An analysis of tourist carbon footprint in Indonesia – The case of D.I. Yogyakarta

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Abstract

Tourism is one of Indonesia's largest economic sectors contributing significantly to the republic's current development . However, there is a price to pay for developing tourism, namely, the increased generation of CO_2 produced by touris and tourism activities which can lead to climate change. To gauge the extent to which this is happening in the country a field study was conducted in D.I. Yogyakarta to determine the amount of carbon produced by individual tourists through tourism activities, and to map the amount of carbon produced by tourists at a tourist destination. The results showed that a) of the total amount of 1,218,416.05 kg of CO_2 produced by tourists in the Province of Yogyakarta about 45 percent or 542,971.48 kg CO_2 was produced by foreign tourists as compared to 55 percent or 675,444.57 kg CO_2 produced by domestic tourists; b) accommodation air conditioning was the biggest carbon contributor with respect to domestic tourists; c) at 5,728.17 kg of CO_2 domestic tourists dominated the amount of transportation carbon produced during their stay in D.I. Yogyakarta; and d) the greatest amount of carbon, viz. 236,648.7 kg or 20% of the total CO_2 generated by tourists was at the heritage tourism sites.

Keywords: carbon analysis, tourism, tourist arrivals, tourist carbon footprint, tourist destinations, Yogyakarta

Introduction

Tourism is one of the largest economic sectors and contributes greatly to the economic development of nations and local economies across the world. In 2008, there were 922 million tourists who travelled to spend 944 billion USD, whereas in 2010 as many as 939 million visitors to 980 million tourists in 2011. Based on this amount, the average growth of the world tourists is 4.4% per year.

It is estimated that globally trips contributed to a 9.6% of PDRB and contributed 7.9% of employment in 2008. The contribution of tourism to PDRB in 2011 was 5%, 6% to an increase in exports, and absorbed one of the 12 people as workers in this sector. Nevertheless, tourists demand gradually decreased in recent years due to global economic crisis. International tourism is an important contributor to economic development in developing countries. Between 1995 through 2007, the tourism industry and markets in developing countries achieved twice higher than in developed countries.

With estimation that by 2020 the number of tourists reaching 1.6 billion, tourism will continue to be the most important sector for achieving the UN-MDGs (United Nations-Millennium Development Goals), particularly in terms of poverty reduction in developing countries. However, there are several challenges in the development of tourism in developing countries. Some of debates on international policy-making suggest that the climate change issue became one of the most serious challenges in economic and environmental development.

Inter-Governmental Panel on Climate Change (IPCC) in 2003 concluded that climate change will affect the ability of developing countries to achieve sustainable development in the middle of next

century. Climate change would also be one of the risks of environmental vulnerabilities, especially because of the large temperature change. The IPCC also concluded that the costs used to reduce greenhouse gas emissions now would be less than the cost of economic and social costs caused by climate change. When high temperatures cannot be avoided, the future temperature will increase and this is the effect of an increase in global emissions in the past. Thuiller (2007) and IPCC (2003) stated that in 2100 the earth's temperature will rise to 4°C.

In the 15th conference in Copenhagen, the International Society agreed that the increase in temperature will not be more than 2°C. The limit is the temperature level that can still be tolerated by various scientists in over 100 countries including the G-8 to demonstrate the dangers of the climate system where it is also underlined by the UN Framework Convention on Climate Change (UN FCCC).

The tourism industry is the most sensitive sector to climate change. Destinations and tourism service providers will be affected by climate change in several ways. Climate will reduce the length of staying of tourists in an area and affect the timing (season) of visits. Climate affects every item of tourism service businesses, such as the presence of water, the cost to heat / cool the room, the cost of evacuation, etc. Climate affects the environmental conditions that would interfere tourists, such as infectious diseases, fire, and explosion of algae, insects, and jellyfish populations to floods, cyclones and tidal waves. Finally, climate change will affect the decisions of tourists who are affected by the level of satisfaction of tourists to tourism attractions.

The relationship between tourism and climate change is mutual. Tourism activities will not be able to run well when the weather and climate do not support them. In the extremely hot and cold climate or even change a few degrees will be able to affect tourism activities. Conversely, tourism activities through the large use of energy and CO_2 produced can lead to climate change. With a growing number of tourists visit around 9.57% per year to various destinations in the province of D.I. Yogyakarta, the province needs to take into account the amount of total number of carbon generated by tourists who come and or transit.

The aims of this paper are, therefore, to: investigate the amount of carbon produced by tourists individually on tourism activities in the province of D.I. Yogyakarta; and, conduct mapping the amount of carbon generated by tourists on a tourist destination.

The relationship between tourism industry and climate change phenomena

In recent years, the relationship between tourism activities with climate change is strongly influenced by the presence of water sources (for example, many areas suffer from floods, drought, and prolonged heating), as well as on small islands, coastal and mountainous areas. Moreover, local climatology and different weather types influence the location of resorts, the calendar of tourist activities, the use of the infrastructure, and the return on investments (Gomez Martin, 2005), and also interrupt or damage tourism operations (Scott, Gossling, & de Freitas, 2008). Lohmann (2009) states processes and effects related to climate change as the main future challenges for tourism.

The increase in air temperature up to 40°C in summer reduces comfort and mental stress appears because of heat until causing death. Some countries such as Greece and Turkey anticipate this situation by changing some of the tourist attraction in summer to the other seasons (Buhalis, 1999). The other disadvantage of this condition is increasingly widespread environmental damage such as water supply shortage for some water tourist destinations, forest fires and haze in some major urban areas.

The tourism industry is a strategic industry for the whole country in the world, so, many countries will compete in providing services of tourist visits that will directly impact on increasing the number of modes of transportation used. Improved modes of transportation that is the one of the concerns of many environmentalists would affect on increasing the amount of carbon in the air.

United Nations World Tourism Organization and Nicholls (2004) also suggest that the tourism sector, the travellers who use air transportation modes contribute the most greenhouse gases than if they use other modes of transport (trains, cars, boats, or buses). Levels of carbon emitted into the atmosphere reaches 5.5 Gtc/yr coming from the burning of jet fuel (Diposaptono et al., 2009).

Research method

The method of this research is survey method supplemented by secondary data from several agencies. The analysis emphasized the impact of the movement and activities of tourists to the amount of carbon produced. This study area is Province of D.I. Yogyakarta with meso and micro-analytical unit. Meso unit is on each tourist destinations while the micro unit of analysis is carried out on individuals, which the analysis is based on data and information obtained from each tourist.

Research indicators and variables

Indicators of this study consisted of accommodation and transportation. Both indicators were used because in addition to already having the carbon converted value for each variable, it can also represent inferences in the analysis. More research indicators and variables are shown in Table 1 below.

Table 1. Research indicators and variables

Indicator	Variable	Variable Unit	Variable Size	Source
ACCOMMODATION				
	Lighting	Lighting	use of lights by wattage and hours of use	Primary data
	AC (Air Conditioner)	Permanent installed unit	Total units, wattage, and hours of use	Primary data
	Heater	Room heater	use of electricity by wattage and hours of use	Primary data
	Cooking	Cookers	use of electricity by wattage and hours of use	Primary data
		Hotplates	use of electricity by wattage and hours of use	
		Toasters	use of electricity by wattage and hours of use	
	Refrigerators	Permanent unit	Average usage per person per day (pppd; per person per day)	Primary data
	Laundry	Washer	Average usage per person per day (pppd; per person per day)	Primary data
		Dryer	Average usage per person per day (pppd; per person per day)	
	Beverages	Water cooler or heater	Average usage per person per day (pppd; per person per day)	Primary data
TRANSPORTATION				
	Transfer	Bus/car/train (from home to airport)	Fuel use	Primary data
		Bus/car/train (from airport to hotel)		
		Internal transfer		
		Air travel		
		Local transportation		
		Cruise		
	Vehicle	Small car	Fuel use	Primary data
		Medium car		
		Large car		

Types and sources of data

The required data in this study is the primary data and secondary data. Primary data are obtained from field observations, in-depth interviews, questionnaires and documentation to the informant (resource persons) from the field. The questionnaire is used as a tool to determine the depth of information from domestic tourists and foreign tourists visiting Yogyakarta. The number of respondents is 50 (25 respondents respectively for domestic and foreign tourists) in each destination basis. Sampling locations are determined based on purposive random sampling. The types of destinations to be location of the data collecting of the questionnaire are mountain-based destinations, beach-based destination, heritage-based destination, living culture-based destinations, destination parks and cultural conservation, and education-based destinations. Secondary data are obtained from the literature and data obtained from various agencies.

Data analysis techniques and measurement objectives

Objective 1: To investigate the amount of carbon produced each traveller

Some of the steps taken to measure the carbon produced by each traveller are as the following:
a) Identify the source of the energy consumed (relating to accommodation and transportation)
b) Make a summary and grouping of the approach used to calculate the total energy used based on the source from DEFRA (Department of Environment Food and Rural Affairs) UK
c) Determine the amount of CO_2 conversion emitted by each traveller from the research variables.

The calculation of carbon produced by each of the tourists is completely shown in Table 2 below.

Table 2. CO_2 Conversion

Energy Consumption	Activity	Approach	Energy Metric (DEFRA)	Conversion to CO_2
ACCOMMODATION				
Lighting	Lighting	The use of lights by wattage and hours use	Kilowatt hours (kWh)	0.43 kg CO_2 per kWh
AC (Air Conditioner)	Permanent installed unit	Total unit, watt, and hours use	kilowatt	0.43 kg CO_2 per kWh
	Unit	Total unit, watt, and hours use	kilowatt	0.43 kg CO_2 per kWh
Heating	Room heating	The use of electricity by wattage and hours use	kilowatt	0.43 kg CO_2 per kWh
Cooking	Cookers	The use of electricity by wattage and hours use	kilowatt	0.43 kg CO_2 per kWh
	Hotplates	The use of electricity by wattage and hours use	kilowatt	0.43 kg CO_2 per kWh
	Toasters	The use of electricity by wattage and hours use	kilowatt	0.43 kg CO_2 per kWh
Refrigerators	Fixed unit	Average usage per person per day (pppd; per person per day)	kilowatt	0.43 kg CO_2 per kWh
Laundry	Washing	Average usage per person per day (pppd; per person per day)	kilowatt	0.43 kg CO_2 per kWh

Energy Consumption	Activity	Approach	Energy Metric (DEFRA)	Conversion to CO_2
	Drying	Average usage per person per day (pppd; per person per day)	kilowatt	0.43 kg CO_2 per kWh
Drinks	Water cooler or heater	Average usage per person per day (pppd; per person per day)	kilowatt	0.43 kg CO_2 per kWh
TRANSPORTATION				
Transfer	Bus/car/train	From home to airport	Petroleum	2.31 kg CO_2 per litre
			Diesel	2.68 kg CO_2 per litre
			LPG	1.51 kg CO_2 per litre
	Bus/car/train	From airport to accomodation	Train	0.06 kg CO_2 per pass km
			Bus	0.36 kg CO_2 per pass km
			Car	0.36 kg CO_2 per pass km
	Internal transfers		Air	0.102 kg CO_2 per pass km
	Air journey		Air	0.102 kg CO_2 per pass km
	Local transport	Fuel use	Diesel	2.31 kg CO_2 per litre
			Petroleum	2.68 kg CO_2 per litre
			LPG	1.51 kg CO_2 per litre
	Cruise holiday		A week cruise (cruise ship)	3000 kg CO_2 per passenger
			Two-week cruise (cruise ship)	6000 kg CO_2 per passenger
Vehicles	Small car	Fuel use	Km/litre	0.17 kg CO_2 per passenger (ppkm)
	Medium car			0.22 kg CO_2 ppkm
	Large car			0.27 kg CO_2 ppkm

Source: Tourism Destinations Carbon Footprint (Sisman, 2007)

Objective 2: to conduct mapping the amount of carbon generated by tourists on a tourism destination.

Several stages of work to achieve this objective are:
a) Preparing the base map of the province of D.I. Yogyakarta using Arc GIS 9.3 software
b) Determining the location of the research sampling on the basis of tourist destinations
c) Determining the sampling points using GPS (Global Positioning System)
d) Processing the field data into the base map to produce a thematic map
e) Entering the results of the carbon conversion into the base map to produce a thematic map production of carbon in each destination basis.

Results and discussion

The amount of carbon based on types of tourist in the Province of D.I. Yogyakarta

Carbon produced from tourist accommodation comes from several sources, among others from the use of lights, air conditioning, room heater, refrigeration, heater, washing machine and cooking activities of tourists. Use of facilities and accommodation in tourist activities appeared to have a significant contribution in producing carbon that can affect the ecological balance and eventually contaminate the environment. Conditions that appear due to carbon produced by industrial activities, transportation and other human activities and the reduced ability of forests to absorb CO_2 (deforestation) will continue to have an impact on climate change.

Based on calculations of carbon produced each traveller on the selected destination, the carbon produced from tourist activity in using accommodations is larger. The amount of carbon produced from tourist accommodation does not only occur on foreign tourists but also on domestic tourists. Domestic tourists contribute more energy that produced carbon than the carbon produced by foreign tourists. The larger energy of accommodation sector produced by tourists came from the energy consumption of air conditioning, either in the form of air conditioning, fans and water coolers. In producing carbon, the use of air conditioning contributes of 0.43 kg CO_2 per kWh. The amount of carbon generated by domestic tourists from the use of air conditioning as a whole produces 544,896.00 kg CO_2. While the number of foreign tourist produces carbon of 435,896.00 kg CO_2 from the use of accommodations in the form of air conditioning. This shows that the use of accommodation facilities in the form of air conditioning in the Province of D.I. Yogyakarta in particular, is still highly favoured by domestic and foreign tourists.

There are several factors that can influence the amount of carbon produced by domestic tourists in air conditioning energy use in tourist destinations, namely: a) domestic tourists still use the accommodation facilities in the form of air conditioning with climate conditions that exist today in Indonesia, and in the Province of D.I. Yogyakarta in particular, b) the use of air conditioning accommodation facilities that has not noticed the impact of environmental damage or pollution produced from the cooling energy consumption. So they did not save, but they wasted energy, and c) the number of domestic tourists visited related tourist attraction is more than the number of foreign tourists, so naturally, the use of accommodation facilities in the form of air cooling is used more by domestic tourists than foreign tourists.

In addition to air conditioning, other accommodation facilities that have an impact on the large amount of carbon produced are by the use of lighting, heating, cooking activities, toasters, refrigerators, and washing machines. The use of accommodation facilities that also produces significant carbon is the use of lamps/lighting and refrigerators. The amount of carbon generated by the energy of lamp/lighting is 0.43 kg CO_2 per kWh, while the amount of carbon produced from the energy of refrigerator is 0.43 kg CO_2 per kWh.

Domestic tourists prefer using accommodation facilities in the form of lamp/lighting more when travelling, for example the use of hotel room lamps room all day. This is shown from the amount of carbon produced is 64,190.49 kg CO_2 is greater than the amount of carbon produced by foreign tourists (34,847.20 kg of CO_2). On the use of refrigerators, foreign tourists contribute more in producing carbon by the amount of 20,296.00 kg of CO_2 (See Figure 1).

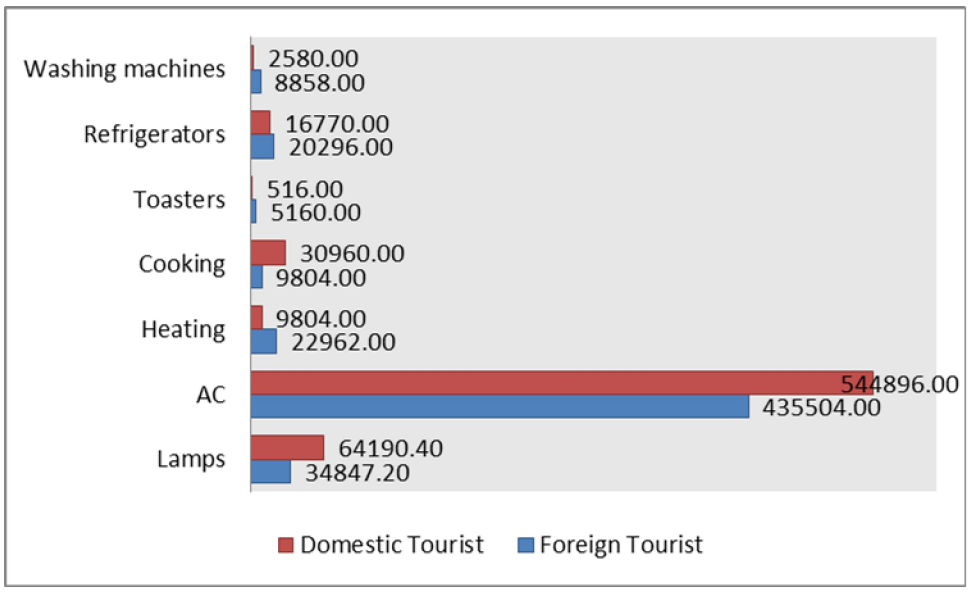


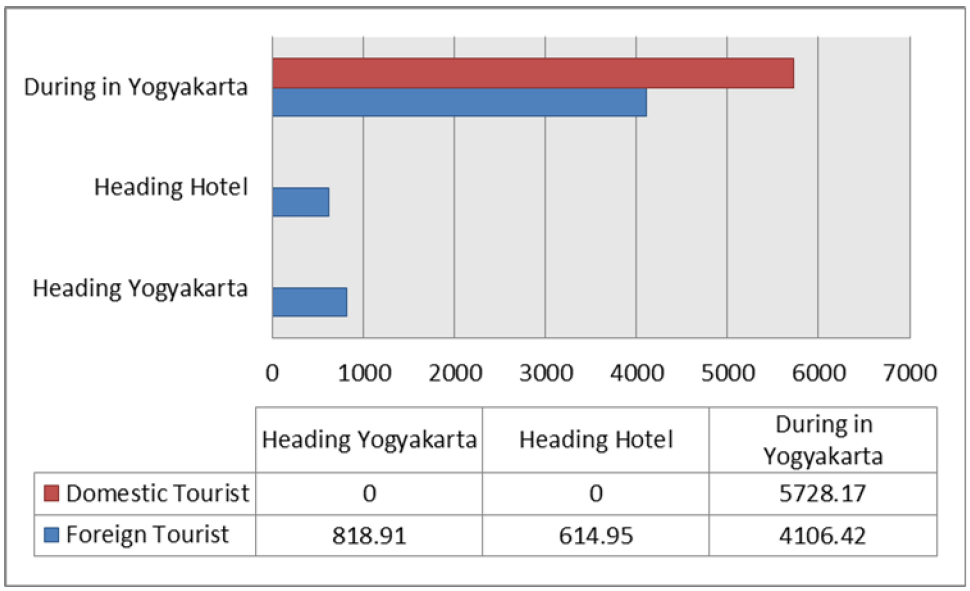
Figure 1. *Graph of total carbon of accommodation facilities produced by tourists*

The development of modes of transport is the most important issue in increasing flow of passanger around the tourism destinations. Moreover, the usage of transportations modes has increased the amount of tourism destination and caused a lot of environmental damage (Black, 2004), energy consumption (Gossling, 2002 and Chapman, 2007), and leisure traffic by private motorized vehicles (Gronau & Kagermeier, 2007). Other research, Martin-Cejas and Sanchez (2010) found that air transport in ‘‘transit zones’’ using more than 90% of energy footprint.

Based on the data processing amount of carbon produced by tourists in the use of facilities, transportation, the amount of carbon produced from tourist activities while in tourist areas (Province of D.I. Yogyakarta) is the most compared to the amount of carbon generated by tourists heading the hotel and Yogyakarta. From these data, it is known that the staying duration of tourist in tourist areas is longer and more moving towards the tourism objects that exist in the Province of D.I. Yogyakarta.

The use of transportation facilities in tourist areas, the amount of carbon produced by domestic tourists is greater than the amount of carbon produced by foreign tourists. The difference in the total amount of carbon produced by domestic tourists and foreign tourists in the use means of transport in the Province of D.I. Yogyakarta is 1,621.75 kg CO_2. Domestic tourists dominate the amount of carbon produced from the transportation used during their stay in tourist areas (Province of D.I. Yogyakarta) in the amount of 5,728.17 kg CO_2. While foreign tourists only produce carbon of 4,106.42 kg CO_2 from their activities in using means of transportation for the Province of D.I. Yogyakarta.

The differences in the amount of carbon produced by the use of transportation by domestic tourists and foreign tourists in the tourist area of the Province of D.I. Yogyakarta can be seen in the graph below (See Figure 2).



	Heading Yogyakarta	Heading Hotel	During in Yogyakarta
Domestic Tourist	0	0	5728.17
Foreign Tourist	818.91	614.95	4106.42

Figure 2. *Graph of total carbon of transportation facilities produced by tourists*

The amount of carbon of tourists on the destination basis

In this analysis of the carbon footprint of tourists, a tourist destination (destination) as the research object is divided into six types: (1) heritage-based destinations, (2) living culture-based destinations, (3) beach-based destination, (4) mountain-based destinations, (5) education-based destinations, and (6) national park-based and cultural conservation-based destinations. Each destination consists of 3 or more tourist attractions with a sample of 50 respondents in each destination. Based on the categories, the amount of carbon produced by tourists in a tourist destination is calculated.

Amount of carbon produced by domestic tourists and foreign tourists with various tourist destinations gives the illustration whether or not there is relationship between tourism destination and the amount of carbon produced. Based on calculations based on the amount of carbon of destinations, it is known that the heritage-based destination is the tourist destination that produces the most amount of carbon (19.42%) compared to other destinations. While the tourist destinations that only gives the least amount of carbon are national park-based and cultural conservation-based destinations (12.82%).

The amount of carbon produced by domestic tourists and foreign tourists in each destination basis are shown in Table 3 and Figure 3 below.

Table 3. Total amount of carbon produced by tourists based on types of destinations in the Province of D.I. Yogyakarta

No.	Destination Basis	Total Carbon Produced (Kg CO2)		
		Foreign Tourist	Domestic Tourist	Total
1.	Heritage	74,437.45	162,211.20	236,648.65
2.	Living Culture	80,427.89	119,440.17	199,868.06
3.	Beach	106,471.28	116,246.30	222,717.58
4.	Mountains	96,779.01	119,137.20	215,916.21
5.	Education	89,337.06	97,676.30	187,013.36
6.	NP&CC	95,518.79	60,733.40	156,252.19
	Total	542,971.48	675,444.57	1,218,416.05

Source: Analysis result, 2011

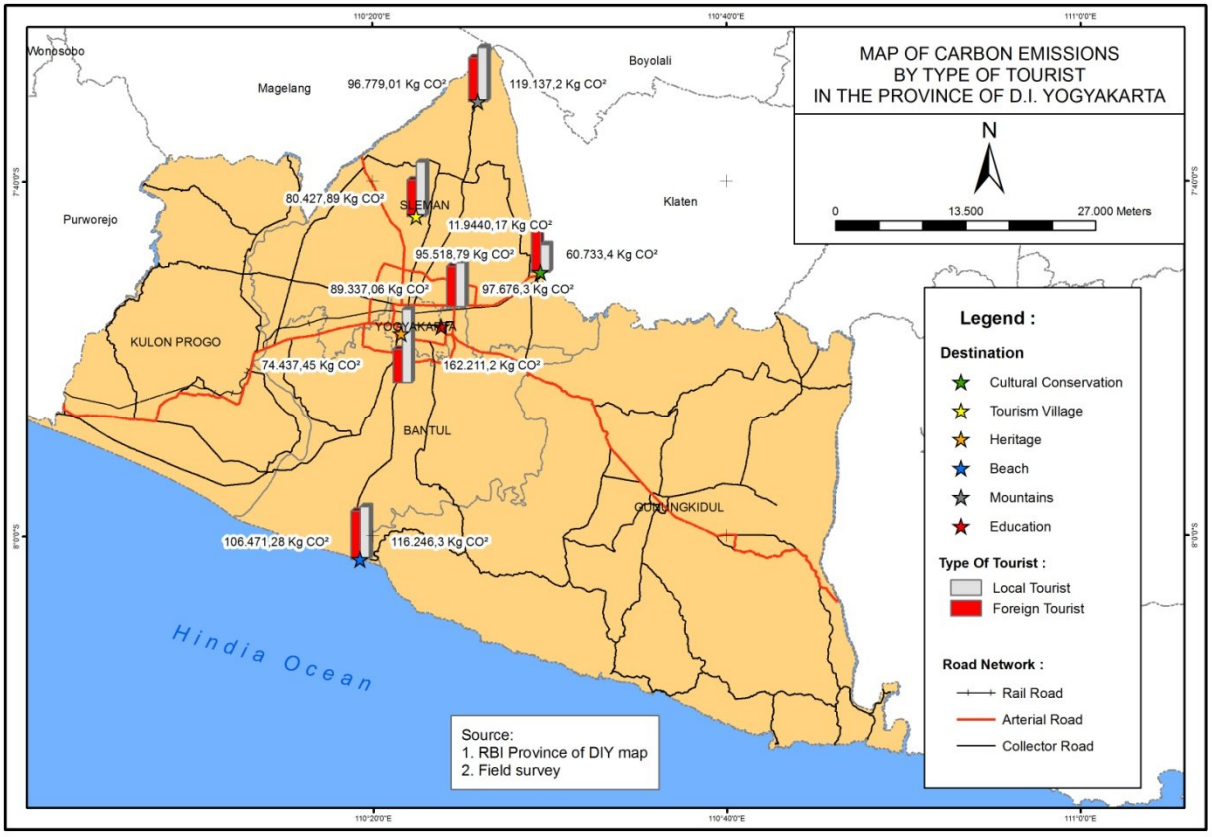


Figure 3. *Map of carbon emissions by type of tourist in the Province of D.I. Yogyakarta*

The amount of carbon produced by tourists on each basis of destinations is described as the following:

a. Heritage-based destinations

Tourist attractions which are sampled for data collecting of tourists in heritage-based destinations are Kraton Yogyakarta (The Sultan's Palace), Taman Sari (Water Castle), and Benteng Vredeburg (Vredeburg Fort). Heritage-based destinations are destinations that produced carbon by 236,648.7 kg CO_2 or 20% from the total carbon produced by tourists. The amount of carbon produced by tourists to the areas of heritage-based destinations is the result of the accumulation of energy produced by tourists from both transportation and accommodation used by them. In other words, the activity of tourists (both domestic tourists and foreign tourists) on heritage-based destinations in Yogyakarta is very potential in causing environmental pollution.

If it is observed more, the use of means of transportation on the destination did not so significantly produce carbon (1,369.85 kg CO_2) or did not produce carbon greater than other destinations, even below the average for transportation use on other destinations. However, the use of accommodation facilities on these heritage destinations (total carbon produced 235,278.80 kg CO_2) is greater than the use of the means of accommodation on other destinations in Yogyakarta. Location of heritage destinations that are in the centre of the city supports the facilities and tourist accommodation that is fairly complete, so the tourist activity in the use of facilities and accommodation facilities is sufficiently large.

The contribution of domestic tourists in producing carbon of heritage-based destination tourists is considerably large. Domestic tourist activities produced carbon twice greater than the amount of carbon produced by foreign tourists, especially in the use of accommodation facilities. The amount of carbon

produced in the activities of foreign tourists in using accommodation facilities is 73,925.6 kg CO_2, while the domestic tourist is 161,353.2 kg CO_2.

b. Living culture-based destinations

Tourist attractions which are sampled for data collecting of tourists in living culture-based destinations are Desa Wisata Kasongan (Kasongan Tourism Village), Desa Wisata Brayut (Brayut Tourism Village), dan Desa Wisata Tembi (Tembi Tourism Village). Desa Wisata Kasongan and Desa Wisata Tembi are located in Bantul regency, while Desa Wisata Brayut is located in Sleman Regency. On living culture-based destinations, tourist activities that produce a lot of energy and produce the most carbon is still caused by the use of accommodation facilities. Whereas, the energy which produces carbon from transportation means are much smaller than the amount of carbon produced from the use of accommodation facilities. Overall amount of carbon generated by domestic tourists and foreign tourists on living culture-based destinations is 16% or 199,868.1 kg CO_2 from the total carbon produced by tourists in the Province of D.I Yogyakarta which is 1,218,461.1 kg of CO_2.

Domestic tourists are still the largest source of carbon produced on living culture-based destinations, mainly from the use of tourist accommodation. From the use of accommodations, foreign tourists produce carbon of 79,446.8 kg CO_2, while the domestic tourists produce the highest carbon in the amount of 118.852 kg CO_2. So the difference of the carbon produced by domestic and foreign tourists in using accommodation facilities is 39,405.2 kg CO_2. On the use of tourist transportation, the amount of carbon produced by foreign tourists is greater (981.09 kg CO_2) compared to the amount of carbon produced by domestic tourists (588.17 kg CO_2).

The proportion of the amount of carbon produced by domestic tourists and foreign tourists on living culture-based destinations each is 80,427.89 kg CO_2 and 119,440.17 kg CO_2. Percentage of domestic tourists on living culture-based destinations that produce carbon is more by 60% while the amount of carbon produced by foreign tourists is 40%.

c. Beach-based destinations

Tourist attractions which are sampled for data collecting of tourists in shore-based destinations are Parangtritis Beach, Depok Beach, Baron Beach, Kukup Beach, and Siung Beach. Those attractions are spread across two regencies in the Province of D.I. Yogyakarta. Parangtritis Beach and Depok Beach are located in Bantul Regency, while Baron Beach, Kukup Beach, and Siung Beach are located in Gunungkidul Regency.

From the results of data processing on the amount of carbon produced by tourists, beach-based destinations are visited by most of tourists with the amount of carbon produced which is considerably large amounted 222,717.58 kg CO_2. With that amount of carbon, the beach-based destinations are on the second place after the heritage-based destinations. The percentage of the amount of carbon produce by tourists who want to go to the beach is 18%, while the percentage of tourists who want to go to heritage destinations is 20% of the carbon produced by all the tourists.

The use of tourist accommodation facilities by domestic and foreign tourists still dominate the amount of carbon produced from energy that has been used, this also occurs on tourists who have a beach-based destinations. The use of accommodation facilities that pays less attention to its impact on the environment, especially carbon produced still occurs on domestic and foreign tourists. The amount of carbon produced from the foreign tourist activity in using accommodation facilities is still lower, at 105,384.4 kg CO_2 compared to the amount of carbon produced by domestic tourist activity (115,807.6 kg of CO_2). However, the use of transportation means, domestic tourists produce less carbon (438.7 kg CO_2) compared to the amount of carbon produced by foreign tourists (1,068.88 kg of CO_2).

Overall, of the amount of carbon produced by either of the means of transportation use and the use of accommodation, domestic tourists still contribute larger amount in supplying carbon produced (52%). Whereas, foreign tourists give larger carbon from the energy used, by 48% of the total carbon. It is as a

result of transportation means and accommodation. In other words, domestic tourists have a major role in the responsibility for causing carbon impact and environmental damage that are still not recognized and cared for because it is not visible in the short term. The presence of beach attractions away from the city centre and tourist residence results in the amount of fuel that must be spent to reach that object. Moving the tourist residential location close to the transition beach area is one way to reduce carbon production on the beach attractions.

d. Mountain-based destinations

Mountain-based destinations in the Province of D.I. Yogyakarta as sample of this research are Kaliurang Tourism Park (Ulen Sentalu Museum) and the peak of Merapi (Lava Tour). Based on the data processing of the amount of energy used by tourists who produce carbon, total carbon produced by domestic tourists and foreign tourists is 215,916.21 kg CO_2 or 16% of the total carbon produced by tourists in the Province of D.I. Yogyakarta amounted 1,218,416.1 kg CO_2. The amount of carbon from the activity of domestic and foreign tourists who travel to the mountains is an activity that contributes production of carbon that is considerably large in the Province of D.I. Yogyakarta. After the heritage-based destinations with the amount of carbon produced (20%), mountain-based destination is the second carbon supplier by 18% (similar to beach-based destinations).

Energy produced from tourist activity in using transportation means and accommodation on tourists aiming to mountain destinations is still dominated by domestic tourists, by 55% or 119,137.20 kg CO_2. Foreign tourists aiming to mountain destinations contribute carbon by 45% (96,779.01 kg of CO_2).

The results of the use of the means of accommodation for tourists are still the largest supplier of carbon producer on these mountain-based destinations. Despite this, foreign tourists are still smaller suppliers compared to the amount of carbon produced by domestic tourists. The low carbon produced by foreign tourists in the Province of D.I. Yogyakarta is not because the number of tourists, because the sampling proportion is the same for tourists. So the use of less wise on transportation means and accommodation will produce waste of energy that impact on environmental pollution and large amounts of carbon. From the use of accommodation facilities, domestic tourists produce 117,940.40 kg CO_2 greater than the amount of carbon produced by foreign tourists in the amount of 96,062.00 kg CO_2.

The use of transportation by tourists aiming to mountain-based destinations produce far less carbon than carbon produced from the activities of the tourist accommodation facilities use. The amount of carbon produced by domestic tourists from the use of transportation is 1,196.80 kg CO_2, while foreign tourists produce less carbon in the amount of 717.01 kg CO_2. Transportation to the mountain destination does have a range that is far enough in comparison with other tourist attractions. In addition, the location of attractions in mountainous areas makes the vehicle must use extra energy to reach the mountain attraction destinations.

e. Education-based destinations

Taman Pintar, Museums around Sultan Palace, and Jogja Kembali Museum are some tourist attractions in the Province of D.I. Yogyakarta that are education-based. Of the total carbon produced by tourists in the Province of D.I. Yogyakarta, education-based destination attractions are destinations that give the impact of tourist carbon that is considerably low compared to other destinations. On education-based destinations, domestic tourists and foreign tourists contribute only 15% of the total carbon produced by tourists in the Province of D.I. Yogyakarta. The amount of carbon produced by tourists aiming to education-based attractions is 187,013.38 kg CO_2. The closeness of education-based destinations to the airport, bus station, hotel, and other public facilities affects the amount of energy produced by the use of transportation means.

Not much different from other destinations, education-based destinations also produce a lot of carbon from the tourist activity in using the accommodation. Domestic tourists are also still the largest suppliers on accommodation used by tourists aiming to education-based destinations. The amount of carbon

produced by domestic tourists from the use of accommodation on education-based destinations is 96,251.2036 kg CO_2, while foreign tourists produce carbon by 88,270.40 kg CO_2. The illustration of the amount of carbon produced by tourists is specified in types of tourists and the means used that can be seen on the graphs below (See Figure 4).

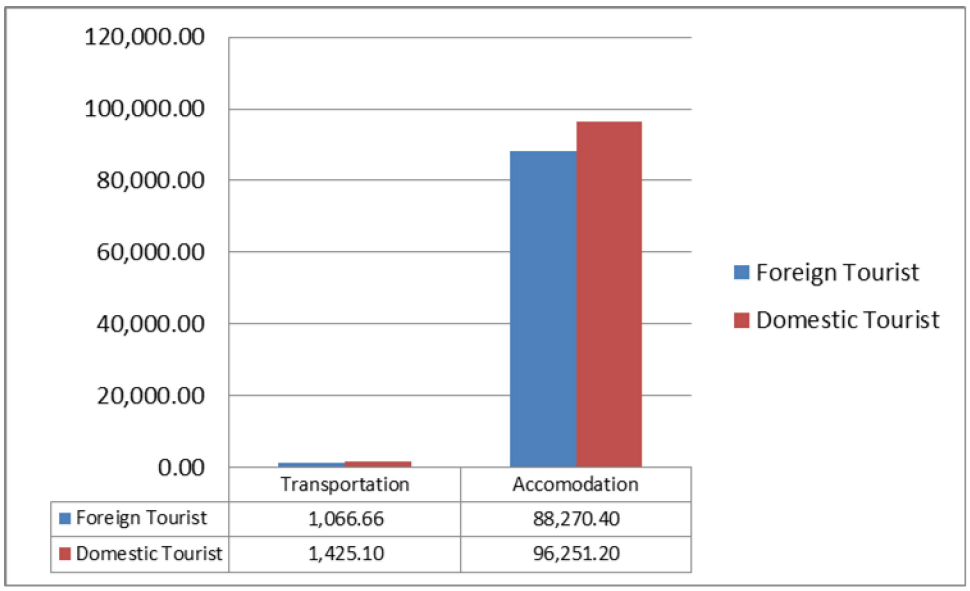


Figure 4. *Graph of the amount of carbon produced by tourist based on education-based destinations*

On the use of transportation means, domestic tourists are also larger carbon suppliers than foreign tourists. The energy that is used to transportation means and produces carbon from domestic and foreign tourists is each 1,066.88 kg CO_2 and 1,425.10 kg CO_2. Compared to the use of accommodation facilities, carbon produced by transportation is 100 times smaller. This shows that wasting occurs in the use of accommodation facility energy which is used on educational destinations. There should be a balance between accommodation providers and tourist as the users of accommodation facilities in order to be able to provide a means of energy-efficient accommodation, but will still be able to meet the needs/demands of the accommodation facilities expected by tourists.

The results of carbon data processing produced by tourists show that the difference in the amount of carbon produced by domestic tourists and foreign tourists who have educational destination is small, which is 8,339.24 kg CO_2. In the graph below, it can be seen that domestic tourists with education-based destinations produce carbon by 53% or 97,676.30 kg CO_2. While foreign tourists produce less carbon, which is 48% or 89,337.06 kg of CO_2.

f. National park and cultural conservation-based destinations

The next destination is the national park and cultural conservation-based in the Province of D.I. Yogyakarta. Those destinations are Gembiraloka Zoo, Prambanan Temple, and Boko Temple. Carbon produced by tourists who have national park and cultural conservation-based in the Province of D.I. Yogyakarta is the smallest carbon. The amount of carbon produced from the energy of transportation and accommodation use is only 13% or 156,252.19 kg CO_2. In other words, tourists who have this national park and cultural conservation-based destinations in the Province of D.I. Yogyakarta are quite wise in choosing the means of transportation and accommodation that can save energy. The following is the differences in the produced carbon by domestic tourists and foreign tourists in the use of transportation facilities and tourist accommodation in Yogyakarta.

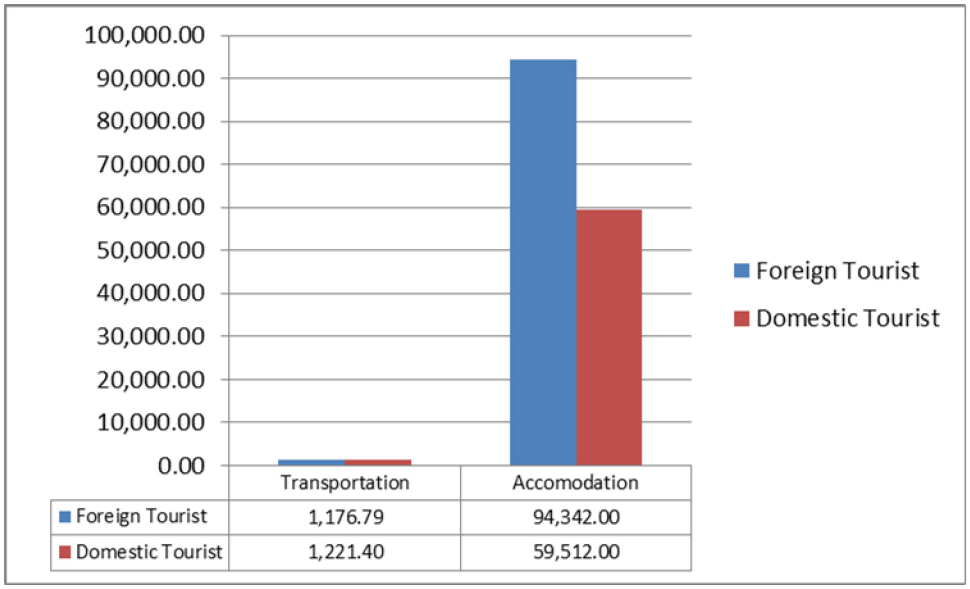


Figure 5. *Graphs of the amount of carbon produced by tourists based on National Park and Cultural Conservation-based destinations*

Different phenomena are shown in the tourists who have national park and cultural conservation-based destinations. The use of accommodation facilities by foreign tourists produces more carbon than domestic tourists. Whereas in other destinations, a high amount of carbon from the use of accommodation facilities are dominated by domestic tourists. The amount of carbon produced by foreign tourists in the use of accommodation facilities is 95,518.79 kg CO_2, while domestic tourists produce only one-third of the use of accommodation, which is 60,733.40 kg CO_2.

The amount of carbon produced from the means of transportation use is still less if compared to the use of tourist accommodation by tourists on national parks and cultural conservation-based. Tourists still produce a lot of carbon from accommodation facilities which is almost 100 times the amount of carbon produced from the means of transportation use. Carbon produced by foreign tourists from the use of transportation is 1,176.79 kg of CO_2. While the carbon produced by domestic tourists has only a small difference in the amount of 1,221.40 kg of CO_2 (See Figure 5).

If it is observed in overall, different phenomena also occur in tourists who have national park and cultural conservation destinations. Foreign tourists produce more carbon than domestic tourists in the total use of accommodation and transport facilities. Foreign tourists contribute to a 61% or 95,518.79 kg CO_2, 22% greater than carbon produced by domestic tourists. The amount of carbon produced by domestic tourists is 60,733.40 kg CO_2 or 39%.

Conclusion

A number of conclusions may be drawn from the findings,. Firstly, the total amount of carbon produced by types of tourist in the Province of D.I. Yogyakarta is 1,218,416.05 kg CO_2, with the dominance of carbon produced by domestic tourist, which is 675,444.57 kg CO_2 or 55.43% of all carbon produced by tourists. Secondly, based on accommodation facilities, air conditioning is the biggest carbon contributor in terms of accommodation by domestic and foreign tourists. On the other hand, the transport used by tourists during their stay in Yogyakarta is a major contributor of carbon in the transportation sector with a major contributor, which is domestic tourists (5,728.17 kg CO_2 or 58.24%). Finally, the amount of carbon produced by tourists on the destination basis from the greatest in a row are heritage (236,648.7, or 19:42%), beaches (222,717.6; 18:28%), mountains (215,916.2; 17.72%); living culture (199,868.1;

16:40%), education (187,013.4; 15:35%), and national parks and cultural conservation (156,252.2; 12.82%).

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