ENVIRONMENTALLY SUSTAINABLE DEVELOPMENT OF HOT SPRING SPA: A CASE STUDY OF GEOTHERMAL SPRINGS IN TENGCHONG, YUNNAN

MEI LIN

A Thesis Submitted to the Graduate School of Naresuan University
in Partial Fulfillment of the Requirements
for the Master of Science in Logistics and Supply Chain
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By Mei Lin

has been approved by the Graduate School as partial fulfillment of the requirements for the Master of Science in Logistics and Supply Chain of Naresuan University

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Title ENVIRONMENTALLY SUSTAINABLE DEVELOPMENT OF HOT SPRING SPA: A CASE STUDY OF GEOTHERMAL SPRINGS IN TENGCHONG, YUNNAN

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ABSTRACT

The rapid growth of the tourism industry has caused the exploitation and destruction of nature. Hot spring bath, as an important form of hot spring tourism in China, is expanding its development scale gradually. Thus, there is a declining in the quality of hot springs leading to a reduction in the number of visitors and a sign of declining in hot spring resorts business. A sustainable direction for development and operation of hot spring is needed in order to preserve natural resources and the quality of hot springs, while visitors can still visit the place for recreation. This study comprised of goal and scope definition, and life cycle inventory analysis, the first two major steps in conducting life cycle assessment, which is an appropriate approach to assess the environmental aspects and potential impacts over the life cycle of an outdoor hot spring bathing. The results showed that the energy footprint of the outdoor hot spring bath (within the system boundary) was 2,111 MJ per functional unit (200 visitors who spent two hour per day) or 10.56 MJ/visitor and the total water footprint was 1,198 m^3 per functional unit or 5.99 m^3/visitor. This study can aid in the energy footprint and water footprint assessment of an outdoor hot spring bathing of a hot spring resort in Tengchong, Yunnan, China. The hot spring bathing process with the major resource consumption can be identified and improved its resource consumption efficiently. Based on the results, the water circulation consumed the most energy consumption among the five energy processes, which accounted 53.82%

of total energy consumption or 5.68 MJ/visitor. The water transportation was the most energy-intensive sub-process in the water circulation process. The energy consumption of the water circulation process can be reduced by using energy-saving pumps. The water using process was the major water-intensive process through splash water and evaporation of the outdoor bathing process. Thus, using sustainable equipment during the water using process is beneficial for water consumption reduction. A deeper understanding and a quantitative approach in improving the resource and environmental protection category of the China's tourist attraction rating system could be obtained by analyzing the LCI results to identify the processes with potentially significant energy and water consumption impacts.

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CHAPTER I

INTRODUCTION

Despite socio-economic benefits of the locals, hot spring tourism could post negative impacts on the local environment. Due to the high return rate of investment on hot spring tourism, currently, the investment on hot spring resorts in China is over 100 million Yuan over the area of 100 hectares (Xiang Yunbo, 2006). The rapid growth of hot spring tourism business also utilizes significant amount of local resources, e.g. agricultural products, electricity, water and labors, in operating and providing services to visitors. Thus, there is a declining in the quality of hot springs leading to a reduction in the number of visitors and a sign of declining in hot spring resorts business.

Tengchong in Yunnan, China, is known as the city of hot springs. The city, where most of the hot spring tourism activities in China occur, has over 88 hot spring hotels and resorts (Feng Chunhong, 2013). Visitors generally visit hot springs to experience hot spring spa or dine at a decent restaurant for relaxation. Other activities of hot spring tourism are e.g. massaging, swimming, golfing and rafting. The hot spring tourism industry in Tengchong is growing and showing a significant demand in resource consumption to maintain and to promote the strong market of hot spring tourism in the city. Examples of the resources used at hot spring hotels and resorts are electricity, water and diesel oil (Tang Qing, 2013). Over consumption of resources could deteriorate the hot springs. Thus, hot spring tourism industry needs development and operation direction to preserve natural resources and the quality of hot springs, while visitors can still visit the place for recreation.

Based on the information from over 931 hot spring hotels in Yunnan, there are various environmental impacts contributed throughout the life cycle of hot springs tourism (Yu Ganqian & Hu Hongbin，2000). Such environmental impacts are over exploitation of natural resources, land subsidence and horizontal displacement, soil damage, water pollution, heat and hazardous gas emissions such as CO_2 and CH_4 (Filimonau, Dickinson, Robbins, & Reddy, 2013). Inventories of inputs and outputs related to such environmental impacts should be quantified and investigated in order to identify processes with the major resource consumption and the major impact contribution. Therefore, life cycle assessment (LCA) is an appropriate tool in quantifying environmental impact and resource consumption (inputs) and production (outputs) over the life cycle of products or services (ISO 14040). A process with major impact contribution (hotspot) can be identified, while a comparative LCA results can aid in a decision making process. LCA consists of four steps which are 1) goal and scope definition, 2) life cycle inventory analysis (LCI), 3) life cycle impact assessment (LCIA) and interpretation of the results(Kuo & Chen, 2009). LCI of the hot spring bathing has not been conducted in any study. This study will be conducted up to LCI step to quantify inputs and outputs of a hot spring bathing of a hot spring resort in Tengchong, Yunnan. The LCI results will be used to provide recommendation on resource consumption efficiency improvement.

The goal of this study is to improve the resource consumption efficiency of activities at hot spring, particularly on hot spring bathing activity, based on LCI results. Hot springs in Tengchong, Yunnan will be investigated as a case study. In addition, China has its tourist attraction rating system called the Tourist Attraction Rating Categories of China. The rating system considered e.g. transportation, health and safety, and resources and environmental protection. However, the rating system does not reflect environmental impacts from resources consumption and production. Therefore the 3 objectives of this study are：

1. To identify the process with major resource consumption of hot spring bathing activities and to provide recommendations on business's efficiency improvement according to the comparative LCI on a yearly basis.

2. To investigate for methods/processes to improve resource consumption efficiency.

3. To provide recommendations on the environmental aspect of Tourist Attraction Rating Categories of China based on the LCI results

CHAPTER II

LITERATURE REVIEW

This chapter describes the existing situation of tourism industry in Yunnan and its trend. Particular information on hot spring tourism in Yunnan is included. The policies of the government of China and other countries related to the hot spring tourism industry are reviewed. Life cycle assessment (LCA) in connection with the hot springs is also presented.

The tourism industry in Yunnan

Yunnan Province is the seventh largest tourist destination in China (Xiang Yunbo, Xu Changle, Peng Xiufen, 2017). The province is located in the Southwest of China. Though the weather of Yunnan is dry and Spring-like all year round, its tourism is seasonal (Xiang Yunbo, Xu Changle, Peng Xiufen, 2017). During the Spring Festival, May Day, National Day, summer vacation and Xishuangbanna Water Splashing Festival, the number of visitors may reach 32,000 persons/day. The number of visitors in February, March and November after the Spring Festival may decrease by 39% compared to other times of the year (Wang Yanping, 2014). Generally, the type of tourism in Yunnan is mass tourism (Liang Naiying, 2018).

Yunnan is abundant in resource-based and manmade scenic spots. Located in Yunnan Province are 6 provincial tourist resorts, covering 13,000 square kilometers or 3.3% of the total land area of Yunnan Province. There are 72 scenic spots, for example, Dali Old Town, Lijiang, and so on in Yunnan. According to the first-hand information obtained by the SPA Association, there are more than 1,266 hot spring sources identified in Yunnan Province, accounting for about one-third of the total number of known hot springs in China (Liu Shibin, 2015). In addition, Yunnan's geothermal activity is the most famous in the country. Among them, Tengchong Hot Spring is the most representative. It not only has a large flow of hot springs, but also has rich geothermal resources (Liu Shibin, 2015). Tengchong is rich in historical and cultural tourist attractions. It is an important port city where Yunnan communicates with Southeast Asia and South Asia. Under the influence of ancient culture and modern civilization, a variety of building types have been formed. There are mainly 6 types of buildings, which are religious buildings, residential buildings, former residences of celebrities, rural buildings, ritual buildings, and bridges. Tengchong also has an earlier history and a more developed culture, thus it has developed mineral resources, animal and plant resources as raw materials. Therefore, this has made Tengchong formed into a tourist product with a certain degree of popularity and characteristics in the domestic and foreign markets. Among which, Tengchong jade carvings, rice paper, Tengchong bamboo ware, root carvings, etc. are more representative (Lin Yingjie & Zhang Yanwen, 2016).

Hot spring tourism is essentially the tourists' experience of bathing culture in hot spring tourist destinations. The development of hot spring tourism is the shaping of hot spring bathing culture. Hot spring tourism economy is a characteristic economy, where characteristic is the soul of tourism, and culture is the basis of characteristic (Liu Shibin, 2015). In China, hot spring tourism resources are a kind of ubiquitous resources. With the emergence of a large number of hot spring tourism resorts, tourists are not only satisfied with the needs of hot spring treatment, but also pursue the comprehensive cultural experience of hot spring tourism destinations (Xiang Yunbo, 2006). The cultural characteristics of hot spring tourism have become a key factor in determining the competitiveness of hot spring tourism destinations. Consequently, hot springs in Tengchong are a tourist project worthy of attention.

Hot spring tourism in Tengchong County, Yunnan Province

Yunnan Province has a long history of geothermal, creating the unique advantages of Yunnan hot springs. Hot spring tourism is defined as a tourism for health preservation, leisure and vacation (Liu Shibin, 2015). Hot spring tourism is popular among both tourists and local people to moisten the skin, dredge pores and relieve pressure (Xiang Yunbo, 2006).

Tengchong County, Baoshan City, Yunnan Province is a geothermal natural museum. Tengchong is well-known for its famous hot spring. The county has the largest number and the largest density of hot springs in Yunnan Province. There are numerous types of hot spring in Tengchong, e.g. giant springs, high-temperature boiling hot springs, low-temperature carbonated springs and fountains. In addition, the hot springs in Tengchong are complex and rare in China.

Yunnan in the southwest is the most concentrated area of geothermal in China (Liang Naiying, 2018). However, due to the underdeveloped economy and inconvenient transportation, the development of hot spring tourism has not been well developed, with an exception for individual hot springs in Yunnan Province, such as Anning Hot Springs. The hot springs, which are relatively close to Kunming, have become a weekend sightseeing destination for urban residents. Some hot springs in the west are used to attract long-distance tourists from places such as Beijing and Shanghai during May Day, National Day, and Spring Festival (Xiang Yunbo, 2006). The hot spring is in the daily life use level of local residents. Although Yunnan's hot spring resources are extremely rich, the lack of funding for the development of hot spring tourism has become one of the obstacles to the development of the industry. For instance, Tengchong is in an underdeveloped area, and its various economic indicators are far below the national average. The development of hot spring tourism projects is a high-investment project planning, requiring a lot of funds for the construction of hot spring scenic spots, infrastructure, and tourist reception facilities.

Tengchong lacks of tourism product development. There are basically no shops or markets specializing in the sale of tourist goods within the territory of tourist destination. The only temporary simple tourist goods store is located at the Tengchong Bus Hot Spring Terminal Station. The store also sells tourist goods imported from the external market. There are no tourist goods with local characteristics in Wenquan Town. In addition, most of the other stores also sell a few foreign tourist goods, incidentally. The emptiness of tourism product development is extremely inconsistent with the goal of building a tourist town in the hot spring town. It lacks individual products, does not have the characteristics of a tourist town, and cannot fully reflect the hot spring town's bathing culture and historical culture.

Some scholars have also conducted research on the problems in the development of hot springs. Xiang Yunbo (2006) proposed a general model for the transformation of China's Wenquan from soup treatment to recuperation, maintenance, sightseeing, and finally entertainment. Lin and Yanwen (2016) provided a more comprehensive discussion on the regional characteristics of hot spring tourism development. The discussion focused on the evolutionary process of China's hot spring utilization and the actual characteristics of hot spring tourism utilization. The results suggested that the actual utilization of hot spring tourism in China should be from two dimensions – temporal and spatial scales.

Hot spring tourism area consists of various elements. Such elements are e.g. a spa, pools with different function, playground, cafeteria, viewing hall and beauty salon. Among the elements, hot spring spa is the most important entertainment activity in hot spring tourism area. After providing a hot spring spa service to tourists, a lot of water was discharged to wastewater treatment system. In addition, the intake of hot spring spa is relatively large. The spa consume vast amount of water and energy (Cai Yihan, 2004). Though other entertainment facilities consume electricity, hot spring spa is the most natural resource and energy intensive one (Lin

Yingjie, Zhang Yanwen, 2016); thus hot spring spa is the main area of investigation in this study.

Policies on hot spring management for tourism

1. International policies on hot spring management

Internationally, the government attaches great importance to hot spring management, and the law guarantees it first. As for the management of resources, it is difficult to rely on enterprises alone, and the government's behavior is also needed. Japan enacted the hot spring law as early as July 10, 1948, with the purpose of protecting hot springs, making rational use of them, and promoting the public welfare of hot springs. In order to promote the public use of hot springs, rectify and improve the hot spring utilization facilities, and make the necessary areas designated possible, laws and regulations are formulated. The protection, utilization and development of hot springs are clearly stipulated in the hot spring law. For example, the contents of hot spring protection include: The criteria of land excavation permission (not permission) for hot spring development, the cancellation of permission, the order of necessary measures to ensure public welfare, the order of original restoration, the permission to expand excavation and set up power plant, the order of hot spring excavation restriction, the approval of the director of the environment department, the restriction of land excavation for destinations other than hot spring development, and so on, hot spring water supply permit for bathing or drinking, publicity of hot spring ingredients, area designation, facility improvement instructions, reporting obligation of hot spring managers, on-site entry inspection, cancellation of bathing and drinking permit, etc. With regard to land mining permission, in order to protect resources, Japan divides area of hot springs into three types: special protection area, protection area and general area. It is forbidden to raise water and dig new hot spring wells in the special reserved area. It is forbidden to excavate new hot spring wells 100-150m around existing hot spring wells in Japan. In order to prevent the negative impact of hot spring mining, the hot spring law of Japan also stipulates the obligation of recovery, which is worth learning (Lin Yingjie & Zhang Yanwen, 2016).

Finally, strict technical standards, regulate industry behavior. In the process of using hot spring resources in Japan, the demand for hot spring resources is high. The use of warm spring raw water is strictly managed to prevent the abuse of hot spring resources. For large water facilities such as hot spring swimming pool and water playing project, the reuse system of backwater purification treatment is used. For the management of hot spring in the process of use, there are also clear provisions in the hot spring law. The consulting and public hearing organization of hot spring management in Japan is the hot spring review conference. According to the hot spring law, the use of hot springs must be considered from the perspective of public health and protection of hot spring sources. When necessary, the hot spring management organization can restrict and cancel the use rights of the exploiters or facility managers. In addition, hot spring operators have the obligation to submit reports on the amount, temperature, composition and utilization of hot springs to the hot spring management organization (Qing Tang, 2013).

2. China policies on hot spring management

In China, there is a special policy for hot spring tourism, called “ The water law of the people's Republic of China”, which is to protect the reasonable development of hot spring resources. It was stated in the law that: 1) The water administrative departments of the local people's governments at or above the county level shall be responsible for the unified management and supervision of water resources within their respective administrative areas within their prescribed limits of authority and 2) Units and individuals that directly take water resources from rivers, lakes or underground shall, in accordance with the provisions of the state water taking license system and the system of paid use of water resources, apply to the water administrative department or the river basin administrative agency for a water taking license, pay the water resources fee, and obtain the right to take water. However, a small amount of water for family life, scattered or captive livestock and poultry drinking is excluded (Peng Li, 2010).

According to the water law, the approval authority of the water taking license is delegated to the county level government. Because the exploitation of hot spring water generally does not exceed the upper limit of the approval authority of the county level government; therefore, the county level local government can directly apply for the water taking license for the hot spring resource exploiters, and has the law enforcement power to supervise and manage the water taking units (Peng Li, 2010).

Life cycle assessment (LCA)

Life cycle assessment (LCA) is recognized as a comprehensive and analytical approach to assess the environmental impact over the entire life cycle of a product or service (ISO, 2006). Phases of a product or service over its life cycle consist of raw material acquisition, manufacturing, use, transportation and end of life (Hellweg and Canals, 2014). LCA was proposed in the early 1970s, aiming to analyze the energy consumption for different processes initially. Later, LCA was also adopted to quantify raw material consumption and emissions. LCA can be conducted by quantifying all inputs and outputs of the entire operating system to study how the outputs affect the environment (Kuo & Chen, 2009).

LCA is a standardized approach by the international organization for standards (ISO) as a technology for assessing environmental aspects and potential impacts associated with a product (ISO, 2006). According to ISO 14040 series, LCA consists of four stages: 1) Goal and scope definition, 2) inventory analysis, 3) impact assessment and 4) interpretation, as depicted in Figure 1.

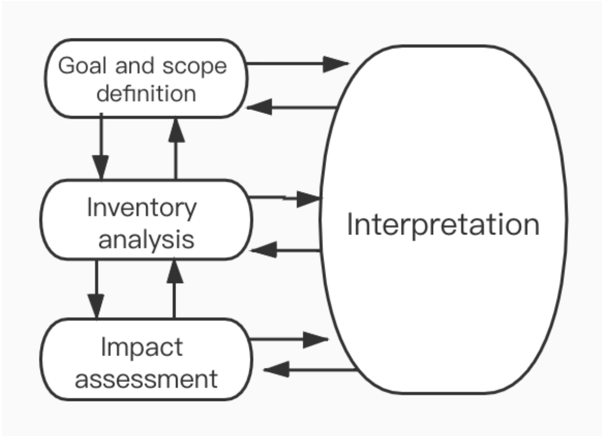

Figure 1 Phases of a LCA

Source: Adapted from ISO 14040, 1997

1. The four stages of LCA

According to standard provisions, LCA includes the following four stages (Abbas & Handler, 2018).

1.1 Goal and Scope Definition: This stage of LCA defines the purpose and scope of the LCA study to make it consistent with the expected application.

1.2 Inventory Analysis: This stage is to compile a list of inputs and outputs related to the researched product system, including data collection and calculation, in order to quantify the related inputs and outputs of a product system. These inputs and outputs include resource use and pollution discharge to air, water and land.

1.3 Impact Assessment: This stage uses the results of life cycle inventory analysis (LCIA) to assess the potential environmental impacts related to the inputs and outputs.

1.4 Interpretation: This stage combines the results related to the research purpose found in the inventory analysis and impact assessment to form conclusions and recommendations.

2. Energy footprint

Energy footprint is used to describe and analyze the energy consumption over the entire life cycle of a process, resulting in environmental impacts (Wang Yanping, 2004). Energy footprint is derived from the concept of ecological footprint, which converts the energy consumption in the region into the area of bio productive land for calculation. (Claude Kaspar, 1985). In tourism contexts, ecological footprint may refer to the area of biological production land necessary for resource consumption and waste absorption related to tourism activities in a certain space-time range (Wang Yanping, Shancun Shunci, 2002). The earliest research results in introducing energy footprint model into tourism industry in China were found in 2004 (Wang Yanping, 2004). At present, an energy footprint approach is still at the exploratory stage in China, and the research results are mostly applied research type (Tang Yuejun, Liang Caixia, 2019). For example, the extension of tourism destination ecological security theory, according to the energy footprint model, and the tourism destination ecological security evaluation method based on the index system were used to evaluate the ecological security status of specific tourism destination in Kaifeng City (Sun J.W., 2002). According to Yang Guihua, *et al.* (2018), comprehensive tourism development is the key to solving singleness of tourist attractions. The richness of the natural and cultural landscapes surrounding the hot spring area becomes the key to the success of the comprehensive development of hot spring tourism. Generally, the more types of natural and cultural landscapes and the higher the resource level of a hot spring area, the greater its overall tourist attraction intensity . Thus, in this study, an energy footprint of hot spring water bath activities will be examined to indicate the level of energy intensity of the activities. (Tang Yong et al, 2016).

3. Water footprint

Water footprint refers to the amount of water resources required for all products and services consumed by a country, a region or a person for certain period of time (Cai Yihan, 2004). Water footprint in tourism industry refers to the total amount of water resource needed to produce products and services consumed by inbound and domestic tourists (Tang Yong et al, 2016).

However, there is a lack of studies on water footprint of tourism industry in China (Liu Shibin, 2015). The concept of the water footprint of tourism destination consists of two parts, direct and indirect water footprints. Direct water footprint is physical water directly used in accommodation, entertainment and other aspects. Indirect water footprint is virtual water implied in catering, transportation and other aspects (Cai Yihan, 2004). Water footprint of tourism consists of 4 parts: accommodation, entertainment, catering and transportation (Lin Yingjie, Zhang Yanwen, 2016). The composition of water footprint of tourism can be extended to the consumption of water resources in environmental sanitation, green space greening, fire protection and other aspects (Tang Yuejun, 2019).

The characteristics of the hot spring tourism market also show that there is a strong negative correlation between seasonal variation and climate. Taking Guangdong Yinzhan Hot Spring Tourism Resort as an example, the correlation coefficient between the annual and monthly average tourists and the monthly average temperature is significant. Specifically, the cold season is the peak season for hot spring tourism, while the hot season is the low season for hot spring tourism. Therefore, the difference between the off-peak and peak seasons has become an unavoidable problem in the development of hot spring tourism. This year, due to the impact of the virus, there is not much difference between off-season and peak season. This study involves direct and indirect water footprints (He Qin, 2010).

Life cycle inventory analysis (LCI) of hot spring tourism

LCI is an analysis of a comprehensive list of inventories over the life cycle of a product or service being investigated (Bacon, 1989). The inventories generally consist of quantity of resources consumption (e.g. water and energy consumptions) and environmental emissions (e.g. wastewater, solid waste and other environmental emissions) over the entire life cycle of products, technologies or activities. The core of inventory analysis is to establish the resource input and output of a product represented per product’s functional unit (Claude Kaspar, 1985).

Although in the research field, the research on the application of LCI in tourist attractions is basically blank, based on the analysis of LCI theory, it is concluded that the development of China's tourism industry also has the characteristics of stages, which can be roughly divided into the take-off stage, the development stage, the mature stage and the high consumption stage. These stage characteristics are closely related to investors' choice and judgment of hot spring scenic spots (Lei Li, 2005).

According to (Liu Shibin, 2015), investor decision-making behavior is primarily based on the choice of the location of hot spring tourism, investor behavior determines the investment scale of hot spring tourist destinations. Generally, large-scale hot spring resorts not only require high-quality environment creation, but also need to build high-standard hot spring bathing, accommodation, catering, entertainment and other tourist facilities, thus large quantity of financial support is needed, such as the Qingxin Mineral Spring Tourism Resort. Small hot spring tourist destinations, such as the family workshop-style hot springs in the mountainous areas of northern Yunnan, require much less capital (Tang Yong et al. 2016). In other words, the grade and scale of the development of hot spring resorts is largely determined by the investment intensity of investors. Thirdly, the behavior of investors determines the development direction of hot spring resorts (Tang Yong et al. 2016). The direction of development is related to personal factors such as investor experience, intelligence, preferences, desires and attitudes. For example, some investors choose the development direction of comprehensive hot spring tourism, and some choose the development direction of themed hot spring tourism.

CHAPTER III

RESEARCH METHODOLOGY

Life cycle inventory analysis (LCI) of outdoor hot spring bathing in Tengchong, Yunnan, was conducted from cradle to grave. The LCI was used to evaluate for energy footprint ,and water footprint of the outdoor hot spring bathing. Then the results were used as guidelines to specify recommendations on the reduction of bathing's energy and water consumption from literature review. In addition, recommendations on improving the Tourist Attraction Rating Categories of China were provided.

Life cycle assessment of outdoor hot spring bathing

1. Goal and Scope Definition

A cradle-to-grave LCA was conducted to assess for energy footprint and water footprint of the traditional outdoor hot spring bathing in Tengchong, Yunnan, China. The outdoor hot spring bathing provides service for 12 hours per day. The functional unit of this study was 200 visitors who spent 2 hours per service, which was averaged from the numbers of visitors of hot springs in Tengchong from 2016 to 2019 before the outbreak of coronavirus 2019 (Additional information are provided in Appendix A). Although outdoor hot spring bathing requires infrastructure in and around, e.g., open pavilion, lounge, and changing room, those were excluded from the system boundary of this study. The energy footprint and water footprint of the construction phase were considerably low compared to the impacts from use phase (Yinghui Zhang, 2012). The system boundary included six processes of outdoor hot spring bathing, which were: 1) spring water collection, 2) spring water processing, 3) spring water using, 4) spring water circulation, 5) spring water equalization, and 6) wastewater treatment, as illustrated in Figure 2.

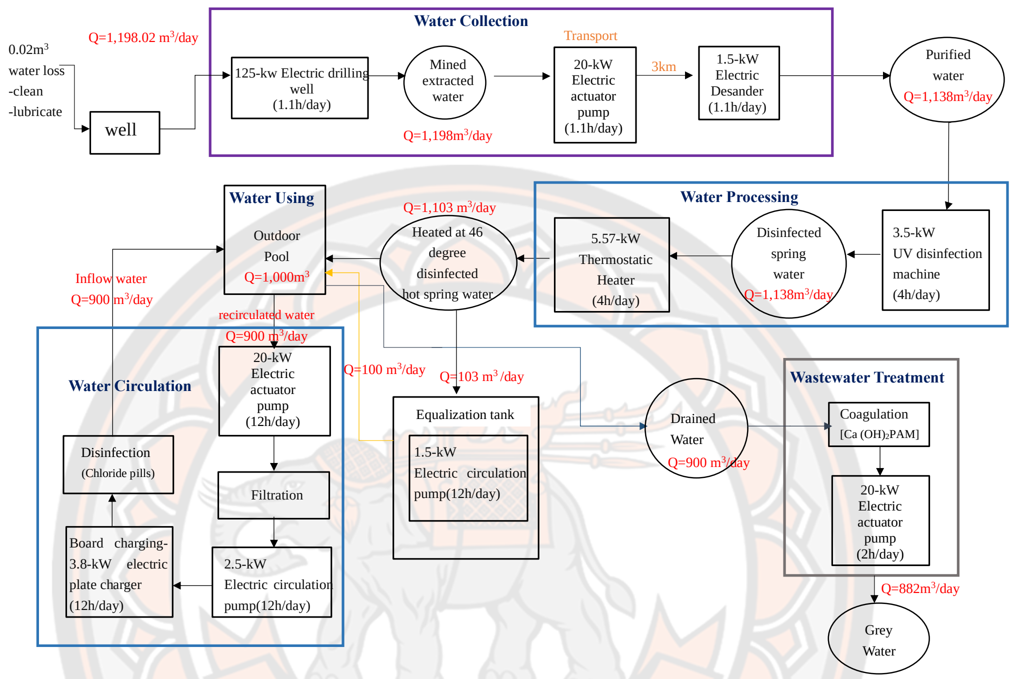

Figure 2 System boundary of outdoor hot spring bath

1.1 Spring water collection

Generally, spring water transported to hot spring baths was from spring water resources located within approximately 3 km of hot spring water bathing's proximity (Wang Yanping, 2011). The water collection process consisted of 3 sub-processes, which were well drilling, water transporting and sand separation. Each well drilling can extract approximately 2,000 m^3 of spring water by using a 125-kW electric drill for 2 hours daily. The volume of spring water needed to be extracted and transported was 1,198 m^3 with 5% loss by volume by using 20-kW electric drill for 1.2 hours daily. Another 0.02 m^3 of water was injected to clean the bottom of the well and to lubricate the drill bit. The drilled water was mined and transported to sand separation unit for 3 km by using a 20-kW electric actuator pump. For the sand separation unit, the 1.5-kW electric desander was used to remove solid particles and tiny suspended particles in the hot spring water. When the hot spring water enters the equipment through the water pipe, it first forms a circular fluid inclined downward along the tangential direction of the circumference of the cylinder, and the water flows downward along the inner wall. When the water reaches the cone and approaches the bottom, it turns upward along the axis of the cylinder. Then the impurities are further intercepted by the filter screen and discharged by the outlet pipe. The impurities fall into the lower sewage collector along the inner wall of the cone under the action of the fluid rotating centrifugal force and its own gravity. During transportation and sand separation sub-processes, mixtures and impurities were filtered, so 5% of the water was lost with the mixtures and impurities. Then, the 1,138 m3 purified spring water was transported to the spring water process.

1.2 Spring water processing

The water processing consisted of 2 sub-processes, which were UV disinfection, and water heating. It is necessary to disinfect and to maintain the level of temperature of water after mining at 46 degree Celsius. Hot spring water was disinfected by using ultraviolet disinfection machine, with the power of 3.5-kW and working 4 hours per day. Then, the disinfected spring water was transported to be heated by using thermostatic heater to maintain the water temperature at 46 degree Celsius, with the power of 5.75-kW and works 4 hours per day. During the sub-process of UV disinfection, there was scale accumulation on the casing, so it was necessary to leave 3% water for automatic cleaning and cleaning of the casing, to ensure the normal operation of the equipment and ensure the bactericidal rate. Then, the 1,103 m^3 disinfected spring water was transported to the spring water using process and spring water equalization tank process.

1.3 Spring water using

The 1,000 m^3 disinfected hot spring water was transported to an outdoor pool, which was the 1,000 m^3 of hot spring water for 200 visitors who spend 2 hours (functional unit) per day. During the whole process of water using, there was totally 10% water loss through splash water and evaporation. Then, the 900 m^3 using water was transported to the spring water circulation process per day.

1.4 Spring water circulation

The 900 m^3 using water was circulated twice a day. The water circulation process was circulating used water to keep the standard of water using, which was combined by four sub-processes: filtration, circulation, board charging, and disinfection including transportations of water, by 20-kW electric actuator pump working 12 hours daily, from one sub-process to another. For the filtration sub-process, it was a kind of anti-corrosion metal filtration, which was installed in the hot spring pool before the circulating suction, and was conducted to filter the hair, fiber and other debris in the spring water pool. After filtration sub-process, the spring water was transferred by using a 2.5-kW electric circulating pump for 12 hours daily. During the using process of spring water, the temperature of water would drop. Therefore, the 3.8-kW electric plate charger was used to maintain the water temperature, which was working 12 hours per day. At last, the caustic soda (water purification agent) was used for disinfection before the cycling using.

1.5 Water Equalization

During the using of the outdoor hot spring pool, changes always occur. These changes resulted in changes in outdoor pool water volume and tank storage volume. The operation of the outdoor system is safe and reliable only when the outdoor pool water volume and tank storage volume of the system are in a state of dynamic balance, which is a function of the water equalization tank. The 103 m^3 disinfected hot spring water was transported to the equalization tank, and the 100 m^3 water was transferred by using a 1.5-kW electric circulating pump for 12 hours daily to maintain the volume of outdoor hot spring pool. Another 3 m^3 water was left as the tank storage volume, which sensing outdoor pool water volume changes, and timely replenishment.

1.6 Wastewater treatment

The wastewater treatment process consists of 2 sub-processes, which are coagulation sedimentation and water transportation. The outdoor bathing produced around 900 m^3 with 2% water loss of hot spring water per day. After condensation, treating the water needed using around 5 ppm $Ca(OH)_2$PAM per one m^3 of water. The wastewater is totally discharged by 20-kW electric actuator pump for 2 hours and the 2% water was used to flush the pump every day and the treated water was used for other purposes, such as watering flowers, car washing, etc.

2. Life cycle inventory analysis

One of the objectives in this study was to examine energy footprint and water footprint of the hot spring bathing in Tecngchong, Yunnan, therefore, inventories relevant to the two main resources, which were energy and water, of each hot spring bathing process were collected. Another objective in this study was to compare the relevant inventories on a yearly basis. Then, energy resources, greenhouse gas emissions (GHGs) and water resources were assessed. Inventories for LCI of hot spring bathing in Tecngchong are listed in Table 1.

Table 1 A list of inventories of outdoor hot spring bathing in Tengchong, Yunnan

Processes	Sub-process	Duration (h/d)	Power (kw)	Water (m^3/d)	Source of data
Water collection	Drilling Well	1.2	Electric drill TSJ600/660 125kw	1,198m^3+5% water loss	Interview the resort's manager Baidu Wenku
	Water transportation	1.2	Engine-RTC pump Engine- AOX Electric actuator 20kw		
	Electric Desander	1.2	DS250 Desander 1.5kw		
Water processing	UV disinfection machine	4	Engine- UVC-60 Ultraviolet sterilize 3.5kw	1,138m^3+3% water loss	Interview the resort's manager Baidu Wenku
	Thermostatic heater	4	Engine- ST-11 Thermostatic heater 5.75kw		

Processes	Sub-process	Duration (h/d)	Power (kw)	Water (m^3/d)	Source of data
Water Using	-	12	-	1,000m^3+10% water loss	Interview the resort's manager Baidu Wenku
Water Circulation	Circulation	12	Engine- AAP-100 water circulating pump 2.5kw	-	Interview the resort's manager Baidu Wenku
	Board charging	12	Engine- XFE-12 plate charger 3.8kw		
	Water transportation	12	Engine-RTC pump Engine- AOX Electric actuator 20kw		
Water Equalization Tank	Circulation	12	Engine- AAP-50 water circulating pump 1.5kw	103 m^3+0.23% water loss	Interview the resort's manager Baidu Wenku
Wastewater Treatment	Water transportation	2	Engine-RTC pump Engine- AOX Electric actuator 20kw	900 m^3+2% water loss	Interview the resort's manager Baidu Wenku

Recommendations on environmental performance improvement of hot spring resorts

1. Recommendations on energy and water consumption reduction

Based on the LCI analysis results from Life cycle assessment of outdoor hot spring bathing, processes, and sub-processes with the most energy , GHG emission and/or water intensive of outdoor bath were identified. Recommendations on energy, carbon and water footprints improvement were provided based on approaches collected from peer-reviewed journal articles, government reports and other reliable sources.

2. Recommendations on Tourist Attraction Rating System in China improvement

One of the objectives of this study is to provide recommendations on the environmental aspect of Tourist Attraction Rating Categories of China, which does not reflect environmental impacts from resources consumption and production. The rating considers the following aspects: transportation, health and safety, and resources and environmental protection. Existing criteria on resource and environmental impacts of the Tourist Attraction Rating System was reviewed. Then, recommendations provided as policy recommendations to improve resources and environmental protection aspect of the Tourist Attraction Rating System, particularly for hot spring spa, were provided based on the LCI analysis results from Life cycle assessment of outdoor hot spring bathing.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter analyzes the footprints of energy, carbon and water of outdoor hot spring bathing in Tengchong, Yunnan. The six major processes of the outdoor hot spring bathing were: water collection, water processing, water using, water circulation, water equalization, and wastewater treatment. For an assessment of the energy footprint and carbon footprint, only five major processes were examined, as presented in Energy footprint and carbon footprint of outdoor hot spring bathing in. Tengchong, Yunnan. The water using process was excluded due to the lack of its energy consumption. The six major processes were evaluated for water footprint. The water footprint is presented in Water footprint of outdoor hot spring bathing in Tengchong, Yunnan. The average annual energy consumption, GHG emissions, and water consumption per tourist of the outdoor hot spring bathing in Tengchong, Yunnan from 2016 to 2019 were compared and presented in Comparative energy, carbon and water footprints of the outdoor hot spring bathing in Tengchong, Yunnan from 2016 to 2019. Then, recommendations on energy consumption reduction and water consumption reduction of outdoor hot spring bathing in Tengchong, Yunnan are given in Recommendations on Energy Consumption Reduction of the Hot Spring and Recommendations on Water Consumption Reduction of the Hot Spring, respectively. The recommendations on improving business's efficiency according to the comparative study on a yearly basis from 2016 to 2019 are presented in Recommendations on improving business's efficiency according to the comparative study on a yearly basis from 2016 to 2019. In addition, recommendations on improving the Tourist Attraction Rating Categories of China based on the LCI results are provided in Recommendations on improving the Tourist Attraction Rating Categories of China based on LCI results.

Energy footprint and carbon footprint of outdoor hot spring bathing in Tengchong, Yunnan

This section presents the energy footprint and carbon footprint of outdoor hot spring bathing in Tengchong, Yunnan. The results include energy consumption and GHG emissions of the five processes, which are water collection, water processing, water circulation, water equalization, and wastewater treatment.

The five processes of the outdoor hot spring bathing process all consume energy (electricity). Energy footprint in the outdoor hot spring bathing process was collected in kWh and then converted to MJ (3.6 MJ/kWh). According to Figure 3, the total energy footprint of the five outdoor bathing processes in serving 200 visitors for 2 hours a day (one functional unit) was approximately 2,111 MJ. Among the five processes, the most energy-intensive process was water circulation process, which accounted for 53.8% of the total electricity consumption in the outdoor bathing process or 5.68 MJ/visitor. Energy consumed by water collection, wastewater treatment, water processing and water equalization accounted for 29.98%, 6.82%, 6.31% and 3.07% of the total electricity consumption in the outdoor bathing process, respectively. The energy footprint of each process of the outdoor bathing processes are presented in Figure 3.

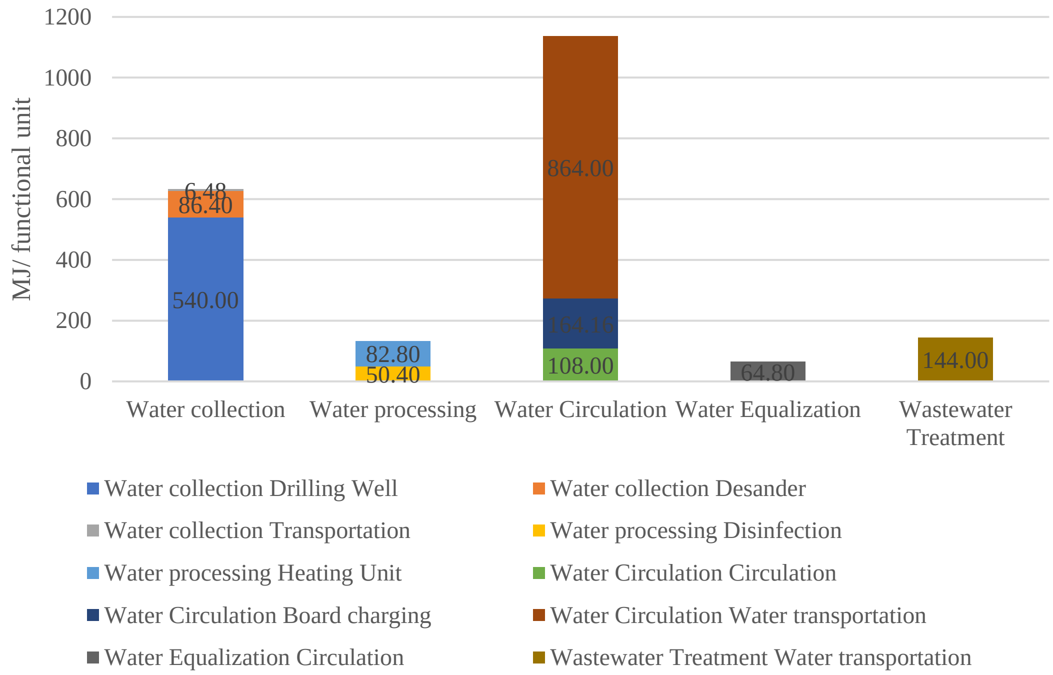

Figure 3 The energy footprint of each process and its sub-processes of hot spring bath

Based on Figure 3, the water circulation process has the largest energy footprint, accounted for 53.82% or 5.68 MJ/visitor. Other energy-intensive processes were water collection, wastewater treatment, water processing and water equalization, accounted for 29.98%, 6.82%, 6.31% and 3.07% of the total energy footprint of the outdoor bathing, respectively. The major energy footprint of the water circulation process was from water transportation, accounted for 76.05% of the total footprint of the water circulation process and accounted for 40.93% of the total footprint of the outdoor bathing or 4.32 MJ/visitor. Also, the water transportation sub-process in the water circulation was the highest sub-process among all the sub-processes of the outdoor bathing. The highest energy footprint of the water transportation sub-process was due to the usage time of the outdoor hot spring pool was 12 hours, and the hot spring water needed to be recycled twice to ensure the quality of the outdoor hot spring water. Each cycle took about 6 hours, thus the transportation of hot spring water has been working for 12 hours, which contributed the highest energy footprint. The second highest sub-process among all the sub-processes of the outdoor bathing was the drilling well, which is a sub-process in water collection process. The energy footprint of the drilling well sub-process was 540 MJ (2.7 MJ/per person), accounted for 85.32% of the total footprint of the water collection process and accounted for 25.58% of the total footprint of the outdoor bathing.

Carbon footprint was evaluated based solely on the energy consumption. The carbon footprint was converted from the energy footprint results by using an emission conversion factor. The conversion factor was 0.96 kg CO_2 eq/kWh of electricity mix produced in China (China Life Cycle Database, 2010). The energy footprint of five processes of the outdoor bathing processes are presented in Figure 4.

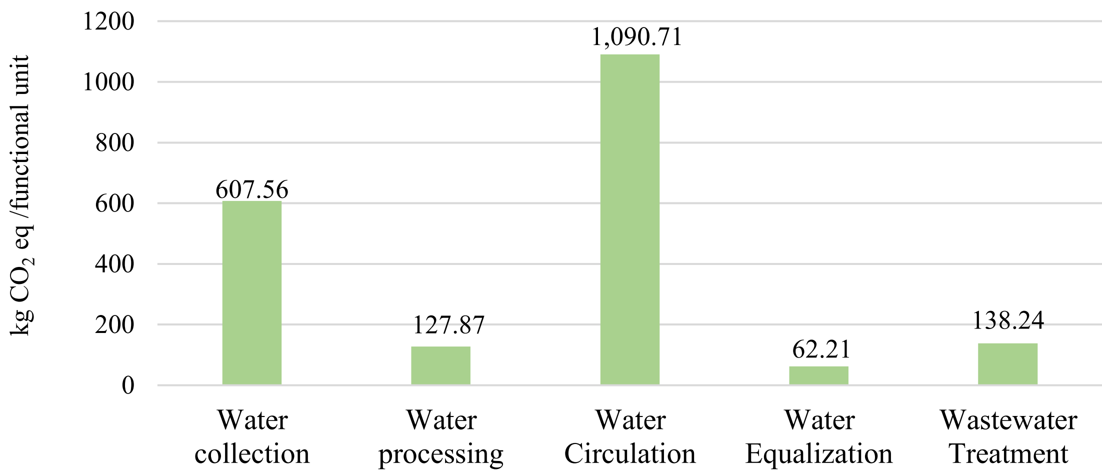

Figure 4 The carbon footprint of five processes of hot spring bath

Based on Figure 4, the total GHG emission in servicing 200 visitors who spent 2 hours per day (one functional unit) in the hot spring outdoor bathing was approximately 2,027 kg CO_2 eq. The process with the highest carbon footprint was water circulation, which generates 1,090.72 kg CO_2 eq (5.45 kg CO_2 eq/per visitor). The process with the least carbon footprint was water equalization, which generates 62.21 kg CO_2 eq/ functional unit (0.31 kg CO_2 eq/per visitor). Other carbon-intensive processes were water collection, wastewater treatment, water processing, generated for 29.98%, 6.31%, and 6.82% of the total GHG emission of the hot spring outdoor bathing, respectively.

Water footprint of outdoor hot spring bathing in Tengchong, Yunnan

This section presents the water footprint of outdoor hot spring bathing in Tengchong, Yunnan. The bathing consisted of 6 major processes, which were water collection, water processing, water using, water circulation, water equalization, and wastewater treatment. The water footprint of each process of the outdoor hot spring bathing is presented in Figure 5.

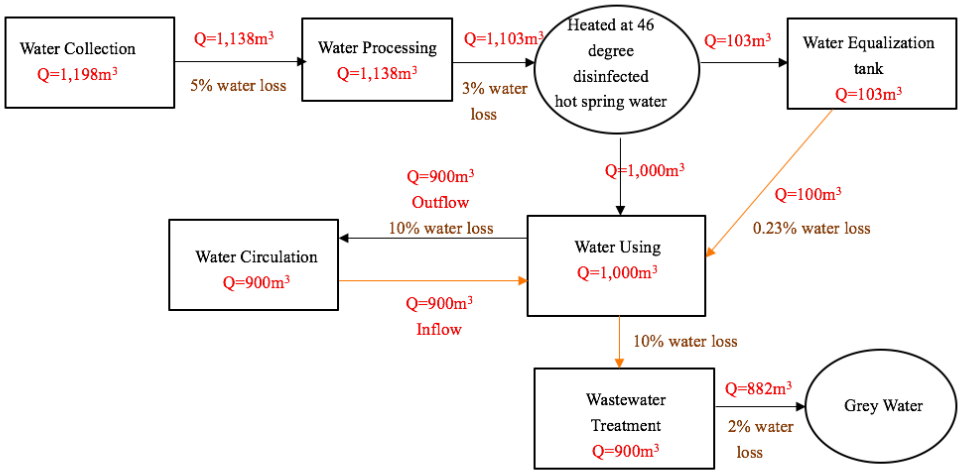

Figure 5 The water footprint of six major processes in outdoor bathing

Total quantity of water consumption of the six outdoor bathing processes in serving 200 visitors, each visitor spends 2 hours a day (one functional unit), was 1,198 m^3 (5.99 m^3 /visitor). As depicted in Figure 4, at the first, the 1,198 m^3 spring water was collected by drilling well and after the desander sub-process, the 1,198 m^3 water with 5% water loss were transported to the water processing. Through UV disinfection process and heating unit, the 1,138 m^3 water with 3% water loss were transported to water using process of 1,000 m^3 and water equalization process of 103 m^3, respectively. Then, when the spring water was been used for about 6 hours, the 1,000 m^3 water with 10% water loss were circulated to the circulation process. After the water circulation process, the 900 m^3 circulation water and 103 m^3 equalization water with 0.23% water loss were transported to the water using process again. When the water using finished, the 900 m^3 water which including bacteria, hair, and impurities was drained to the wastewater treatment. At last, after disinfection treatment, the 882 m^3 water with 2% water loss were used for other purposes, such as, watering flowers, car washing, ect.

In order to reach 1,000 m^3 of water in the outdoor pool in the water using process, various quantities of water were required in different processes. These six processes required 1,198 m^3, 1,138 m^3, 1,000 m^3, 900 m^3, 103 m^3, and 882 m^3 volume of water, respectively, to reach 1,000 m^3 of water in water using process (outdoor pool). The water using process is the most water consumption process among the six major processes, which had 10% water loss of the total water consumption in the outdoor bathing process through splash water and evaporation in the outdoor bathing process. On the other side, the water equalization tank process had the least water consumption, which was 0.23% water loss of the total water consumption in the outdoor bathing process. The 0.23% water loss of the water equalization was used as the tank storage volume, which sensing outdoor pool water volume changes, and timely replenishment. Other three water-consuming processes were water collection, water processing and wastewater treatment, which lost water for 5% by filtering the mixtures and impurities, 3% by automatic cleaning and cleaning of the casing, and 2% by flushing the pump, respectively. To ensure the quality of the hot spring, the water used in the hot spring pool is drained every day.

Comparative energy, carbon and water footprints of the outdoor hot spring bathing in Tengchong, Yunnan from 2016 to 2019

This section presents the yearly energy, carbon and water footprints of the outdoor hot spring bathing in Tengchong, Yunnan from 2016 to 2019. The results included the average annual energy consumption, GHG emissions, and water consumption per tourist from 2016 to 2019. The three footprints (energy footpring, carbon footprint and water footprint) per visitor on daily basis of the outdoor hot spring bathing are presented in Figure 6.

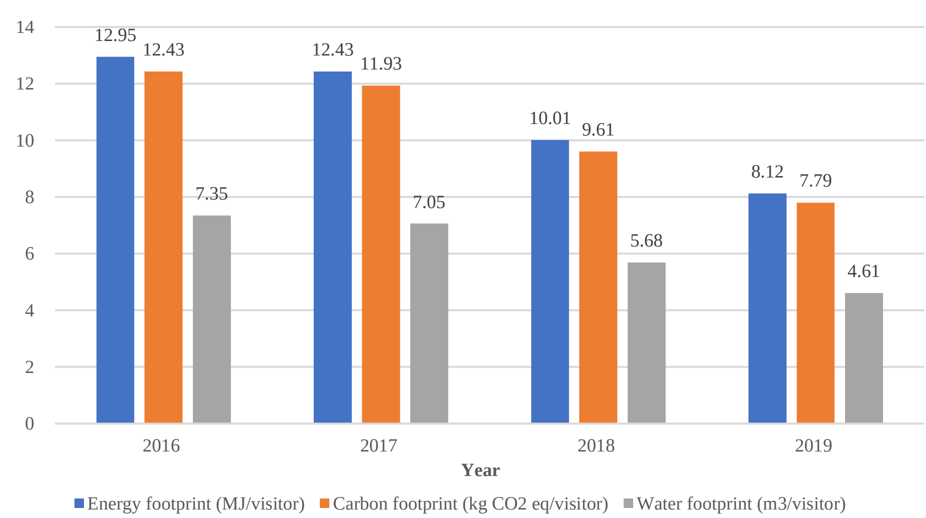

Figure 6 The annual energy footprint, carbon footprint and water footprint per visitor of hot spring bath in Tengchong, Yunnan, from 2016 to 2019

Based on the total number of visitors from 2016 to 2019 (Appendix A), the number of average daily visitors from 2016 to 2019 were around 163 visitors, 170 visitors, 210 visitors and 260 visitors, respectively. According to Figure 6, as the number of daily visitors increased each year, the ratio of energy footprint, carbon footprint, and water footprint gradually decreased. The highest resources consumption year was 2016, which consumed 12.95 MJ of energy and 12.43 m^3 of water, while emitting 7.35 kg CO_2 eq per visitor. The least resources consumption year was 2019, which consumed 8.12 MJ of energy and 7.79 m^3 of water, while emitting 4.61 kg CO_2 eq per visitor.

Recommendations on Energy Consumption and Water Consumption Reduction of the Hot Spring

According to the LCI results, the most energy intensive and water intensive of an outdoor hot spring bathing in Tengchong, Yunnan, was the water circulation process and the water using process, respectively. A deeper understanding of improving the energy footprint and water footprint of hot spring was obtained by further analyzing the LCI results.

1. Recommendations on Energy Consumption Reduction of the Hot Spring

Based on the energy footprint results, the highest energy-intensive process, among the five major processes, was the water circulation process. The top two energy-intensive sub-processes were the water transportation and the board charging sub-process, respectively. Therefore, to improve the energy efficiency and/or reduce the energy (electricity) consumption of the water circulation process, two techniques are recommended.

The first technique is by using energy-saving pumps for water transportation. For example, Shanghai Changzheng Water Pump, produced by Shanghai Changzheng Pump Valve (Group) Co., Ltd., which has been widely used in industries such as chemical, power, environmental protection, water supply and drainage engineering, should be applied. Shanghai Changzheng Water Pump adopts multi-channel fluid transformation technology on the inner wall of the water pump through fluid analysis of various environments. By changing the pressure difference between the inlet and outlet of the water pump, using good motors internally, and the redundancy in design is removed to achieve energy-saving treatment of the water pump. Simple changes, not simple theoretical foundations, have achieved excellent energy-saving technology for water pumps. Shanghai Changzheng Water Pump has been certified by the China Quality Certification Center (CQC) and has obtained the China Energy Saving Product Certification. Shanghai Changzheng Water Pump is 5% more energy-efficient than the non-energy-saving water pump, therefore using Shanghai Changzheng Water Pump is a way to reduce the energy consumption (Yinghui Zhang, 2011). Another technique is by using thermostat devices in outdoor pools to indirectly reduce energy consumption of the board charging. There are many types of thermostat devices, such as Steam heating thermostat equipment, heat pump heating thermostat equipment, and air energy thermostat heat pump equipment, etc. With the government's promotion of energy conservation and environmental protection, many manufacturers have promoted the production of air energy thermostat heat pump equipment. Air energy thermostat heat pump equipment is a type of thermostat heat pump that only requires a small amount of electric drive to operate, absorbing free heat from the air energy for heating. When working, 1 kWh of electricity can generate the heat energy that ordinary electric water heaters generate using 4 kWh of electricity, and its energy consumption is only 25% of that of electric water heaters and 50% of that of gas boilers. At the same time, the air energy heat pump does not emit polluting gases or harmful particles during operation. It is not only clean and environmentally friendly, but also has no open flames during heating, avoiding safety accidents. It is widely used in residential heating, school hot water, swimming pool constant temperature, hospital hot water, and other projects (WenXiang Xu, 2011）.

2. Recommendations on Water Consumption Reduction of the Hot Spring

As shown in Figure 4, the water using process had the highest water loss among the six processes, which consumed 1000m^3 with 10% water loss of the total water consumption in the outdoor bathing through splash water and evaporation sub-processes. In order to reduce water consumption of water using process, some measures could be applied. For example, due to the evaporation of the surface of the hot spring water, the hot spring pool can be equipped with a new type of swimming pool water circulation power system invented by Xi'an Shangshang Electromechanical Co., Ltd, (Li Feng, 2015). The new system can heat the filtered water to a certain temperature by heat exchange with the water vapor that evaporates from the hot spring pool into the air, and the water vapor in the air condenses into water. On one hand, this invention recovers heat to heat up the pool water, and at the same time, it can also reheat the air. On the other hand, by lowering the temperature to the freezing point, the water vapor condenses into water, achieving dehumidification effect by drying the air. Meanwhile, the evaporated water can be recovered to the hot spring pool, reducing the replenishment of water in the hot spring swimming pool and thereby reducing water consumption. Another way is to use intelligent control cabinet, this technique was in design studies and had not been employed by existing bathing (Gen Fei, 2021). The traditional manual control method of outdoor hot springs requires multiple professional maintenance personnel. Also, the use of manual control to manage the hot spring pool is labor-intensive and cumbersome. The changes in the water quality of the hot spring pool can hardly be constantly detected. There are also defects such as large detection errors, scattered data, and inability to reflect water quality changes in real-time, resulting in waste of chemicals and low efficiency of water use. The intelligent control cabinet can collect and monitor real-time data information such as water quality, water temperature, air temperature, and humidity throughout the day. It can control equipment operation in a timely manner through water environment indicators and equipment operation, indirectly reducing the consumption of hot spring water and improving the utilization rate of hot spring water.

Recommendations on improving business's efficiency according to the comparative study on a yearly basis from 2016 to 2019

As shown in Figure 6, as the number of daily visitors increases every year, the footprints of energy, carbon, and water gradually decreased. Based on the hot spring scenic spot manager's feedback, the max number of visitors that can be served is around 360 people per day, rather than using 1198 m^3 of water and 2,111 MJ of energy to serve 200 visitors ,which was the average number,using the same amount of resources to serve more visitors is more efficiency for business.Therefore, the easiest way to improve hot spring bathing business's efficiency is by increasing the number of visitors. Utilizing marketing methods to attract more tourists. Online and offline can be combined to establish a hot spring tourism website, WeChat official account, microblog and other social media platforms to attract more people to experience hot spring tourism and attract more people to pay attention to and understand hot spring tourism through online booking, coupons and other ways. At the same time, advertising can be placed on transportation vehicles such as subways and buses, or hot spring tourism promotion activities can be held in shopping malls, supermarkets, and other places to attract more people to learn and experience hot spring tourism. Another point is to develop sustainable hot spring tourism. To achieve ecological sustainability, it is necessary to effectively integrate the development of hot spring tourism with basic ecological processes, biodiversity, and the maintenance of ecological resources. It is necessary to minimize the impact on the ecological environment during the development of hot spring tourism. The selection of hot spring tourist attraction and the construction of scenic spots should be carried out under the condition of protecting the integrity of the ecological environment. Hot springs belong to limited resources and are not inexhaustible. Therefore, it is necessary to ensure that the development of hot spring tourism resources is scientific and reasonable, and does not violate the principle of sustainable development. Only in this way the hot spring business can improve their efficiency and the hot spring tourism business can prosper and develop.

Recommendations on improving the Tourist Attraction Rating Categories of China based on LCI results

The rating system considered e.g., transportation, health and safety, and resources and environmental protection. Based on the results of this study, it can be used to improve the rating system of resources and environmental protection category. The government currently only provides qualitative rating standards for hot spring attractions, and the quantitative evaluation standards provided are not comprehensive. Therefore, each hot spring attraction should promote LCA to quantitatively evaluate its performance in terms of resource consumption and environmental protection. Afterwards, the government can develop quantitative standards for this category based on the LCI results to set resources and environmental protection levels and/or baselines among similar attractions. The results can be used to improve each attraction's environmental performance since LCA can identify attractions' major processes with the highest consumption in energy and water, which are the major resources in outdoor hot spring bathing.

Based on the results of this study, some recommendations on the reduction of energy footprint and water footprints could be adopted. Energy consumption reduction can be enhanced by promoting the use of energy-saving equipment, e.g., Shanghai Changzheng Water Pump. The technique used in this pump is a multi-channel fluid transformation technology on the inner wall of the water pump through fluid analysis of water in various environment. For water consumption reduction, the use of water-saving equipment, e.g., the new type of swimming pool water circulation power system should be promoted. The system uses new heat recovery techniques to warm the outdoor pool water and recycle water vapor back to the outdoor pools. Therefore, reducing the replenishment of water in the hot spring swimming pool and thereby reducing water consumption. Nevertheless, a LCA of an outdoor hot spring bathing should be conducted to identify major resource consumption process(es), thus resource reduction can be achieved effectively. A deeper understanding in improving the rating system of resource and environmental protection categories could be obtained by analyzing the LCI results to identify the processes with potentially significant energy and water consumption impacts. Therefore, according to the LCI results, other related industries can also use this method to reduce energy and water consumption, such as water parks, swimming pools, water supply stations, etc.

CHAPTER V

CONCLUSIONS

This paper conducts a process LCA of an outdoor hot spring bath to analyze energy and water footprints of the current situation in Tengchong, Yunnan. This cradle-to-gate LCA considered spring water collection, processing, using, circulation, equalization, and wastewater treatment. LCI, a step of LCA, was a major method used in this study to examine the energy footprint and water footprint of an outdoor hot spring bathing. The energy footprint and water footprint of 200 visitors who spent two hours per day (one functional unit) in outdoor hot spring bathing were 2,111 MJ and 1,198m^3, respectively. The results showed that the water circulation process consumed the most energy consumption among the five energy processes, which accounted 53.82% of total energy consumption or 5.68 MJ/visitor. The water transportation is the most energy-intensive sub-process in the water circulation process. The energy consumption of the water circulation process can be reduced by using energy-saving pumps, such as using Shanghai Changzheng Water Pump. Within the system boundary, the water using process is the highest water-intensive process through splash water and evaporation of the outdoor bathing process. Thus, using sustainable equipment during the water using process is beneficial for water consumption reduction. A deeper understanding in improving the China's Tourism Attraction Rating System of resource and environmental protection categories could be obtained by analyzing the LCI results to identify the processes with potentially significant energy and water consumption impacts.

Future work can be carried out from the following aspects:

1. LCI should be conducted based on inventories related to resources consumption collected from multiple hot spring tourist attractions to strengthen the research findings as to promote sustainable development of hot sing attractions.

2. Carrying capacity of hot spring attractions should be assessed to preserve while maximizing the utilization of hot spring resources and to improve the efficiency of hot spring attractions.

3. Analyzing the entire supply chain of hot spring attractions, including all energy and water consumption activities from the beginning of operation, in order to promote the related activities of hot spring tourism in Tengchong, Yunnan, so as to expand the scale of the development of hot spring attractions in Tengchong, Yunnan.

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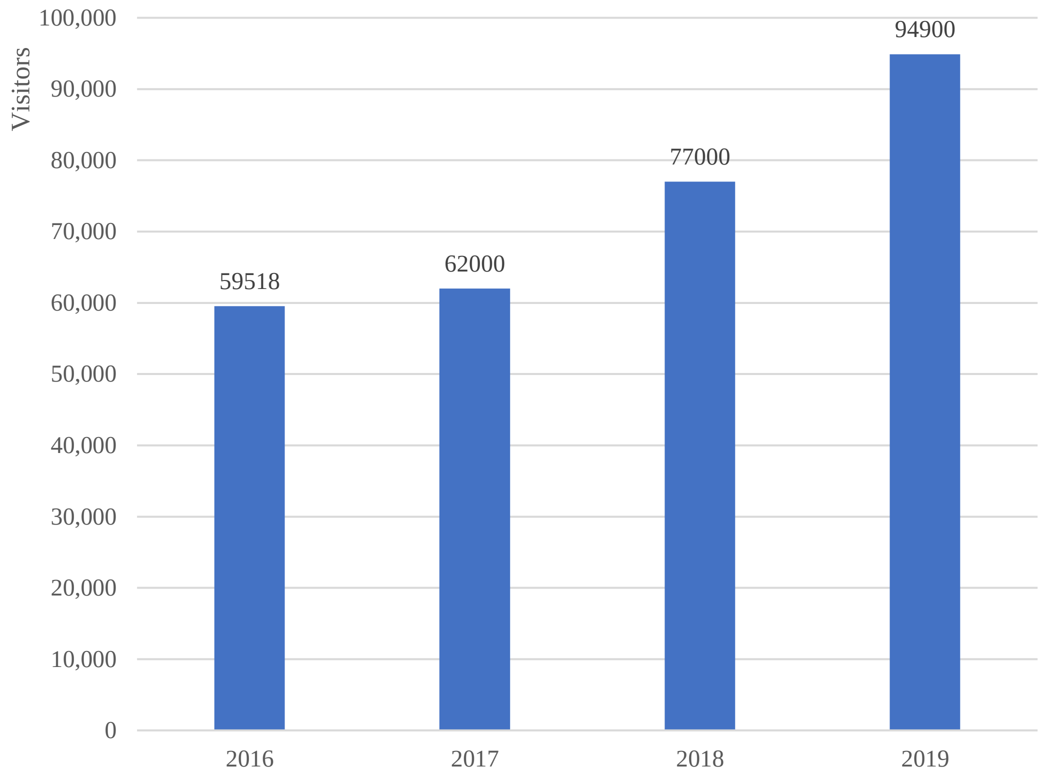
APPENDIX

APPENDIX A The number of visitors of hot spring in Tengchong Yunnan, China from 2016 to 2019



Source: Offered by the manager of Dongshan hot spring spa in Tengchong Yunnan, China

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