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Greenhouse Gas Emission and Mitigation from Sports Tourism in Benja Burapha Cycling Rally, Sa Kaeo, Thailand

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Sport tourism is very popular with new generation tourists because they can enjoy recreation activity while improving their health and awareness towards environmental sustainability. The indirect benefit is reduction of air pollution and greenhouse gas (GHG) emissions from burning fossil fuel. The aims of this study were to estimate amount of carbon balance from energy consumption and reduction of sport tourism based on the case study from Benja Burapha Cycling Rally, Sa Kaeo province, Thailand. CO_2 emission from fuel consumption of tourist transportation and CO_2 reduction by cycling rally and tree plantation were calculated according to the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines. 108 questionnaires were distributed to the tourists. The results found that the ratios of male and female were 68 % and 32 %. The average distance between home and start destination at Pang Sida National Park, Sa Kaeo province, was 313.79 ± 204.60 km. Total gasoline and diesel consumption for transportation was 1,127 and 1,409 L. Total GHG emission for fuel consumption was 6,333 kg CO_2-eq. The average GHG emission per person of transportation was 27.43 kg CO_2-eq. The GHG reductions from the bike cycling and tree plantation were 1,448 kg CO_2-eq and 1,786 kg CO_2-eq y^{-1}. The total CO_2 emission and reduction of the sport tourism were 27.43 and 36.37 kg CO_2-eq $person^{-1}$. The net CO_2 balance of the sport tourism was -8.94 kg CO_2-eq $person^{-1}$ y^{-1}.

1. Introduction

Earth's climate has changed during the past century and will continue to change significantly over the next few centuries. The mean temperature in the world was relative increasing changes of 0.6 ± 0.2 °C per year (Intergovernmental Panel on Climate Change (IPCC, 2001). The increasing rate of the mean temperature in Thailand during 1965 - 2006 was about +0.81 °C y^{-1} (Limsakul and Goes, 2008). The increasing rate of mean temperature in Thailand was higher than the mean temperature of the world of about 0.016 °C per decade (Chidthaisong, 2009). The predicted changes for the next 50 to 100 y are larger and faster than previously thought. Reilly et al. (2001) predicted and estimated the global mean temperature over the next 100 y will be at the high end of, or even exceed the IPCC 2001 predictions of 1.4 to 5.8 °C above the temperatures of the 1990 and 1 to 4.5 °C compared to the present for a doubling of atmospheric CO_2 (Kattenberg et al., 1996). Global warming is an important environmental problem nowadays because it involves remains of life on the earth. Global warming was resulted from the enhanced greenhouse effect in the atmosphere, caused by the elevated concentrations of greenhouse gases (GHG) such as mainly carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6) and Chlorofluorocarbons (CFCs). Among these greenhouse gases, CO_2 accounts for more than 60 % of total global warming potential (IPCC, 2001). The global average atmospheric CO_2 concentration has increased from about 285 ppmv (parts per million on a volume basis) in 1,850 to 367 ppmv in 1999, and is increasing at a rate of 0.5 % y^{-1} (IPCC, 2001). Daily human activities have caused severe impacts on global warming and an increase in greenhouse gas emissions. The transport sector was the fastest growing source of greenhouse gas emissions (GHG) worldwide especially the most traffic in the world for 2016 was Bangkok, Thailand (INRIX, 2016). Fuel burning from transportation sector was produced GHG emission in 2000 as about 44.70 Tg CO_2-eq or 28 % of total GHG emission of energy sector in Thailand (Office of transport and traffic policy and planning, 2013). Particularly in big countries, the increased use of cars is contributing to low air quality, traffic congestion and an increase in GHG emissions. In 2010, the

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transport sector was responsible for 22 % of global CO_2 emissions worldwide (IEA, 2013). Global transport related CO_2 emissions were expected to increase by 57 % in between 2005 - 2030 timeframe, representing the fastest growing source of GHG emissions worldwide (UITP, 2013). The scientists found the good practice for reducing impact of the environment from transportation sector, especially reducing energy consumption. Sustainable transport policy, with a clear role and place for cycling to public transport, can directly mitigate these negative side effects. As European cities such as Amsterdam and Copenhagen in Germany can significantly contribute to cleaner and safer cities, with and improved quality of life. The release of the fuel which used by transportation is an important factor that contribute to global warming. The tourism industry has very strong correlation with transport industry. When persons travel, we have to use transportation for travel. In this industry chain, each cluster contributes both direct and indirect carbon emissions. Normally, the mainly GHG emission in tourist activity was produced from transportation sector, according to previous research shown that GHG emission in transportation of Chinese tourism industry was the highest contributor about 48.25 % (Meng et al., 2016). According to the United Nations World Tourism Organisation statistics (2008), travel and tourism land transport (road and rail ways) direct carbon emissions were predicted to grow at an annual rate of 2 % per y through 2035. The trends of tourism industries in Thailand were very fast increasing growth in the past decade. International tourism is a major source for Thailand and a forceful developmental drive to circulate money from domestic tourists within the country (MTS, 2015). Estimates of tourism receipts directly contributing to the Thai GDP of 12 trillion baht range from 9 % (1 trillion baht in 2013) to 17.7 % (2.5 trillion baht) in 2015 (Turner, 2015). The income of tourism industry is an important for developing people and country but environmental care is similarly necessary protection. Tourism policy was supported and stimulated the green tourism of each country such as low carbon tourism and sport tourism. Currently, sport tourism in Thailand is promoting and supporting by tourism and sports minister in Thailand for example bike cycling is very popular activity of sport tourism because travelers get new experience for natural attraction and improve their health. It has indirect benefit for environmental care such as GHG emission reduction from tourist activity. Some activity of transport tourism can produce GHG emission to the atmosphere, for example, tourist transportation between home to start destination. The net GHG balance as well as emission and reduction of sport tourism in Thailand were limitation. We would like to estimate net GHG balance of transportation and sport tourism activities based on the case study from Benja Burapha Cycling Rally, Sa Kaeo province, Thailand.

Sa Kaeo is located about 50 km west of Poipet Cambodia - Thailand border and 245 km East of Bangkok in Eastern Thailand. In the past, it was once an important and prosperous community with a long history dating to the Suvarnabhumi and the Dvaravati Kingdoms, which is evident from various remains of ancient monuments and architecture scattered throughout the province as well as artefacts attesting to the history and glory of the past. Sa Kaeo also possesses abundant natural resources such as the Pang Sida National Park and the Ta Phraya National Park as well as the nice natural canyon-like soil sculpture caused by ground subsidence with unique characteristics. Sa Kaeo is a grand gate opening to Cambodia connecting international transportation and tourism within one route and near Thai border in Aranyaprathet. Rong Kluea Market offers both cheap and second-hand products from various neighbouring countries. The high potential of Sa Kaeo attractions is stimulate tourism in the province. The tourism industry is one of the activities resulting in the generation of primary gases causing climate change (Huang and Tang, 2016). Bike cycling is good alternative and new activity for travelling in this region. This has reduced GHG emission energy consumption in transportation. The estimated GHG emission and reduction from sport tourism as well as bike cycling in Thailand is very limited. The purpose of this study is to estimate the amount of CO_2 emission and GHG reduction of sport tourism in case study at Benja Burapha Cycling Rally for 2017, Sa Kaeo province, Eastern of Thailand.

2. Materials and Methods

2.1 Questionnaire Design

The 108 questionnaires were used to collect data to estimate the CO_2 emission and reduction in sport tourism in Benja Burapha Cycling Rally for 2017, Sa Kaeo province, Eastern of Thailand on 22 July and 20 August 2017. The questionnaire form was distributed in bike cycling website. To ensure the validity of the questionnaire by calculating the Item-Objective Congruence (IOC) index, the test was given to five experts to examine and rate each item so that the content met the objectives of the study. The IOC was calculated by assigning scores to three types of answers: congruent = 1, uncertain = 0, incongruent = -1. The result of IOC was 0.96 which was acceptable. Data were analysed by using statistical computer program and interpreted by section as follow;

Section 1: Personal information were analysed in terms of frequency and percentage.

Section 2: CO_2 emission and reduction of sport tourism activities in Sa Kaeo province were analysed energy consumption and reduction by cycling Rally, and tree plantation in forest.

2.2 Calculation of CO_2 Emission and Reduction in Transportation

A calculation of CO_2 released from energy used in tourist transportation during home to Pang Sida National Park. CO_2 emission was calculated by energy consumption and the emission factors of fossil fuel types via referencing the method of estimation and emission factors following the 2006 Intergovernmental Panel on Climate Change (IPCC) criteria (IPCC, 2006). The formula was as follows:

$$CO_2 \text{ emission} = \Sigma (EF_{Fuel} \times FC_{Fuel}) \quad (1)$$

Where CO_2 emission was the amount of CO_2 released from energy consumption, emission factor of fuel (EF_{Fuel}) was the CO_2 emission factor by fossil fuel types (based on the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC, 2006)). The EF_{Fuel} of gasoline and diesel fuels for transportation were 2.1896 and 2.7446 kg CO_2-eq L^{-1}. Fuel consumption (FC_{Fuel}) was calculated by multiple by the distance and fuel consumption rate separated by the vehicle types (Table 1). The GHG mitigation from bike cycling in Benja Burapha Cycling Rally for 2017, Sa Kaeo province was similarly calculated the GHG emission in transportation. We separated the vehicle and fuel type follow by questionnaire consequence. Total bike cycle distances of both cycling rally during 22 July 2017 and 20 August 2017 were 70 and 76 km.

Table 1: Fuel consumption rate separate by vehicle type

Vehicle type	Fuel type	Fuel consumption rate (km/L)	References
1. Small car (1,500 cm^3)	Gasoline	17.770	Pollution Control Department, 2012
2. Medium car type 1 (1,600 cm^3)	Gasoline	15.238	Pollution Control Department, 2012
3. Medium car type 2 (1,800 cm^3)	Gasoline	13.796	Pollution Control Department, 2012
4. Big car (≥ 2,000 cm^3)	Gasoline	12.248	Pollution Control Department, 2012
5. Average truck	Diesel	6.369	American Petroleum Institute, 2016
6. Van	Diesel	10.204	American Petroleum Institute, 2016
7. Bus	Diesel	2.850	American Petroleum Institute, 2016
8. Motor bike	Gasoline	36.625	Pollution Control Department, 2012
9. Big bike	Gasoline	38.655	Pollution Control Department, 2012

2.3 Calculation of carbon stock by forest plantation

Generally, aboveground biomass can be estimated from the allometric equations of stem, branch, leaf, and root. The equation for each forest is different because trees of different species may differ greatly in tree architecture and wood density. The carbon content is assumed to be 50 %. The average carbon stock in the biomass based on IPCC 2006 guidelines for national greenhouse gas inventory was 47 % carbon fraction (Thomas and Martin, 2012). In this experiment, carbon sequestration from forest plantation was used as the local emission factor as about 5.9375 t CO_2-eq ha^{-1} y^{-1} at tree density as about 625 trees ha^{-1} (TGO, 2015). 200 trees were planted in Pang Sida National Park. The biomass and carbon stock in the tree plantation at Pang Sida National Park, Sa Kaeo province were 3,800 kg dry matter ha^{-1} y^{-1} and 1,786 kg CO_2 ha^{-1} y^{-1}.

3. Results and Discussions

3.1 Demographic Information

Demographic information of tourist was shown in Table 2. The results found that the ratios of male and female were 68 % (73 persons) and 32 % (35 persons). The most status of the tourists was married about 71.30 %. They were come with their family to join the bike cycling and travel on the weekend. Everybody had like and enjoy the sport tourism activities as well as biking cycle and planting trees. The age frequencies of the tourists were 31 - 40 and 41 - 50 years old as about 76 %. The tourist age referred to the people was in working age period. The results found that 39% of the tourists had working in government sector and non-government officers were 47 %. The tourist group has quality and quantity potential for sport tourism in the country because they had more budget and body energy to relax and travel. Most of the tourist education level was graduated in bachelor degree. The salary rate per month of the tourist was quite high level rate in

the country as about 40,001 - 50,000 baht because some sport activity was more expensive. For example, the bicycle price is increasing according to the quality of material and safety system.

Table 2: Frequency and percentage of visitors' personal information

Personal information of visitors		Frequency N = 108	Percent (%)	Personal information of sample	Frequency N = 108	Percent (%)
Gender	Male	73	67.59	Occupation:		
	Female	35	32.41	Public Sector	26	24.07
Status	Single	28	25.92	State Enterprise	16	14.81
	Married	77	71.30	Private Sector	10	9.26
	Divorce	3	2.78	Merchant/Own Business	37	34.26
Age	< 20 years	0	0	Agriculturist	3	2.78
	20 - 30 years	6	5.56	Student	8	7.41
	31 - 40 years	27	25.00	Others	8	7.41
	41 - 50 years	55	50.93	Income:		
	51 - 60 years	20	18.52	0 - 15,000	12	11.11
	> 60 years	0	0	15,001 - 20,000	22	20.37
Education	Primary school	2	1.85	20,001 - 30,000	17	15.74
	High school	18	16.67	30,001 - 40,000	15	13.89
	Vocational school/Collage diploma	3	2.78	40,001 - 50,000	22	20.37
	Bachelor degree	54	50.00	> 50,000	14	12.96
	Higher Bachelor degree	31	28.70	N/A	6	5.56

3.2 CO_2 emission and reduction in sport tourism at Sa Kaeo province

The results shown that the average distances between home and start destination at the Pang Sida National Park, Sa Kaeo province was 313.79 ± 204.60 km. Total energy consumption of gasoline and diesel in transport sector of 108 tourists were 1,126.65 and 1,408.51 L (Table 3). Car and truck were the most popular vehicles for visiting this area with 48 % and 39 % frequency. Cars were occupied of Thai's more compared to previous times because Thai government's promotes economic policy by reducing the tax if they bought the first car on 2011 (Jammongchob et al, 2017). Total CO_2 emissions in transportation sector separated by the fuel consumption as gasoline and diesel were 2,466.92 and 3,865.81 kg CO_2-eq. The average CO_2 emission from transportation in the sport tourism was 27.43 kg CO_2-eq person^{-1} (Table 3). Jamnongchob et al, (2017) studied the CO_2 emission of tourist transportation in Suan Phueng Mountain, Thailand. They found that the average distances and CO_2 emissions in tourist transportation were 208.15 ± 139.38 km and 21.20 kg CO_2 person^{-1}. Car was the most popular vehicle for visiting tourism about 78 %. The distances of tourist transportation was mainly factor for estimated GHG production. The vehicle type was also necessary consideration since it was different fuel type and energy consumption rate. Loading of baggage, body weight, and automobile performance are also effect to fuel consumption. We should be consideration for estimate GHG emission from transportation in the future work.

Table 3: The energy consumption and CO_2 emission from tourist transportation to Sa Kaeo province

Type of fuels	Total energy consumption (L)	Average energy consumption (L/person)	Total CO_2 emission (kg CO_2-eq)	Total CO_2 emission (kg CO_2-eq /person)
Gasoline	1,126.65	8.19	2,466.92	17.94
Diesel	1,408.51	12.83	3,865.81	37.10
Total	3,758.35	10.83	6,332.73	27.43

Normally, mainly GHG emission in tourism industry occur fuel burning in transportation and tourism activity. Dwyer et al, (2010) studied about quantifying carbon dioxide emissions of Australian tourism industry. They found that carbon emission of tourism industry was 26.3 Mt CO_2-eq, accounting for 4.60 % of the total carbon emissions of Australia, including transportation 16.65 Mt CO_2-eq (63.30 %), accommodation 2.42 Mt CO_2-eq (9.22 %), shopping 1.85 Mt CO_2-eq (7.05 %), restaurants 0.75 Mt CO_2-eq (2.84%), and other services 4.63 Mt

CO_2-eq (17.59%). The tourism activity can produce GHG emission of about 40 % of the total carbon emissions in tourism industry. The mitigation options from the tourism activities are important to reduce the total GHG emission in this sector. Sport tourism is a good choice for reducing the CO_2 emission from the tourist activities. This is very popular with tourists of new generation because they can enjoy the recreation activity for improving their health and environmental care. The indirect benefit is the reduction of air pollution and greenhouse gas (GHG) emissions from burning fossil fuel. The result of carbon reduction was calculated from Benja Burapha Cycling Rally 2017 activities as well as bike cycling and tree plantation. The total energy avoids consumption from bike cycling as 576.28 L (Table 4). The total CO_2 mitigation of bike cycling separated by the fuel consumption as gasoline and diesel were 528.15 and 919.64 kg CO_2-eq. The average CO_2 reduction of bike cycling was 6.43 kg CO_2-eq person^{-1} (Table 4). CO_2 sink of 200 trees plantation in Pang Sida National Park was 1,786 kg CO_2-eq ha^{-1} y^{-1}. Tree is important with regards to carbon exchange between the earth and atmosphere. Normally, carbon cycle in the forest is initiated when carbon is fixed via photosynthesis. Some of the fixed organic carbon compounds are used to grow tissues and storage in plant biomass such as leave, stem and root. 200 trees were planted in Pang Sida National Park. The biomass and carbon stock in the tree plantation at Pang Sida National Park, Sa Kaeo province were 3,800 kg dry matter ha^{-1} y^{-1} and 1,786 kg CO_2 ha^{-1} y^{-1}. The total of GHG reduction from bike cycling and tree plantation from Benja Burapha Cycling Rally 2017 at Sa Kaeo province were 1,447.79 kg CO_2-eq and 1,786 kg CO_2-eq ha^{-1} y^{-1}. Both activities could reduce GHG emission from the tourist transportation as about 3,232.79 kgCO_2-eq y^{-1} or 51% of CO_2 emission from the transportation. The total CO_2 emission and reduction of the sport tourism were 27.43 and 36.37 kg CO_2-eq person^{-1}. The net CO_2 balance of the sport tourism was -8.94 kg CO_2-eq person^{-1} y^{-1}. It can avoid CO_2 production by both activities of sport tourism. We should reduce the CO_2 emissions by using public transport for tourism. Specific practices include promoting public transport and hybrid vehicles, electric vehicles, bicycles and other low carbon or carbon-free ways. Tourism area can adopt as far as cable car and other environmental transport models to reduce carbon emissions. For example, the Shanghai World Expo makes use of new environmental friendly vehicles to achieve a zero carbon emission (Yang, 2010). Sport tourism was good alternative green tourism for reduced GHG emission from tourism activity in Thailand.

Table 4: The fuel and CO_2 mitigation from bike cycling in Sa Kaeo province

Type of fuels	Total energy consumption (L)	Average energy consumption (L/person)	Total CO_2 emission (kg CO_2-eq)	Total CO_2 emission (kg CO_2-eq /person)
Gasoline	241.21	2.04	528.15	4.46
Diesel	335.07	3.07	919.64	8.43
Total	576.28	2.55	1,447.79	6.43

4. Conclusions

Transport sector represents a major share in the GHG emissions from the tourism sector. Sport tourism is one of the green tourism with low GHG emission. It is a new and popular tourism in Thailand because travelers get new experience from the natural attraction and improve health. Indirect advantages are the reduced fuel combustion and GHG emission in the transportation sector. Total energy consumption of gasoline and diesel in the transport sector in BENJA BURAPHA CYCLING RALLY for 2017, Sa Kaeo province, Eastern of Thailand during 22 July and 20 August, 2017 were 1,126.65 and 1,408.51 L. The total GHG emission of fuel consumption was 6,332.73 kg CO_2-eq. The average GHG emission in transportation was 27.43 kg CO_2-eq person^{-1}. The GHG reductions from bike cycling and trees planting for a year were 1,447.79 kg CO_2-eq and 1,786 kg CO_2-eq ha^{-1} y^{-1}. The total of GHG reduction from both activities for a year was 3,233.79 kg CO_2-eq or 36.37 kg CO_2-eq person^{-1}. The net CO_2 balance of the sport tourism was -8.94 kg CO_2-eq person^{-1} y^{-1}. CO_2 production can be avoided by both the activities of sport tourism. Sport tourism was a good alternative of green tourism for reducing the GHG emission in Thailand.

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