & Tourism Council – WTTC, the International Tourism Partnership - ITP (2016), and the United Kingdom Department for Environment, Food & Rural Affairs (DEFRA, 2012).

This article starts with the presentation of the theoretical framework, describing the current state of studies and research on the topic of CO_2 emissions in accommodation facilities, as well as the discussion of conceptual and methodological issues that guided the development of investigations on that topic. In sequence, the methodological procedures are described, with the characterization of the study area and the details of the data analysis process based on the aforementioned manuals. The results are presented and discussed in the following topic, with the exposure of the collected data and its comparison with other studies, as well as the proposal of managerial, technological, and educational measures aimed at mitigating emissions in the hotel sector. In the concluding remarks, general reflections and trends arising from the results obtained are listed, research limitations are presented, as well as suggestions for further studies to contribute to the advancement of scientific knowledge on the examined subject.

2 ACCOMMODATION FACILITIES AND CARBON DIOXIDE EMISSIONS (CO_2)

The strategies for understanding the association of climate change with tourism, according to Sun, Lenzen and Liu (2019), are mainly anchored in the characterization of emissions based on national and sector inventories (transport, food, accommodation facilities, recreational activities etc.). However, the authors impose a reflection on the urgency of improving these inventories for the effective management of carbon in tourism.

Lai, Yik and Man (2012) mention that globally manuals for carbon auditing are being developed for the quantification and qualification of sectoral emissions, however those intended to understand the emissions produced in the hotel sector are limited. They also reveal that the audits employed in hotels, through empirical investigations, are essential to characterize the sources and extent of emissions in the sector, as well as to contribute to the analysis of the carbon footprint in these organizations, thus promoting management decisions aimed at mitigating carbon emissions.

In their study with 150 hotel groups, Grosbois and Fennell (2011) reported that the measurement of the carbon footprint in lodging facilities is scarce, and when carried out by the investigated hotel companies they are inaccurate and with limited information on the methodologies used for estimating emissions. Associated with this limitation, the authors highlighted the lack of transparency and the selective way of choosing the reported data, which made it difficult to compare the performances of different companies in the hotel sector.

According to Abeydeera and Karunasena (2019), there are 18 surveys referring to CO2 emissions in accommodation facilities, with a focus on the carbon footprint, energy consumption, life cycle assessment, and environmental and energy audits. The studies are concentrated mainly on European and Mediterranean countries, with few works being carried out in developing countries.

In such a context, information on the general picture of direct emissions from accommodation facilities is concentrated in some regions, on traditional kinds of accommodation and on the behavior of a given accommodation profile. In the words of Becken (2013) and Gössling (2013), the accommodation sector has an important responsibility in CO_2 emissions regarding tourism, especially due to energy and water consumption, and production of solid waste, contributing significantly to the framework of global direct and indirect CO_2 emissions. It is considered that in studies on tourist emissions resulting from the production and disposal of solid waste, methane gas (CH_4) should be incorporated into the analytical process, as it is one of the main gases that trigger climate change and derives notably from the decomposition of organic waste in landfills and dumps.

Detailing consumption, it was noted that the main sources of energy consumption are the use of water, gas, and electricity (Wu & Shi, 2011). Regarding the average consumption per night, in some countries, the data varies: New Zealand - 43 kWh/per night, Majorca - 14 kWh/per night, Hong Kong - 3 kWh/per night (Becken; Frampton, & Simmons, 2001), China - 43 kWh/per night (Wu & Shi, 2011), among others. Gössling (2001) proposed that the average value of energy consumed by the hotel sector is 36 kWh/per night. In addition, as noted by the authors, energy expenditure depends on the size and typology of the accommodation establishment, the characteristics of the equipment used in the establishments, the services offered, and the behavior of guests and employees in the hotel facility.

Gössling (2013) observes that the consumption of water in the lodging facilities comes mainly from the guests' bath and from cleaning activities. The author also mentions activities such as laundry service and washing utensils after meals, which can be minimized using equipment and low water consumption measures, such as taps and showers that regulate the water flow.

In the words of Jimmy, Munna and Khan (2020), hotels consume water significantly to maintain the landscape and their facilities, notably the rooms, kitchens, and recreational areas. Furthermore, the authors emphasize the relevance of the rational use of water resources to allow present and future generations to have access to this resource. In addition, Rajini and Samaracon (2016) listed the factors that contribute to the expenditure of water in the hotel environment, with emphasis on the following: the establishment built area size, the hotel category, the number of guests and the occupation rate, the availability of laundry service, the number of employees, the use of water controlling technologies, the adoption of environmental management programs, the behavior and habits of guests, individual responses to institutional and social standards, among others.

When estimating that each guest generates, on average, more than 1 kg of solid waste per day, Bohdanowicz (2005) calls attention to recycling actions, reusing materials, and encouraging conscious consumption as essential attitudes to reduce carbon emissions resulting from solid waste. However, the author emphasized that the production of organic waste in the kitchen environment is still an element that has caught the attention of researchers, because of wasting being the rule and recycling the exception. In this scope, it is recommended that energy expenditure in the recycling process be considered as an analytical factor. Such a strategy will only be efficient if there is an adequate energy balance in choosing the transformation method, considering the specificities of the potential inputs and the resulting costs for transporting the recyclable materials to the processing site. Therefore, the option for recycling the waste is relevant but one must consider the above factors to mitigate GHG emissions.

In this context, Singh, Cranage and Nath (2014) considered that the characterization of solid waste management in hotel organizations is fundamental to the composition of the picture regarding sectorial emissions, since the production and subsequent disposal in landfills produces the release of harmful gases, especially methane (CH_4), the contamination of ground and surface water etc. For this reason, the authors reinforced the need to expand research, since a significant number of studies on CO_2 emissions in lodging facilities rest in the analysis of the infrastructure and design of buildings, transport, energy and water consumption, being

scarce those that are intended to examine the production of waste and its respective local emissions in hotel organizations.

In reflection, Teng, Horn, Hu, Chien and Shen (2012) discussed that climate change promoted an increase in public awareness about energy consumption and derived carbon emissions and that studies indicate that for the effectiveness of sustainable management in the hotel industry it is essential to propose energy efficiency measures in the industry operations. Thus, they proposed 32 indicators for the implementation of energy conservation measures and reduction of carbon emissions in accommodation facilities, which require the support of managers and the engagement of employees and guests. As examples of these indicators, there are the recycling and reuse of waste water, the monitoring of energy consumption, water and solid waste, adjustments in the temperatures of air conditioning units, provision of information for guests on public transport and bicycle rentals, purchase of materials from local suppliers, adoption of natural lighting and ventilation in the building, etc.

In addition, Al-Aomar and Hussain (2017) emphasize that if planned and focused on meeting the principles of sustainability, the hotel industry can contribute to a change in consumption habits in society, generating less environmental impact and, therefore, can be considered as low carbon tourism. It is important to emphasize that the technologies and practices applied to hotels must be incorporated from the facility architectural project and be thought as one, so that the building, in addition to energy efficiency, has a character of sustainable construction. The main objective of these technologies is to improve the management of environmental resources, especially electricity and water, reducing costs, contributing to the conservation of the environment, and showing an image of an environmentally responsible company.

According to Kim, Lee and Fairhurst (2017), there was a significant increase in studies on sustainable practices in lodging facilities, especially since the 2000s. Most of these studies highlight that the main adopted practices are aimed at the rational use of energy and water (especially with the installation of more modern and eco-efficient equipment) and at the incorporation of waste recycling in the hotel companies. The authors consider that sustainable practices are notably adopted because of the benefits resulting from business efficiency and as a competitive differential and, therefore, do not reflect a real concern of managers with environmental conservation.

In this theoretical picture, Zhang, Joglekar, Heineke and Verma (2014), when discussing the ecoefficiency theme in the hotel sector, stated that the studies are especially directed to the understanding of the financial impacts of the sustainability actions, perception and behavior of guests and employees on sustainable practices, environmental programs, and certification initiatives, etc.

Furthermore, according to Huang and Deng (2011), it is reinforced that in order to mitigate CO_2 emissions from hotels, there is a need for alignment with the low carbon tourism model, which is intended to propose a reflection on global processes and sectors of tourism that produce CO_2 emissions and their influences on the internal and external environments. This model leads to a relevant debate on the dimensioning of the carbon footprint of tourism, as a foundation for tourism planning and management in the context of global climate changes characterization.

In this context, it is considered that the characterization of the sectorial emissions of the hospitality sector will help in the understanding of the sector's contribution to the global amount of CO_2 emissions from the tourist activity, as well as allowing to identify the main consumption in the facility and their respective environmental impacts.

3 METHODOLOGICAL PROCEDURES

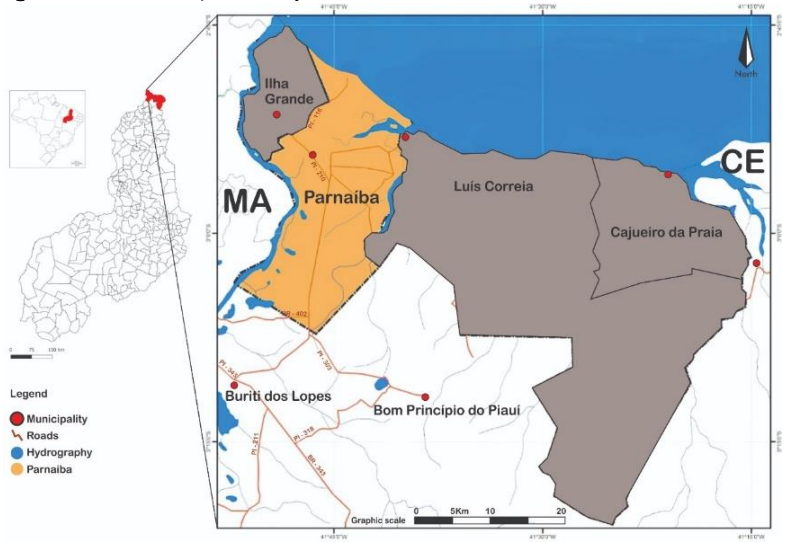
3.1 Characterization of the study area

The city of Parnaíba is located in the northern portion of the state of Piauí, in the northeastern region of Brazil (Figure 1). It has an estimated population of 152.653, with a gross domestic product (GDP) per capita of R$ 12.787,32 and a municipal human development index (MHDI) of 0.687 (IBGE Cidades, 2019). Parnaíba stands out as the second largest GDP rate and population of the state, and 343 km from the capital Teresina, via BR-343. The city also stands out as commercial and health centers for neighboring cities, and has an

international airport with only one weekly commercial flight from Azul Airline Company, bound for Campinas (SP).

In terms of tourism, the city is part of the tourist region called Polo Costa do Delta and it is one of the 65 tourism-inducing destinations in Brazil. Another highlight is its integration with the national route named Rota das Emoções (SEBRAE, 2014), in association with neighboring states of Ceará and Maranhão. The main tourist attractions of the city are the Parnaíba Delta, Portinho Lagoon, Pedra do Sal Beach, and the cultural heritage downtown.

Figure 1 - Location map of the city of Parnaíba in the state of Piauí



Source: The authors, 2020.

Regarding the typology of the investigated accommodation facilities in the city, the categories of inns and hotels predominated, respectively, with an average of 32 housing units (HUs) and 42 beds per establishment. Most establishments are family-owned and only two belong to hotel chains, one national and the other international. All of them offer only one meal per day to guests (breakfast), they have an average of 14 permanent employees and the average time of 16 years working in the city. Inside the HUs, the main equipment listed are air conditioning units (split model), electric shower, minibar, TV, and phone.

3.2 Methods and techniques

This research is characterized as descriptive and exploratory (Gil, 1999), as the theme of CO_2 emissions in lodging facilities is still little investigated in the Brazilian literature, thus requiring more knowledge to contribute to the construction and expansion of an emerging field of study in the context of climate change.

The data collection technique used was the structured interview (Gil, 1999) applied together with the managers of the accommodation facilities in the city of Parnaíba (Appendix A). The universe of research was the lodging facilities registered with CADASTUR (Brazil, 2018), totaling 17 registered companies. Among them, a sample of 10 lodging facilities (58% of the total) were selected to carry out the research. In addition, it is emphasized that the intention was to operate the study on all registered equipment, however, some of them did not authorize the research, so it was only possible to carry it out on those with the proper authorization.

The analysis and characterization of the direct CO_2 emissions from the lodging facilities was adapted from the methodology proposed by the World Travel & Tourism Council - WTTC and International Tourism Partnership - ITP (2016), detailed in the Hotel Carbon Measurement Initiative - v.1.1, and in the manual "Guidelines to DEFRA's GHG conversions factor", organized by the United Kingdom Department for Environment, Food & Rural Affairs (DEFRA, 2012).

The methodology proposed by the WTTC and the ITP (2016) consists of a tool that allows the lodging facilities to measure and report CO_2 emissions, allowing the understanding of the carbon footprint of guests and the different types of accommodation. According to the institutions, about 24 thousand hotels use this methodological platform in the organizational environment to quantify and qualify their sectorial emissions, as manuals and online support systems are freely available to interested parties.

Thus, the consumption of energy, cooking gas, and water, and the production of organic and inorganic waste were defined as analytical categories. Chart 1 presents the details of the emission sources and their respective variables to support the referred investigation process.

Chart 1 – Emission sources and variables for the analysis of direct CO_2 emissions

Emission sources (ES)	Variables of emission sources (VES)
Energy consumption	The measurement of energy consumption (kWh and R$) occurred in the lodging facilities, collecting the establishment's energy consumption data, per night, and dividing the total consumption value by the number of guests registered during the investigated period.
Water consumption	The measurement of water consumption (liters) occurred in the lodging facilities, collecting the establishment's water consumption data, per night, and dividing the total consumption value by the number of guests registered during the investigated period.
Gas consumption	The measurement of cooking gas consumption (m^3) occurred in the lodging facilities by dividing the total amount of gas consumption, per night, and dividing the total amount of consumption by the number of guests registered during the investigated period.
Organic waste production	Measurement of the amount of organic waste (kg) produced in the lodging facilities, making the sum of the weighing of the waste produced during an overnight stay.
Inorganic waste production	Measurement of the amount of inorganic waste (kg) produced in the lodging facilities, making the sum of the weighing of the waste produced during an overnight stay.

Source: The authors, 2020, adapted from WTTC and ITP (2016) and DEFRA (2012).

Thus, the data collected through these variables were transformed into CO_2 emissions based on the conversion factors proposed by DEFRA (2012). The formula below demonstrates the procedure for estimating emissions.

$$E(CO2): \sum Qi \times Fc$$

Legend:

E(CO2): total CO_2 emissions in kilograms (kg);

Qi: energy consumption in kilowatt hours (kWh), water consumption in liters (l), cooking gas consumption in cubic meters (m^3), and waste production in kilograms (kg);

Fc: conversion factors to transform the collected data into $kgCO_2$, as proposed by DEFRA (2012).

In summary, it is reinforced that the process of analysis of direct CO_2 emissions in the investigated accommodation facilities was based on the application of structured interviews with the managers of these companies to collect data in the mater of energy, gas, and water consumption, and in the measurement of the daily production of solid waste, which was later converted into kilograms of carbon ($kgCO_2$) based on the conversion factors proposed by DEFRA (2012). Furthermore, managerial, technological, and educational measures were listed in each variable investigated as a way to mitigate the emissions described.

4 RESULTS AND DISCUSSION

In this section, the results are exposed and compared with other international and national studies that address the researched problem. It begins with the exposure and discussion of the collected data regarding the energy consumption, production of solid waste and consumption of water and gas variables in the investigated accommodation facilities, with the subsequent conversion of the aforementioned data into CO_2 emissions. Throughout the text, managerial, technological, and educational measures are listed to mitigate the characterized emissions, as well as the reflections on the connections between the composition of the investigated variables and the general picture of emissions in lodging facilities.

Regarding energy consumption in the accommodation facilities in the city of Parnaíba (PI), it was observed that the daily average was 192.5 kWh, with an average of 9.0 kWh per night (Table 1).

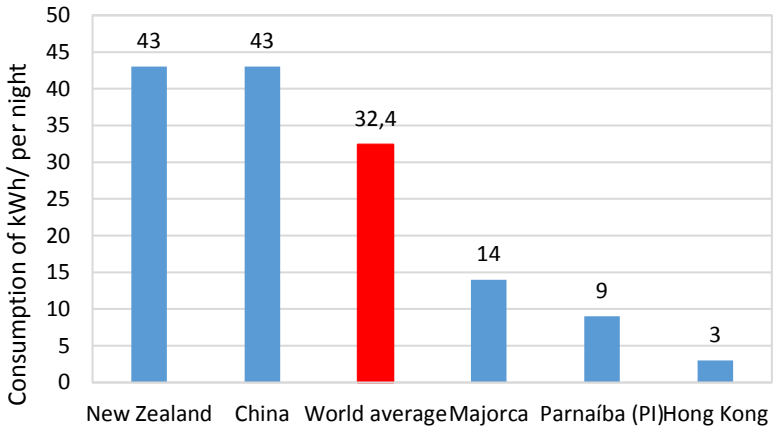
Table 1 – Daily energy consumption (kWh) in the accommodation facilities in the city of Parnaíba

Items	Values	
	Total (kWh)	Per night (kWh)
Average	192.5	**9.0**
Maximum	292.3	**14.0**
Minimum	104.0	**3.4**
Standard deviation	78.2	**5.2**

Source: Direct search (2018).

Based on Table 1 and Figure 2, it was noted that the recorded consumption rate of 9.0 kWh/per night was lower than that of other tourist destinations, such as New Zealand (Becken, 2013), Majorca (Wu & Shi, 2011) and China (Wu & Shi, 2011), and superior to that of Hong Kong (Becken, 2013). It should be noted that Gössling (2011) proposed that the average value of energy consumed by the hotel sector is 36 kWh/per night and the UNWTO (2008) pointed out that the average consumption is 32.4 kWh/per night.

Figure 2 – Consumption of kWh/per night in the lodging facilities in Parnaíba x tourist destinations



Source: Direct search (2018), UNWTO (2009) and Gössling (2011)

The explanation for lower consumption of kWh of the accommodation facilities in Parnaíba and that of some countries and below the world average (Figure 2) is due to the fact that guests spend part of the day outside the facility, visiting tourist attractions in the region. Other reasons are due to the typology of the accommodation facilities (hotels and inns) and the dimension of the equipment and services offered, since most of the analyzed establishment did not have large leisure areas, laundry facilities and only offered one meal a day, in this case, breakfast.

It is noteworthy that in only one accommodation facility the energy consumption was far above the average compared to the other analyzed accommodations facilities, because this facility provides laundry service to meet internal and external demands, thus contributing to a significant increase in consumption rates. Despite the smaller dimension of the accommodation facilities and the limitation of the available hotel services having contributed to the low consumption of kWh/per night, with the exception of the lodging facility that provides laundry service, it is necessary to pay attention to the expansion and diversification of the hotel sector in the city and surrounding regions, with the consequent increase in energy consumption.

In this perspective, according to Teng, Horng, Hu, Chien and Shen (2012), it is possible to reduce 20 to 40% of energy consumption in hotels without compromising the functionality of the various activities available in the establishment. To this end, the authors recommend incorporating low energy consumption equipment

and services, which consists of an efficient technological measure with a high financial and environmental return.

Furthermore, the main objective of these technologies is to improve the management of natural resources, especially electricity and water, reducing costs, contributing to the conservation of natural resources, and showing an image of an environmentally responsible company. In the electricity consumption category, the total and per night CO_2 emissions were 82.7 $kgCO_2$ and 3.8 CO_2, respectively, as shown in Table 2.

Table 2 – Description of the total and per night emissions of the visitors' daily energy consumption category in the lodging facilities in Parnaíba

Items	Values	
	Total ($kgCO_2$)	Per night ($kgCO_2$)
Average	82.7	3.8
Maximum	125.7	6.3
Minimum	44.7	1.4
Standard deviation	33.6	2.2

Source: Direct search (2018).

It was observed that the total and per night CO_2 emissions from the lodging facilities were 47.9 $kgCO_2$ and 3.8 $kgCO_2$ (Table 2), respectively, and reflected the typology of the predominant accommodation facilities in the city of Parnaíba, which was mainly of inns, that is, smaller dimensions facilities, with fewer housing units and hotel services. In this scenario, Yu-Guo and Zhen-Fang (2014) pointed out that the CO_2 emissions in the lodging facilities vary according to the typology examined and its location, and can range from 1.7 to 145.1 kg CO_2/per night.

It is reinforced that in the hotel sector energy consumption was the main responsible for CO_2 emissions, since the use of air conditioning, television, electric shower, and minibar, demanded the intense use of this energy source. Thus, the mitigation of these emissions could occur using renewable energies, such as solar and wind, by replacing old and more polluting equipment, by waste recycling and by implementing an environmental management system.

It is added that according to the UNWTO (2009), one of the sustainable measures to reduce energy consumption in hotels is the use of keycards for entry to hotel rooms, which allows the energy systems of the apartments to go automatically in or off when keycards are inserted or removed from the base device. According to the United Nations Environment Program - UNEP (2011), investments in technological efficiency can reduce tourist emissions by 38% and thus, the replacement of transport modes, the decrease in the time spent in the hotel rooms in 44% and the combination of both would contribute to curb CO_2 emissions in 2035 by around 68%.

In addition to these mitigating measures, the reduction in energy consumption depended on educational actions directed at guests and employees. According to Horng, Hu, Teng, Hsiao and Liu (2013) educational actions to sensitize the diverse participants in the tourist experience must be based on the principles of low carbon literacy, with emphasis on the themes of climate change, carbon emissions, efficiency in the use of energy, among others. In sequence, the daily production of total and per capita waste in the investigated accommodation facilities are listed in Table 3.

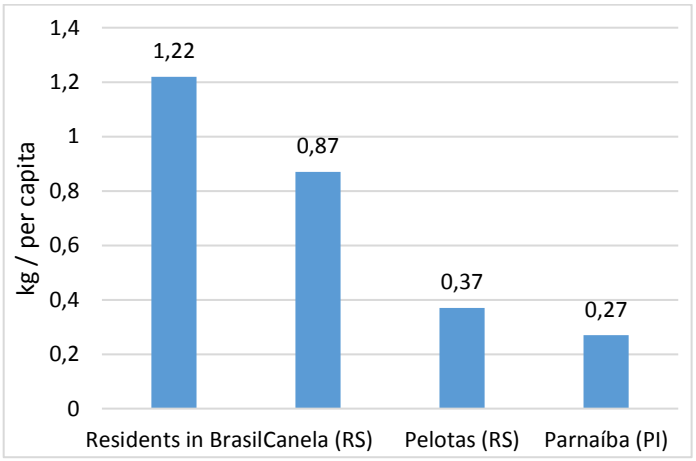
Table 3 – Total and per capita waste production in Parnaíba's lodging facilities

Items	Daily Values	
	Total waste weight (kg)	Waste weight (kg) per capita
Average	8.0	0.27
Maximum	12.0	0.46
Minimum	5.1	0.15
Standard deviation	3.5	0.16

Source: Direct search (2018).

It can be noted in Table 3 that the daily waste production in the lodging facilities in Parnaíba was 8.0 kg, with a per capita average of 0.27 kg. This rate is lower than the volume generated by other accommodation facilities in Brazil and the average of residents in Brazil (Figure 3).

Figure 3 – Per capita production of waste from visitors in lodging facilities and from residents in Brazil



Source: Direct search (2018), De Conto, Bonatto, Feldkircher & Posser (2015), Peruchinn, Ferrão, Guidoni, Corrêa & Corrêa (2015) and Abrelpe (2013).

The average production of waste in the accommodation facilities in Parnaíba was significantly lower than that of residents in Brazil. Therefore, the generated waste volume in the accommodation facilities in Parnaíba corresponded to only 20% of the total generated in homes (Figure 3). This finding is in line with that of De Conto, Bonatto, Feldkircher and Posser (2015), who identified that the per capita production of solid waste per day in the lodging facilities of Canela (RS) was on average 0.87 kg, composed by 72.8% putrescible organic matter, and the factors that influenced the volume of solid waste were the number of guests and staff, seasonality, hotel classification, the existence of gardens and parks, the services offered to guests, the age group, the purchasing power of guests, and the reason for the stay.

Peruchinn, Ferrão, Guidoni, Corrêa and Corrêa (2015) estimated per capita waste production in the establishments in Pelotas (RS) at 0.37 kg, due to the accommodation facilities serving only one meal a day and the guests' profile, since most of them were business travelers and spent little time in the accommodation facility. They also pointed out that the number of guests, employees and other people influenced the amount of waste generated. Singh, Cranage and Nath (2014) estimated that in India the production of waste per room in hotels ranged from 1 - 6 kg, and it was necessary to promote the idea of low carbon among guests to decrease such production.

Despite this problem, sustainable practices could easily be developed in the lodging facilities, such as selective collection, sending waste to waste pickers' cooperatives, storage and correct disposal of cooking oil, search for local suppliers, etc. Also, the positions of the entrepreneurs were found to be relevant when investing in environmental education actions, with employees and with guests, through educational campaigns for the reuse of towels and the incentive to the conscious consumption of energy, water, and food products.

Therefore, it is recognized the implementation of projects for selective collection and environmental awareness as necessary actions to consolidate the rational use of solid waste in the lodging facilities. However, on the other hand, it is emphasized that merely separating waste internally, without the adoption of public policies for solid waste management in cities, is only a palliative for the problem.

In order to face this conflict, it is imperative that the state of Piauí obeys the principles and objectives of the Solid Waste National Policy, established by Law 12.305/2010 and its respective instruments: solid waste plans; inventories and the annual solid waste reporting system; selective collection, reverse logistics systems;

encouraging the creation and development of cooperatives; environmental, sanitary and agricultural monitoring and inspection; technical and financial cooperation between the public and private sectors for the development of research on new products, methods, processes and technologies for management, recycling, reuse, waste treatment and environmentally appropriate final disposal of waste; scientific and technological research and environmental education (Brasil, 2010).

In this context, it is emphasized that two lodging facilities had equipment and actions to minimize the generation of waste in the accommodations, and revealed the entrepreneurs' initiatives for waste separation and later collection and recycling. This contextualization made it possible to verify that although entrepreneurs were aware of the inexistence of a selective collection system in the municipality of Parnaíba, they did their part by separating the compounds, with the perspective that the procedure would be recognized and validated by the Parnaíba City Hall in the later stages of the solid waste management process.

Given the waste production presented in Table 4, the corresponding total and per capita CO_2 emissions are listed.

Table 4 – Description of the total and per capita emissions of the waste production category in the lodging facilities in the city of Parnaíba

Items	Values	
	Total ($kgCO_2$)	Per capita ($kgCO_2$)
Average	14.1	0.49
Maximum	21.2	0.81
Minimum	8.8	0.27
Standard deviation	6.3	0.28

Source: Direct search (2018).

Table 4 shows that the daily averages of total and per capita CO_2 emissions from waste production in the lodging facilities were 14.1 and 0.49 respectively, derived mainly from organic and inorganic residues generated during breakfast. In the facilities that optionally offered snacks and meals, it was found that the total and per capita CO_2 emissions were higher, in this case, 21.2 and 0.81 $kgCO_2$, respectively.

According to Gössling, Garrod, Aall, Hille and Peeters (2011), restaurants in a tourist destination also cause climate change, since the food production chain releases carbon significantly, mainly through agriculture, processing, transportation, and food preparation. Thus, to minimize emissions, they suggest that food could be purchased close to tourist destinations, with a view to promoting family farming and its diversification, to avoid the purchase of imported foods that require air transportation and other measures. In relation to the other categories analyzed, water and cooking gas consumption were less significant in relation to energy consumption and the production of solid waste (Table 5).

Table 5 – Values referring to water (l) and cooking gas (m^3) consumption and CO_2 emissions in the lodging facilities in the city of Parnaíba

Items	Values		CO_2 emissions ($kgCO_2$)	
	Monthly average	Per night	Monthly average	Per night
Water consumption (l)	24000	26.6	0.42	0.006
Gas consumption (m^3)	22.9	0.76	47.4	0.050

Source: Direct search (2018).

As specified in Table 5, it was noted that water and cooking gas consumption produced emissions of 0.0006 and 0.050 $kgCO_2$/per night, respectively, which are low values when compared to the previous categories. In addition, the consumption of 26.6 liters of water/per night was lower than the estimates proposed by Gössling et al. (2012), that guests consume between 84-2000 liters/day of water in lodging facilities, and that this variation stems from the variety and classification of the accommodation facilities. In Brazil, the average water consumption rate per inhabitant is 150 liters (Brasil, 2014).

In such a context, Styles, Schoenberger and Galvez-Martos (2015) highlights that water stress is an extreme challenge for tourist destinations. In the hotel sector they estimated that the average consumption rate per night was ≤ 140 liters, originating especially from the water expenditure in the swimming pool, kitchen (dish washing), water flow from toilets and water flow from taps and showers at the HUs.

In this sense, it is reinforced that other management measures could be incorporated for the rational use of water resources in hotel enterprises, such as the reuse of rainwater, the control of water flow in the toilets and the efficiency in irrigation of gardens and in cleaning operations in general. With this in mind, Vieira's (2004, p. 9) reflection on the wasteful tendency of the hotel sector is made explicit and calls attention to the behavior of most guests whom generate large expenses with actions such as “long baths, running water in the washbasin without concern for the consumption it represents, air conditioning working with open doors and windows and other forms of waste that are beyond the control of the hotel management”.

Table 6 presents the summary of per capita CO_2 emissions of accommodation facilities and the percentage contribution of each analyzed category.

Table 6 – Summary of per capita CO_2 emissions of accommodation facilities in the city of Parnaíba

Categories	Per capita emissions/per night ($kgCO_2$)	Percentage (%)
Energy consumption	3.800	94.7
Waste production	0.200	4.8
Gas consumption	0.050	1.2
Water consumption	0.006	0.7
TOTAL	4.01	100

Source: Direct search (2018).

It was shown that overnight emissions from Parnaíba's lodging facilities amounted to 4.01 $kgCO_2$, mainly derived from the consumption of electricity, with 94.7% of the total, followed by the production of waste (4.8%) and consumption of water (1.2%), and cooking gas (0.7%). Such data are similar to the world average of CO_2 emissions in accommodation facilities, since, according to the UNWTO (2008), the average of emissions per night is 4.0 kg CO_2 for domestic visitors and from developing countries.

This context revealed that the highest emissions were related to the consumption of electricity, because the facilities do not use renewable sources, such as solar and wind energy, and do not adopt educational measures directed at employees and guests. In this perspective, it is understood that in the face of the emerging climate crisis, the accommodation facilities will need to develop adaptation and mitigation actions to remain competitive, such as reducing water and energy consumption, and replacing the fossil fuel matrix with renewable energies sources.

To this end, it is understood that low-carbon tourism can be configured in a strategic development model for environmental management in lodging facilities, due to the availability of sustainable technologies that can replace the most polluting technologies, which can contribute to the rational use of energy and water, and to mitigate CO_2 emissions. However, the materiality of this procedure requires the establishment of government incentives, businessmen and users’ awareness, and the mobilization of tourist actors. Furthermore, it was understood that in a scenario of climatic uncertainties that affects tourism development, knowing and characterizing the picture of emissions in attractions and sectors became essential to guide the planning and management of the impacts resulting from climate changes for the lodging facilities.

5 CONCLUSIONS

This study examined the direct emissions of CO_2 in lodging facilities in the municipality of Parnaíba, Piauí, a tourist destination in the northeast of Brazil, part of the outstanding national route Rota das Emoções. The parameters adopted were based on the analytical categories of energy, water, and cooking gas consumption, and on the production of solid waste. The results reported that the main contributor to direct emissions in the accommodation experience was energy consumption, that is, the expenditure made by guests. Other emitters, to a lesser extent, were the generation of waste and the consumption of cooking gas and water, respectively.

It was noted that the characterization of the emissions differs compared to the studies carried out in other global regions. It was possible to conclude that the consumption of the analyzed variables was below the averages found in those studies, thus the emissions were lower than those of accommodation facilities in developed countries. However, it should be highlighted that the per capita emissions were similar to the behavior of domestic visitors in developing countries.

The characterization of the contribution of lodging facilities for local and global CO_2 emissions proved to be strategic to compose the overall picture of the emissions and the analysis of the variables that influenced the amount of carbon emitted. Such references must be undertaken to propose mitigation and adaptation actions for the investigated destination.

It is important to reinforce the need for further research in other Brazilian tourist destinations and in the South American region, since in the European and Asian contexts there are already ongoing or concluded studies, that allow us to understand the contribution of the accommodation facilities to the context of global emissions in those continents. In this sense, the present study contributes to filling the gap in the literature reported by authors in the geographic context of South America.

However, it is necessary to expand the analysis to include indirect emissions produced by the hotel sector, which involves studies of hotel purchases, origin of suppliers, etc. In addition, for future studies, it is suggested that guests' direct emissions be compared with their daily lives emissions to understand whether conscious behavior at home extends to their hotel stays.

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APPENDIX A – Model of the structured interview applied to managers of the accommodation establishments in the city of Parnaíba (PI).

Date: _____ Interviewer: _____ Place: _____

1. Time in the hotel industry:_____

2. HUs:_____ Beds:_____

3. Equipment in the HUs:

Kind of HU	Amount	Description of the equipment

4. Number of employees: High Season: _____ Low Season: _____

5. High season period: _____

6. Accommodation facilities and services: _____

_____

_____

7. What kind of energy source is used in the establishment? ( ) electrical ( ) wind ( ) solar
Other: _____

8. How much is the average monthly energy bill? Reals: _____ kWh: _____

Measurement of energy consumption

Stay	KWh (Start of the stay)	KWh (End of the stay)	Number of guests
1			
2			
3			
4			
5			

9. Are there any actions taken to reduce energy consumption? ( ) yes ( ) no.

9.1 If so, what are they? _____

_____

10. How much is the average monthly water bill? Reals: _____ Liters: _____

Stay	KWh (Start of the stay)	KWh (End of the stay)	Number of guests
1			
2			
3			
4			
5			

11. Are there any actions taken to reduce water consumption? ( ) yes ( ) no.

1.1 If so, what are they? _____

_____

12. Are there any kind of actions in order to reuse water? ( ) yes ( ) no

If so, what are they? _____

_____

13.What is the destination of the waste generated? _____

_____

_____

14.Is there selective garbage collection? ( ) yes ( ) no

15.Weight of the waste generated in the establishment:

Day	Weight of the waste (kg)	Number of guests
1		
2		
3		
4		
5		

16.What is the destination of the sewage? _____

_____

_____

17.Does the establishment have a restaurant? ( ) yes ( ) no

17.1 If so, how many cooking gas canisters does the establishment consume per month?? Un._____ Kg_____

18.What is the destination of leftover food? Is there any kind of reuse?

_____

_____

_____

_____