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Assessing carbon emissions from hotel services in Unawatuna Tourism Area, Sri Lanka

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Abstract

Tourism accounts for 9% of global carbon emissions, necessitating an examination of its environmental impact and the key subsectors driving emissions. This study focuses on Unawatuna in Sri Lanka's Galle district, a popular tourist destination with the highest number of tourist arrivals, hotels, and services in the South Coast region. The objective of the study was to identify carbon dioxide emission drivers and assess the CO_2 emissions from hotels and other related services. Data were collected through structured questionnaires using a stratified random sampling method from 56 hotels and related establishments (50% of the total registered with the Sri Lanka Tourism Development Authority). The study was carried out from December to April 2023. Key CO_2 emission drivers included energy consumption, fuel consumption for cooking-related practices, transportation, power generators, operational logistics, and waste management. Electricity, primarily supplied by the national grid, is a significant contributor, with only 23.21% of establishments using renewable energy. Five-star hotels and boutique villas demonstrate the highest electricity and LP gas consumption due to luxury offerings, while power generator usage, mainly during outages, adds to emissions. Diesel and petrol are extensively used for transportation and backup power, with five-star hotels and restaurants showing the highest fuel consumption. Laundry services, provided by 76.79% of establishments, further amplify emissions, especially in luxury hotels. These findings underscore the energy-intensive nature of tourism operations and their substantial carbon footprint.

Keywords: Carbon emissions, CO2 emissions, Hotel services, Tourism in Unawatuna, Sri Lanka

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Introduction

Since the industrial revolution in the mid-19th century, global carbon emissions have steadily increased, contributing to the ongoing challenge of climate change (Erans et al., 2022). However, the introduction of coal as a primary energy source marked a significant increase in CO_2 emissions. Annual CO_2 emissions rose from 54 million metric tons in 1850 to 1.6 billion metric tons by 1950. Atmospheric CO_2 concentrations also climbed from 280 ppm pre-industrially to 412 ppm in 2020, the highest level in over two million years, significantly contributing to the challenge of climate change (Boden et al., 2017; Marlan, 2017; Erans et al., 2022).

CO_2 can cause changes in the atmosphere, the ocean, the ice sphere, and the biosphere (IPCC, 2023). Climate change is a significant consequence of increased carbon emissions, as greenhouse gases (GHGs) trap heat in the Earth's atmosphere, leading to a rise in global temperatures. This warming has numerous cascading effects on the planet's climate systems, including increased frequency and severity of extreme weather events, heatwaves, sea level rise, and ocean acidification, all of which contribute to increased death rates and morbidity (IPCC, 2015; Runkov et al., 2023).

There are four global sectors that account for most carbon emissions: 1) energy generation, 2) industry, 3) agriculture, and 4) waste management. Tourism is one of these industries, classified as a tertiary economic activity. The tourism industry is globally spread and is associated with a wide range of carbon-emitting activities. Approximately 9% of global carbon emissions are attributable to tourism (Lenzen et al., 2018; Rico et al., 2019). Many activities contribute to tourism's carbon footprint (CF), from lodging and souvenirs to boat rides and airplane travel. The primary source of GHG emissions from tourism is transportation. Additionally, lodging facilities use energy for air conditioning and heating to maintain comfortable temperatures in guest rooms, resulting in CO_2 emissions. Energy-intensive systems, such as water heaters for swimming pools, spas, and showers, also contribute to emissions. Electricity used for appliances like laundry machines, televisions, refrigerators, lights, and other devices further adds to carbon emissions. Smaller lodgings, like homestays and guesthouses, tend to have lower emissions compared to larger lodgings such as resorts and hotels with contemporary amenities (Sustainable Travel International, 2020). Many social and economic activities related to tourism contribute to the emission of GHGs, particularly CO_2 (Becken and Patterson, 2006; Robaina-Alves et al., 2016). In 2013, global tourism accounted for 8% of total GHG emissions, with a carbon intensity measured as emissions per dollar of revenue 20% higher than the global economic average. Tourism-related emissions are projected to increase by 25% by 2030, reaching 1.8 gigatons of CO_2 annually, if mitigation efforts are not implemented (UNWTO, 2020).

As a result, sustainability has become increasingly important to travelers and tourism investments (Weber, 2019; Wehrli et al., 2011). Therefore, it is essential to analyze the effects of tourism on emissions and determine which subsectors are responsible for the increase (Robaina-Alves et al., 2016). Empirical studies must re-examine the relationship between tourism and carbon emissions (Sun et al., 2022). More research is warranted to understand the role of tourism suppliers in promoting sustainable development (Stalmirska and Ali, 2023).

Sri Lanka is an island nation that has become a popular tourist destination in Asia (United Nations World Tourism Organization, 2015). The tourism industry generates the third-largest share of foreign exchange earnings in Sri Lanka, contributing 15.9% of the total (SLTDA, 2018). Sri Lanka has several key tourist destinations, including the Historic City Region, Colombo Urban Region, Greater Colombo, East Coast Region, and South Coast Region (SLTDA, 2018). The South Coast region holds the second-largest distribution of accommodation capacity and occupancy rates in Sri Lanka. Research on the tourism industry has primarily focused on the Colombo region, with limited studies on the southern region. The Galle district has the highest number of tourist accommodations and the highest occupancy rate in the southern province. Major tourist areas in the southern coastal region, such as Hikkaduwa, Mirissa, Weligama, Hirikatiya, and Tangalle, have seen significant tourism activity.

The Unawatuna area in the Galle district records the highest number of tourist arrivals, hotels, and services. Recognized by CNN as one of the world's 100 best beaches, Unawatuna Beach is known for its semicircular shape, clean sands, and shallow waters, making it safe for year-round activities. Popular from November to March, the beach attracts many tourists daily to Kudawella and Suduwella. With the Galapitela and Napoleon coral reefs, Unawatuna is a prime diving location in Sri Lanka, offering scuba diving, snorkeling, surfing, and whale watching, accessible 20 minutes offshore by boat Sri Lanka Tourism Development Authority (SLTDA). (2023). Thus, the Unawatuna beach area has been selected as the study area due to its high number of tourist visits, popularity, and focus on ecosystem conservation.

Accordingly, this research aims to identify the carbon dioxide emission drivers and assess the carbon dioxide emissions of hotel services in the Unawatuna tourist area, in Sri Lanka.

Methodology

Study area

The Unawatuna tourist area was the selected study site (Figure 1). It is located in the Southern Province of Sri Lanka, within the coastal region of the Galle District. Unawatuna is a popular tourist destination situated between the Talpe tourist beach area and Galle city to the south. In the Galle District (Figure 1A). The Unawatuna coastal town lies within the administrative boundaries of Yaddehimulla, Unawatuna Central, Unawatuna West, Unawatuna East, Maharamba, Bonavista, and Dalawella(Figure 1C). , which form part of the Habaraduwa Divisional Secretariat Division (Figure 1B). (SLTDA, 2018). The area encompasses approximately 5 km^2 of picturesque beaches with rich biodiversity. The geographic coordinates of Unawatuna are approximately 6.0101° N latitude and 80.2767° E longitude.

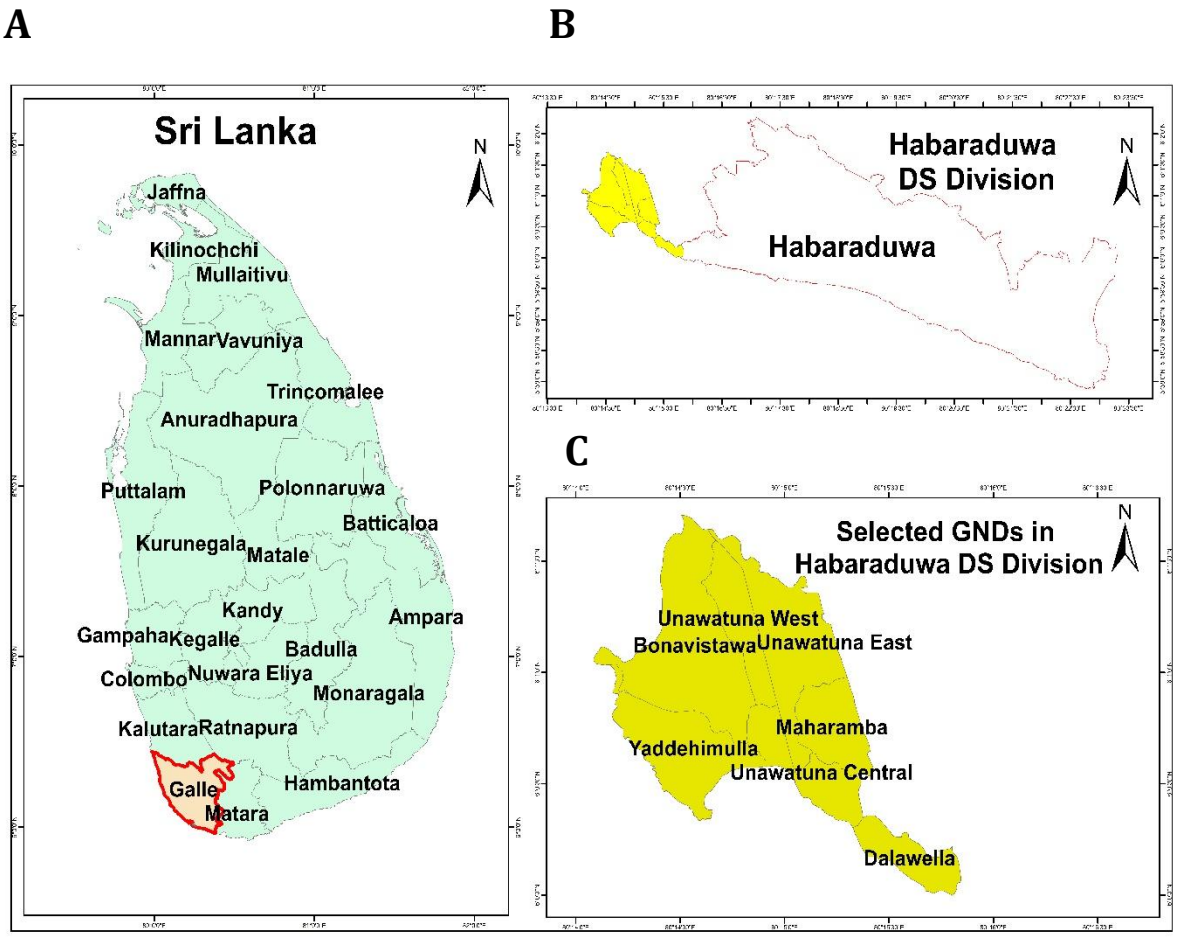

Figure 1. Location of the study area. A: Galle District in Sri Lanka **B:** Habaraduwa DSD **C:** Selected GNDs in Habaraduwa DS Divison

Data collection

The Unawatuna tourist area offers a variety of accommodations and services, including 3-star and 5-star hotels, guest houses, restaurants, boutique villas, rented apartments, shared lounges, homestays, boutique hotels, unclassified hotels, and other lodging options. A total of 110 hotels and service centers in Unawatuna tourist area are registered with the Sri Lanka Tourism Development Authority (SLTDA) by 2023 (SLTDA, 2023).

For this study, a sample size of 50% of the registered tourist hotels and services was used, resulting in a total of 56 samples selected through a stratified random sampling method, with samples drawn proportionally from different strata of hotels and services. A 50% sample ensures that a significant portion of the population is included, reducing sampling error and providing results that are more representative of the entire population (Babbie, 2020). Table 1 presents the number of samples obtained from each category. Data for the study were collected using a questionnaire survey. The questionnaire survey gathered information on energy consumption, operational logistics, transportation, and waste management.

The study period was from December to April 2023 as the arrival of tourists in the Unawatuna tourist area peaks during this period. The occupancy rate of the Unawatuna tourist area is approximately 80% during this time (SLTDA 2018).

Table 1: Sample size by hotel category (SLTADA database, 2023)

Hotel Category	Total Numbers of Hotel	Selected Sample Size
3 Star	8	4
5 Star	1	1
Guest House	20	10
Restaurant	26	13
Boutique Villas	10	5
Rented Apartments	8	4
Shared Lounge	16	8
Home Stay	6	3
Boutique Hotels	2	1
Unclassified Hotels	12	6
Other	1	1
Total	**110**	**56**

Data analysis

The Hotel Carbon Measurement Initiative (HCMI) Version 2 and its accompanying Excel Tool, developed by the Sustainable Hospitality Alliance (Sustainable Hospitality Alliance, 2023), were used to calculate hotel and service-related carbon emissions. HCMI is a methodology, and accompanying excel tool, which was developed by the hospitality industry to calculate and communicate the CF of hotel stays and meetings in a consistent and transparent way. It enables a hotel property to calculate the total CF, the CF per occupied room daily, the CF per area of meeting space on an hourly basis, and renewable energy and electricity as a portion of total consumption. HCMI covers all on-site energy usage, including fuels, purchased electricity, and mobile fuels, as well as emissions from refrigerants and, where applicable, carbon emissions from outsourced operations like laundry services.

This was established in partnership with 23 of the world's leading international hospitality companies, the Sustainable Hospitality Alliance (formerly known as the International Tourism Partnership (ITP) and the World Travel and Tourism Council (WTTC) launched HCMI in June 2012.

The data from HCMI is used by hotels in the Cornell Hotel Sustainability Benchmark Index and the Hotel Foot printing benchmarking tool (Cornell Hospitality Report, 2023). Although the HCMI tool effectively calculates hotel CF, it has limitations, including less focus on seasonal variations, emissions from the production of purchased materials and consumables in the hotel, product use, and other outsourced activities (except laundry) are excluded.

Also, the methodology is not an assessment of all environmental risks and opportunities. For broader assessments, tools like GHG Protocol, Life Cycle Assessment (LCA), and ISO 14064 standards can complement HCMI in future studies. Further, bar charts were also used to visualize the results using MS Excel.

Results

The occupancy rate in the Unawatuna tourist area was approximately 80% during the study period (SLTDA, 2018). The results indicated that 80.5% of hotels and services achieved an occupancy rate of 50% or higher during the period under consideration. Essentially, most hotels accommodated at least half or more of their available rooms during the season.

The key areas contributing to CO2 emissions included fuel consumption for cooking related activities, power generation, transportation, operational logistics, and emissions from waste incineration. Significant factors impacting electricity consumption were lighting, onsite combustion, onsite power generation, refrigerators, fuel consumption, air conditioners, and their potential leaks.

Drivers that notably affected operations in logistics include laundry services and cleaning activities. Hotel-owned vehicles represent the primary contributor to CO_2 emissions in transportation. For waste management, solid waste disposal mechanisms are the most significant influencing factors.

The Unawatuna tourist area, the national power grid primarily supplies electricity to hotels and other hospitality services. Only 23.2% of hotels and services in the area utilize renewable energy sources for electricity consumption. Electricity is predominantly used to power cooling and heating systems and fulfill other internal energy needs.

It is important to note that private areas not used for tourism purposes can occasionally be found within hotels and tourism services. This factor should be considered when calculating the carbon emissions of tourist hotels and services.

In the sample of hotels and services analyzed for this study, 33.9% had private space restrictions. Within this subset, 10.5% had electricity consumption exceeding 2,000 kWh. The remaining 66.1% of the total land area of hotels and services has been dedicated to tourism purposes. Among these, 51.3% had electricity consumption exceeding 1,000 kWh, and within this group, 36.8% consumed over 2,000 kWh (Table 2).

Table 2: Electricity consumption pattern of the hotel sector in Unawatuna tourist area

Determinants	% of Hotel and Services	Electricity Usage more than 2000kWh
Private space available	33.9%	10.5%
Private space unavailable	66.1%	36.8%

The primary source of CO_2 emissions in the Unawatuna tourist area was electricity consumption, with significant variations across hotel types. Five-star hotels and boutique villas exhibited the highest average electricity intensity due to their luxury and comfort offerings, requiring substantial energy (Figure 2). Three-star and unclassified hotels also consumed over 1,500 kWh per month, vastly exceeding Sri Lanka's average household consumption of 64 kWh—about 23

times more. This highlights the energy-intensive nature of hotel operations, driven by guest service demands, which significantly contribute to their CF.

Carbon emissions from fuel consumption in food-related services

Five-star hotels in Unawatuna are the largest consumers of liquefied petroleum (LP) gas for food-related services, using over 21 times more than other hotels (Figure 2). LP gas was widely utilized across various establishments, including boutique villas, three-star hotels, unclassified hotels, and restaurants, emphasizing its versatility in the accommodation and dining sectors. However, the degree of consumption varied significantly among these establishments.

Fuel consumption for energy in hotels contributes significantly to CO_2 emissions. Fuel combustion for food-related services is a prominent source, with LP gas being the primary energy source, supplemented by a minor use of firewood.

Most establishments offer food-related services, with 66% of hotels and related services relying exclusively on LP gas for their operations. Firewood alone was never used, while 5% of hotels used a combination of LP gas and firewood. Meanwhile, 29% of establishments did not use any fuel for food-related services as they do not provide such offerings.

Additionally, fuel was primarily consumed in hotels and services through power generators, typically used during unexpected power outages. Approximately 28.6% of these establishments utilize power generators, with 62.5% operating on diesel and 37.5% on petrol.

Among the establishments using diesel generators, 50% consume more than 50 liters per month. Similarly, 16.7% of those using petrol generators exceed 50 liters of fuel consumption monthly. Of the establishments that use both types of fuel, 37.5% burn more than 50 liters per month.

Carbon emissions from power generators

In the Unawatuna tourist area, only 28.6% of hotels used power generators at the time of the study, with 62.5% operating on diesel. Five-star hotels had the highest diesel consumption, driven by their substantial energy needs to deliver uninterrupted luxury services. Three-star hotels, guest houses, and boutique villas also utilized diesel generators, but their consumption remained lower, with none exceeding an average of 200 liters per month—less than half of the usage reported.

Table 3: Electricity consumption pattern of the hotel sector in Unawatuna tourist area

Determinants	% of Hotel and Services	Electricity Usage more than 2000Kwh
Private space available	33.9%	10.53%
Private space unavailable	66.07%	36.84%

The primary source of CO_2 emissions in the Unawatuna tourist area was electricity consumption, with significant variations across hotel types. Five-star hotels and boutique villas exhibited the highest average electricity intensity due to their luxury and comfort offerings, requiring substantial energy (Figure 2a). Three-star and unclassified hotels also consumed over 1,500 kWh per month, vastly exceeding Sri Lanka's average household consumption of 64 kWh, about 23 times more. This highlights the energy-intensive nature of hotel operations, driven by guest service demands, which significantly contribute to their CF.

Carbon emissions from fuel consumption in food-related services

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Fuel consumption for energy in hotels contributes significantly to CO_2 emissions. In particular, fuel combustion for food-related services is a prominent source, with LP gas being the primary energy source, supplemented by a minor use of firewood.

The majority of establishments offer food-related services, with 66% of hotels and related services relying exclusively on LP gas for their operations. Firewood alone was never used, while 5% of hotels used a combination of LP gas and firewood. Meanwhile, 29% of establishments did not use any fuel for food-related services as they do not provide such offerings.

Additionally, fuel was primarily consumed in hotels and services through power generators, typically used during unexpected power outages. Approximately 28.57% of these establishments utilize power generators, with 62.5% operating on diesel and 37.5% on petrol.

Among the establishments using diesel generators, 50% consume more than 50 liters per month. Similarly, 16.7% of those using petrol generators exceed 50 liters of fuel consumption monthly. Of the establishments that use both types of fuel, 37.5% burn more than 50 liters per month.

Carbon emissions from power generators

In the Unawatuna tourist area, only 28.57% of hotels used power generators at the time of the study, with 62.5% operating on diesel. Five-star hotels had the highest diesel consumption, driven by their substantial energy needs to deliver uninterrupted luxury services. Three-star hotels, guest houses, and boutique villas also utilized diesel generators, but their consumption remained lower, with none exceeding an average of 200 liters per month, less than half of the usage reported.

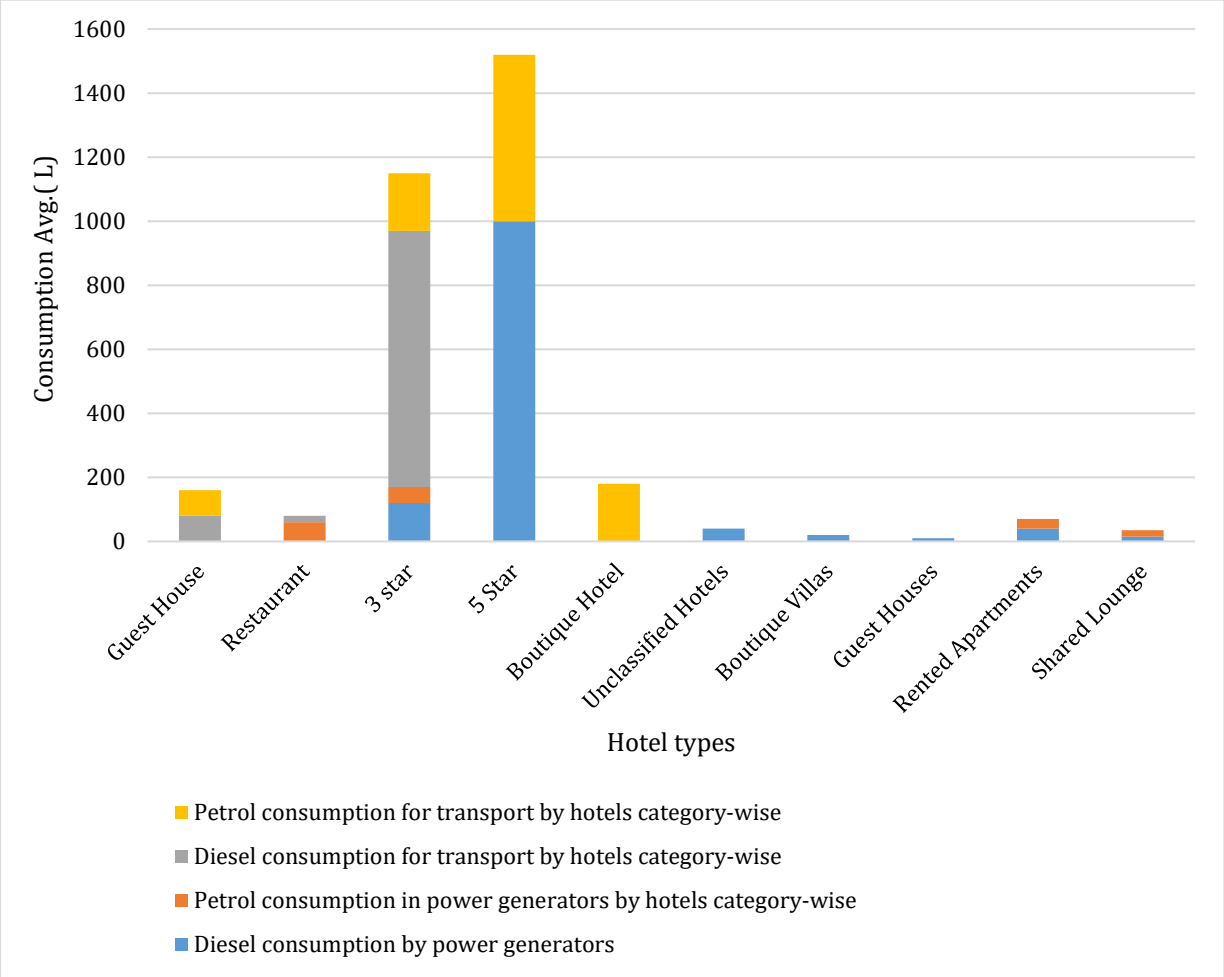

Figure 2: Petrol and Diesel consumption in the different hotel categories

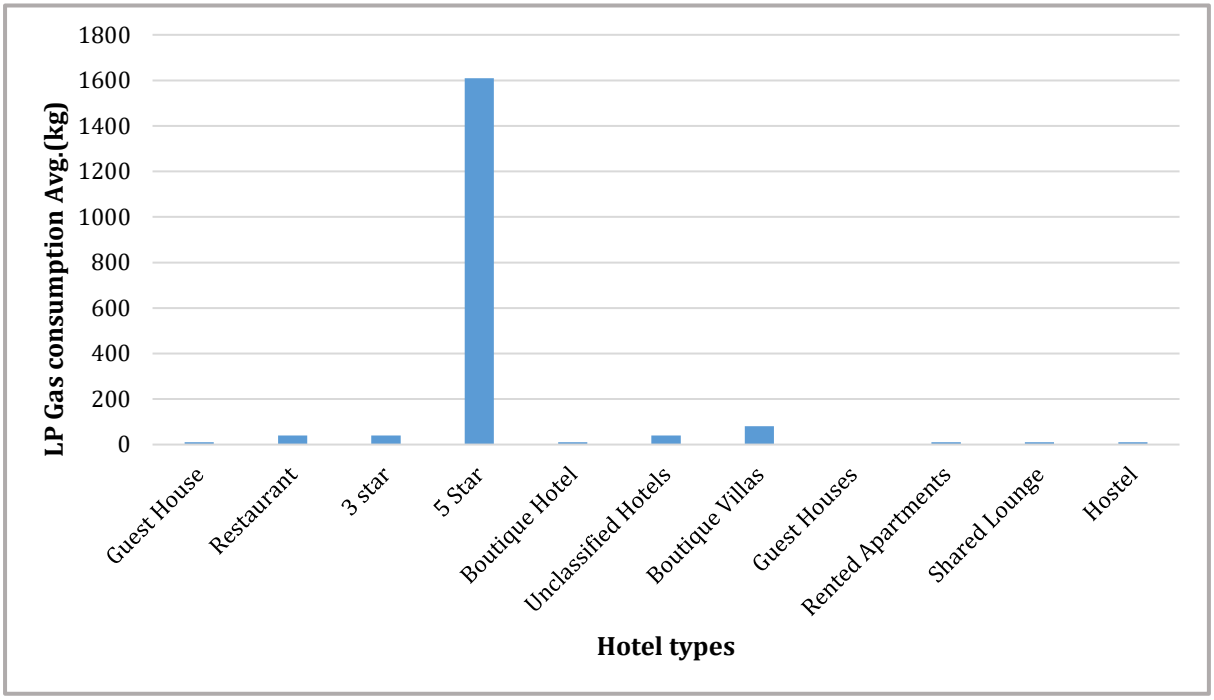

Figure 3: Consumption of LP Gas in food-related services by hotel categories

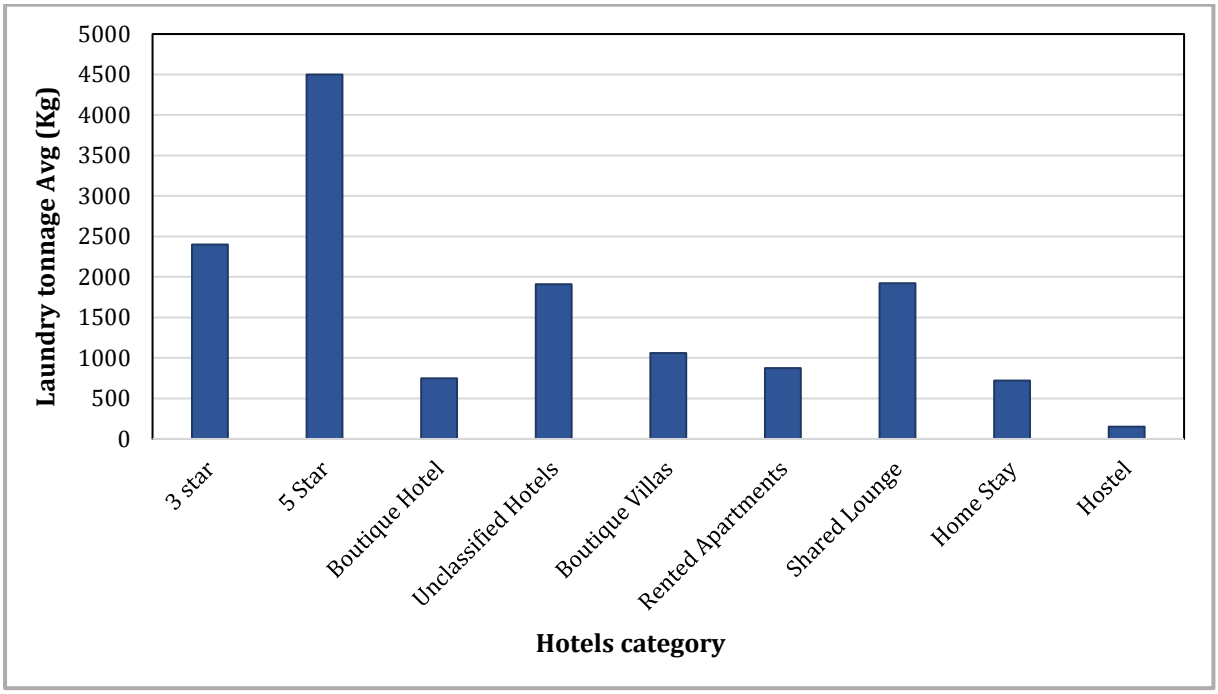

Figure 4: Consumption of Outsourced laundry tonnage by hotels category wise

In the Unawatuna tourist area, 37.5% of establishments relied on petrol-powered generators, with restaurants forming the largest segment due to their substantial energy needs. Three-star hotels also showed significant reliance on petrol generators to ensure uninterrupted power supply and maintain service standards. In contrast, rented apartments and shared lounges contributed minimally to overall fuel consumption, reflecting their lower energy demands and smaller operational scales within the diverse tourism sector of Unawatuna (Figure 2).

Carbon emissions from transportation activities

Questionnaire survey conducted with local residents in Unawatuna area reveal that 42% of hotels used diesel as the preferred fuel for transporting goods and personnel. Three-star hotels had the highest diesel consumption rates among hotel types, reflecting their significant transportation needs, particularly for transfer, tour, and logistical services—key activities in the hospitality industry. Guest houses and restaurants also used diesel, but their consumption was lower compared to cement industries, indicating lower transportation requirements. Three-star hotels consumed approximately eight times more diesel for transportation than other establishments, highlighting the essential role of transportation in their business operations (Figure 2).

In the Unawatuna tourist area, only 12.5% of tourist hotels provided transportation services to their guests. Of these, 47.3% relied on petrol as their primary fuel source. The average monthly petrol consumption for hotels offering transportation does not exceed 200 liters. However, five-star hotels showed significantly higher petrol consumption, averaging 525 liters per month—more than twice that of other hotel types. This indicates the elevated service standards and comprehensive transportation options provided by five-star establishments (Figure 2).

Carbon emissions from operational logistics

When analyzing the internal operations of tourist hotels and services, it is essential to recognize laundry services as a significant source of CO_2 emissions. This is primarily due to the high consumption of electricity and water, which contributes to energy-related CO_2 emissions. Notably, restaurants do not face similar concerns, as they typically do not provide laundry services.

Some hotels that offer laundry services outsource their requirements to external companies, an important factor to consider. When laundry services are managed internally, their associated energy consumption is included in the overall energy usage calculations. However, if outsourced, this energy usage must be accounted for separately.

Within the Unawatuna tourist area, a substantial majority, 76.8% of establishments—provide laundry services. Among these, 51.2% outsource their laundry needs to external companies. This reliance on external services underscores the importance of incorporating such considerations into energy and emissions assessments.

The majority of laundry services, around 75%, are provided by hotels, with occasional inclusion from restaurant service establishments. In this context, luxury hotels contribute the most to CO_2 emissions, while shared lounges and unclassified hotels also make a significant contribution. Despite differences in monthly laundry volume and averages, it is challenging to identify substantial variations between different types of hotels. Hostels have a lesser impact on CO_2 emissions within this sector (Figure 4).

Carbon emission from waste incineration

Effective waste management is crucial for monitoring and controlling carbon emissions, as waste incineration is a significant source of CO_2 emissions. However, this study faces limitations in analyzing carbon emissions specifically from waste management activities in tourist hotels and related services. Since the local council oversees all waste produced by hotels and services in the area, the lack of precise data and a definitive identification process prevents the determination of CO_2 emissions solely from waste management practices within hotels and related services. This limitation underscores the need for more detailed and localized data collection to enhance the scope of future research.

Discussion

The study identifies fuel combustion, as a significant contributor to carbon emissions in the hotel industry. Key sources include LP gas and fuel for onsite power generators. High fuel consumption is particularly evident in food-related services and water heating, emphasizing the resource-intensive nature of hospitality services (Tachir & Alalı. 2023). In this context, sources such as electricity generation, boilers, and gas cooking stoves within hotel premises release considerable CO_2 into the atmosphere (Abeydeera & Karunasena, 2019: Marasinghe, 2024).

Electricity usage emerges as a predominant contributor to CO_2 emission in the hotel and service industry. This is largely due to the continuous operation of hospitality services, which often function 24/7, and the extensive amenities provided to guests (Ba et al., 2022). Heating and cooling systems, particularly air conditioning, are significant contributors, with luxury hotels showing disproportionately high energy usage. Research indicates that five-star hotels consume the most electricity due to their focus on guest comfort and the provision of upscale services. Hotels and restaurants in the luxury segment are major contributors to CO_2 emissions, accounting for 21% of total emissions from tourism buildings (Spiller et al., 2022). These findings highlight the need for energy efficiency measures targeted specifically at high-end hospitality establishments to mitigate their environmental impact (Salehi et al., 2021).

In the Unawatuna tourism sector, transportation's overall carbon emissions are relatively low due to infrequent use. However, transportation remains a factor in Scope 1 emissions, particularly from activities such as hotel staff operations and guests' arrivals and departures. Waste management presents another challenge in accurately measuring carbon emissions. In Unawatuna, the local governing body, the Pradeshiya Sabha, oversees waste management, making it difficult to attribute specific emissions to hotels. It is very important to establish partnerships with local authorities to collect granular data related to waste management. Further, an individual database could be developed within the hotel complexes. Thereby, future researchers will be able to accurately measure the carbon emissions from waste in hotel sector. However, improper waste management practices can exacerbate CO_2 emissions. Onsite fuel combustion and inefficient waste handling contribute to these emissions (Abeydeera & Karunasena, 2019). Effective waste management strategies, on the other hand, can significantly reduce emissions. Globally, proper waste management and energy conservation strategies are recognized as vital in reducing the CF of the hospitality industry. Sustainable practices such as minimizing waste, improving energy efficiency, and adopting renewable energy sources are essential for mitigating carbon emissions and addressing the environmental impact of hotels.

The findings emphasize the importance of implementing comprehensive sustainability measures in the hotel industry, particularly in regions like Unawatuna, where tourism plays a significant role in the economy. By addressing fuel consumption, electricity usage, transportation, and waste management, the hospitality sector can significantly reduce its CF and contribute to broader environmental conservation efforts.

Conclusions

The Unawatuna tourist area demonstrates a robust tourism demand, with an occupancy rate averaging around 80% during the period considered. The study identifies key drivers of CO_2 emissions in the hotel industry, specifically energy consumption, operational logistics, transportation, and waste management. In the Unawatuna tourist area, most hotels and hospitality services rely on electricity supplied by the national power grid, with only 23.2% incorporating renewable energy sources. Electricity consumption, primarily used for cooling, heating, and other internal operations, emerges as the primary driver of CO_2 emissions. Energy usage varies significantly among hotel types, with five-star hotels and boutique villas demonstrating the highest electricity intensity due to their luxury offerings. On average, three-star and unclassified hotels consume over 1,500 kWh per month, approximately 23 times the

average household consumption in Sri Lanka, underscoring the energy-intensive nature of hotel operations. Private areas within hotels, accounting for 33.9% of the sampled properties, further complicated CF calculations. Among properties with private areas, 10.5% report electricity consumption exceeding 2,000 kWh. For the remaining 66.1% of land dedicated to tourism, 51.3% have electricity consumption exceeding 1,000 kWh, with 36.8% consuming over 2,000 kWh. These findings highlight the urgent need for adopting energy-efficient practices and integrating renewable energy sources to reduce the CF of hotels in Unawatuna while meeting guest expectations and sustainability goals.

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Conflict of interest statement

The authors declare no conflict of interest.

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