

# Policy Recommendations for Carbon Footprint Reduction to Enhance Carbon Neutral Tourism in Krabi Province, Thailand

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## Abstract

This research aimed (1) to analyze the carbon footprint of tourism activities and businesses in Krabi province focusing on marine tourism, (2) to evaluate the carbon footprint of tourism activities and businesses in Krabi province, and (3) to propose recommendations to the policy maker to reduce the carbon footprint and enhance carbon neutral tourism in Krabi province. This study employed a qualitative approach, using semi-structured interviews and focus groups. The key informants were selected by purposive sampling technique. The key informants were experts in the carbon footprint of tourism-related activities from three groups: government agencies, the private tourism sector, and local communities. The data was analyzed using the content analysis technique. The findings revealed that tourism activities in Krabi province consist of four primary tourism services. Transportation was identified as the most significant contributor to greenhouse gas emissions, reaching 36.25%, with a greenhouse gas emission of 0.3658 tCO<sub>2</sub>e, followed by waste management, food and beverage service, and accommodation, respectively. This research proposed four policies to promote carbon-neutral tourism as follows: (A) prioritize the use of alternative or renewable energy sources in transportation and improving travel planning efficiency, (B) reduce waste or garbage during the service process and promote tourism service management practices that minimize leftover materials from tourism activities, (C) prioritize local organic or non-chemical food sources and minimize food processing, reduce or avoid purchasing animal products with high carbon footprint, and purchase local products, and (D) support green management hotels which manage carbon reduction, compensation, and repurchase.

**Keywords:** carbon footprint; carbon neutral tourism; tourism activities; tourism businesses; Krabi province

## Introduction

The tourism industry supports many businesses, especially in the hospitality sector. Tourism benefits the destination areas, such as economic stability and infrastructure development from upstream to downstream. (Kariyapol & Agarwal, 2020). Furthermore, the positive impacts of tourism extend beyond economic facets to encompass cultural preservation and the promotion of foreign language exchange, contributing to social and cultural enrichment. However, it was necessary to acknowledge that alongside these benefits, the tourism industry also exerted a notable environmental toll, notably in terms of natural resources exhaustion and its significant contribution to global carbon emissions, which could exacerbate climate change because tourism emitted about 8% of the world's carbon from upstream to downstream in all tourism activities. These gases trap heat in the Earth's atmosphere, similar to wrapping the Earth in a plastic bag, leading to the planet's rapid warming and resulting in a phenomenon known as Global Warming (The Tourism Authority of Thailand, 2021). Countries with high tourism revenues were mainly responsible for high carbon generation. Many travelers refer to the high amount of carbon in the environment.

For this reason, decarbonized tourism is significant in many countries worldwide, including Thailand (El et al., 2019; Lenzen et al., 2018). Thailand's tourism sector must still strive for a more eco-friendly tourism industry. Government organizations have recently collaborated to enhance the capacity for net-zero carbon tourism management among government agencies, the private sector, entrepreneurs, tourism communities, and travelers (Bhaktikul et al., 2021) to be a part of mitigating the climate change impacts on the world and helping reduce global warming. This included the Ministry of Tourism and Sports policy, which focused on driving the Thai tourism industry under "The BCG Model," a bioeconomy, circular economy, and green economy. It was believed that it would lead to sustainable development through the reduction of greenhouse gas emissions that contributed to climate change and the encouragement among stakeholders in the tourism industry to apply the new eco-conscious tourism trends that contribute to low-carbon tourism or net-zero carbon emissions into practice (MGRonline, 2021).

The tourism sector in Thailand, particularly in Krabi province, has experienced significant economic growth and has become a major contributor to the local economy. Krabi, as an international tourism province, attracted a large number of both Thai and foreign tourists. Before the COVID-19 pandemic, Krabi had the highest number of tourists among the Andaman Sea provinces. In 2019, Krabi welcomed a total number of 29,152,932 tourists. In 2021, during the post-COVID tourism recovery period, it continued attracting various tourist groups. It remained the most popular tourist destination, just as it was before COVID. An in-depth breakdown of services consumption in the province in 2019 revealed that accommodation services gained the most significant income from 4,186,069 guests in 22,405 lodging services. Followed by food and beverage consumption was the second-largest tourist expenditure. Two million eight hundred seventy-eight thousand seven hundred sixteen people traveled within the province, or 67% of the total trips (Department of Tourism, 2020, 2022; The Office of Strategy Management for Southern Province Cluster, 2020).

Previous studies focused on Krabi's tourism business. Pongsakornrunsilp (2016) has studied developing guidelines and analyzing the brand image of a green tourism city for tourism business in Krabi province. Thongchim (2014) examined collaborations in tourism management. Additionally, Thientuma, Emphandhu, and Phongkhieo (2022) studied tourism attraction potential and tourists' perceptions toward Krabi attractions. Referring to the literature review on carbon footprint in various locations around the world, the study on the estimation of carbon footprint in Heilongjiang province, China (Huang & Tang, 2021), Barcelona, Spain (Rico et al., 2019), the overview of carbon footprint of global tourism (Lenzen et al., 2018),

and carbon footprint Analysis of Tourism Life Cycle in (Cao et al., 2023). However, only a limited amount was done on carbon footprint analysis for tourism businesses and businesses development of all tourism strategies development Vince.

In response to the policy and concept of promoting Krabi province as Thailand's first province to achieve carbon-neutral tourism by 2040, this study proposed analyzing tourism activities and businesses in Krabi that contribute to carbon emissions. Thus, Krabi's marine tourism industry provides an ideal context for examining the carbon footprint of various activities. The research aimed to propose policy recommendations for reducing the carbon footprint and enhancing carbon-neutral tourism in Krabi province. Moreover, it provided valuable information to entrepreneurs and related sectors, helped them understand carbon emissions, and implemented carbon emissions measurements to minimize the environmental impact of their tourism activities. Eventually, the goal was to promote sustainable travel practices in Krabi.

### **Research Objectives**

1. To analyze the carbon footprint of tourism activities and businesses in Krabi province
2. To evaluate the carbon footprint of tourism activities and business in Krabi province
3. To propose policy recommendations for reducing the carbon footprint and enhancing carbon-neutral tourism in Krabi province

### **Literature Review**

#### **1. Carbon Footprint Analysis in the Tourism Industry**

Carbon footprint analysis was crucial in the tourism industry due to its significant environmental impact. Hence, understanding and curbing its footprint is necessary (Higham & Miller, 2018; Jamal & Robinson, 2011). In addition, conducting a carbon footprint analysis is crucial in evaluating a company's absolute and comparative efficiency. It served as a valuable instrument for engaging with management and evaluating the organization's strategic trajectory (Dyott and Ladiwala, 2017). Therefore, carbon footprint analysis was the result that served as a measurable indicator of the extent to which human activities affected the current state of the world, including the tourism factor (The Tourism Authority of Thailand, 2021).

Over the past decade, tourism contributed about 8% of global greenhouse gas emissions or 4,500 MtCO<sub>2e</sub>, with transportation, accommodation, and activities as the primary emission sources (Becken & Hay, 2007; Office of Natural Resources and Environmental Policy and Planning, 2023). Among the various components of this sector, air transportation, car transportation, and other forms of transportation generated 40%, 32%, and 3% of these emissions, respectively. In contrast, accommodation services and tourism-related activities collectively contributed 21% of the carbon footprint, with an additional 4% emanating directly from these activities. By the year 2035, the carbon emissions from the tourism sector were expected to surge by 130% (DASTA, 2015). Consequently, the urgency of tackling tourism's carbon footprint has been underlined in several studies, as governments and businesses worldwide have committed to reaching zero emissions by 2050 (United Nations, 2021). The studies emphasized the importance of carbon footprint analysis in mitigating tourism's environmental impact. It helped identify emission sources and informs strategies for sustainability. For instance, hotels could reduce their carbon footprint through energy-saving measures and resource conservation (Gössling et al., 2013, 2016).

A key advantage of carbon footprint analysis in tourism is its role as a source of information to tourists about their travel choices (Koens et al., 2018). It also empowered them to make decisions regarding transportation modes, promoting sustainable options like ecotourism and responsible travel (Hall & Gössling, 2013). Additionally, carbon footprint analysis played a pivotal role in

fostering sustainability within the tourism industry by identifying emissions sources and raising awareness among tourists.

Several methodologies and frameworks exist for measuring tourism carbon footprint, with prominent examples including Life Cycle Assessment (LCA) and Input-Output Analysis (IOA). LCA tracks emissions throughout a tourist's journey, encompassing transportation, accommodation, and activities. On the other hand, IOA estimated economic and environmental impacts by tracing emissions associated with goods and services tourists purchase.

The practical applications of carbon footprint analysis were multifaceted. One notable use was the identification of emission sources within the tourism industry. This process helped pinpoint specific areas contributing to emissions, enabling the development of targeted emission-reduction strategies. Another application was the ability to compare environmental impacts that empowered stakeholders to evaluate and contrast the environmental footprint of various tourism options, providing vital information for tourists to make informed and sustainable choices. Moreover, carbon footprint analysis served as a tool for tracking progress. It facilitated monitoring efforts by tourism businesses and governments in reducing emissions, thereby contributing to sector-wide sustainability improvements over time.

## **2. The concept of carbon footprint assessment in tourism in Thailand**

Carbon footprint analysis was crucial in Thailand's tourism industry, facilitated by "Product Category Rules" (PCR) established by the Thailand Greenhouse Gas Management Organization (TGO). These rules were applied to various tourism services, including ecotourism, arts and science, history, nature and adventure, recreational, and cultural, with a specific thematic focus. Data collection in Thailand's diverse tourism sector primarily aligned on four critical activities for greenhouse gas emissions reduction: transportation, accommodation, food services, and waste management. Emphasizing these aspects enabled the industry to diminish its carbon footprint and endorse sustainable practices (Higham & Miller, 2018; Jamal & Robinson, 2011).

Carbon footprint assessment was gaining traction in Thailand due to its substantial tourism-related emissions. Initiatives like the "Green Leaf" certification program encourage businesses to adopt sustainable practices and reduce their carbon footprint (Lenzen et al., 2018; Khemthong & Srisaeng, 2021). Moreover, the "Carbon Footprint for Tourism" project, initiated by TGO in 2010, provided a carbon calculator tool for businesses to measure their footprint and identify emission reduction opportunities (National et al. Board, 2016; Thailand Greenhouse Gas Management Organization, 2010).

In Thai tourism, conducting a carbon footprint assessment was crucial for fostering sustainability and aligning with endeavors to mitigate climate change. According to the United Nations report (2021), the carbon footprint of tourism operations was divided into three categories depending on greenhouse gas emissions and operational responsibilities, including Scope 1: Direct emissions from fuel use and combustion, Scope 2: Indirect emissions from electricity, steam, or heat used during events, including preparation and venue setup, and Scope 3: All additional indirect emissions, encompassing tourist travel (both domestic and international), purchased goods and services, business travel, employee commuting, transportation up and downstream, investments, and accommodations, as well as emissions from waste management.

This categorization allowed for a comprehensive understanding of emissions across the life cycle of tourism services, specifically focusing on food and beverage services, transportation, accommodation, and waste management. It excluded travel services in the travel package, such as separate paid food services and transportation. Carefully considering these emissions categories was essential for practical carbon footprint analysis and mitigation efforts in the tourism industry.

However, achieving carbon neutrality was the balance between emitting and the voluntary compensation (offsetting) of emissions. This concept addressed emissions within Scope 1 and 2 but not necessarily Scope 3 (United Nations, 2021).

### **3. Related research about carbon footprint assessment in tourism**

Carbon footprint assessment in tourism has become more critical due to the industry's substantial contribution to greenhouse gas emissions. This article reviewed prior research on this topic, highlighting critical methodologies, implications, and areas for further exploration. One significant research focus involved the development of methodologies and tools for carbon emissions measurement. The Life Cycle Assessment (LCA) methodology assessed the environmental impact of tourism activities, encompassing transportation, accommodation, and activities (Gössling et al., 2013). Another tool that has been developed for assessing carbon emissions in tourism product category rules (PCR). PCRs offer guidelines for measuring carbon emissions in specific tourism products or services spanning various tourism types (UNWTO, 2016, 2019).

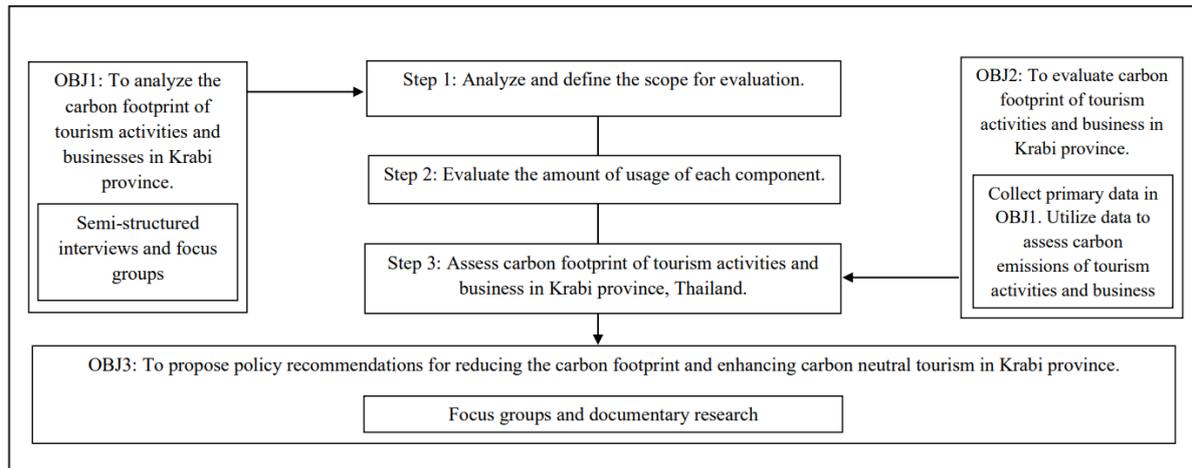
Other research investigated the implementation of carbon footprint assessment in the tourism sector. Case studies underlined the importance of stakeholder engagement, data collection, and appropriate metrics. For instance, a study in Chiang Mai, Thailand, emphasized stakeholder engagement for accurate data collection and sustainable practices (Thongplew & Ruhanen, 2018).

Effectiveness studies revealed that carbon footprint assessment raised tourist awareness and encouraged sustainable practices among businesses. For example, Costa Rica facilitated sustainability in ecotourism businesses (Khemthong & Srisaeng, 2021; Chompu-Inwai & Jindal-Snape, 2016).

However, previous research has mainly focused on emissions measurement rather than reduction. To enhance sustainability, further research should have explored emission-reduction technologies, practices, and the promotion of eco-friendly tourist choices. In conclusion, previous research on carbon footprint assessment in tourism enhances our understanding of its environmental impact and the significance of sustainable practices. The tourism industry could contribute to climate change mitigation by measuring and reducing emissions. Nonetheless, further research is necessary to explore emissions reduction strategies and promote eco-conscious tourist choices.

### **Research Framework**

This research assessed the carbon footprint of tourism activities and businesses based on Greenhouse Gas Management Organization principles. It also recommended policies to reduce the carbon footprint, promote carbon-neutral tourism in Krabi province, and foster active participation from all relevant sectors. The details were as follows.



**Fig.1 Research Framework**

## Research Methodology

This study employed a qualitative approach to explore the perspectives of experts and stakeholders across various sectors in Krabi province. While the specific population size in Krabi province was not precisely quantified, the samples were carefully selected based on purposive sampling. The data were collected from government agencies, the private tourism sector, and local communities with the following criteria: (1) a minimum of 5 years of experience in carbon footprint or marine tourism in Krabi province, (2) a significant role in influencing the environmental impact of tourism in Krabi province, and (3) active promotion of concepts such as low carbon tourism, green tourism, sustainable tourism, or carbon-neutral tourism. The data collection process involved engaging ten critical informants for each categorized group, 30 informants in total, in focused group discussions centered around activities and tourism services during journeys. Additionally, in-depth insights on promoting carbon-neutral tourism were gleaned through semi-structured interviews with nine selected informants. The data for this research were gathered and analyzed between September 2022 and February 2023. The tools used were an interview guide and focus group guidelines, which were instrumental in obtaining quality and comprehensive data (Prasongthan, 2020). Three experts examined these tools to ensure structure, content, and language correctness and completeness.

After data management, including data organization, investigator triangulation, and review triangulation, the data was analyzed using content analysis techniques on the segments obtained from interviews and focus groups. Additionally, the data obtained from the analysis were assessed to derive the carbon footprint value generated by tourism activities and businesses in Krabi province. In this context, the carbon footprint calculation adhered to the criteria set by the Greenhouse Gas Management Organization.

## Research Results

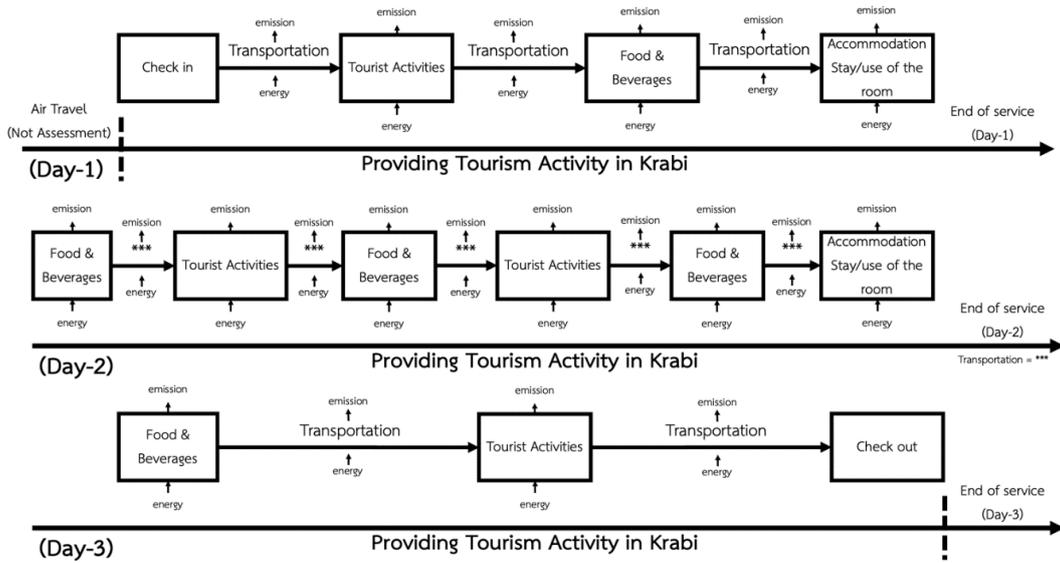
**Objective 1.** The findings from interviews and focus groups revealed that tourism activities in Krabi province consisted of four primary tourism services: accommodation, transportation, food and beverage service, and waste management. In marine tourism, it was observed that carbon emissions and pollutants are primarily released through water transportation, excluding land transportation, bringing tourists to the ports. According to the insights gained from focus group discussions with key informants, it was highlighted that carbon emissions were predominantly attributed to maritime transport. The second significant source of emissions was providing food and beverages during the trips. As for recreational activities, they mainly involved snorkeling or diving with reusable equipment. Additionally, carbon emissions were calculated based on the amount of waste generated during these activities. Overall, the research provided insights into the carbon emissions of tourism activities in Krabi province, which service providers could utilize to formulate carbon management strategies.

### **Program for three days two nights tour**

The result indicated that the carbon emission activity of the tour would begin with transportation, which was to pick up tourists from the airport or any other pick-up location to the accommodation. Then, a van was used to transfer tourists to the tour program's destination. The carbon emission from the tourist activities would mostly be organic and inorganic waste generated from activities in the area. According to the Thailand Greenhouse Gas Management Organization guidelines, greenhouse gas emissions from waste management in tourism services were estimated to be 2.5 kilograms per person per day. Following this, tourists were transported by van for dinner on day one. The dinner typically involved a simple one-dish meal or other options, depending on each tour company's pricing and tour program. The carbon emission activity concluded with the hotel stay if dinner was served at the accommodation. However, when tourists were transported to other locations for dining, the van was required, leading to eventual carbon emissions.

On day 2, carbon emissions commenced with breakfast, which typically depends on the hotel's star rating. After the tourists have enjoyed breakfast, the tour company will pick them up by van to transport them to the destination for the tour program's activities. These activities could vary depending on the type of tourism, such as scuba diving, visiting islands, or using water sports services. Food service at restaurants or simple food options available at tourist destinations was involved during midday. The van would be required for the restaurant outside the tourist destination. In the afternoon, the tourist activities continued, depending on the tour program organized by each tour company. However, greenhouse gas emissions from electricity consumption and waste disposal would also be calculated. Then, at the accommodation or a restaurant, dinner time typically served buffet-style food. Finally, on day 2, the tour company transported tourists back to their accommodation to rest. The accommodation services provided by the hotel were concluded in the carbon emission activities.

Most service providers would provide a tourist activity on the last day before ending the service. The carbon emission activity would again occur from breakfast, transportation, tourist activities, and transportation to the destination, which would not differ from the previous day. Therefore, the analysis of tourism activities and businesses emitted carbon footprints in Krabi province was synthesized as shown in Fig. 2

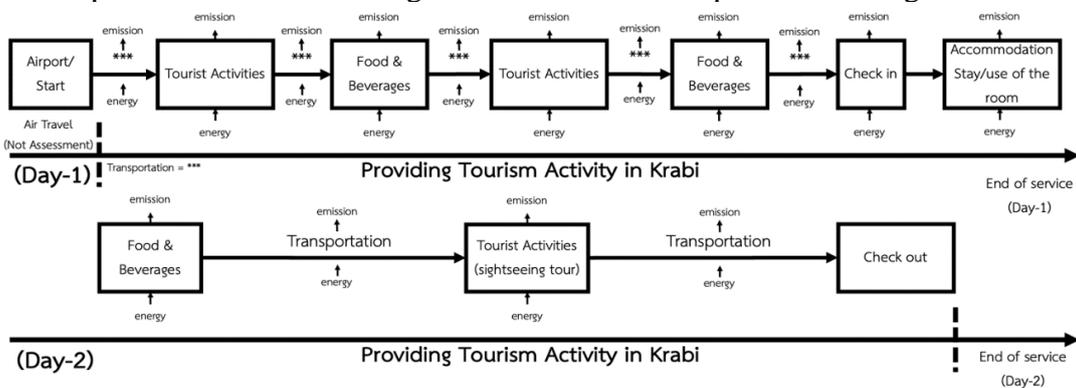


**Fig. 2** Carbon emission in tourism activities and businesses in Krabi province (3 days two nights)

**2) The 2-day, 1-night tour**

The tour offered activities similar to the 3-day, 2-night program but with fewer activities due to the shorter duration or tourists' preferences. Typically, the tour program commences with transportation by van, which may lead to varying levels of carbon emissions depending on the distance covered and the type of vehicle employed engine. The morning activity also created carbon emissions, depending on energy consumption and waste generation. Lunch usually consisted of a simple meal at a tourist destination or a restaurant along the tour route. The afternoon activity could be a continuation of the morning activity or a distinct one, depending on the tour company's program. Therefore, carbon emissions would be computed based on electricity usage and waste production during these activities. Dinner was typically provided as a buffet at the accommodation or a nearby restaurant.

On the last day of the tour program, tourists would be transported back to their accommodation, concluding the carbon emission activity associated with using accommodation services. The activities on the last day mirrored those of the 3-day, 2-night program or be adjusted according to the tour company's design. Carbon emissions during this phase are caused by transportation (transportation businesses), food and beverage service (restaurant businesses), and energy consumption and waste generation during tourist activities. A more comprehensive understanding of carbon emission is presented in Fig. 3



**Fig 3** Carbon emission in tourism activities and businesses in Krabi province (2 days one night)

### 3) The 1-day tour

The tour program included all the activities of the second day of the 3-day, 2-night program and one day of the 2-day, 1-night program. However, it solely involved transportation (transportation businesses), food and beverage services (restaurant businesses), energy consumption, and waste generation during tourist activities, which affected carbon emissions. A more detailed representation of carbon emission is illustrated in Fig. 4.

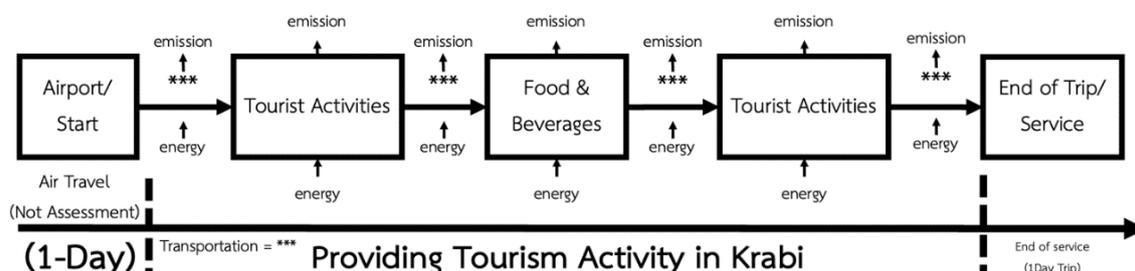


Fig. 4 Carbon emission in tourism activities and businesses in Krabi province (1 day)

Regarding tourism activities, the consideration of carbon emissions is based on the assessment model of the Thailand Greenhouse Gas Management Organization. The amount of carbon emissions from electricity and fuel consumption, gas stoves, and waste generated during tourism activities was calculated, as shown in Fig. 5.

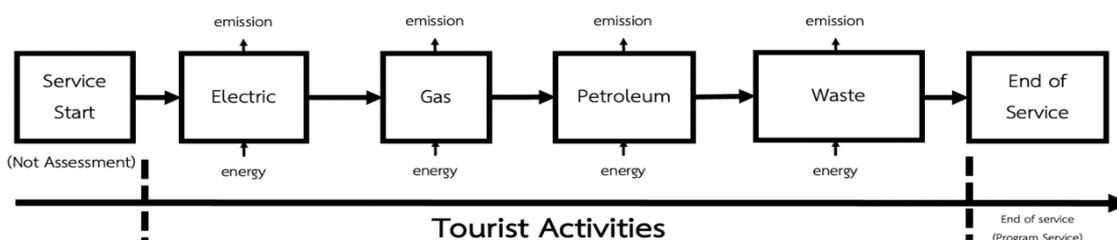


Fig.5 Carbon emission in tourism activities

**Objective 2.** The research assessed the carbon footprint of tourism activities in four primary marine tourism services. It considered four case studies based on tour programs occurring in Krabi province from September 2022 to February 2023, which were: (A) Tour program in 3-day 2-night, (B) Tour program in 1-day with high-speed boat, (C) Tour program in 1-day with long-tailed boat (2500CC), and (D) Tour program in 1-day with long-tailed boat (3000CC). The result showed that transportation has the highest carbon emissions, reaching 36.25%, with a greenhouse gas emission of 0.3658 tCO<sub>2e</sub>. Followed by waste management contributed 22.91% of carbon emissions, with a greenhouse gas emission of 0.2312 tCO<sub>2e</sub>. The third-ranking sector was food and beverage services, at 21.56% of carbon emissions, with greenhouse gas emissions of 0.2175 tCO<sub>2e</sub>. Lastly, accommodation added carbon emissions of 19.28%, with greenhouse gas emissions totaling 0.1945 tCO<sub>2e</sub>. As shown in Table 1

**Table 1.** The comparison of the total carbon footprint emissions of marine tourism

Tourism service	Case study				Total	%
	A	B	C	D		
Transportation	0.1161	0.0987	0.0718	0.0792	0.3658	36.25
Accommodation	0.1945	0.0000	0.0000	0.0000	0.1945	19.28
Food and beverage service	0.1412	0.0209	0.0277	0.0277	0.2175	21.56
Waste management	0.2088	0.0084	0.0070	0.0070	0.2312	22.91
<b>Total</b>	<b>0.6607</b>	<b>0.1279</b>	<b>0.1065</b>	<b>0.1139</b>	<b>1.0090</b>	<b>100.00</b>

**Objective 3.** The research analysis proposed that the policy recommendations for carbon footprint reduction to enhance carbon-neutral tourism in Krabi province were as follows:

**(1) Transportation policy (T):** Tourism businesses and the public sector should consider using alternative energy vehicles, such as electric cars or electric engine vehicles, as they release minimal pollutants, almost close to zero. Electric cars do not emit greenhouse gases since they are powered by batteries to drive the electric motor, eliminating the need to burn fuels for propulsion. Therefore, electric cars contribute significantly less to dangerous gas emissions and use fewer liquid substances in the engine system, such as oil and coolant. In addition, the government should promote ride-sharing services to reduce the number of individual cars on the road and invest in electric railway and rail systems that consume low-carbon energy sources, such as electric trains or trains powered by renewable energy, to be the leading public transportation service. Furthermore, tourism businesses should design route programs to increase travel efficiency. Emphasis should be placed on route integration and travel planning to reduce travel distances and times for service users, consequently reducing energy consumption in transportation and cutting down on business costs.

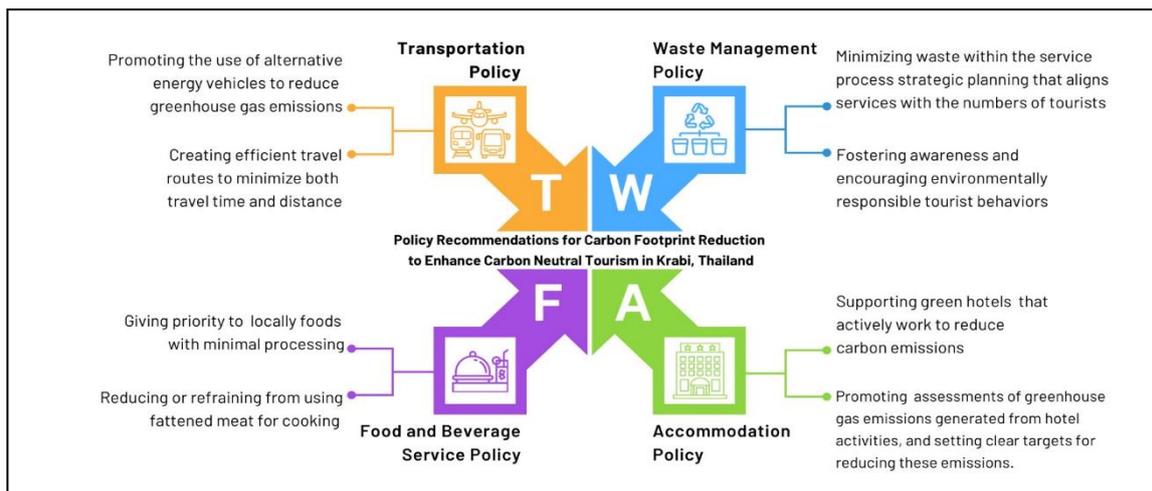
**(2) Waste management policy (W):** Tourism businesses should reduce waste and garbage within the service process by planning services to suit the number of tourists or usage needs. For instance, an online booking system predicts customer needs in advance. Additionally, the operation and service process should use environmentally friendly materials and choose recycling or reusing waste in business processes as part of raw materials or production. However, entrepreneurs should employ the tourism service management scheme to prevent the creation of waste from the use of services by tourists as follows: (A) preparing additional facilities such as extra trash cans or disposal services for customers, (B) raising awareness among customers about the importance of reducing waste and its effects, and (C) creating programs and activities that promote environmentally friendly service behavior, such as exchanging waste generated from service use.

**(3) Food and beverage service policy (F):** Tourism businesses should provide food made from ingredients that are harmless to the soil. The government should offer farmers knowledge on growing organic vegetables and fruits to promote food production from raw materials that are beneficial to the soil and reduce the use of production factors that impact the environment. Moreover, reducing or refraining from using fattened meat for cooking because feedlot meat or beef that was fattened before being it to the butchering process or processing into food increases methane gas emissions from the fattening process where cows eat much feed and require much water. Finally, buying local products helps reduce transportation distances, thus reducing carbon dioxide emissions.

**(4) Accommodation policy (A):** Tourism businesses should support green hotels that actively operate to reduce, compensate for, and offset carbon emissions. Hotel management should publicize and promote their green initiatives to customers and through the media to raise

awareness and build confidence in choosing environmentally responsible hotels. This includes using eco-friendly materials to minimize unnecessary waste, conducting assessments of greenhouse gas emissions generated from hotel activities, and setting clear targets for reducing these emissions. In addition, hotels should implement carbon offset programs linked to projects for purchasing carbon credits or investing in initiatives developed directly or in collaboration with local organizations to reduce greenhouse gas emissions.

The framework of the policy recommendations for carbon footprint reduction to enhance carbon-neutral tourism in Krabi province, Thailand, could be concluded through "TWFA Policy" and illustrated in Fig. 6:



**Fig.6** "TWFA Policy" The Policy Recommendations for Carbon Footprint Reduction to Enhance Carbon Neutral Tourism in Krabi Province, Thailand.

## Discussions

The research provided valuable information for a comprehensive understanding of the carbon footprint associated with marine tourism activities in Krabi province. By analyzing the collected data, the research intended to develop policies to minimize carbon emissions and promote carbon-neutral tourism practices. During the semi-structured interviews conducted with experts and scholars, it was found that tourists visiting Krabi province generally desired to include marine tourism activities in their itineraries, starting from the moment tourists arrived in Krabi province until the day they departed, encompassing all the activities they participated in. Furthermore, the findings indicated that tourism activities in Krabi province encompassed four primary services: accommodation, transportation, food and beverage services, and waste management. Similarly, the research of Campos et al. (2022) studied sustainable tourism under a carbon footprint approach in Camino Lebaniego, concentrating on the carbon footprint arising from accommodation, food and beverages, and waste management. These findings were consistent with the Tourism Authority of Thailand (2023), which stated that tourism activities contributed to carbon footprint emissions in transport, food and beverage businesses, accommodation, and attractions, including waste management, fuel consumption, and lighting systems. Furthermore, the study of Kitamura et al. (2020) on carbon footprint evaluations based on tourism consumption in Japan was also aimed at transport, accommodation, food and beverages, souvenirs, leisure activities, and travel agencies.

The findings significantly found that the amount of greenhouse gas emissions in transport activities was the highest among all, waste management was ranked second, and food services and accommodation were placed third and last, respectively to Katircioglu et al. (2014) identified that transportation mainly contributed to total emissions in the tourism. This aligns

with the findings of Rico et al. (2019), who examined the carbon footprint of tourism activities in Barcelona. They asserted that transportation to and from the port was the primary source of both direct and indirect emissions attributable to energy use. Similarly, the Department of Alternative Energy Development and Efficiency (2020) study indicated that transportation contributed to the largest share of final energy consumption, accounting for approximately 38.40%. Moreover, the data revealed that in 2020, the electricity sector recorded the highest volume of carbon emissions, followed by transportation, manufacturing, others (agriculture, construction, and mining), and residential and commercial businesses, in descending order. However, it was noteworthy that in the transportation sector, emissions from renewable energy and international bunker oil, specifically diesel and jet fuel, were excluded from the calculation. Hence, if we were to include emissions from these sources, it could potentially result in a significant increase in carbon dioxide emissions for the transportation sector because the emission of carbon footprint is contingent on factors such as the passenger count, duration, and distance of the journey, engine type, and fuel utilized (Sustainable et al., 2020).

Based on the study's findings outlined in Objective 1, carbon footprint emissions from marine tourism activities in Krabi province were categorized into three scopes (United Nations, 2021). Scope 1 encompassed the combustion of fuel derived from various vehicles, including vans, buses, high-speed boats, long-tail boats, and refrigerant leaks. Scope 2 pertains to using electrical energy within accommodations, restaurants, and tourist attractions. Scope 3 encompassed a broader spectrum, including transporting goods and services from upstream to downstream. It also took into consideration waste management practices associated with diverse business activities, as well as employee travel. The disposal of product waste, such as food boxes, water bottles, snack packets, and document paper, was also accounted for under this scope. Marine tourism services in Krabi province encompassed various facets, including transportation, accommodations, restaurants, and travel agencies. A study conducted by the Tourism Authority of Thailand (2023) revealed that the transportation business demonstrates a higher proportion of direct greenhouse gas emissions (Scope1) attributed to fuel consumption compared to indirect greenhouse gas emissions (Scope2) stemming from electricity usage.

In contrast, the restaurant, accommodation, and tourism businesses had more indirect greenhouse gas emissions (Scope2) from electrical energy usage than direct greenhouse gas emissions (Scope1). However, a key revelation from this research emphasized that transportation is consistently integral, irrespective of the duration of the marine tour program. This transportation activity was the predominant source, contributing the most significant quantity of greenhouse gases. Furthermore, the tourism services were connected to various related businesses, directly and indirectly generating greenhouse gases, particularly from the restaurant and accommodation sectors.

The TWFA Policy comprised recommendations to reduce carbon footprint to promote carbon-neutral tourism in Krabi province, divided into four aspects.

1. **Transportation Policy:** This aspect emphasizes the importance of focusing on alternative energy sources and enhancing travel planning for increased efficiency. Tourists and tourism service providers can contribute to reducing greenhouse gases by conscientiously planning their trips. This included the proactive consideration of selecting the closest and most economical travel routes to minimize carbon emissions. Aligning with the suggestion from the Tourism Authority of Thailand (2023), the policy advocated for measures such as reducing fuel consumption, adopting low-carbon fuels, and utilizing alternative vehicles.

2. **Waste management policy:** This policy was designed to minimize waste or garbage generated throughout the service process. Correspondingly, the research conducted by Obersteiner, Gollnow, and Eriksson (2021) supported this approach, revealing that initiatives such as food waste prevention, reductions in single-use plastic, and the implementation of

enhanced separate collection and recycling systems had the potential to reduce greenhouse gas emissions significantly.

3. Food and beverage service policy: This policy emphasized the preference for locally sourced foods with minimal processing. Gössling et al. (2011) confirmed that food management significantly mitigated climate change. Similarly, Pruksorranan and Batra (2018) suggested that using island-specific ingredients and avoiding external ingredient consumption contribute to reducing the carbon footprint in culinary tourism on Samui Island.

4. Accommodation policy: This facet endorsed environmentally conscious hotels that proactively strived to decrease carbon emissions and raise awareness about the significance of reducing carbon footprints among customers and employees. Gössling and Lund-Durlacher (2021) recommended that policies supporting mitigation should focus on building awareness among guests and employees through effective communication strategies, as this constitutes a crucial cornerstone in any low-carbon strategy.

Overall, this research was an essential step toward promoting sustainable tourism practices in Krabi province by comprehensively understanding the carbon footprint associated with different tourist activities. Furthermore, the research helped promote Carbon Neutral Tourism practices and ensured that the area remains a popular destination for tourists in the future.

## **Conclusion**

In conclusion, the research project analyzed the carbon emissions of tourism activities and businesses in Krabi province. The data was collected through focus groups and interviews. Additionally, literature reviews were utilized to develop a framework for calculating carbon emissions based on the Thailand Greenhouse Gas Management Organization (TGO) guidelines for tourism services. The results showed that marine tourism activities in the area consisted of four main categories: accommodation, transportation, food and beverage service, and waste management. The amount of greenhouse gas emissions in transport activities was the greatest, and waste management, food services, and accommodation came in second to the lowest, respectively. Therefore, guidelines for carbon footprint reduction to promote carbon-neutral tourism were divided into four aspects as follows: (A) Transportation should focus on choosing alternative energy and improve travel planning to be more efficient; (B) Waste management, reducing waste or garbage during the service process to prevent waste from using the service of tourists, (C) Food and beverage service should bring food which benefits the soil or the food cultivation process which relies on less production factors to cook and serve, (D) Green hotels or hotels with carbon reduction, offset and repurchase arrangements should be prioritized chosen. The research provided valuable insights for tourism service providers to develop carbon management strategies and contribute to sustainable tourism practices.

## **Recommendation for further research**

1. The study employed a qualitative research approach. Future research endeavors should employ quantitative research methods to investigate factors influencing the enhancement of carbon-neutral tourism.

2. The study obtained data from the supply side. Future research should focus on collecting data from the tourist perspective, specifically exploring their behavior and awareness regarding carbon-neutral tourism.

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