Climate Risks, Regional Integration, and Sustainability in the Mekong Region

Edited by Louis Lebel, Chu Thai Hoanh, Chayanis Krittasudthacheewa, and Rajesh Daniel
Greenhouse Gas Emissions from Tourism Service Providers in Chiang Mai, Thailand, and Hue, Vietnam

Sivannappan Kumar, Kyoko Kusakabe, Pravakar Pradhan, Puja Shrestha, Srujana Goteti, Tran Anh Tuan, Ekwit Meteejaroenwong, Trinnawat Suwanprik, and Khanh Linh

Travel and tourism-related activities contributed about 16.3 percent and 10 percent, respectively, to the GDP of Thailand and Vietnam in 2011; this sector also generated about 1.8 million jobs in each of these countries. The total number of jobs in this sector would be more than 3 million and 2.1 million in Thailand and Vietnam, respectively, in 2022 (WTTC 2012a, 2012b).

Tourism, both domestic and international, although making important contributions to these economies, also contributes to greenhouse gas (GHG) emissions (UNEP et al. 2008; WTO and UNEP 2008). It is estimated that tourism-related activities contribute around 5 percent of global carbon dioxide (CO₂) emissions (WTO and UNEP 2008). And, although major cities offer the widest range of tourist attractions, small and medium-sized cities with considerable cultural offerings and heritage sites are increasingly becoming popular destinations. Promoting tourism in such cities will need to take into consideration environmental impact issues (e.g. GHG emissions, local air pollution, waste management, soil degradation) so that they will continue to be attractive destinations.

This study principally focuses on the hitherto little-documented impact of tourism on GHG emissions. Estimating GHG resulting from the products and services of tourism is also a necessary step in order to develop and evaluate strategies toward mitigating such impacts (Becken and Patterson 2006; Filimonau et al. 2013). In a city that also uses its cultural heritage as a tourist attraction, such mitigation strategies can lead to a ‘win-win’ situation for locals and visitors alike by reducing GHG emissions while creating ‘green jobs’—environmentally friendly, decent work and income—and a sustainable tourism industry.

This approach—starting with estimating emissions and then identifying activities that reduce emissions as well as have a positive socioeconomic impact—was followed in the SUMERNET/CDKN-sponsored project on sustainable tourism in Chiang Mai, Thailand, and in Hue, Vietnam. Both cities are historically significant and medium-sized growing cities in the Mekong region where tourism is an important and growing economic sector. They are also mid-sized cities where relatively small initiatives are visible, with municipal authorities that are also keen on climate-compatible tourism development. However, a major stumbling block in achieving sustainable tourism is a lack of knowledge of the tourism sector’s impact on GHG emissions. As a first step, this study discusses how tourism service providers (TSPs)1 and their activities in Chiang Mai and Hue are linked to GHG emissions, and mitigation options that would also help to create green and decent jobs for the local people.

We have used the Bilan Carbon® tool developed by the Agence de l’Environnement et de la Maîtrise de l’Energie (ADEME) to estimate GHG emissions by considering direct and indirect emissions from the TSPs (ADEME 2009; Bader and Bleischwitz 2009). Direct emissions by the tourism sector for this study refer to emissions within the boundary of the city by the TSPs and indirect emissions refer to those produced outside the city (Ahmad and Wyckoff 2003; WBCSD and WRI 2004; Baumert et al. 2005; Forsyth et al. 2008) as shown in Table 13.1. Data was collected from four major types of tourism-related entities (hotels/accommodation, restaurants, tour and travel operators, spas, etc.) in both cities.

Methods

Estimates of GHG emissions by the urban tourism sector were limited to those produced by TSPs within the administrative boundaries of Chiang Mai municipality and Hue city (hereafter Chiang Mai and Hue), respectively (see Fig. 13.1), using the steps listed in Fig. 13.2.
Greenhouse Gas Emissions from Tourism Service Providers in Chiang Mai, Thailand, and Hue, Vietnam

Sivannap Kan, Kyoko Kusakabe, Pravakar Pradhan, Ujan Shrestha, Srijana Goteti, Tran Anh Tuan, Ekwit Meteejaroenwong, Trinnawat Suwanprik, and Khanh Linh

Travel and tourism-related activities contributed about 16.3 percent and 10 percent, respectively, to the GDP of Thailand and Vietnam in 2011; this sector also generated about 1.8 million jobs in each of these countries. The total number of jobs in this sector would be more than 3 million and 2.1 million in Thailand and Vietnam, respectively, in 2022 (WTTC 2012a, 2012b).

Tourism, both domestic and international, although making important contributions to these economies, also contributes to greenhouse gas (GHG) emissions (UNEP et al. 2008; WTO and UNEP 2008). It is estimated that tourism-related activities contribute around 5 percent of global carbon dioxide (CO₂) emissions (WTO and UNEP 2008). And, although major cities offer the widest range of tourist attractions, small and medium-sized cities with considerable cultural offerings and heritage sites are increasingly becoming popular destinations. Promoting tourism in such cities will need to take into consideration environmental impact issues (e.g. GHG emissions, local air pollution, waste management, soil degradation) so that they will continue to be attractive destinations.

This study principally focuses on the hitherto little-documented impact of tourism on GHG emissions. Estimating GHG resulting from the products and services of tourism is also a necessary step in order to develop and evaluate strategies toward mitigating such impacts (Becken and Patterson 2006; Filimonau et al. 2013). In a city that also uses its cultural heritage as a tourist attraction, such mitigation strategies can lead to a ‘win-win’ situation for locals and visitors alike by reducing GHG emissions while creating ‘green jobs’—environmentally friendly, decent work and income—and a sustainable tourism industry.

This approach—starting with estimating emissions and then identifying activities that reduce emissions as well as have a positive socioeconomic impact—was followed in the SUMERNET/CDKN-sponsored project on sustainable tourism in Chiang Mai, Thailand, and in Hue, Vietnam. Both cities are historically significant and medium-sized growing cities in the Mekong region where tourism is an important and growing economic sector. They are also mid-sized cities where relatively small initiatives are visible, with municipal authorities that are also keen on climate-compatible tourism development. However, a major stumbling block in achieving sustainable tourism is a lack of knowledge of the tourism sector’s impact on GHG emissions. As a first step, this study discusses how tourism service providers (TSPs) and their activities in Chiang Mai and Hue are linked to GHG emissions, and mitigation options that would also help to create green and decent jobs for the local people.

We have used the Bilan Carbon® tool developed by the Agence de l’Environnement et de la Maîtrise de l’Energie (ADEME) to estimate GHG emissions by considering direct and indirect emissions from the TSPs (ADEME 2009; Bader and Bleischwitz 2009). Direct emissions by the tourism sector for this study refer to emissions within the boundary of the city by the TSPs and indirect emissions refer to those produced outside the city (Ahmad and Wyckoff 2003; WBCSD and WRI 2004; Baumert et al. 2005; Forsyth et al. 2008) as shown in Table 13.1. Data was collected from four major types of tourism-related entities (hotels/accommodation, restaurants, tour and travel operators, spas, etc.) in both cities.

Methods

Estimates of GHG emissions by the urban tourism sector were limited to those produced by TSPs within the administrative boundaries of Chiang Mai municipality and Hue city (henceforth Chiang Mai and Hue), respectively (see Fig. 13.1), using the steps listed in Fig. 13.2.
In Chiang Mai, the number of tourist arrivals was 5,545,009 in 2011. The average stay was 3.6 days. The main tourist attractions are: the Ping River, temples, the night bazaar, Sunday Market (Walking Street), spa and massage treatments, and golf.

A total of 686 entities (175 hotels, 321 restaurants, 100 tour and travel companies and 90 other activities) are engaged in the tourism sector in Chiang Mai\(^3\) (S2 in Fig. 2). However, data collection was restricted to 36 hotels, 12 restaurants, 12 tour and travel businesses, and 24 other activities. This amounted to a total of 84 entities, including small, medium, and large hotels, tourism agencies, car rentals, spas, and restaurants (S3 in Fig. 13.2).
Emmissions from Tourism in Chiang Mai and Hue

Fig. 13.2 Methodology used in this study for GHG emissions estimates

S1: Selection of cities and sector for GHG emission analysis

S2: Identification of tourism entities for data collection from each tourism service provider

S3: Develop data collection questionnaire for Bilan Carbone® spreadsheet

S4a: Collection of primary data

S4b: Collection of secondary data

S5: Data input to Bilan Carbone® spreadsheet

S6: GHG emission estimation and analysis

S7: Other activities related to TSP

Travel, Buildings and infrastructure, Electricity & fuel consumption, Food production, Waste & wastewater, A/C & other materials used
Table 13.1 Direct and indirect emission sources considered for GHG estimates

<table>
<thead>
<tr>
<th>Direct emissions caused by</th>
<th>Indirect emissions caused by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooking using fossil fuels (CO$_2$)</td>
<td>Air travel by visitors (CO$_2$)</td>
</tr>
<tr>
<td>Own electricity generator used (CO$_2$)</td>
<td>Bus or coach used by visitors to travel to city (CO$_2$)</td>
</tr>
<tr>
<td>Own car and motorcycle used (CO$_2$)</td>
<td>Construction materials used for infrastructure, such as buildings, roads, and footpaths (CO$_2$)</td>
</tr>
<tr>
<td>Own vehicle used for goods transport (CO$_2$)</td>
<td>Electricity used by hotels, restaurants, travel agencies, tours and travels, spas, etc. (CO$_2$)</td>
</tr>
<tr>
<td>Fertilizer used for agriculture in Garden Houses (N)</td>
<td>Materials and products used, such as, glass, paper, metal, plastic, food, etc. (CO$_2$)</td>
</tr>
<tr>
<td>Air conditioner leakages (HCFC &amp; CFC)</td>
<td>Materials used for vehicle manufacture, such as buses, cars and vans used in tours and travel (CO$_2$)</td>
</tr>
<tr>
<td>Waste and wastewater generation at own premises (CH$_4$)</td>
<td>Incineration of wastes outside the city boundary (CO$_2$)</td>
</tr>
</tbody>
</table>

Notes: CFC = chlorofluorocarbon; HCFC = hydrochlorofluorocarbon; N = Nitrogen. Direct emissions refer to emissions within the boundary of the city by TSPs. Indirect emissions are the emissions produced outside the boundary of the city. Electricity used by hotels, restaurants, travel agencies, tours, travel, and spas are indirect emissions because the electricity is supplied by government and produced by the cities themselves. If the cities use their own electric generator (or use diesel) to produce electricity then they are direct emissions.

In Hue, the number of tourist arrivals was 1,590,900 (in 2011) with an average stay of two days. The main tourist attractions are: the Perfume River, temples, monuments, and the Citadel.

In Hue, a total of 265 entities (130 hotels, 97 restaurants, 12 tour and travel businesses, and 26 other activities) were found to be engaged in tourism related activities$^4$ (S2 in Fig. 13.2). The data collected from these entities using a questionnaire was restricted to 18 hotels, 18 restaurants, 6 tour and travel companies, and 8 other activities that accounted to a total of 50 entities (S3 in Fig. 13.2).

The primary and secondary data was input into a Bilan Carbone® spreadsheet. The primary data refers to electricity and fossil fuel consumption by/in the entity; energy used for the production of food, materials and other products consumed by visitors; travel by visitors and employees (amount of fuel used by vehicles, vehicle distance traveled, etc.); fuel combustion for goods transport, waste generation due to the consumption of food and materials used in buildings; These were obtained from a number of employees in the consumption of energy (fossil fuels, local trains, food, etc.), air and road); vehicle weight, and the number of vehicle journeys collected from city authorities.

A Bilan Carbone® spreadsheet was used to consolidate and total emissions of every activity to estimate the total GHG emissions.

Individual (entity and TSP) data was then added to consolidate the results into five categories; accommodation (building and travel related), and others (other activities).

**Assumptions**

GHG emissions by TSPs in Hue account for the following assumptions:

- **Meal consumption at restaurants:** 70% of the meals consumed in restaurants was in Hue and the remainder elsewhere.
- **Fossil fuel used for personal transport:** 70% of the personal transport amount of fossil fuel used by tourists was 70 percent of the fuel consumed and the remainder was solicitor.
- **Use of infrastructure and services:** the infrastructure and services included in the calculation were: Chiang Mai, 3 percent in Chiang Mai, 3 percent in Hanoi, 3 percent in Hue, 3 percent in Chiang Mai, 3 percent in Mekong Delta, and 3 percent in Danang.

Visitors:

- All domestic visitors were assumed to travel from Bangkok and all international visitors (888,900) were assumed to travel from Danang, Minh City, and Danang
the consumption of food and use of other materials; and construction materials used in buildings and related infrastructure (S4a in Fig. 13.2). These were obtained from a survey of hotels, restaurants, travel agencies, spas, and city authorities using a questionnaire.

The secondary data refers to the number of tourists; number of TSPs; number of employees in the tourism sector; emission factors for electricity, fossil fuels, local trains, food and materials used; traveling distance (by air and road); vehicle weights, etc. (S4b in Fig. 13.2), and this data was collected from city authorities, publications, and websites.

A Bilan Carbone® spreadsheet was used to calculate the direct, indirect, and total emissions of every entity within a TSP, and the sum was used to estimate the total GHG emissions of that TSP (S5 and S6 in Fig. 13.2).

Individual (entity and TSP) direct and indirect emissions were also available as an outcome of the Bilan Carbone® analysis. These were used to consolidate the results in terms of tourism activity emissions, namely, accommodation (building and infrastructure related), transport (tours and travel related), and others (recreation, etc.).

Assumptions

GHG emissions by TSPs in both cities were estimated by taking into account the following assumptions:

- **Meal consumption at restaurants**: The total emissions by tourists in restaurants was 70 percent in Chiang Mai and 6 percent in Hue and the remaining was from locals (Box 1; equation 1).

- **Fossil fuel used for public transport**: The total emissions by the amount of fossil fuel used for public transportation from tourists was 70 percent in Chiang Mai, 7 percent in Hue, and the remainder was from locals (Box 1; equation 2).

- **Use of infrastructure and services**: The total emissions by city infrastructure and services related to tourists was 28 percent in Chiang Mai, 3 percent in Hue, and the remainder was from locals (Box 1; equation 3).

 Visitors:

- All domestic visitors to Chiang Mai (3,680,192) were assumed to travel from Bangkok to Chiang Mai. Domestic Vietnamese visitors (888,900) were assumed to travel from Hanoi, Ho Chi Minh City, and Danang, to Hue.
• International visitors (1,864,817) to Chiang Mai were assumed to either fly from Bangkok or to Chiang Mai. Similarly, foreign visitors (702,000) flew from Hanoi, Ho Chi Minh City, or Danang, and then travelled to Hue.

Box 13.1 Basis for assumptions

The assumptions used for the analysis are based on the following considerations:

If, no. of tourists in the year 2011 = T; no. of stay days per tourist = S; no. of local people = P; no. of meals consumed per day per visitor at restaurants in the city boundary = F; no. of meals consumed per day per local person at restaurants in the city boundary = F; no. of days local people visit restaurants per year = D; and no. of days local people used fossil fuel for public transportation = D,

The ratio of ‘meals consumption’ per year by the visitors at the restaurants was calculated by using the following equation, and converted into percentage:

\[
\frac{(T \times S \times F)}{[(P \times D) + (T \times S \times F)]}
\]

Equation 1

The ratio of ‘fossil fuel used for public transport’ per year by the visitors was calculated by using the following equation, and converted into percentage:

\[
\frac{(T \times S)}{[(P \times D) + (T \times S)]}
\]

Equation 2

The ratio of ‘infrastructure and services’ used per year by the visitors was calculated by using the following equation, and converted into percentage:

\[
\frac{(T \times S)}{[(P \times D) + (T \times S)]}
\]

Equation 3

The values for T were obtained from Chiang Mai municipality and Thua Thien Hue Provincial Department of Culture, Sports and Tourism, while values for S and P were obtained from the published literature (Chiang Mai Provincial Office 2011; Hue City Office for Statistics 2011). The values for F, F, D, and D, were based on a survey and from discussions with the city authorities.

<table>
<thead>
<tr>
<th>City</th>
<th>T</th>
<th>S</th>
<th>P</th>
<th>a_F</th>
<th>F_1</th>
<th>D_8</th>
<th>b_D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiang Mai municipality</td>
<td>5,545,009</td>
<td>3.6</td>
<td>137,793</td>
<td>2</td>
<td>1</td>
<td>124</td>
<td>62</td>
</tr>
<tr>
<td>Hue City</td>
<td>1,590,900</td>
<td>2</td>
<td>339,000</td>
<td>2</td>
<td>1</td>
<td>128</td>
<td>117</td>
</tr>
</tbody>
</table>

Notes:

1. Some visitors just came for a day in Hue city (had lunch) and went to other cities (for dinner) later.
2. The majority of local people (in general all Chiang Mai municipality people) used their own vehicle to travel within the municipality.

Analysis of GHG emissions

The results of emissions estimation of TSPs is presented and discussed. The analysis includes infrastructure, and other activities.

The ‘transport’ sub-sector includes the movement of all visitors and employees (of the tourism industry, transport, (b) goods transport, and (c) other transport related to the services provide by the tourism industry).

The visitor’s travel was broken down into the mode of travel from the airport to the city, and from the city to tourist attractions. An appropriate categorization would help to examine the level, as the city authorities are responsible for the mode of travel from other cities to Hue. The emissions were calculated for all shifts made by visitors traveling by vehicles between the city and points of interest abroad.

Goods transport also took place within the city boundaries, and the services provided by the city authorities, such as a bus service to the tourism attractions, and public parks, etc.

The ‘buildings and infrastructure’ sub-sector includes emissions from (a) electricity and fossil fuels, (b) materials used for hotels, restaurants, and other buildings, (c) construction for tourism services, and (d) the produce materials for infrastructure, such as construction of roads, footpaths, (c) electricity generation, and (d) the production of building materials. Most of these emissions are attributed to the production of building materials from wastewater treatment, and the production of building materials. Emissions from wastewater treatment were calculated using the biochemical oxygen demand (BOD) values (Northrise Management Information, Control Department (PCD) O&M, 2011) for Hue.

The ‘other activities’ sub-sector includes emissions from industries, activities and sources, such as agriculture, manufacturing, and other activities (e.g. production of building materials that make up vehicles, etc.).
Analysis of GHG emissions

The results of emissions estimation using Bilan Carbone® (in terms of TSPs) is presented and discussed in terms of transport, buildings and infrastructure, and other activities (Table 7 in Fig. 13.2).

The 'transport' sub-sector covers emissions caused by (a) travel by visitors and employees of (the tourism industry) using various modes of transport, (b) goods transport to support the visitors, and (c) transport related to the services provided by the city/municipality.

The visitor’s travels were further categorized into travel within the city, and travel from other cities (within the country or abroad). This categorization would help to develop GHG mitigation options at the city level, as the city authorities do not have direct control over the tourists’ mode of travel from other cities (within the country or abroad). The GHG emissions were calculated based on the fuel consumption and distance traveled by vehicles between the visitor’s cities within the country or abroad.

Goods transport also took into account travel within and outside city boundaries, and the services provided (30 percent) took into consideration travel made by the personnel of the city authority or municipality for its services to the tourism sector, e.g. waste collection, maintenance of public parks, etc.

The 'buildings and infrastructure' sub-sector covers all emissions from (a) electricity and fossil fuels used to produce the construction materials used for hotels, restaurants, travel agencies, and other buildings constructed for tourism services, (b) electricity and fossil fuel used to produce materials for infrastructure development, such as roads, parking lots, footpaths, (c) electricity and fuel used in the buildings, and (d) other activities, such as energy (electricity or fuel) used in the production of food for hotels and restaurants, and waste and wastewater generation. Most of these emissions are created by hotels and restaurants. The GHG emissions from wastewater were calculated using standard values on biochemical oxygen demand (BOD) generated by the Thai Pollution Control Department (PCD) (2002) for Chiang Mai, and Hue College of Science (2011) for Hue.

The 'other activities' category covered GHG emissions from other activities and sources, such as leakage of refrigerants, use of fertilizers and other materials (e.g. paper, glass, plastic, metals, office equipment, materials that make up vehicles, etc.) used by TSPs. Almost all TSPs use
air conditioning, refrigerators, and other energy-consuming devices, while fertilizer use is only for agriculture at Hue’s ‘Garden Houses.’

Results

Both these cities are popular tourist destinations because of their natural beauty and interesting historical sites. The number of domestic and foreign visitors to these cities during 2008–2011 is given in Table 13.2. Chiang Mai had around 3.5 times more visitors as compared to Hue in the year 2011. The majority of visitors stayed on an average for 3.6 and 2 days in Chiang Mai and Hue, respectively (Chiang Mai Provincial Office 2011; Hue Office for Statistics 2011).

Table 13.2 Chiang Mai and Hue: Visitor numbers

<table>
<thead>
<tr>
<th>No. of Tourists</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiang Mai</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thai</td>
<td>3,842,549</td>
<td>3,101,790</td>
<td>3,345,629</td>
<td>3,680,192</td>
</tr>
<tr>
<td>Foreigners</td>
<td>1,470,802</td>
<td>1,241,300</td>
<td>1,695,288</td>
<td>1,864,817</td>
</tr>
<tr>
<td>Total</td>
<td>5,313,351</td>
<td>4,343,090</td>
<td>5,040,917</td>
<td>5,545,009</td>
</tr>
<tr>
<td>Hue City</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vietnamese</td>
<td>684,714</td>
<td>734,530</td>
<td>844,030</td>
<td>888,900</td>
</tr>
<tr>
<td>Foreigners</td>
<td>703,896</td>
<td>561,570</td>
<td>607,600</td>
<td>702,000</td>
</tr>
<tr>
<td>Total</td>
<td>1,388,610</td>
<td>1,296,100</td>
<td>1,451,630</td>
<td>1,590,900</td>
</tr>
</tbody>
</table>

Sources: Chiang Mai Provincial Office (2011); Hue City Office for Statistics (2011).
* Data for the year 2011 was collected from Chiang Mai municipality and Thua Thien Hue Provincial Department of Culture, Sports and Tourism.

Greenhouse Gas emissions from tourism service providers

The GHG emissions from the TSPs are categorized into three sectors, namely, transport, buildings and infrastructure, and other activities.

Transport sector

1. Visitors

Visitors’ travel is separated into two categories to provide insight on direct and indirect GHG emissions at the city level: visitors within the city boundary (factored as direct emissions) and visitors coming from other cities in the same country or abroad (indirect emissions).
Travel by visitors within the city: The GHG emissions are based on the number of visitors (Table 13.2) and days traveling inside the city boundary only. The GHG emissions include car rentals, travel provided by tourism agencies, and local transport. Chiang Mai city generated 51,070 tons of CO\textsubscript{2} equivalent (tCO\textsubscript{2}-eq) GHG whereas Hue emitted around 2,370 tCO\textsubscript{2}-eq. Emissions per visitor per day of travel in Chiang Mai is estimated at around 3 kg of CO\textsubscript{2} equivalent (kgCO\textsubscript{2}-eq). In Hue, it was 1 kgCO\textsubscript{2}-eq per visitor per day of travel.

Travel by visitors from other cities (within the country) and abroad: international visitors arriving by car, coach, or train within the country were similar to that of travel by domestic visitors. The total GHG emissions from travel by visitors (both local and international) is estimated to be 4,169,300 and 371,000 tCO\textsubscript{2}-eq for Chiang Mai and Hue, respectively (Fig. 13.3). Air travel alone contributed 94 percent of each city’s emissions. The average emissions by domestic (Thai) and international visitors’ travel to Chiang Mai is about 100 kgCO\textsubscript{2}-eq and 2,000 kgCO\textsubscript{2}-eq, respectively. Similarly, average emissions by local Vietnamese and international visitors’ travel to Hue is 97 kgCO\textsubscript{2}-eq and 400 kgCO\textsubscript{2}-eq, respectively.

Fig. 13.3 CO\textsubscript{2} emissions (%) by different modes of visitors’ travel to
a) Chiang Mai municipality and b) Hue city


table

<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3,345,629</td>
<td>3,680,192</td>
</tr>
<tr>
<td></td>
<td>1,695,288</td>
<td>1,864,817</td>
</tr>
<tr>
<td></td>
<td>5,040,917</td>
<td>5,545,009</td>
</tr>
<tr>
<td></td>
<td>844,030</td>
<td>888,900</td>
</tr>
<tr>
<td></td>
<td>607,600</td>
<td>702,000</td>
</tr>
<tr>
<td></td>
<td>1,451,630</td>
<td>1,590,900</td>
</tr>
</tbody>
</table>

*Source: Statistics (2011).*
2. Travel by employees

The GHG emissions of employees' traveling between their homes to work, and travel during office hours was also estimated. The home to work (both ways) commute emitted the largest proportion of employees' travel-related emissions. Although the majority of employees used motorcycles to travel to their offices, this contributed to a small portion of the CO₂ emissions in both cities (Fig. 13.4). A few used private vehicles and some also traveled abroad to attend official activities (e.g. meeting travel agencies, tour groups, marketing) particularly in Hue. The total GHG emissions resulting from employees' travel were around 8,360 and 4,320 tCO₂-eq. for Chiang Mai and Hue, respectively, and the per capita emissions from each TSP in each city is shown in Table 13.3.

![Fig. 13.4 CO₂ emissions (%) by employees' travel in a) Chiang Mai municipality and b) Hue city](image)

<table>
<thead>
<tr>
<th>Tourism service provider</th>
<th>Chiang Mai municipality</th>
<th>Hue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employees</td>
<td>Per capita emission (kgCO₂-eq/year)</td>
<td>Employees</td>
</tr>
<tr>
<td>Hotels</td>
<td>3,940</td>
<td>1,218</td>
</tr>
<tr>
<td>Restaurants</td>
<td>4,213</td>
<td>569</td>
</tr>
<tr>
<td>Tours and travel</td>
<td>1,150</td>
<td>814</td>
</tr>
<tr>
<td>Others activities</td>
<td>246</td>
<td>931</td>
</tr>
</tbody>
</table>

Sources: Chiang Mai Municipality Office (2011); Hue City Office for Statistics (2011).

3. Transport of goods and services

Some TSPs, such as hotels and restaurants, collect waste and materials from outside areas and transport to goods transport and service sectors in the tourism sector generated 4,600 tCO₂-eq., alone contributed to 47 percent of emissions from goods transport and services, while the other activities contributed to only 20 percent, 14 percent, and 7 percent respectively.

The transport of consumables to the regular municipal services, for example, Paradise tourist area, Thuy Tien and Tuan Anh, estimate the emissions related to these activities to the city authority. These activities contributed to 37 percent of emissions in Hue. The study also shows that emissions from restaurants, travel agencies, and others contributed to only 14 percent, 12 percent, and 12 percent respectively.

Buildings and infrastructure

The buildings of TSPs in Chiang Mai generated emissions with about 48,400 tCO₂-eq., such as roads and footpaths contributed to around 5,520 tCO₂-eq.

In Hue, the buildings of TSPs generated emissions with about 19,400 tCO₂-eq., such as roads and footpaths contributed to 7,400 tCO₂-eq.

TSPs also use electricity to operate and generate waste and wastewater emissions (Fig. 13.5).
between their homes to work, a significant portion of the CO₂ emissions in Chiang Mai and Hue. Employees used motorcycles to travel home or work, which contributed to a significant portion of CO₂ emissions. Some also traveled by plane, contributing to additional emissions. In Chiang Mai, travel by plane accounted for 10.3% of CO₂ emissions, while in Hue, it accounted for 8.7%. Travel by plane, 8.7%
Travel home–work, 76.8%

3. Transport of goods and services (freight)
Some TSPs, such as hotels and restaurants, purchased consumable goods and materials from outside the city. The municipality also regularly collects waste and maintains the public parks. The GHG emissions due to goods transport and services provided by the municipality to the tourism sector generated 4,600 tCO₂-eq emissions in Chiang Mai. Hotels alone contributed to 47 percent of total emissions from 'transport goods and services,' while the other two services, namely restaurants and other activities contributed to only 21 percent and 32 percent of emissions, respectively.

The transport of consumable goods to and from hotels and restaurants, regular municipal services, and constructions such as the Thuan An resort, Paradise tourist area, Thuy An Ecotourism area, in Hue were used to estimate the emissions related to the transport of goods and services by the city authority. These activities generated around 58,570 tCO₂-eq GHG emissions in Hue. The study shows that hotels alone contributed 61 percent of the total emissions from TSPs, while the other three services, namely restaurants, travel agencies and tours, and other activities, contributed to only 20 percent, 14 percent, and 5 percent of emissions, respectively.

Buildings and infrastructure sector
The buildings of TSPs in Chiang Mai are the largest emitters of GHG with about 48,400 tCO₂-eq. The municipality has also constructed other infrastructure, such as the extension of road networks, footpaths, which contributed to around 5,520 tCO₂-eq emissions.

In Hue, the buildings of TSPs are also the largest source of GHG emissions with about 19,400 tCO₂-eq. In comparison, infrastructure such as roads and footpaths contributed less GHG emissions, only 80 tCO₂-eq/yr.

TSPs also use electricity and fuel (LPG, petrol and diesel), require food, and generate waste and wastewater. These activities cause significant GHG emissions (Fig. 13.5).
1. Electricity and fuel

Electricity and fuel (LPG, petrol, and diesel) are used in TSPs to run their activities in Chiang Mai and Hue (Fig. 13.5). Electricity is used in almost all TSPs for lighting and air conditioning. The fuels are used mainly for cooking, power generation in case of electricity outages, lawn and tree cutting, etc., at the hotels and restaurants. The GHG emissions from the electricity and fuels used in the TSPs are estimated at about 77,700 tCO$_2$-eq and about 17,800 tCO$_2$-eq in Chiang Mai and Hue, respectively. Electricity and fuel consumption per visitor per day are about 4 kgCO$_2$-eq in Chiang Mai and 5.6 kgCO$_2$-eq in Hue.

2. Food production

This accounts for only the emissions during food production processes in farms that consume fossil fuels directly (tractor fuel) or indirectly (manufacture of fertilizers, phytosanitary products, etc.). The emissions from food production depend only on the food consumed by tourists and their duration of stay in the cities (Table 13.2).

Food production emissions are calculated based on the food consumption by visitors, and is estimated at around 20,300 tCO$_2$-eq emissions in Chiang Mai. The emissions related to food per visitor per day is about 1.2 kgCO$_2$-eq.

Hue generated around 9,920 tCO$_2$-eq emissions from food production. Emissions related to food per visitor per day is about 3 kgCO$_2$-eq in Hue.

3. Waste and wastewater

Both the cities have a large number of visitors, and these hotels and restaurants also generate large amounts of waste. In Hue, this leads to the generation of solid waste and liquid waste, which is managed in large waste pile sites and at landfills. In Chiang Mai, for example, the total amount of solid waste generated in 2016 was 4,860 and 2,170 tCO$_2$-eq respectively, from waste generation per person per day of 0.25 kgCO$_2$-eq and 0.25 kgCO$_2$-eq, respectively.

Other activities

Other tourism-related activities, such as transport, food and beverage, and entertainment categories, are discussed below.

Both cities have a hot climate and a large number of TSP, especially hotels and restaurants. Air conditioning equipment is used extensively to cool the interior of the buildings. The GHG emissions from the air conditioning equipment are estimated to be about 5,830 and 2,200 tCO$_2$-eq/yr in Chiang Mai and Hue, respectively.

TSPs utilize various types of equipment, including refrigerators, air conditioners, and stationary equipment. In these cities, TSPs also engage in activities such as constructing new buildings, painting, and pest control services. In Chiang Mai and Hue, these activities emit about 12,800 and 5,400 tCO$_2$-eq respectively in 2016.

Therefore, the GHG emissions from these activities are estimated to be about 22,760 and 12,600 tCO$_2$-eq respectively.
3. Waste and wastewater

Both the cities have a large number of hotels and restaurants to serve visitors, and these hotels and restaurants produce food waste, which also generates large amounts of GHG emissions due to their disposal at landfills. In Chiang Mai, food waste contributed to 83 percent of total waste-related emissions.

In Hue, food wastes contributed to 89 percent of GHG emissions from the total wastes generated in 2011. The GHG emissions from all wastes were 4,860 and 2,170 tCO₂-eq in Chiang Mai and Hue, respectively in 2011.

Besides solid waste generation, hotels and restaurants also use huge amounts of water. Therefore, hotels and restaurants also discharge huge amounts of wastewater that contributes to GHG emissions. The Chiang Mai and Hue TSPs generated around 4,740 and 800 tCO₂-eq emissions, respectively, from wastewater in 2011. The GHG emissions related to wastewater per visitor per day in Chiang Mai and Hue were 0.24 kgCO₂-eq and 0.25 kgCO₂-eq, respectively.

Other activities

Other tourism-related activities which do not come under the above two categories, are discussed below:

Both cities have a hot climate, and air conditioners are used by every TSP, especially hotels and restaurants. The leakage of refrigerants from air conditioning equipment in both cities and the use of nitrogen-containing fertilizers in ‘Garden Houses’ in Hue were identified as potential/important GHG emission sources. The common refrigerants used in air conditioning equipment are R22, R134a, and R410a. The GHG emissions by leakage of refrigerants from air conditioning equipment contributes to 5,830 and 2,200 tCO₂-eq/yr in Chiang Mai and Hue, respectively. Only 8 tCO₂-eq GHG emissions came from the ‘Garden Houses’ from the use of urea fertilizers.

TSPs utilize various types of materials such as glass, plastic, paper, metals, stationery, IT equipment, vehicles, etc. Most of these items are used in hotels, restaurants, and travel agencies everyday. In Chiang Mai and Hue, these activities emitted around 16,930 tCO₂-eq and 3,690 tCO₂-eq emissions respectively in 2011.

Therefore, the GHG emissions from ‘other activities’ of the TSPs are estimated to be about 22,760 tCO₂-eq and about 5,900 tCO₂-eq in Chiang
Mai and Hue, respectively. GHG emissions related to ‘other activities’ per visitor per day were 1 kgCO₂-equivalent in Chiang Mai and 2 kgCO₂-equivalent in Hue.

**Discussion**

This section analyzes the emissions calculated in the previous section. It also presents the possible opportunities for GHG mitigation and discusses the limitations of the analysis.

**GHG emissions by tourism sector**

GHG emissions due to tourism in both cities can be summarized as:

- GHG emissions from TSPs in Chiang Mai and Hue were 0.8 and 0.3 tCO₂-equivalent per capita/year, respectively.

- The largest proportion of CO₂ emissions from TSPs is, as expected, by the transport sub-sector in 2011 (Fig. 13.6). It contributed to 96 percent of the total emissions in Chiang Mai and to 89 percent in Hue. It is important to note that, out of this, approximately 89 percent and 71 percent of these emissions in Chiang Mai and Hue, respectively, were from air transport alone.

- Emissions from ‘buildings and infrastructure’ and ‘other materials’ used were substantially lower than transport emissions (Fig. 13.6).

**Fig. 13.6 Contribution of three tourism sub-sectors to total CO₂ emissions (%) in a) Chiang Mai municipality and b) Hue city**

A joint study by the UN Environment Program (UNEP) and the World Tourism Organization (UNWTO) found that tourism emitted about 5 percent of GHG emissions (21 percent, mainly from air transport). This study also shows that Chiang Mai (96 percent) and Hue (89 percent) are the most significant contributors, with emissions from transport the major share. The average tourist visiting Chiang Mai is estimated to generate 3.6 kgCO₂-equivalent and the tourist journey to Chiang Mai probably due to the establishment of a special economic zone in Chiang Mai, and there is a significant amount of transport within the city. In Hue, tourists first have to travel to Hue, and then travel to Hue. The city of Hue in Chiang Mai (average 3.6 tCO₂-equivalent per visit) was higher than the city of Hue (average 10 kgCO₂-equivalent per visit) in 2011. Moreover, Chiang Mai has more attractions (waterfalls, pagodas, temples, etc.).

Yet per capita, GHG emissions from Chiang Mai’s ‘other activities’ are higher than those of Hue. This is due to the construction of more tourist facilities as well as more infrastructure development. Chiang Mai has the much higher number of GHG emissions of ‘building and infrastructure’ in that city compared to Hue.
A joint study by the UN World Tourism Organization and the UN Environment Program (UNWTO and UNEP 2008) noted that globally, tourism emitted about 5 percent of total GHG emissions (1,302 MtCO₂ equivalent), primarily from transport (75 percent) and accommodation (21 percent; from air-conditioning and heating systems). Air travel alone covers approximately 40 percent of tourist transport emissions. A globally-averaged tourist journey is estimated to generate 250 kgCO₂-eq. This study also shows that the tourism GHG emissions in the cities of Chiang Mai (96 percent) and Hue (89 percent) are also clearly dominated by emissions from transport, with emissions from air transport having the major share. The average tourist journey to Chiang Mai and Hue is estimated to generate 800 kgCO₂-eq and 300 kgCO₂-eq, respectively, and the tourist journey to Chiang Mai causes higher emissions. This is probably due to the establishment of an international airport in Chiang Mai, i.e. 2,000 kgCO₂-eq emissions per visitor, as tourists can fly direct to Chiang Mai, and there is no emission sharing with other cities, as in the case of Hue, with its 400 kgCO₂-eq emissions per visitor (Table 13.4). In Hue, tourists first have to travel to Ho Chi Minh, Hanoi or Danang, and then travel to Hue. Second, the majority of visitors stayed longer in Chiang Mai (average 3.6 days) as compared to Hue (average 2 days). Chiang Mai received around 3.5 times more visitors as compared to Hue in 2011. Moreover, Chiang Mai has more recreational offerings (spas, massage parlors, the night bazaar/night market, Sunday Walking Street, temples, etc.). Hue has comparatively fewer tourist sites and activities (boating in the Perfume River, temples, handicraft markets, etc.) compared to Chiang Mai.

Yet per capita, GHG emissions from ‘buildings and infrastructure’, and ‘other activities’ are higher in Hue than in Chiang Mai (Table 13.4). This is due to the construction of a large number of new hotels, restaurants, as well as more infrastructure in Hue in 2011. It should also be noted that the much higher number of visitors to Chiang Mai reduces the per capita GHG emissions of ‘building and infrastructure’, and ‘other activities’ in that city compared to Hue.
Table 13.4 Summary of GHG emissions from TSPs in Chiang Mai and Hue (tCO₂-eq/year)

<table>
<thead>
<tr>
<th>Category</th>
<th>Chiang Mai</th>
<th>Hue</th>
<th>Category</th>
<th>Chiang Mai</th>
<th>Hue</th>
<th>Category</th>
<th>Chiang Mai</th>
<th>Hue</th>
<th>Category</th>
<th>Chiang Mai</th>
<th>Hue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employees</td>
<td>8,362</td>
<td>4,315</td>
<td>Buildings</td>
<td>48,390</td>
<td>19,345</td>
<td>Air conditioning</td>
<td>5,829</td>
<td>2,203</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visitors (local &amp; foreign) travel</td>
<td>51,065</td>
<td>2,348</td>
<td>Infrastructure</td>
<td>5,515</td>
<td>78</td>
<td>Materials</td>
<td>16,927</td>
<td>3,684</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visitors (local &amp; foreign) travel</td>
<td>4,169,276</td>
<td>370,934</td>
<td>Electricity &amp; fuel</td>
<td>77,695</td>
<td>17,805</td>
<td>Fertilizer</td>
<td>-</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goods and services</td>
<td>4,601</td>
<td>58,571</td>
<td>Food</td>
<td>20,256</td>
<td>9,915</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Waste</td>
<td>4,854</td>
<td>2,174</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wastewater</td>
<td>4,741</td>
<td>800</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4,233,304</td>
<td>4,36,188</td>
<td>161,451</td>
<td>50,117</td>
<td>22,756</td>
<td>5,895</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share</td>
<td>95.8%</td>
<td>89%</td>
<td>3.7%</td>
<td>10%</td>
<td>0.3%</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only air travel (SHARE)</td>
<td>3,936,530</td>
<td>349,951</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(89%)</td>
<td>(71%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chiang Mai:</td>
<td>4,417,511</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total emissions (tCO₂-eq/yr)</td>
<td>Hue: 492,200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emissions per visitor</td>
<td>Chiang Mai:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(tCO₂-eq/yr/visitor)</td>
<td>0.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hue: 0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GHG emissions mitigation options**

Earlier studies on GHG emissions of tourism and related activities considered direct GHG emissions from transport, buildings, industry, energy sectors, waste and industrial processes, with little or no mention of indirect GHG emissions (Gillenwater 2008; Schulz 2010; Jun et al. 2011). Similarly, only a few studies dealt with how to reduce GHG emissions in the tourism sector while creating decent jobs for local people (Becken and Patterson 2006; Lebel et al. 2007; Dodman 2011). A comparison of GHG emission distribution for tourism with other cities/countries is difficult because the studies do not consider the same system boundaries, e.g. including emissions of private households, markets, and excluding international flight emissions.

At the national level, total GHG emissions from tourism were estimated to be 2.29 billion tCO₂-eq/year (Gossling et al. 2005) showing that tourism in the United States generates more emissions associated with tourist visits than any other sector. Table 13.4 estimated the total GHG emissions from tourism in the Algarve, Portugal, to be 629 tCO₂-eq/year. The emissions from tourism are now recognized as needing a more comprehensive approach, and this will need to focus on the integration of tourism and infrastructure (i.e., public transport and infrastructure) if substantial reduction is to be achieved.

The estimated GHG emissions from tourism in Chiang Mai and Hue were discussed by the feasibility and confirmed with stakeholders were assessed through local engagement. The concerns were taken as important drivers for the selection of indicators were considered for the feasibility assessment: employment creation; air quality improvement; and feasibility of implementation. The stakeholders identified measures to reduce GHG emissions in the tourism sector. Hence, a combination of policies to reduce GHG emissions from the tourism sector was identified. The following are some of the measures identified:

1. **Non-motorized transport (NMT)**: NMT is any form of transport that does not use internal combustion engine (ADE-ETI 2018). Examples include walking, bicycling, small-wheeled transport, and other options to mobility. It can be further divided into four categories:

   - **Walking**: Includes walking for personal transport, tourism, and daily activities. Walking is a mode of transport that is simple, affordable, and has a significant impact on health and well-being. It is also a mode of transport that can be sustained over long distances and is suitable for all age groups.
   - **Cycling**: Bicycles are an efficient mode of transport for short to medium distances. They are also a mode of transport that is easy to use and is suitable for all age groups. Cycling is a mode of transport that can be sustained over long distances and is suitable for all age groups.
   - **Small-wheeled transport**: Includes electric scooters, electric motorcycles, and electric cars. These are modes of transport that are efficient for short to medium distances and are suitable for all age groups. Small-wheeled transport is a mode of transport that is easy to use and is suitable for all age groups.
   - **Public transport**: Includes buses, trains, and trams. Public transport is a mode of transport that is efficient for long distances and is suitable for all age groups. Public transport is a mode of transport that is easy to use and is suitable for all age groups.
### Emissions from Tourism in Chiang Mai and Hue

<table>
<thead>
<tr>
<th>Category</th>
<th>Chiang Mai</th>
<th>Hue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioning</td>
<td>5,829</td>
<td>2,203</td>
</tr>
<tr>
<td>Materials</td>
<td>16,927</td>
<td>3,684</td>
</tr>
<tr>
<td>Fertilizer</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>17,805</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20,256</td>
<td>9,915</td>
</tr>
<tr>
<td></td>
<td>4,854</td>
<td>2,174</td>
</tr>
<tr>
<td></td>
<td>4,741</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td>161,451</td>
<td>50,117</td>
</tr>
<tr>
<td></td>
<td>22,756</td>
<td>5,895</td>
</tr>
<tr>
<td></td>
<td>3.7%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>0.5%</td>
<td>1%</td>
</tr>
</tbody>
</table>

The estimated GHG emissions in the tourism sector of Chiang Mai and Hue were discussed by stakeholders, and based on these discussions, the feasibility and confirmation of employment-creation possibilities were assessed through local surveys. To ensure that pro-poor and gender concerns were taken as important criteria for selection, three assessment indicators were considered: GHG emission reduction areas; potential employment creation; and stakeholders’ interest in pursuing and feasibility of implementation of the strategies/programs. The stakeholders identified measures to reduce emissions by developing ‘non-motorized transport’ (NMT) in Chiang Mai and promoting ‘Garden Houses’ in Hue, both of which had the potential to reduce emissions as well as generate jobs, increase income, and provide a much cleaner environment for visitors and locals. It is noted that these measures might not be the best options for reducing GHG emissions per se, but they are decisions by stakeholders to balance both technical and social aspects of the tourism sector.

**Non-motorized transport (NMT) in Chiang Mai**

NMT is any form of transportation that uses human energy or animal power for personal or goods mobility by methods other than the combustion engine (Adebambo and Yetunde 2010). It includes walking, bicycling, small-wheeled transport, carts, etc., and provides flexible options to mobility. It can also reduce pollution and help to generate
income for the poor. The Chiang Mai consultation with stakeholders proposed the Three Kings Monument area near the centre of the Old City in Chiang Mai for developing NMT (around 600 m) that can be connected to the other roads that go around the moat which forms a boundary for the Old City (around 6,000 m). If NMT is promoted in this location, it could replace 535,800–1,339,600 local vehicle (diesel) km travel per year, which could reduce 230–570 tCO₂-eq emissions per year (i.e. reduce 0.6 percent to 1.6 percent of GHG emitted by land-based travel within the city) of the transport sector of Chiang Mai.

For tourists, NMT enhances recreational opportunities by reducing congestion. Facilitating NMT, particularly walking and cycling, will directly reduce the CO₂ which would have otherwise have resulted from their use of other modes of transportation. Cycling and walking are also access modes for public transport and thus their promotion may lead to increased public transport use. Furthermore, promotion of NMT can deliver important co-benefits such as noise and pollution reduction, and improved health (OECD/ITF 2009). On the socio-economic side, the restricted motorized transport will provide opportunities for tourists and others to purchase handicrafts and other goods from local vendors, thereby contributing to the local economy. Moreover, it can provide additional income-generating opportunities for the cyclo drivers, bicycle shops, and related industries. Nevertheless, the city authorities need to develop parking places for motorized and non-motorized transport at different locations to promote NMT and to avoid traffic congestion in the city center.

Garden Houses in Hue

For tourists to Hue, Garden Houses offer serene nature along with a touch of local tradition, and a place to relax within the city limits. More importantly, Garden Houses help to mitigate GHG emissions by acting as carbon sinks as well as lessening the amount of wastes going to landfills by managing household wastes through composting, or as animal feed. At the city scale, such houses can help reduce GHG emissions from freight resulting from importing fruit and vegetables to Hue by producing them for household consumption and sale, and by restricting motorized vehicles around the Garden Houses and promoting cyclo drivers as transport for the visitors.

Thua Thien Hue Province Tourism estimated that if the Garden Houses could attract 20–40 percent of the tourist authority and Garden House owners or ride bicycles to the Garden Houses, the local vehicle (petrol) km of the city is about 100–200 tCO₂-eq GHG emissions to 9 percent of GHG emitted by land-based travel within the city’s transport sector. The Garden Houses could generate additional income for the owners and garden vendors. Besides, restrictions for Garden Houses could generate additional income for the garden vendors.

A separate survey conducted in 2010 of development costs (and lower) onError and the dominance of mass food production, created sustainable garden houses on a large scale and the involvement of garden vendors.

Limitations

Only TSPs inside the administrative boundary of Hue were considered for the study aimed at domestic and international tourists. Shopping malls, night markets, and public parks were not included in this study. In goods transport (freight) was not analyzed. The assumptions are based on the average emission factors of buildings. Food items were not used, therefore not included in the analysis. The average GHG emissions were 0 percent for transport, +/-29 percent for building, and +/-37 percent for other materials.

For the development of the garden houses, it was not possible to estimate
Thua Thien Hue Provincial Department of Culture, Sports and Tourism estimated that if Hue promotes Garden Houses in the city, it could attract 20-40 percent more visitors. At the same time, if the city authority and Garden House Association encourage visitors to use cyclos or ride bicycles to the Garden Houses, it could replace 127,950-255,900 local vehicle (petrol) km of travel per year, which could help to reduce about 100-200 tCO₂-equiv GHG emissions per year (i.e. reduction of 4 percent to 9 percent of GHG emitted by land-based travel within the city) from the transport sector. The Garden Houses also help in income generation for the owners and garden workers from the sale of produce such as fruit and vegetables. Besides, restricting motorized vehicles around the Garden Houses could generate additional income for the cyclo drivers and street vendors.

A separate survey conducted in 50 Garden Houses indicates that high development costs (and low returns), low demand, lack of essential skills, and the dominance of mass tourism operators are some of the barriers to promoting Garden Houses as local tourist attractions in Hue. Thus, creating sustainable garden houses requires interventions of a different scale and the involvement of different stakeholders.

**Limitations of the study**

Only TSPs inside the administrative boundaries of Chiang Mai and Hue were considered for the study. However, many recreational activities aimed at domestic and international visitors such as the Chiang Mai Zoo, shopping malls, night markets, golf courses, temples, karaoke bars, etc., were not included in this study. In the case of Chiang Mai, travel data on goods transport (freight) was not considered for GHG emission analysis. The assumptions are based on discussions with the city authorities. Local emission factors of buildings, infrastructure, waste generation, and some food items were not used, but IPCC (default) emission factors were used for the analysis. The average uncertainties of the results range from +/-18 percent for transport, +/-29 percent for buildings and infrastructure, and +/-37 percent for other materials (see further ADEME 2009).

For the development of recommended strategies, an initial survey was conducted to understand local people's interests in changing their current business or their perceptions about new business opportunities, but it was not possible to estimate the number of jobs that could be created by
mitigation projects. Mobilities and businesses newly created through the recommended strategies were only for NMT without actually reducing the use of motorized vehicles as such. A more detailed economic analysis of job creation with detailed employment and income data is needed to determine the extent of newly created jobs and expected job losses.

Conclusion

The tourism sector is one of the most important sectors of the economies of Chiang Mai in Thailand and Hue in Vietnam. Both cities have invested in substantial infrastructural projects to promote tourism. Visitors, local and foreign, travel to these cities because of their good road connections with other big cities, and the establishment of accessible international/domestic airports. The increasing numbers of visitors in both the cities are also generating higher GHG emissions. This study showed that the transport sub-sector generated the largest proportion of CO₂ emissions, equivalent to 96 percent in Chiang Mai and 89 percent in Hue—with 89 percent and 71 percent of these emissions, respectively, attributed to air transport alone. The urban tourism sector in Chiang Mai is more carbon-intensive than Hue mainly because Chiang Mai receives more than thrice the number of visitors as Hue; Chiang Mai also has its own international airport and more recreational activities than Hue. Emissions from buildings and infrastructure and other materials used were low compared to those from transport.

On the basis of this GHG emissions inventory, the cities in consultation with their stakeholders recommended emission reduction strategies, and selected city-specific mitigation options that also support existing government tourism policies. Chiang Mai and Hue have identified strategies to implement NMT and promote ‘Garden Houses’ respectively. The implementation of these mitigation strategies will not only help to reduce emissions of GHG, but also create more green jobs for local people. The assessment of GHG emissions in this study also enables better understanding of the scope and magnitude of the impact of tourism on climate change for similar cities in the region (e.g. Bali, Phuket, Langkawi) that rely on tourism, and provides a useful and implementable example of developing and designing local strategies for mitigating carbon impacts and increasing employment potential.

Notes

This research for this chapter was funded by: USER, Chiang Mai.
1 Tourism service provider: TSP. We have used four TSPs for operators and other activities to one (unit) of a hotel, restaurant, and tourism TSP, working for the tourism sector.
2 Bilan Carbone® is a Microsoft GHG emissions. It provides an equivalent in kilograms (kg)
3 Personal communication with the author.
4 Personal communication with the author.
5 MONRE (2011): Hue City websites consulted were: http://123.242.133.66/tourism/
6 http://thaiarbonlabel.tgo.or.
7 BOD (biochemical oxygen demand) is the amount of oxygen consumed by aerobic organisms in a body of water in a given time period at a certain temperature.
8 Garden Houses are a special type of building usually used as restaurants, cafes, and cafes. See http://www.2privacy/.
9 Stakeholders refer to representatives of the stakeholders involved in: Tourism and Sport Office, United Nations, Garden House
Notes

This research for this chapters was funded by SIDA and CDKN through SUMERNET. The authors appreciate the help, support and comments provided by Louis Lebel of USER, Chiang Mai.

1 Tourism service provider (TSP) for this study refers to a group of similar entities. We have used four TSPs for the analysis—hotels, restaurants, tour and travel operators and other activities (including spas, travel agencies, etc.). Entity refers to one (unit) of a hotel, restaurant, travel agency or other institutes/organizations working for the tourism sector in both the cities.

2 Bilan Carbone® is a Microsoft Excel spreadsheet developed by ADEME to calculate GHG emissions. It provides GHG emission results in carbon or carbon dioxide equivalent in kilograms (kgCO₂) or tonnes (tCO₂). See further http://www.terre.tv/?lang=en&vid=1151 or www.ademe.fr.

3 Personal communication with Chiang Mai municipality authorities.

4 Personal communication with Hue city authorities.


6 BOD (biochemical oxygen demand) is the amount of dissolved oxygen needed by aerobic organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific period.

7 Garden Houses are a special style of Vietnamese traditional house. These houses are mostly used as restaurants, and surrounding lands are used for growing vegetables and fruits. See http://www.asianwaytravel.com/blog/hue-garden-houses-model-of-privacy/.

8 Stakeholders refer to representatives from various organizations, such as tour operators, researchers, business associations, media, etc., related to tourism. Some examples of stakeholders in Chiang Mai included the guide association, Provincial Tourism and Sport Office, restaurant clubs, and those in Hue included the Youth Union, Garden House owners, Association of Entrepreneurs, and Hue University.
Rapid economic growth coupled with current and projected climate risks are challenging livelihoods and ecosystems in the Mekong region. In some locations unsustainable development has created or deepened vulnerabilities to climate change as well as global, regional, and transborder socioeconomic processes. More accessible and appropriate information is urgently needed on ways to reduce the negative aspects of development and adapt to the impacts of climate change in this region.

In this book, the Sustainable Mekong Research Network (SUMERNET) brings together multi-country studies, each of which included significant engagement with boundary partners, to analyze the impacts of, and ways to adapt to, climate risks and unsustainable growth in a highly interdependent region.

This book improves our understanding of the linkages between drivers, opportunities, and constraints on the sustainability of the Mekong region's ecosystems—at the transborder, sub-national, and local levels. Economic integration, urbanization, and climate change have impacts that vary greatly among locations. Hence, one key lesson in this book is that it is important to tailor policies and actions to specific places and communities, paying particular attention to the most vulnerable sections of the population, and the capacities of local actors. These multi-site and -country case studies provide much stronger tests of the merits and limitations of common policies than studies carried out in a single country, underlying the benefits of collaborative research.