An Empirical Study of Island Tourism on Carbon Dioxide Emissions and Economy: The Case of Xiao-Liu-Qiu, Taiwan

by

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DISSERTATION

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List of abbreviations and acronyms

B&B	Bed and Breakfast
DBNSA	Dapeng Bay National Scenic Area Administration, Taiwan (R.O.C.)
DGBAS	Directorate-General of Budget, Accounting, and Statistics, Taiwan (R.O.C.)
BPoA+5	Five-year review of the Barbados Programme of Action
GJ	Gigajoule
GDP	Gross Domestic Product
MJ	Megajoule
Mt	Megatonnes
NDC	National Development Council, Taiwan (R.O.C.)
NGOs	Non-governmental organizations
OECD	Organization for Economic Co-operation and Development
PJ	Petajoule
R. O. C.	Republic of China (Taiwan)
SIDS	Small Island Developing States
JPOI	The Johannesburg Plan of Implementation
Rio+20	The short name for the United Nations Conference on Sustainable Development to take place in Rio de Janeiro, Brazil, in June 2012
WSSD	The World Summit on Sustainable Development
UN	United Nations
UNEP	United Nations Environment Programme
UNWTO	United Nations World Tourism Organization
WCED	World Commission on Environment and Development
TWD	New Taiwanese Dollar

CHAPTER 1

INTRODUCTION

1.1 Background

Starting from the mid-nineteenth century, many visitors began to visit some offshore islands as new tourism destinations because of accessibility (Robinson & McCarroll, 1990) and greater amounts of leisure time and disposable income (Lockhart, 1997). Since then, more and more small islands began to develop their tourism industry, including some Small Island Developing States (SIDS). In the contemporary world, tourism has been regarded as a crucial engine to bring economic benefits to a country or a particular region (Eccles, 1995; Hamzah & Hamptn, 2012 ; Tanguay, Rajaonson, & Therrien, 2013). It has the estimate of 5% of the portion of worldwide Gross Domestic Product (GDP) (UNWTO, 2010).

In some SIDS, they are even more dependent on the tourism industry, and their international tourism receipts were counted for more than 50% of the total value of exports in 2007, on average (UN, 2010). However, tourism development does not only bring economic benefits but also environmental costs[1], and this appears a significant concern of tourism impacts (Patterson & McDonald, 2004). In particular, with increasing global environmental consciousness, more and more environmental issues on islands have been raised recently. Most are related to environmental damages and pollution issues resulting from human economic activities, including tourism development.

In the early 1980s, sustainable development appeared as an integrative idea to simultaneously deal with economic, social, and environmental concerns that began to dominate the worldwide political landscape (McKenzie & Durango-Cohen, 2010). The economic

[1] According to the definition by UN (1997), environmental costs are "costs connected with the actual or potential deterioration of natural assets due to economic activities". The costs can be viewed from two different viewpoints. One is costs caused, which is costs associated with economic units actually or potentially causing environmental deterioration by their own activities; the other is costs borne, which is costs incurred by economic units independently of whether they have actually caused the environmental impacts.

conditions of remote islands, in comparison to the main economic system of a country, always performed weakly due to their limited resources and geographic limitations. Therefore, barely two decades ago, researchers started to use the sustainability framework on tourism development of the islands (Beedasy & Whyatt, 1999; Carroll & Turpin, 1997; Conlin & Baum, 1995; Dale & Robinson, 1999; García-Falcón & Medina-Muñoz, 1999; McElroy & De Albuquerque, 1998; Pantin, 1999; Parker, 1999; Stott, 1998; Thorn, 1994).

It is well-known that tourism as an export-based industry plays a significant role in a local economy because it can bring in new money (Hearn & Tanner, 2009). Many governments in the world have promoted tourism as an important economic growth strategy. For remote islands, it remains to be seen whether such a strategy would yield the same results. In the past decades, local governments in the world have gradually tried to propose the strategy of tourism development to boost island development to reduce regional economic disparity.

Nevertheless, in the past, regional development has always overemphasized GDP growth and ignored the increasing social cost brought about by environmental degradation. Hence, if environmental impacts are taken into consideration whether it still lead to sustainable development, as expected by everyone and as proclaimed by the government? This idea has motivated the interest of this study.

1.2 Research objectives, questions, approaches, and conceptual framework

In modern society, the concept of sustainability has become an important idea for rapid development. In particular, it has been taken by the governments in the world as the principle while making policy-making on offshore islands. The offshore island development policy of Taiwan is influenced by the international island development consensus and the ethos of sustainability. Under the framework of the offshore island development policy, tourism is taken as a strategy to improve the regional development on offshore islands of Taiwan. This development statement is a starting point and the core of this study. In this study, the elements and its conceptual flow involved in the conceptual framework (Figure 1.1) are explained as below.

The objectives of this dissertation are to provide insights into the effects of tourism expansion on the environment (carbon dioxide emissions) and the economy of an island tourism

destination, Xaio-Liu-Qiu. Four research questions are raised based on the objectives of this study. The statements of research questions and approaches are described as follows.

Xiao-Liu-Qiu is one of the inhabited offshore islands of Taiwan. The development strategy of the island is planned under the scope of island development policy of Taiwan which is influenced by the consensus of global island development. In particular, tourism is promoted on Xaio-Liu-Qiu by the Taiwanese government, and it has become a popular island tourism destination since 2000. To understand the background and the context of tourism expansion on Xiao-Liu-Qiu, the first and the second research questions are raised. Literature review and on-site survey are utilized to answer the research question one.

I. What are the global agreement trends and the national policy of island tourism development of Taiwan?

II. What is the current situation of island tourism development on Xiao-Liu-Qiu?

It has been well known that tourism expansion is expected to contribute economic profits; however, it is also noticed that unplanned growth of tourism causes environmental damage (Ghulam Rabbany, Afrin, Rahman, Islam, & Hoque, 2013; Zaman, Khan, & Ahmad, 2011). The impacts of tourism are determined by the tourist factors and destination factors (Kread, 2001). Undoubtedly, tourist spending contributes to the local economy, and the quality of the destination environment is one of the key factors to attract the tourists. In other words, there is an interactional relationship between the environment and the economy of a tourism destination. Therefore, it is necessary to measure the environmental change of a destination in order to maintain sustainable economic development of tourism. Especially, when a destination's economy highly relies on the tourism receipts, the degradation of the environment may decrease the tourists' interest to visit, and it may further affect the island development. Based on this statement, the second research question is suggested as follows.

III. What is the environmental impact of the tourism expansion of an island tourism destination in terms of energy use and carbon dioxide emissions on Xiao-Liu-Qiu?

Regarding responding the research questions two, tourism energy use and carbon dioxide emissions on Xiao-Liu-Qiu is estimated under the bottom-up data framework. The tendency of

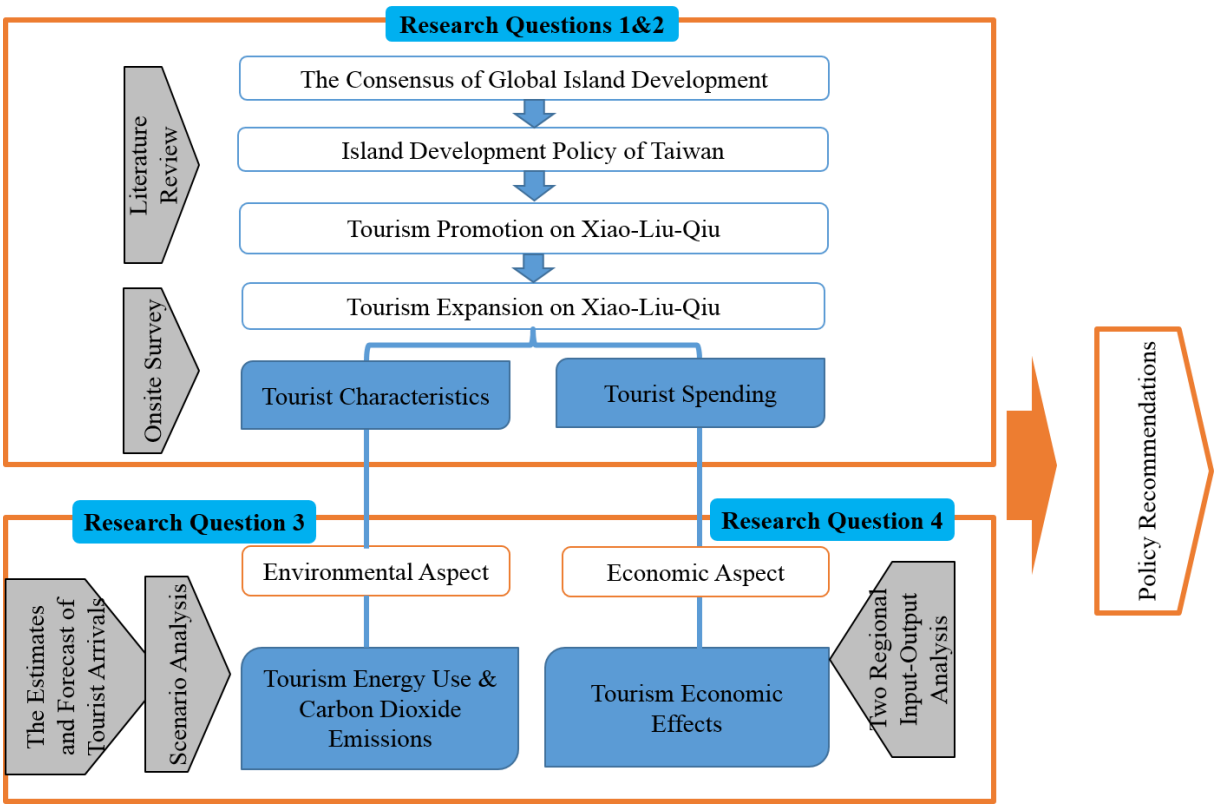
tourist arrivals is a key factor to affect the amounts of energy use and carbon dioxide emissions. Therefore, the trend and the forecast of tourist arrivals are estimated. In addition, tourist characteristics is the other key factors to be considered. Furthermore, a scenario analysis is designed to observe the change in tourism carbon dioxide emissions if different mitigation strategies are implemented.

Besides, this study also intends to measure economic benefits on Xiao-Liu-Qiu where tourism activities have been booming rapidly from the last decade. The third research question comes out as,

IV. What is the economic impact of tourism on Xiao-Liu-Qiu?

A two-region input-output analysis is used to respond the research question three. Finally, the results and the findings of this study are expected to contribute the recommendations for the further policy making.

Figure 1.1 The conceptual framework of the dissertation



Source: Drew by author.

1.3 Significance of this study

Since the last decade, the Taiwanese government has intended to implement policies to improve the development of the offshore islands using tourism as a strategy, in particular. It appears the phenomenon of tourism expansion on the offshore islands of Taiwan in the past years. At the national level, tourism impacts on economic and environmental conditions have been discussed for Taiwan as a whole (Sun, 2014a; Sun & Chang, 2014; Sun & Pratt, 2014). However, there is a lack of studies that focus on the regional level in both economic and environmental conditions, in particular for the offshore islands.

The island named Xiao-Liu-Qiu has been chosen as this study site because the tourist arrivals of this island has been increasing year by year due to its unique geographical formations, natural tourism resource, and an easy-going culture. In addition, under the scheme of the Offshore Island Development Plans by the Taiwanese government, Xiao-Liu-Qiu is reputed to be an "island tourism destination with low carbon dioxide emissions." It can be noticed that the tourism promotion has brought the tourists to island destinations, and the tourists' characteristics and spending patterns are formed. However, this issue of tourism impacts on both economic and environmental conditions on Xiao-Liu-Qiu has not been studied yet. Therefore, to accomplish the objective of this study, the findings will help the Taiwanese government to know the economic and environmental impacts of tourism on Xiao-Liu-Qiu. The present study will also contribute to the empirical experience while the Taiwanese government makes policy regarding the offshore island development in the future.

1.4 Dissertation outline

This dissertation is composed of five chapters. Chapter 1 introduces the background, conceptual framework, research objectives and research questions. Chapter 2 utilizes the literature review to understand global and national island development policy trend. Besides, two on-site investigations are conducted to explore the current tourism development on Xiao-Liu-Qiu. Chapter 3 aims to explore the energy use and carbon dioxide emissions from tourism on Xiao-Liu-Qiu. A time series analysis is used to extrapolate and forecast the tourist arrivals, both in the past and future. In addition, combined the data of on-site investigation with the forecasts of tourist arrivals, a scenario analysis is employed to observe the trend of the carbon dioxide emissions from tourism on Xiao-Liu-Qiu based on the bottom-up data framework.

Chapter 4 explores the economic structure and the economic effects applied to tourism on Xiao-Liu-Qiu by using a two-region input-output analysis. Regional technical coefficients, industry linkage, and multipliers in production, employment, and wage of Xiao-Liu-Qiu are researched. In addition, an empirical analysis focused on the inter- and intra- regional economic impacts of tourism is studied as well. The last chapter summarizes the findings of this dissertation, the further implications and applications, and contributions and limitations of this study.

CHAPTER 2

SMALL ISLAND DEVELOPMENT POLICY ON GLOBAL, NATIONAL, AND REGIONAL SCALES

2.1 Introduction

This chapter aims to review the global island development agreements and the Taiwanese offshore island development policies since the international consensus on sustainable island development and the Taiwanese national policies have laid the basis for the development strategies on offshore islands of Taiwan. The policy outcomes under the Offshore Island Development Act and its Fund are explained both in general and on Xiao-Liu-Qiu. In addition, the other objective is to understand the tourists' characteristics and the tourist spending of Xiao-Liu-Qiu. The tourists' characteristics will be utilized to estimate the energy use and carbon dioxide emissions from tourism in Chapter 3, and the tourist spending will be used to measure the tourism economic effects in Chapter 4.

The main research questions of this chapter are two:

I. What are the global agreement trends and the national policy of island tourism development of Taiwan?

II. What is the current situation of island tourism development on Xiao-Liu-Qiu?

To that end, I will use literature review and on-site investigation to respond the following sub-questions:

i. What is the trend of island development relating to tourism at the global and national levels?

ii. What are the current tourists' characteristics and spending patterns on Xiao-Liu-Qiu?

iii. What are the current tourism developments and business models on Xiao-Liu-Qiu?

2.2 Global consensus and national island development policy

2.2.1 International agreements on sustainable tourism on islands

Sustainable resource use in island tourism became an important topic after the 1992 United Nations (UN) Conference on Environment and Development. It became more prominent in the succeeding years as small island communities that have tourism industries, experienced considerable and unprecedented changes in social and economic development, international policies, technology, and the world environment (Lockhart, 1997). It is also relevant because tourism is a high resource-consuming sector, that is, of water, electricity, and land use (Velazques, 2006). Environmental assets, including direct value (e.g. scenic places) and indirect value (e.g. maintenance of a wetland for nutrients and water disposal from an area of concentrated population, buffer against wind or noise), are crucial and need to be managed in order to maintain a sustainable tourism industry (Lacy, Battig, Moore, & Noakes, 2002).

However, the community of small island nations have their particular vulnerabilities and characteristics like small size, geographic isolation, limited resources, sensitive environments, and distance from market (Banuri, 2010). According to World Commission on Environment and Development, WCED (1987), the definition of sustainable development is the "development that meets the needs of current generations without compromising the ability of future generations to meet their needs and aspirations"(p. 41). The classic representation of sustainable development is the meeting point of three interlocking circles representing the economy, the community/society, and the environment. However, sustainable development does not imply in stasis, sustainability means that humans meet these changing needs without reducing our capability to do so (Morse, 2004). Seven important international conferences and meetings were held from 1992 to 2012; the purposes, issues of focus and outcomes are described briefly in Table 2.1.

Table 2.1 International agreements for sustainable development of SIDS

Organization (year)	Conference name/ initiative, document	Core message
UN (1992)	United Nations Conference on Environment and Development (the Earth Summit) /Agenda 21[2] (the Barbados Declaration)	— "Small Island Developing States (SIDS)" were first officially recognized as a distinct group of developing countries.
UN (1994)	The Barbados Programme of Action	— The concept of sustainability was emphasized in island development. — Tourism development and management was listed in the priority issues of island development.
UN (1999)	The Barbados Programme of Action (BPOA+5)/ State of Progress and Initiatives for the Future Implementation of the Programme of Action for the Sustainable Development of SIDS	— Six urgent problems areas were identified, including climate change, natural and environmental disasters and climate variability, freshwater resources, coastal and marine resources, energy, and tourism. — The need to focus on means of implementation through sustainable development strategies was highlighted.
UN (2002)	The World Summit on Sustainable Development (WSSD) / The Johannesburg Plan of Implementation (JPOI)	— Reaffirming the international community's commitment to 'full implementation' of Agenda 21. — Setting up new commitments and priorities for action on sustainable development.
UN (2004)	The World Summit on Sustainable Development (WSSD)	— Reaffirming the special case of SIDS and identifying a set of priority actions in the JPOI. — Requesting the General Assembly, to consider convening an international meeting on the sustainable development of SIDS, at its 57th session.

(continued)

[2] Chapter 17 of Agenda 21 on the protection of oceans, all kinds of seas, and coastal areas includes a programme area on the sustainable development of small islands. *Agenda 21: 17.124. Small Island developing States and islands supporting small communities are a special case both for environment and development. They are ecologically fragile and vulnerable. Their small size, limited resources, geographic dispersion and isolation from markets, place them at a disadvantage economically and prevent economies of scale.*

Table 2.1 International agreements for sustainable development of SIDS (continued)

Organization (year)	Conference name/ initiative, document	Core message
UN (2010)	The 65th Session of the UN General Assembly	— Undertaking a 5-year review of the Mauritius Strategy for the further implementation of the BPOA for the sustainable development of SIDS. — Key issues and priorities highlighted in this meeting include strengthening data management capacities of SIDS for monitoring and evaluation; enhancing strategic partnerships, including strengthening South-South and SIDS-SIDS cooperation; assessing effectiveness of UN system support to SIDS; need for results-oriented approach and improved measures to effectively address SIDS' vulnerabilities; and exploring the formal recognition of SIDS as a special category in the UN.
UN (2012)	The United Nations Conference on Sustainable Development (Rio+20)	— Securing renewed political commitment for sustainable development. — Assessing the progress to date and the remaining gaps in the implementation of the outcomes of the major summits on sustainable development, and address new and emerging challenges. — A green economy in the context of sustainable development and poverty eradication; and the institutional framework for sustainable development were two of main themes in this conference. — SIDS held a series of consultations in preparation for global negotiations for Rio+20.

Source: Compiled by author.

To sum up, from these international conferences, it shows that the development of island communities has captured the attention of the world, resulting in wider participation of more countries and international non-governmental organizations which participated in the agreement-making process every five years. Now, sustainability has become the core idea in island development and management strategy. Tourism development, on the other hand, has become one of the critical issues since the 1994 UN Global Conference on the Sustainable Development of SIDS in Barbados. The conference emphasized the importance of sustainable island tourism development.

2.2.2 Taiwan's island development policy

In the following section, the history of the Offshore Island Development Act and the transformation of policy for offshore island development are introduced. Besides, the distribution of the Offshore Island Development Fund in the past years is explained as well.

2.2.2.1 Offshore Island Development Act

Taiwan is a country consisting of the main island and 121 smaller offshore islands. Among the offshore islands, only six islands are inhabited and each of them has their unique culture, geography and ecosystem. Compared to the mainland of Taiwan, the economic development and the quality of life on the islands are poor due to the limited resources and geographical isolation. For the purpose of reducing the inequality and imbalance in development between the mainland of Taiwan and the offshore islands, the Taiwanese government passed the Offshore Island Development Act in 2000 (Appendix 1). The purpose is described in Article 1: to "promote the developmental construction, enhance the industrial development, protect the natural environment, preserve the cultural features, improve the quality of life, and augment the welfare of residents of Offshore Islands". The implementation plans of the Offshore Island Development can be split into three stages, including the pioneer stage, the developing stage, and the maturity stage. The period of each stage and its administrative organizations are listed in Table 2.2.

Table 2.2 The stages of implementation plans of the Offshore Island Development of Taiwan

Stage	Period	Administrative organization
Pioneer	From April, 2000 to September, 2004	Construction and Planning Agency, Ministry of the Interior, Taiwan (R.O.C.).
Developing	From September, 2004 to February, 2009	National Development Council, Taiwan (R.O.C.).
Maturity	From February, 2009 to December, 2009	Construction and Planning Agency, Ministry of the Interior, Taiwan (R.O.C.).
	From December, 2009 to present	National Development Council, Taiwan (R.O.C.).

Source: Department of Supervision and Evaluation, National Development Council, Taiwan (R.O.C.)(2012), translated by author.

2.2.2.2 The Offshore Island Development Fund

In the period 2001-2010, the Taiwanese government composed a 30-billions New Taiwanese Dollars (TWD) worth of extra-budgetary fund, named the Offshore Island Development Fund, for improving offshore islands' development. Table 2.3 summarizes the basic information and the share of the Fund received during 2001-2011. The Fund was applied on the six offshore islands administrated by five Counties. The level of administrative division of the six offshore islands are different. Kinmen, Penghu, and Matsu are identified as the Counties, and Lanyu, Green Island, and Xiao-Liu-Qiu are identified as the Districts/ Townships, officially.

Kinmen is the biggest in area size, and Xiao-Liu-Qiu is the smallest among the six offshore islands. Regarding the population density, Xiao-Liu-Qiu is the most intensive offshore island, with 1,837.2 people per square kilometer. In terms of the distribution of the Fund, Kinmenn had received the highest amount of the Fund (33.6%) among six offshore islands, followed by Penghu, with the share of 30.9%. However, Xiao-Liu-Qiu as an island with the highest population density, but it received the lowest (5.8%) of the Fund from the government in total in the past years.

Table 2.3 The profile of islands in the Offshore Island Development Act, Taiwan

Name of offshore island	**Area (km^2)**	**Population* (Person)**	**Population density (Person/km^2)**	**Fund distribution** (%)**	**County**
Kinmen	151.6	132,995	877.5	33.6%	Kinmen
Penghu	128.9	102,355	794.3	30.9%	Penghu
Matsu	29.6	12,533	423.4	21.9%	Lienchiang
Lanyu	48.4	5,047	104.3	7.8%	Taidong
Green Island	15.1	3,766	249,6		
Xiao-Liu-Qiu	6.8	12,493	1,837.2	5.8%	Pingtung

Note: * The statistics is collected up to January, 2016.

**The Fund was distributed from 2001 to 2011.

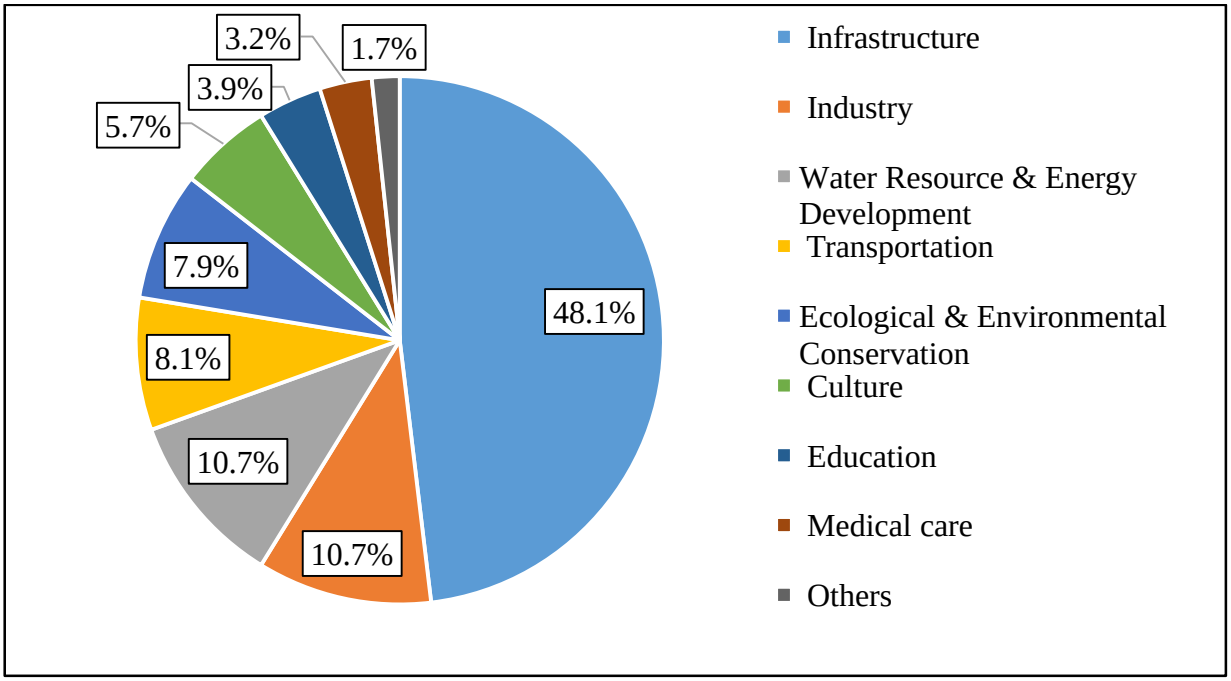
Source: National Development Council, Taiwan (2012), Lienchiang County Government (2016), Kinmen County Government (2016), Taitung County Government (2016), Pingtung County Government (2016), and Penghu County Government (2016).

Figure 2.1 shows the nationwide investment to the development of the six offshore islands of Taiwan. Based on the official report and document by National Development Council, Taiwan (2012) and the Department of Supervision and Evaluation of National Development Council, Taiwan (2012), the investment was distributed to nine categories, including the infrastructure[3] (48.1%), industry[4] (10.7%), water resource & energy development (10.7%), transportation (8.1%), ecological & environmental conservation (7.9%), culture (5.7%), education (3.9%), medical care (3.2%), and others (1.7%). Viewing the distribution of the Offshore Island Development Fund, it can be found that the offshore islands of Taiwan were lack of the infrastructure construction the most. The investment had improved the environment for living in general.

[3] For example, the construction of incineration plant, and the road construction.

[4] For example, the guidance of regional industry.

Figure 2.1 The share of the Offshore Island Development Fund by category in general

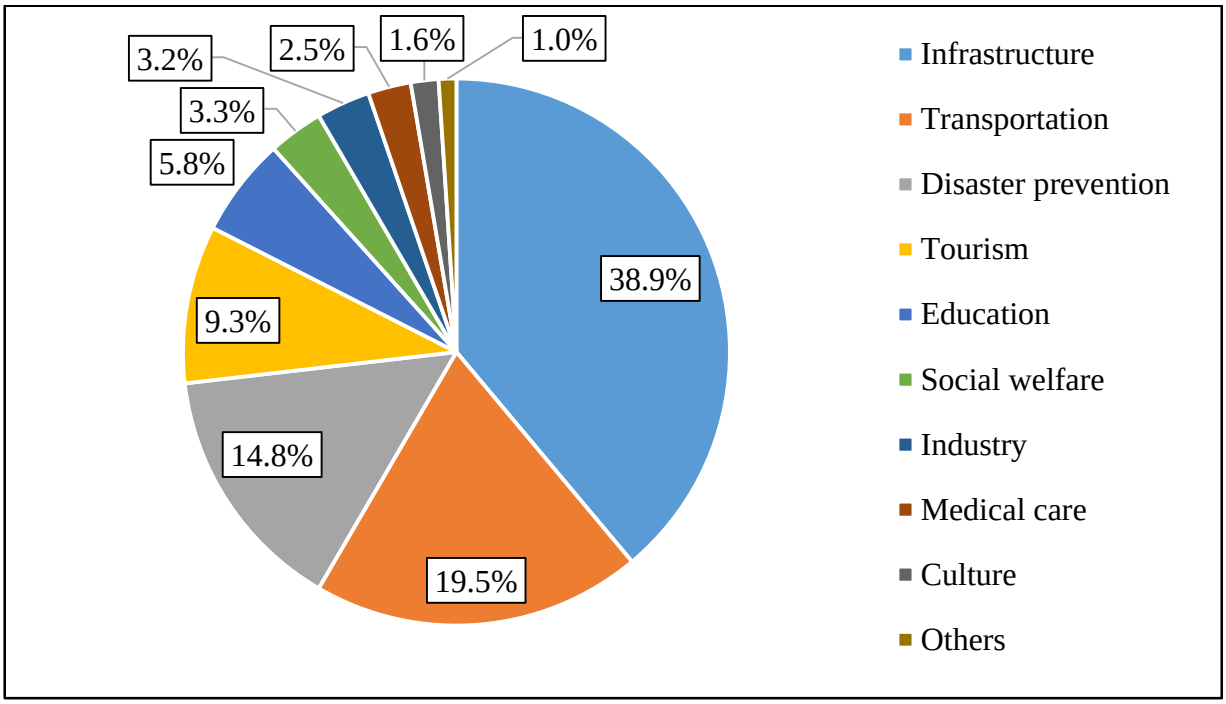


Note: The total amount of the Fund was accumulated from 2001 to 2010, and it was distributed to the six offshore islands. Unit: (%).

Source: Department of Supervision and Evaluation, National Development Council, Taiwan (R.O.C.) (2012), modified by author.

Figure 2.2 shows the distribution of the Offshore Island Development Fund to Xiao-Liu-Qiu by category. The amount of the investment and its distribution depended on the importance and the urgency of development items on Xiao-Liu-Qiu in different periods. Overall speaking, 38.9% of the total spending in 2003-2014 was invested in the category of infrastructure, followed by the transportation (19.5%), and the disaster prevention (14.8%). The minor investment went to the categories of culture (1.6%) and others (1.0%). It is worth to noting that about 9.3% of the Fund went to the category of tourism, it indicates tourism was taken as a significant item for the government to improve the development of Xiao-Liu-Qiu.

Figure 2.2 The share of the Offshore Island Development Fund to Xiao-Liu-Qiu by category



Note: The total amount of the Fund was accumulated from 2003 to 2014. Unit: (%).
Source: Pingtung County Government (2014), calculated by author

Table 2.4 summarizes the government spending on Xiao-Liu-Qiu during the years of 2003-2014. In terms of the period, the first period (2003-2016) received the biggest investment (44.8%). The objective of this period was mainly "focus on the construction of the facilities and the infrastructure on Xiao-Liu-Qiu (著重於硬體設施建設，完成琉球鄉基礎建設)," and it shared 57.3% of the total investment in this period.

In the years, 2007-2010, the objective was set up as "sustainable management of the balance of development on the ecology, life and production (著重生態、生活、生產，三生平衡發展，達到永續經營目的)." In this period, 29.9% of the spending went to the category of infrastructure, followed by 19.3% of spending was invested in tourism.

In the third period (2011-2014), the objective was built as "the development of life, production and ecology, and to build Xiao-Liu-Qiu as a low-carbon island (生活、生產及生態基本發展，打造小琉球為低碳示範島嶼)." In this period, the major investment went to the category of transportation (36.0%), followed by the infrastructure (16.8%) and the tourism (11.2%).

Table 2.4 The Offshore Island Development Fund to Xiao-Liu-Qiu by period by category

Period / Category	2003-2006	2007-2010	2011-2014	Total
Infrastructure	317,890 (57.3%)	111,732 (29.9%)	52,180 (16.8%)	481,802 (38.9%)
Transportation	64,100 (11.6%)	65,640 (17.6%)	111,770 (36.0%)	241,510 (19.5%)
Disaster prevention	95,910 (17.3%)	57,000 (15.2%)	30,000 (9.7%)	182,910 (14.8%)
Tourism	8,500 (1.5%)	72,250 (19.3%)	34,800 (11.2%)	115,550 (9.3%)
Education	32,570 (5.9%)	15,834 (4.2%)	24,024 (7.7%)	72,428 (5.8%)
Social welfare	15,890 (2.9%)	10,085 (2.7%)	14,347 (4.6%)	40,322 (3.3%)
Industry	8,650 (1.6%)	24,000 (6.4%)	6,700 (2.2%)	39,350 (3.2%)
Medical care	2,800 (0.5%)	6,082 (1.6%)	22,568 (7.3%)	31,450 (2.5%)
Culture	8,000 (1.4%)	11,300 (3.0%)	1,000 (0.3%)	20,300 (1.6%)
Others	0 (0.0%)	0 (0.0%)	12,900 (4.2%)	12,900 (1.0%)
Total	554,310 (44.8%)	373,923 (30.2%)	310,289 (25.1%)	1,238,522 (100.0%)

Note: The total amount of the Fund was accumulated from 2003 to 2014. Unit: Thousand TWD (%).

Source: Pingtung County Government (2014), compiled by author.

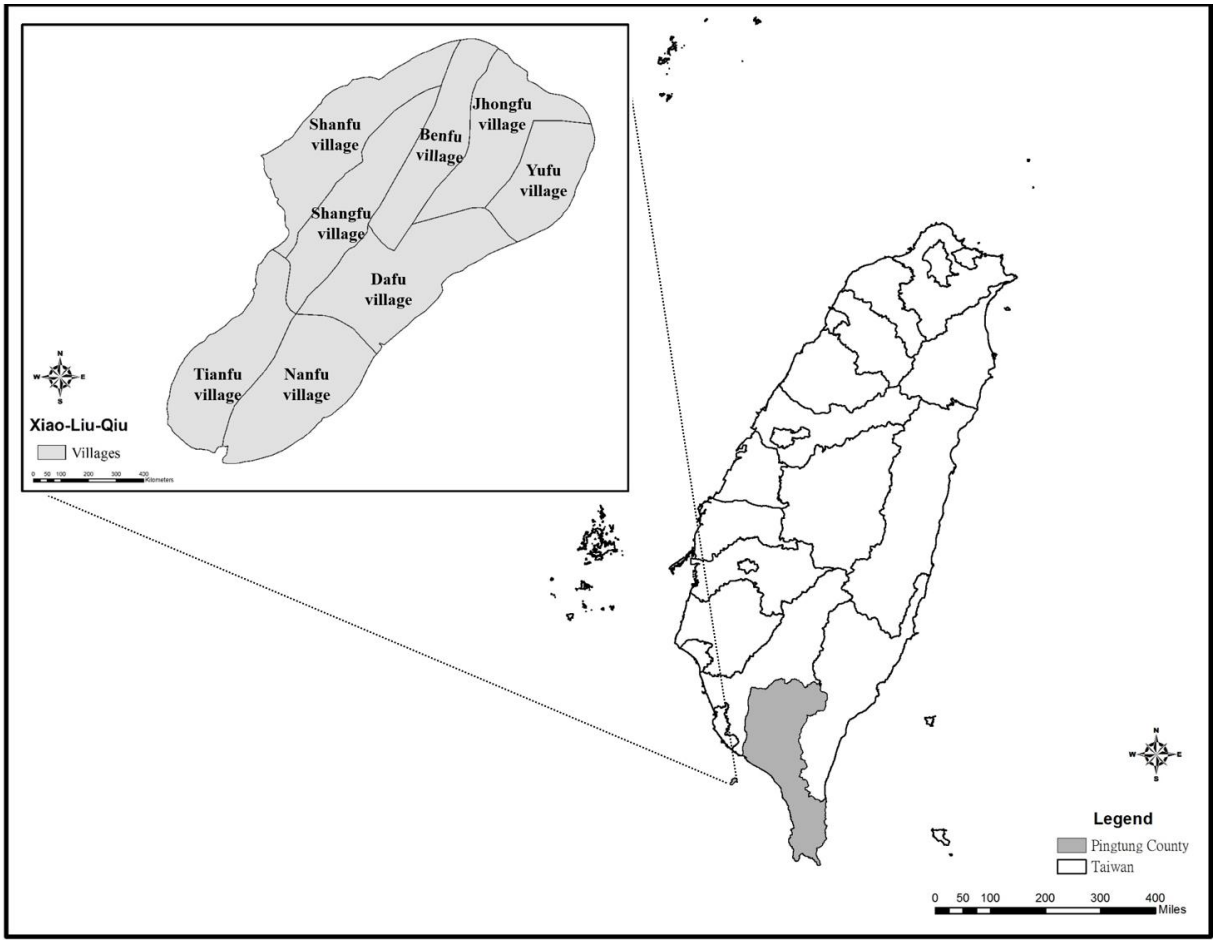
In summary, the targets of the investment by the Taiwanese government can be observed in terms of the distribution of the Fund of each period. The main investments went to the infrastructure of islands during the years of 2003-2006, and it shifted to the infrastructure and the industry development during the years of 2007-2010. Currently, the Fund is distributed to the items of social and educational aspects. In other words, the investment by the Taiwanese government was gradually transferred from the hardware facilities to the software facilities in the past decade.

2.3 The development of Xiao-Liu-Qiu

Xiao-Liu-Qiu, located in the Taiwan Strait near the south-west part of Taiwan, is the only coral offshore island of Taiwan with 6.8 km^2 of the total territorial area. Xiao-Liu-Qiu is officially categorized as a District/ Township, which is administrated by the Pingtung County

government[5]. The island is composed of eight villages, they are Jhongfu village, Yufu village, Dafu village, Nanfu village, Tianfu village, Shanfu village, Shangfu village, and Benfu village (Figure 2.3).

Figure 2.3 The location of Xiao-Liu-Qiu



Source: Drew by author.

2.3.1 Population

Table 2.5 shows the number of households and registered residents of Xiao-Liu-Qiu during the years 1987-2014. The number of households were increasing year by year, but the number

[5] The administrative division of Taiwan is categorized into village, district/ township, county, and city in terms of the administrative level of each region.

of residents remained almost the same. One of the reasons is that the demand to build accommodation for tourists has been increasing because of tourism development.

Table 2.5 The number of the households and the residents of Xiao-Liu-Qiu

Year	Household*	Resident**	Year	Household*	Resident**
1987	3,100	14,822	**2001**	3,475	14,485
1988	3,084	14,677	**2002**	3,400	13,326
1989	3,104	14,602	**2003**	3,456	13,215
1990	3,090	14,169	**2004**	3,607	13,139
1991	3,069	13,898	**2005**	3,777	13,289
1992	3,049	13,463	**2006**	3,701	12,813
1993	3,045	13,671	**2007**	3,743	12,652
1994	3,053	13,161	**2008**	3,814	12,550
1995	3,084	12,886	**2009**	3,922	12,620
1996	3,065	12,619	**2010**	3,977	12,300
1997	3,096	13,800	**2011**	4,020	12,169
1998	3,149	12,562	**2012**	4,057	12,145
1999	3,184	12,472	**2013**	4,146	12,415
2000	3,232	12,514	**2014**	4,278	12,675

Source: Pingtung County Government (2015), compiled by author.

As mentioned earlier, Xiao-Liu-Qiu is composed of eight villages. Table 2.6 shows the population of each village on Xiao-Liu-Qiu up to January, 2016. About 20% of the residents live in the Benfu village, it is the most flourishing area on Xiao-Liu-Qiu. Dafu village is the region with the second biggest population, with 16% of the total residents. Fishing is the main industry on Xaio-Liu-Qiu, and the main fishing port, Dafu port, is located in Dafu village. Therefore, residents who rely on fishing for their living usually live in the Dafu village.

In terms of the share of the male and female, the distribution are about 55% for the males and 45% for the females in general. The share of the male and female residents do not appear big difference in each village.

Table 2.6 The population of Xiao-Liu-Qiu by village

Village \ Sex	Male	Female	Total
Benfu village	1,328 (54%)	1,153 (46%)	2,481 (20%)
Jhongfu village	771 (54%)	649 (46%)	1,420 (11%)
Yufu village	645 (56%)	500 (44%)	1,145 (9%)
Dafu village	1,072 (55%)	876 (45%)	1,948 (16%)
Nanfu village	744 (55%)	605 (45%)	1,349 (11%)
Tianfu village	701 (55%)	578 (45%)	1,279 (10%)
Shangfu village	1,066 (56%)	852 (44%)	1,918 (15%)
Shanfu village	536 (56%)	417 (44%)	953 (8%)
Total	6,863 (55%)	5,630 (45%)	12,493 (100%)

Note: The statistics is collected up to January, 2016.
Source: Pingtung County Government (2016).

2.3.2 Economic structure in general

The economy of Xiao-Liu-Qiu is typified by a large fishing industry and a small service industry. The economic size of the secondary industry is very limited, but the tertiary industry is getting bigger, in particular in tourism characteristic industries. Table 2.7 shows the economic structure for Xiao-Liu-Qiu in 2006 and 2011.

The total production value was 1,625.4 million TWD in 2006, including 1,020.8 million TWD (62.8%) from the primary industry[6], 127.7 million TWD (7.9%) from the secondary industry, and 476.8 million TWD (29.3%) from the tertiary industry. In 2011, the production value was 1,950.1 million TWD in total. The contributions were from the primary industry with 1,073.0 million TWD (55.0%), from the secondary industry with 204.8 million TWD (10.5%), and from the tertiary industry with 672.3 million TWD (34.5%), respectively.

[6] The primary industry includes the categories of agriculture, forestry, fishing and animal husbandry. The category of fishing shares the biggest portion in the primary industry of Xiao-Liu-Qiu.

Table 2.7 The economic structure of Xiao-Liu-Qiu

Year / Industry	Production Value*		Workforce**	
	2006	**2011**	**2006**	**2011**
Primary	1,020.8 (62.8%)	1,073.0 (55.0%)	4,911 (89.3%)	4,379 (83.5%)
Secondary	127.7 (7.9%)	204.8 (10.5%)	38 (0.7%)	70 (1.3%)
Tertiary	476.8 (29.3%)	672.3 (34.5%)	551 (10%)	797 (15%)
Total	1,625.4 (100%)	1,950.1 (100%)	5,501(100%)	5,246 (100%)

Note: * Unit: Million TWD.

** Unit: Person.

Source: Calculated by author based on statistics provided by DGBAS (2007, 2008, 2009, 2012, 2013) and PTCG (2007, 2012).

In addition, the total workforce in the primary industry declined from 4,911 people to 4,379 people. However, the workforce in the secondary industry increased from 551 people to 797 people. The resident numbers working in the secondary industry remained small, but it had a big increase. Although most labor force still worked in the primary industry, the number of the workforce by industry showed that the economy of Xiao-Liu-Qiu was gradually shifting its gravity center from the primary industry to the tertiary industry.

2.3.3 Water transportation (Ferry)

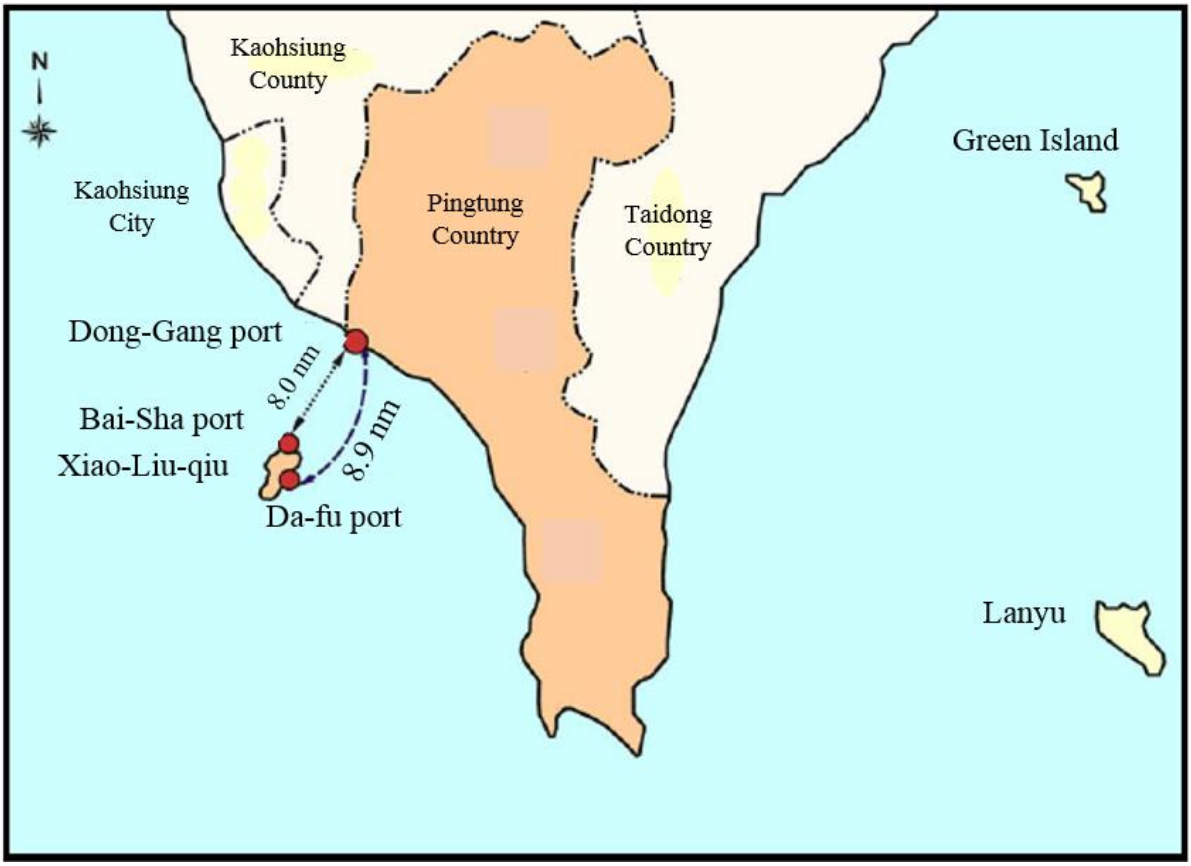
The water transportation plays a significant role since it is the only approach to access Xiao-Liu-Qiu, it not only for carrying the tourists to the island, but it also provides the service to the locals for commuting between Xiao-Liu-Qiu and the mainland of Taiwan. The Dong-Liu Water Route (東琉線) offers regular transportation service between Dong-Gang port (東港碼頭) and Xio-Liu-Qiu.

Two companies provide water transportation services: one is Liu-Shin Company (琉興公司), which is funded and managed by the local government, Liuqiu Township Office (琉球鄉公所). The distance between Dong-Gang port (東港碼頭) and Da-Fu port (大福漁港) of Xiao-Liu-Qiu is 8.9 nautical miles.

The other route is operated by a united private ownership, called Dong-Liu United Water Transport (東琉線交通客船聯營處), and the distance is counted as 8.0 nautical miles, between

Dong-Gang port (東港碼頭) and Bai-sha port (白沙觀光港). The information regarding the two water routes operating between Dong-Gang port (東港碼頭) and Xiao-Liu-Qiu is showed in Figure 2.4.

Figure 2.4 The water routes between Dong-Gang port and Xiao-Liu-Qiu



Source: Chen et al. (2012), modified by author.

Table 2.8 shows the information regarding ferry boats in operation of Dong-Liu Water Route (東琉線). Until 2015, two ferries were owned by Liu-Shin Company (琉興公司), and eight ferry boats were owned by Dong-Liu United Water Transport (東琉線交通客船聯營處).

The construction year of the ferry boats was from 1993 to 2014; it shows that some ferry boats has been used for more than 20 years. Overall speaking, the size of ferries are similar, with the length of 25.1-28.5 meters, the width of 5.8-6.8 meters, the draught of 2.2-2.9 meters, and all ferry boats are under 200 tonnes. The capacity of each ferry boat is slightly different, with the range of 174-193 passengers; and all ferries are operated by using diesel fuel.

Table 2.8 The information of the ferries in operation of Dong-Liu Water Route

Ownership	Ferry name	Capacity (Person)	Length (Meter)	Width (Meter)	Draught (Meter)	Construction year
Liu-Shin Company (Public ferry)	Xin-Tai	193	28.6	6.3	2.7	1996/10
	Ji-Xiag-Ru-yi	191	28.5	6.8	2.8	2003/10
Dong-Liu United Water Transport (Private ferry)	Dong-Xin	174	25.1	6.4	2.2	1993/02
	Qun-yi	190	25.1	5.8	2.8	1995/12
	Fei-Ma	185	26.6	6.2	2.6	2003/09
	Dong-Sheng	187	23.4	6.0	2.8	1996/11
	Guang-Hui	188	25.6	6.5	2.7	2007/03
	Tai-Fu No.1	192	28.5	6.5	2.9	2013/02
	Tai-Fu No.2	192	28.5	6.5	2.9	2013/07
	Tai-Fu No.3	192	28.5	6.5	2.9	2014/03

Source: Chen et al. (2012) and Tai-Fu shipping (2014), compiled by author.

Table 2.9 provides the scheduled timetable and fares for the different type of passengers. Liu-Shin Company (琉興公司) voyages between Dong-Gang port (東港碼頭) and Xiao-Liu-Qiu for five times per day, and Dong-Liu United Water Transport (東琉線交通客船聯營處) voyages for seven times per day, according to the schedule. The transit time for one-way journey takes about 30 minutes.

Regarding the fare, Dong-Liu United Water Transport (東琉線交通客船聯營處) charges the passengers for a bit higher price than Liu-Shin Company (琉興公司) because Dong-Liu United Water Transport (東琉線交通客船聯營處) is a private and profit-oriented company. The residents of Xiao-Liu-Qiu only have to pay about one-third to one-second of full price to get a round-way journey due to the government subsidy for their transportation.

Table 2.9 The timetable and fare of Dong-Liu Water Route

Liu-Shin Company (Public ferry)			
Dong-Gang—Xiao-Liu-Qiu		**Xiao-Liu-Qiu—Dong-Gang**	
8:00		7:00	
11:00		9:30	
14:00		13:00	
16:30		15:00	
18:45		18:00	
Fare: Resident (one-way): 60 TWD (Adult), 30 TWD (Child, under 12 years old) Non-resident (round-trip):380 TWD (Adult), 220 TWD (Child, under 12 years old)			
Dong-Liu United Water Transport (Private ferry)			
Dong-Gang—Xiao-Liu-Qiu		**Xiao-Liu-Qiu—Dong-Gang**	
7:00	12:36	7:40	14:00
7:30	13:30	8:30	14:30
8:00	14:00	9:00	15:00
9:00	15:00	10:00	16:00
9:30	15:36	10:36	17:00
10:45	17:00	12:00	17:30
11:30	17:30	12:30	18:00
Fare: Resident (one-way): 100TWD (Adult), 50TWD (Child, under 12 years old) Non-resident (round-trip):410 TWD (Adult), 210 TWD (Child, under 12 years old)			

Note: The transit time is about 30 minutes for one-way journey. The timetable and fare is retrieved in October, 2015.

Source: Liu-Qiu Township Office (2009), Dong-Liu United Water Transport (2015), and Tai-Fu shipping (2014).

In terms of the ferry fare for a round-trip journey, Liu-Shin Company (琉興公司) charges the residents for 120 TWD for an adult passenger and 60 TWD for a child passenger. Regarding the non-resident, they charge 380 TWD for an adult passenger and 220 TWD for a child passenger. In regard to the ferry fare charged by Dong-Liu United Water Transport (東琉線交通客船聯營處), the company charges the residents for 200 TWD for an adult passenger and 100 TWD for a child passenger. Regarding the non-resident, they charge 410 TWD for an adult passenger and 210 TWD for a child passenger

2.3.4 Tourism attractions of Xiao-Liu-Qiu

With regarding to tourism attractions, there are twenty eight tourism attractions recommended by the local government while tourists visit on Xio-Liu-Qiu (Liuqiu Township Office, 2009).

Figure 2.5 Tourism attractions of Xiao-Liu-Qiu

Source: Liu-Qiu Township Office (2009).

Tourism attractions on Xiao-Liu-Qiu can be briefly divided into two categories, including natural attraction and artificial attractions. The brief introduction of each attraction is described in Appendix 2. The location of tourism attractions are showed in Figure 2.5. Most sites are

located on the coastal road, and the distance between each tourism site is short because Xiao-Liu-Qiu is a small island.

2.3.5 Tourist-resident ratio and seasonality

Figure 2.6 shows the number of registered residents, the total tourist numbers, and the tourist-resident ratio of Xiao-Liu-Qiu in the years of 1996-2014. The number of residents stayed around 12,000 persons, but the visitor numbers increased sharply. Between 1996 and 2014, tourist arrivals grew from 153,278 to 868,115 people. During 1996-2007, the ratio of tourist to resident was estimated at 12.1-24.5 to 1. However, the ratios have exceeded 50 since 2011.

Figure 2.6 The number of residents and tourists, and the resident-tourist ratio of Xiao-Liu-Qiu

Note: Total tourist number is estimated by author, and the estimation procedure is described in Chapter 3.

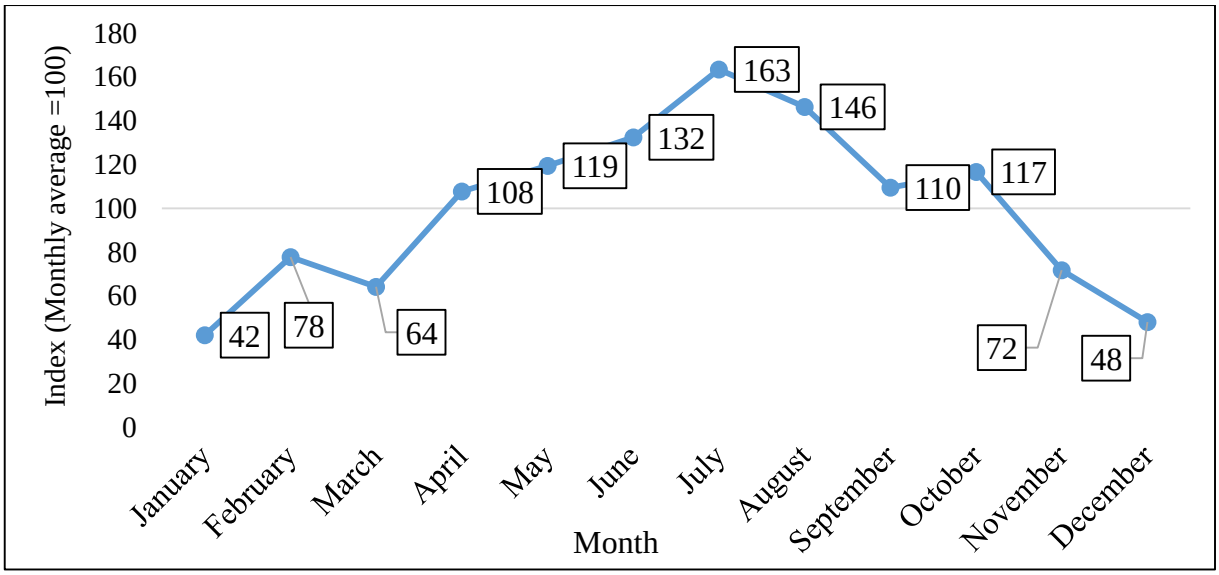
Source: Donggang Household Registration Office (2015), calculated by author.

As suggested by Shafaei and Mohamed (2015), the tourist-resident ratio can be served as a variable that affects residents' perception of social impacts in tourism. During tourists' stay at a destination, they share the public spaces, services and natural resources with residents. It can be considered as pressure on the environment and socio-culture system of the host community if tourism activities are not properly planned and managed.

Seasonality is regarded as a repeated and predictable cycle of tourist visitation across a year (Zaman et al., 2011). The irregular tourist arrivals over the year have an impact on the utilization rate of tourism facilities (i.e. transportation, accommodation). Figure 2.7 shows the seasonality of the tourist visitation of Liouciou Scenic Area (琉球風景區) in 2012-2014. Liouciou Scenic Area includes three fee-charged spots named Beauty Cave, Black Dwarf Cave, and Wild Boar Ditch. They are the only government owned scenic spots on Xiao-Liu-Qiu and they are managed by the Liu-Qiu Township Office. The monthly average index of the number of tourist visitation of Liouciou Scenic Area is 100.

Comparing to the average index, the high season starts from April to October, and the low season includes January to March, and November to December. Observing the index of each month, the lowest and the highest ones was about 3.88 times difference. The index of June was calculated at 163, and the index of January was calculated at 43. Particularly in summer (from May to August), a quarter of the year, the scenic area handles 46.8% of all tourists on average. These figures do not represent the real total tourist arrivals of Xiao-Liu-Qiu since not all tourists visit Liouciou Scenic Area, but it can characterize the trend of the tourist arrivals by month.

Figure 2.7 The seasonality of the tourist visitation of Liouciou Scenic Area



Note: Indices are calculated based on the sales of ticket of Liouciou Scenic Area, 2012-2014.
Source: DBNSA (2015), calculated by author.

2.4 The characteristics of tourism of Xiao-Liu-Qiu

It seems to be easily notice that the tourism scale is growing year by year on Xiao-Liu-Qiu. However, there is no study or official document reporting the tourists' characteristics and the tourism business system of the island. For this reason, I conducted the on-site investigations in order to draw a broad outline of the current tourism development of the island. In total, two on-site investigations were conducted: one in 2012 for understanding the tourists' characteristics and their spending patterns[7]; and the other was in 2014 for explore the tourism business system.

2.4.1 Tourists' characteristics and their spending

In total, 380 on-site questionnaires were carried out on the 31st of August and the 1st -2nd and 7th -10th of September, 2012, considering both weekdays and weekends. The locations for distributing the questionnaire were at the both public and private ferry ports. The sampling method was purposive sampling. Visitors who were not registered as residents and had completed their trips on Xiao-Liu-Qiu were considered as the sample target. The survey collected information on tourist itineraries, transportation modes used (both water and land transportations), accommodation choice, attractions visited, and activities undertook.

2.4.1.1 Tourists' characteristics

Table 2.10 show the tourists' characteristics and their behavioral choices on Xiao-Liu-Qiu. To summarize the results of survey: the majority of visitors (93.2%) arranged the tour by themselves and approximately 55.7% of visitors were female. 61.6% of respondents stayed overnight on Xiao-Liu-Qiu, and 87.6% of them used Bed & Breakfast (B&B) accommodations for their lodgings. 53.9% of total respondents were in the age range of 18-25, followed by about 32.3% of respondents 26 to 35 years old. 46.3% of respondents were from the southern Taiwan, followed by 27.1% from the northern Taiwan.

[7] The investigation was conducted through an on-site questionnaire survey, the questionnaire used is showed in Appendix 3.

Table 2.10 Tourists' characteristics of Xiao-Liu-Qiu

Item	Category	Valid number (%)
Tour arrangement (n=380)	By travel agency	26 (6.8)
	Self-arranged	354 (93.2)
Sex (n=375)	Male	166 (44.3)
	Female	209 (55.7)
The length of stay (n=376)	One day	145 (38.6)
	Two-day	211 (56.1)
	Three-to-five day	20 (5.3)
Lodgings during the stay (n=379)	No stay overnight	145 (--)
	Bed and Breakfast (B&B) accommodations	205 (87.6)
	Hotel	19 (8.1)
	Friend/relative's house	9 (3.8)
	Camping and others	1 (0.4)
Age (n=375)	18-25	202 (53.9)
	26-35	121 (32.3)
	36-45	33 (8.8)
	46-55	16 (4.3)
	Above 56	3 (0.8)
Residence* (n=376)	South of Taiwan	174 (46.3)
	North of Taiwan	102 (27.1)
	Central of Taiwan	91 (24.2)
	East and offshore island of Taiwan	9 (2.4)
Visit time (n=380)	First time	259 (68.2)
	Second time	82 (21.6)
	Third time	17 (4.5)
	More than fourth time	22 (5.8)
Land transportation choice (n=377)	Rental Motorcycle	307 (81.4)
	Owned Motorcycle	35 (9.3)
	Car	14 (3.7)
	Tour bus	10 (2.7)
	Electric scooter	6 (1.6)
	Bicycle	5 (1.3)
Water transportation choice (n=370)	Private ferry	276 (74.6)
	Public ferry	94 (25.4)

Note: The total respondent numbers (n) of each item excluded the missing values.
* Residence denotes the current living area of respondents.
Source: Surveyed by author in 2012.

68.2% of respondents visited Xiao-Liu-Qiu for the first time, and one-third of the respondents were repeat visitors. Regarding land transportation, the majority of respondents

(90.7%) used motorcycle, both rental and self-owned, as the transportation means during their stay on Xiao-Liu-Qiu. In terms of water transportation, 74.6% of respondents took the private ferry from the mainland of Taiwan to Xiao-Liu-Qiu.

2.4.1.2 Tourist spending of Xiao-Liu-Qiu

Table 2.11 summarizes the result of tourists spending on Xiao-Liu-Qiu by length of stay by category in 2012. Three types of the spending are categorized by the length of stay of the tourists. 56% of respondents spent two days with an average expenditure of 2,965 TWD; and 39% of tourists spent one day with a 1,388 TWD on average. Only 5% of tourists stayed three to five days, with an average of 4,605 TWD.

Table 2.11 Tourist spending of Xiao-Liu-Qiu by length of stay by category, 2012

The length of stay / Category	**1 day**	**2 days**	**3-5 days**	**Average sum**
Valid surveyed numbers	135 (39%)	193 (56%)	19 (5%)	347 (100%)
Water transportation (ferry)	410 (30%)	410 (14%)	410 (9%)	410 (12%)
Accommodations	-- (--)	1,032 (35%)	2,218 (48%)	1,625 (46%)
Food & Beverages	315 (23%)	452 (15%)	726 (16%)	498 (14%)
Leisure & Recreation Services*	93 (7%)	244 (8%)	288 (6%)	208 (6%)
Land transportation	253 (18%)	435 (15%)	676 (15%)	455 (13%)
Shopping (souvenirs)	317 (23%)	392 (13%)	287 (6%)	332 (9%)
Total	1,388 (100%)	2,965 (100%)	4,605 (100%)	3,528 (100%)

Note: Unit: TWD.

* Leisure and recreation services are the outdoor activities provided by the locals, it mainly includes scuba diving, snorkeling, intertidal zone tour, night land tour, and semi-submersible tour.

Source: Surveyed by author in 2012.

For one-day trip tourists, the ferry fare is the major expenditure (30%), followed by categories of shopping (souvenirs) (23%) and food and beverages (23%). However, the spending on accommodation is the main expenditure for two-day tourists, it shared 35% of the total spending during their trip, followed by food and beverages (15%) and land transportation (15%). Regarding three-to-five days tourists, they spent 48% of the total spending on accommodation, 16% for food and beverages and 15% for motorcycle rental, on average.

In general, tourist spending can be divided into six categories. On average, tourists spent the most on accommodation while they have overnight trips on Xiao-Liu-Qiu. But, they spent the least on leisure and recreation services during their trips. A possible reason is that the average length of stay is too short to enjoy these outdoor activities. It is not surprising that the amount of spending is higher while the length of stay is longer. However, it is not the case that the amounts of spending on shopping (souvenirs) are not different no matter how long the tourists stay.

2.4.1.3 The visit rate of tourism sites

In the on-site survey, the respondents were asked to point out the tourism sites that they had visited during their trips.

Table 2.12 The visit rates of tourism site of Xiao-Liu-Qiu, 2012

Tourism site	Visit rate (%)	Tourism site	Visit rate (%)
Beauty Cave*	74.9	White Lighthouse	31.0
Black Dwarf Cave*	72.6	Chung-Au Beach	30.3
Wild Boar Ditch*	55.7	San-Min Road	28.5
Vase Rock	50.4	Indian Rock	28.0
Sea View Pavilion	46.2	San-Fu Port	25.6
Sunset Galley	44.3	Mouse Rock	17.7
Ger-ban Bay (Beach)	42.5	Duo-Zai-Ping intertidal zone	15.9
Guanyin Rock	39.1	Wetland Part	12.4
Hou-Shi Fringing Reef	36.1	Ling-Shan Temple	11.6
Bi-Yun Temple	31.4	Hai-Tzu-Kuo port	10.1
Lobster Cave	31.4	Climbing Tiger Rock	6.6
San-Fu Ecological Path	31.1	Restoration Pavilion	5.3

Note: Each respondent was requested to respond whether they visited the sites in this trip.
* denotes the entrance fee charged site.
Source: Surveyed by author in 2012.

Table 2.12 shows the visit rates of each tourism site on Xiao-Liu-Qiu. Most tourism sits of Xiao-Liu-Qiu are free of charge. According to the survey result, the entrance fee charged sites had a higher visit rate comparing to other tourism sites of Xiao-Liu-Qiu, with 74.9% on Beauty Cave, 72.6% on Black Dwarf Cave, and 55.7% on Wild Boar Ditch. In contrast, the attractions such as Restoration Pavilion (5.3%), Climbing Tiger Rock (6.6%), Ling-Shan Temple (11.6%), and Wetland Part (12.4%) appeared the relatively lower visit rates.

The information from this table provides a view to understand the tourists' interest on each tourism site. The entrance fee charged sites appear higher visit rates, it may result from the good publicity promoted by the local government. Besides, the ticket of entrance fee charged sites is usually included in the tour package sold by the accommodation providers of Xiao-Liu-Qiu. These strategies may have increased the tourists' interest in visiting the entrance fee charged sites. Regarding the tourism sites with lower visit rates, it may require promotion to attract tourists' visit.

2.4.2 Tourism business system

The number of tourism-related business establishments (e.g. B&B accommodations) of Xiao-Liu-Qiu have been growing rapidly in recent years because of the boom in tourism. There is no official statistics provided regarding tourism-related business, including accommodation, restaurant, recreational activity service, souvenir selling service, or motorcycle rental service.

Table 2.13 The number of the tourism-related business establishments of Xiao-Liu-Qiu, 2012

Category of tourism-related business establishment	**Number (%)**
Accommodation service	156 (47)
Food service (restaurants and regular vendors)	89 (27)
Motorcycle rental service	22 (7)
Recreational activity service	10 (3)
Shopping service (souvenirs)	53 (16)
Total	330 (100)

Source: Surveyed by author in 2012.

To obtain a quick picture of tourism-related business establishments on the island, an on-site investigation was conducted on April, 3rd-4th, 2014 by using a wireless GPS logger and digital camera. The GPS logger is used to obtain real-time coordinates for each geographical site, and the digital camera is used to record the images of each business and verify the data obtained by the GPS logger.

Data for 330 businesses establishments was recorded in Table 2.13 based on the on-site investigation. They are 156 places that provide accommodation services (mainly B&B accommodations))[8], 89 restaurants and regular vendors, 22 motorcycle rental service providers, 10 recreational activity service providers, 53 souvenir sellers, and the rest of the business establishments mainly provide services to the residents, such as pharmacy, hardware, and local market for selling livestock and other food ingredients.

Accommodation service is the main tourism-related business on Xiao-Liu-Qiu. It is because that the demand of overnight stay tourists were increasing, and the accommodation types of Xiao-Liu-Qiu are mainly B&B accommodations. The B&B accommodations have a very limited capacity due to small scale of investment by the locals, it results in more B&B accommodations are constructed.

Figure 2.8 shows the spatial distribution of the tourism-related business establishments on Xiao-Liu-Qiu. Tourism services are mostly provided by residents, which are family owned

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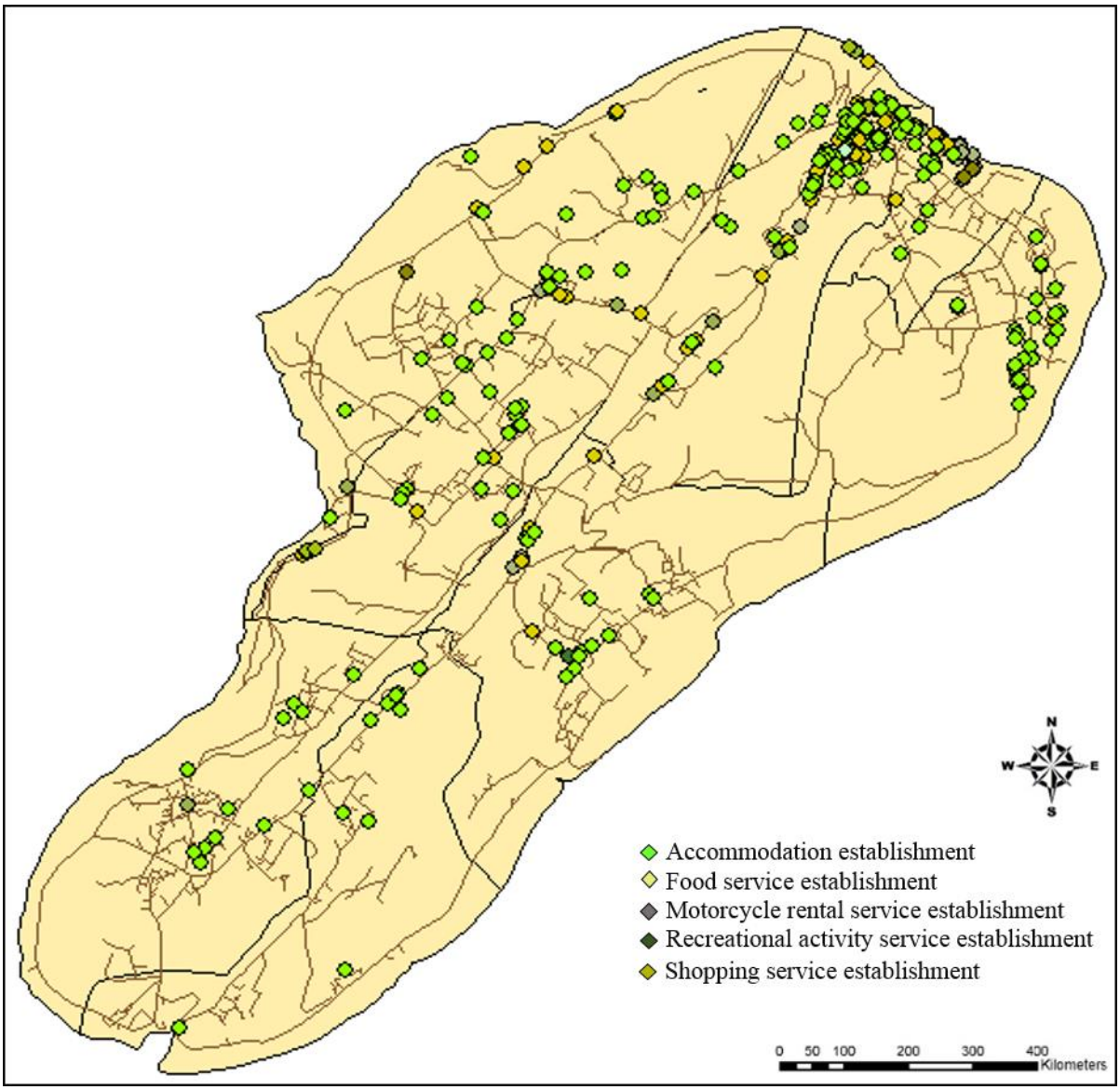
[8] Although a few bigger scale of accommodations were built recently, the majority of accommodations of the island are categorized as the type of bed & breakfast (B&B)/home stay facility. According to the Regulations for the Management of Home Stay Facilities issued by (MOTC (2001)), Article 3, *the term "home stay facility" as referred to in these Regulations shall mean a lodging facility run as a family sideline business, using the spare rooms of a self-used residence to provide tourists with a rural living experience. Such lodging facilities usually incorporate local culture, natural landscape, ecological environment, environmental resources, and agricultural, forestry, fishery, or livestock farming activities."* Besides, the size of the home stay facility is regulated in Article 6, "*…a business registration certificate may be issued to a home stay facility with specific tourism features that has an operating scale of no more than 15 guest rooms, with a total floor area of no more than 200 square meters, provided that such home stay facility is located in an aboriginal reservation, a recreational farm with a business registration certificate issued by the administrative authority for agriculture, a recreational agriculture area designated by the administrative authority for agriculture, a tourist site, a remote area, or on an offshore island.*".

business. In other words, there is no corporate finances invested in the tourism market of the island, and the business are of small scale.

Most tourism-related business are intensively located in the northeast of Xaio-Liu-Qiu where is the most flourishing region of the island, and Bai-sha port is also located in this area. Besides, there is a tendency that tourism-related businesses are located along the main roads, it is a good advantage to provide the convenient services to the tourists.

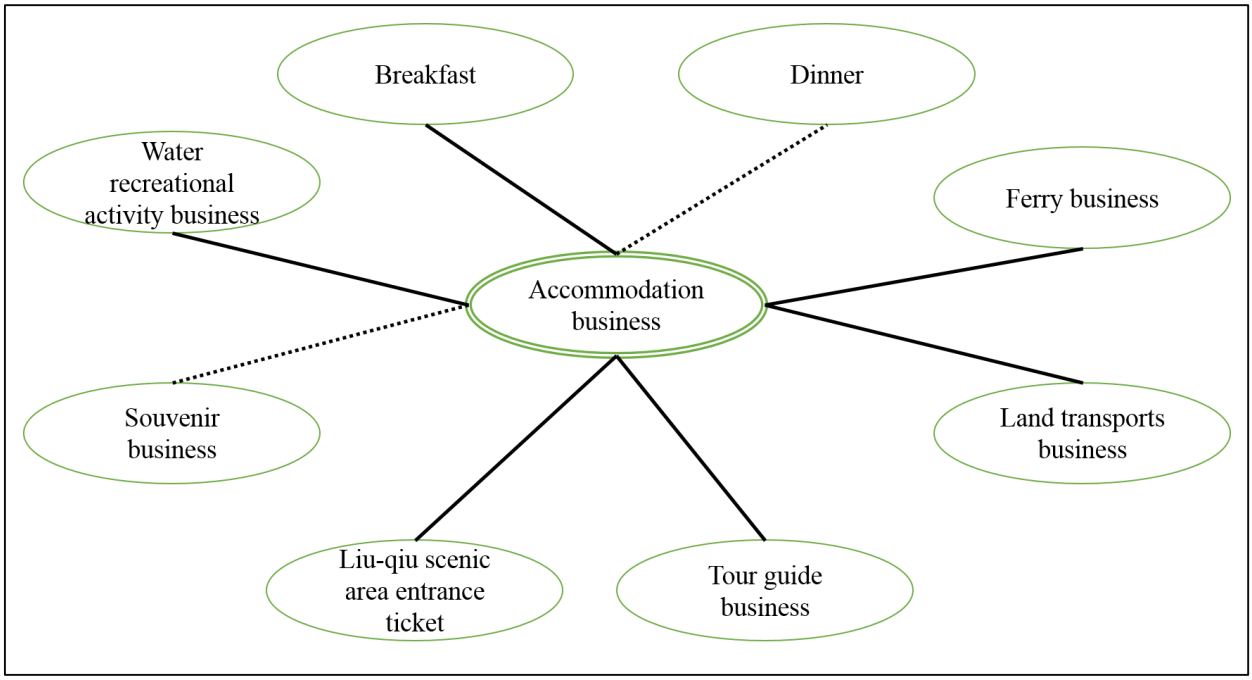
Figure 2.8 The spatial distribution of tourism-related business establishments of Xiao-Liu-Qiu



Source: Created by author based on the on-site survey in 2012.

As the tourism demand increased in the past years, individual business started to form alliances with each other in order to provide more convenient and comprehensive services to the tourists. The accommodation providers offer tour packages usually including loading (e.g. B&B accommodations), a round trip ferry ticket, land transportation (e.g. motorcycle rental), a tidal tour/ night land tour with a tour guide, a Liouciou Scenic Area entrance ticket, water recreational activities (e.g. snorkeling), and breakfast. Some of the tour packages even includes the meal for dinner and souvenir. That is to say, the accommodation providers take the role of tour coordinator in the tourism business system. The concept of tourism business system of Xiao-Liu-Qiu is showed in Figure 2.9.

Figure 2.9 Tourism business system of Xiao-Liu-Qiu



Note: The solid line denotes the common services are provides in the package tour, and the dotted line denotes the services sometimes are included.

Source: Created by author based on the on-site survey in 2012.

2.5 Discussions and Summary

The purpose of this chapter is to understand the trend of global island development and Taiwanese island tourism development, and to explore the island tourism development on Xiao-

Liu-Qiu. Three sub-questions were raised under the main research questions: (1) what are the global agreement trends and national policy of island tourism development of Taiwan? and (2) what is the current situation of island tourism development on Xiao-Liu-Qiu? For answering the questions, literature review and on-site questionnaire survey and investigation were conducted.

First, island communities had received the attention by the world on their development issues. It can be seen from the international conferences since 1992, and the concept of sustainability has become the core while building the developmental plans for island communities.

Second, the government policy of offshore island development of Taiwan was influenced by the international consensus. Since 2000, the period of the Offshore Island Development Fund can be divided into three stages in general. The investment from Taiwanese government was distributed to six inhabited offshore islands and mainly on the construction infrastructure. Look at the Offshore Island Development Fund invested on Xiao-Liu-Qiu in 2003-2014, 38.9% of the spending went to the infrastructure, followed by 19.5% went to the transportation, and 14.8% went to the disaster prevention. The category of tourism shared 9.3% of the total spending in 2003-2014, and it ranked as the third biggest investment, shared 19.3% of the total spending in the period of 2007-2010.

Third, the tourist-resident ratio was analyzed in 1996-2014. It can be regarded as an indicator to examine the pressure on the host, particular on the aspects of environment and socio-culture. The ratios were increasing stably in 1996-2007, it about 12.1-24.5 tourists to 1 resident. However, it exceeded 50 tourists to 1 resident since 2011.

Fourth, the seasonality of Liouciou Scenic Area was observed, it was taken to explore the tendency of the tourist arrivals on Xiao-Liu-Qiu. The high season and the low season were identified in terms of the ratio of the tourist numbers of each month to the monthly average. The high season was from April to October. The gap between the highest month (the index of June: 163) and the lowest month (the index of January: 42) was calculated at 3.88 times difference. 46.8% of the tourists visited Liouciou Scenic Area concentrated in the months from May to August. In other words, tourists prefer to visit Xiao-Liu-Qiu in summer, one possible explanation is that most attractions and activities are outdoor-oriented, the warm climate is more

suitable for tourists to visit the destination. Besides, summer vacation is one of the factors to bring young generation to visit this island.

Fifth, the on-site survey was conducted in 2012 to investigate the tourists' characteristics and their spending on Xiao-Liu-Qiu. The majority of respondents (93.2%) were self-arranged tourists. 90.7% of the respondents answered that they used motorcycles for their land transportation, and about 87.6% of overnight stay tourists selected B&B accommodations. Regarding the tourist spending, 56% of the respondents spent two days with the average expenditure of 2,965 TWD, 39% of the respondents had a one-day trip with the average expenditure of 1,388 TWD, and the rest of respondents stayed three to five days with a 4,605 TWD of expenditure on average. Although agriculture is the main industry on Xiao-Liu-Qiu, tourism income is getting important to the locals. The effect of tourism income to the economy of Xiao-Liu-Qiu will be analyzed in Chapter 4.

The last, a type of tourism business system was observed to develop in this chapter. It was formed based on a collaborative network system by the locals. The system not only simplifies the procedure of traveling arrangement by the tourist themselves, but also guarantees the profits from tourism would benefit to the local people.

CHAPTER 3

ENERGY USE AND CARBON DIOXIDE EMISSIONS OF SMALL ISLAND TOURISM

3.1 Introduction

3.1.1 Background

Almost all tourism activities need to consume energy, such as fuels, electricity, and so on (Sisman, 2007), and energy use in tourism destinations is usually disproportionately greater compared to normal energy consumption in communities of similar size (Tabatchnaia-Tamirisa, Loke, Leung, & Tucker, 1997). Unavoidably, the more energy used, the more greenhouse gases generated, mainly carbon dioxide (CO_2). Therefore, limiting the use of fossil energy has been regarded as an essential issue for achieving sustainable development (Gössling et al., 2005).

Since the beginning of the 21st century, the issue of greenhouse gas emissions generated from tourism has been taken into consideration due to its negative effects on biogeochemical cycles, the biosphere, and global warming (Gössling, 2002; UNWTO, 2003). The major impact from greenhouse gas emissions results in climate change, and climate is one of the important factors for tourism development. In the report of "Climate Change and Tourism: Responding to Global Challenges" published by United Nations World Tourism Organization (2007) clearly stated, tourism industry must respond to climate change rapidly because tourism relies on climate as a resource and tourism is highly sensitive to the impacts of climate change. Tourism contributed 5% of the total world carbon dioxide emissions in 2005: 75% came from transportation, including 40% from aviation and 32% from land transportation (UNWTO, 2008). In particular, the tourism road segment is increasing rapidly without any saturation sign (Martı´n-Cejas & Sa´nchez, 2010).

It has been known that climate change will negatively affect tourism development, such as the decrease in tourist numbers and profits because of the direct and indirect impacts on

environment and the effects of mitigation policies on tourism mobility. Countries in the world have started to make policies for carbon dioxide emission reduction, e.g. increasing energy cost (Sun, 2014b), and also through indirect societal change impacts, for example, global warming may cause economic recession (Stern Report on Economics of Climate Change, 2006).

As Tang, Zhong, Fan, and Cheng (2015) suggested, a study on energy use and carbon dioxide emissions from tourism could contribute to the sustainable development of the regions where tourism is considered as a pillar industry. In this chapter, Xiao-Liu-Qiu is taken as an example to discuss the issue of tourism environmental impact in terms of carbon dioxide emissions.

3.1.2 Research objectives and questions

The purpose of this chapter is to quantify energy use and carbon dioxide emissions from tourism-related transportation and accommodation in terms of the tourist choices. The main research question is what the environmental impact of the tourism expansion of an island tourism destination is in terms of energy use and carbon dioxide emissions on Xiao-Liu-Qiu as mentioned in Chapter 1. To that end, this study utilizes a bottom-up approach[9] to answer the following sub-questions:

i. How much tourism-related energy is consumed on Xiao-Liu-Qiu?

ii. How much carbon dioxide emissions is attributed to tourism activities of Xiao-Liu-Qiu?

iii. How much carbon dioxide emissions can be mitigated through the green transportation policy implemented for land transportation?

3.1.3 Measure boundary

Becken and Patterson (2006) suggested that the scope of tourism impact can be divided into three categories, including transportation, accommodation, and attraction/ activities. The categorization system is utilized by the United Nations (UN), United Nations Environment Programme (UNEP), and World Meteorological Organization (WMO) since 2008, and it is

[9] Bottom-up approach is described in the section of 3.2.1 of this chapter.

considered suitable for this type of research since limited information and data are available on emissions from restaurants.

The measure scope of this study only focused on CO_2 emissions (simple direct emissions) in terms of transportation and accommodation. Transportation includes the journey to and from the destination and travel on the island of Xiao-Liu-Qiu. Since water transportation is the only way to reach the island, mainly via Dong-Liu water route, and Dong-Gang port is set as the origin and Xiao-Liu-Qiu is the destination in this study.

The tourism experience on the island of Xiao-Liu-Qiu was taken as an evaluation period, from the time that the tourists take the ferry boat, until they return to the port at Dong-Gang. The travel from the Dong-Gang port to the place of the origin (home/next destination) will be excluded. The negative tourism impacts happen while the level of tourists' use is greater than the capacity of the environment. Uncontrolled tourism activities can cause threats. According to UNEP (n.d.), the negative impact from tourism can be categorized into three areas, including natural resources depletion (e.g., land degradation, water resources), pollution (e.g. air pollution, solid waste), and physical impact (e.g. ecosystem degradation). Regarding pollution, air pollution from tourism activities can cause the impact globally, particular from carbon dioxide emissions, and it also cause serious local air pollution. On Xiao-Liu-Qiu, tourists are suggested to use gasoline motorcycle for their land transportation, the exhaust is the main source for air pollution on Xiao-Liu-Qiu, and it directly affects the air quality of the locals. Besides, the water transportation (ferry) and the accommodation also contribute to air pollution as well. Therefore, in this study, carbon dioxide emissions is taken as the proxy of the negative impact from tourism on the environment of Xiao-Liu-Qiu.

3.2 Literature review

3.2.1 Approaches for quantifying carbon dioxide emissions

The term "carbon dioxide emissions" originated from the field of Ecological Footprint. At the beginning of the 1990's, the concept of Ecological Footprint was first introduced by Mathis Wackemagel and William Rees. Ecological Footprint analysis is defined as "an accounting tool that enables us to estimate the resource consumption and waste assimilation requirement of a defined human population or economy in terms of a corresponding productive land area"

(Wackernagel & Rees, 1996, p.9, as cited in Hunter & Shaw (2007). In other words, it was initially designed to quantify the amounts of gaseous emissions that are associated with human activities in a given geographical boundary (Chi & Stone Jr., 2005; Wiedmann & Minx, 2008).

There are two main quantitative approaches for estimating carbon dioxide emissions. One is the top-down approach, usually built on environmental and economic accountings, which is based on monetary flow (Björnsson, 2014; Forsyth et al., 2008). The other is the bottom-up approach, that is regarded as an activity-based model or an expenditure-based measure (Forsyth et al., 2008; Howitt, Revol, Smith, & Rodger, 2010). This approach concerns the behavior of users, energy use, and users' activities at a given destination. Table 3.1 summaries the comparison of these two approaches in terms of the viewpoint, data source, and characteristics.

Table 3.1 Two approaches for carbon dioxide emissions estimation

Approach / Category	Bottom-up approach	Top-down approach
Viewpoint	— It provides a perspective of tourism as a disaggregated sector and is therefore reductionist. — It takes a sample of activities and then scales it up to the national/regional situation.	— It provides an abstract overview of tourism as a sector in the national/regional economy. — It considers the whole economy, then scale activities down to only include the tourism sector.
Data	— Business surveys: to obtain the information which reflect the regional differences in the production function and the intensity of carbon dioxide by detailed subindustries. — Visitor surveys: different travel behaviors and tourism choices (transportation modes, the length of stay, type of accommodation), leading to a distinct energy-use coefficient.	— Based on economic-environmental accounting (e.g. Input-output table, Tourism satellite account, ecological resources/ waste emissions data by industry).

(continued)

Table 3.1 Two approaches for carbon dioxide emissions estimation (continued)

Approach / Category	Bottom-up approach	Top-down approach
Characteristics	— It is suited for small regions, the investment of data collection at the industry level is manageable, and visitor surveys can be customized to reflect greater levels of detail. — It provides detailed information on energy end-uses and the main drivers of carbon dioxide emissions.	— Tourism does not appear in the framework of a single acknowledged industrial sector, it rather is defined as a combination of items and services that tourists purchase. — Multiplier effects of greenhouse gas emissions resulting from tourism consumption can be quantified for either destinations or for events. — It can be used to compare the eco-efficiency among different industries or for formulating macroeconomic instruments (e.g. carbon taxes).

Source: Compiled by author based on Cadarso Vecina, Gómez Sanz, López Santiago, and Tobarra Gómez (2011) and Sun (2014a).

3.2.2 Carbon footprint studies in the tourism field

Reviewing the related academic works in the tourism field, some studies focus on estimating destination-oriented greenhouse gas emissions from tourism at global and national levels, and some of them are at regional level.

Becken and Patterson (2006) used both bottom-up and top-down approaches to estimate energy use and carbon dioxide emissions from tourism. Their focus includes domestic and inbound tourists. Factors such as tourist spending in tourism characteristic industries, and domestic and international aviation were also considered. These two approaches result in estimates of a similar order for energy consumption (between 25 and 28 petajoule, PJ), and carbon dioxide emissions (between 1,400 and 1,600 kilotonnes).

A study conducted by Forsyth et al. (2008) aimed to measure of global greenhouse gas emissions from tourism in Australia. The production based estimates and the expenditure based estimates were both concerned in their study. The former included the greenhouse gas emissions directly and indirectly generated from tourism based on the Australian Tourism Satellite Account. The latter was analyzed in terms of the data from the air travelers to Australia. In terms of the production approach, the total global greenhouse gas emissions was estimated at 54.4 megatonnes (Mt), it included 26.3 Mt from the total direct greenhouse gas emissions and 28.1Mt from the total indirect greenhouse gas emissions. In terms of the results of expenditure approach, they estimated 29.5 Mt for the total direct greenhouse gas emissions and 32.0 Mt for the total indirect greenhouse gas emissions. They concluded that the emissions from international aviation were not attributed, however it remain a risk to the tourism industry in Australian.

The other study by Howitt et al. (2010) intended to measure the international cruise ship journeys to and from New Zealand. They utilized a bottom-up approach and estimated the individual journey by cruise ship to and from New Zealand at the ranges of 250 and 2,200 g of CO_2 per passenger-kilometer. Besides, the passengers took these cruises for the accommodation function, and the energy use was estimated 12 times larger than a land hotel.

Sun (2014a) attempted to estimate the energy use and carbon dioxide emissions for Taiwanese tourism based on the tourism satellite account and the environmentally extended input-output model. The results revealed, in terms of domestic tourism, international aviation industry, and imports, the carbon dioxide emissions for tourism were estimated at 47%, 28%, and 25% of the total tourism carbon footprint. This study concluded that Taiwan as an island country are highly relying on aviation and international trades. These contributed to a larger amount of carbon dioxide emissions in tourism.

Cordove-Vallejo, Blanco, Yang, and Ponce-Cueto (2012) quantified the greenhouse gas emissions of the Galapagos Islands. Their measurement system included the energy use and emissions generated from the tourism-related activities. A bottom-up approach was used and the supply chain for supporting tourism activities were concerned in their study. The results showed that 68.82% of carbon footprint was from the international air travel, and followed by the fuel consumption for energy generation, with the share of 17.86%.

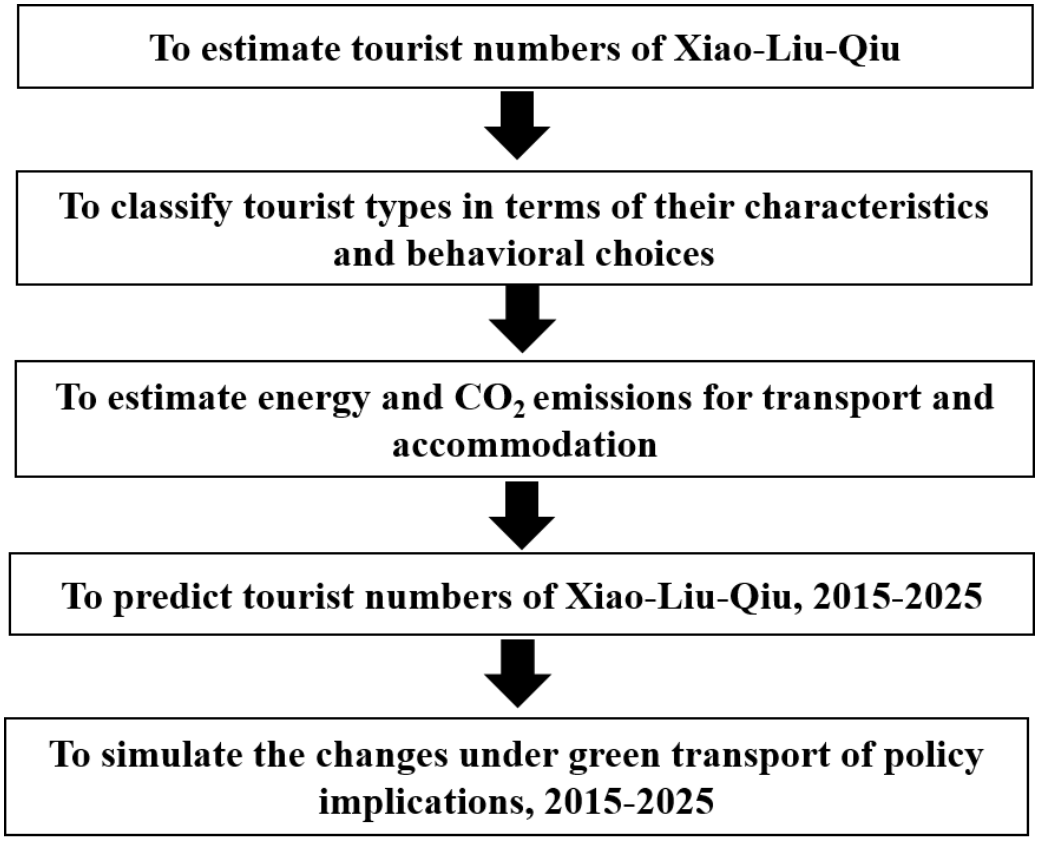
To sum up, more and more studies paid attention to the carbon dioxide emissions from tourism. Although the estimation approaches, and measurement boundary and levels were different, most scholars had discovered that tourism could consume big amounts of energy and generate unneglectable amounts of carbon dioxide emissions, in particular transportations. Since the issue of carbon dioxide emissions is relatively new in the tourism field, the results of these studies are served as a baseline for the purpose of monitoring the environmental change because of the tourism expansion.

3.3 Method for Estimating Carbon Dioxide Emissions

3.3.1 Estimation procedure

This aim of this chapter is to quantify the energy use by tourism activities and its generation of direct carbon dioxide emissions on Xiao-Liu-Qiu by using a bottom-up approach. The environmental impact of tourism is related to the total tourist numbers, tourist choices, and the environmental factor (e.g. amount of energy use on tourism facilities, emissions factors of energy use). Therefore, the results of the on-site survey in Chapter 2 were taken for measuring tourism environmental impact. The procedure of data collection and analysis can be simplified as Figure 3.1. The first step is to estimate tourist numbers in the period of 1996-2014. Step 2 is to classify tourist types in terms of their characteristics and behavioral choices (the details of the results shown in Chapter 2. Step3 is to estimate energy and carbon dioxide emissions for transportation and accommodation in 2012. Step 4 is to predict the tourist numbers in the periods 2015-2025. The last step is to simulate the changes in green transportation of policy implications, 2015-2025.

Figure 3.1 The procedure of the estimation of carbon dioxide emissions and simulation



Source: Author.

3.3.2 Data collection

Table 3.2 shows a brief description of data collection in this chapter. These data can be divided into two, which are the tourist dimension and the industry dimension. For the tourist dimension, two data sets are required. The first is the estimate of tourist numbers based on the secondary data. The second is the information of tourists' characteristics and their behavioral choices obtained by the results of the on-site investigation showed in Chapter 2. Regarding the industry dimension, the data related to energy use and carbon dioxide emissions (e.g. carbon dioxide emissions factor) were collected from the secondary data. Each data source used is described in the following sections.

Table 3.2 Data for energy use and carbon dioxide emissions estimation of Xiao-Liu-Qiu

Dimension	Data set	Series item
Tourist	Tourist number*	Passenger numbers of public ferry. Passenger numbers of private ferry. Tourist numbers of Liouciou Scenic Area. Resident numbers.
	Tourists' characteristics and behavioral choices**	Island visitor demographics. Water transportation choices Land transportation choices. The length of stay.
Industry	Energy use and carbon dioxide emissions***	Energy use factor and carbon dioxide emissions factors in terms of transportation and accommodation.

Note: * The detail of data sets are listed in Table 3.3.

** Data is obtained based on the result of on-site survey showed in Chapter 2.

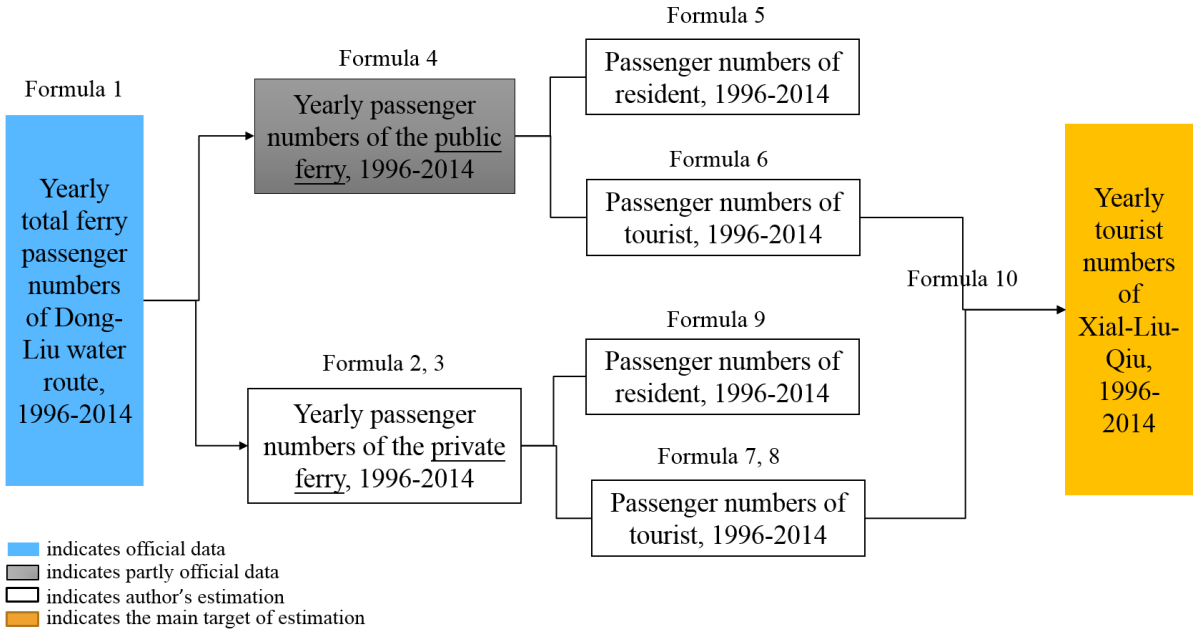
*** The detail of data sets are listed in Table 3.5, Table 3.6, and Table 3.7.

Source: Compiled by author.

3.3.3 Measurement for estimating tourist numbers, energy use, and carbon dioxide emissions

This part includes two sub-sections related to tourist activities. The first section is to estimate tourist numbers from decomposing ferry passenger numbers, and the estimation flow is showed in Figure 3.2. The second section is the measurement of the land transportation distance on Xiao-Liu-Qiu..

Figure 3.2 The estimation procedure for tourist numbers of Xiao-Liu-Qiu



Source: Author.

3.3.3.1 Estimating tourist numbers by decomposing ferry passenger numbers

The data used to estimate tourist numbers by decomposing ferrying passenger numbers are listed in Table 3.3.

Table 3.3 Data and sources for estimating tourist numbers of Xaio-Liu-Qiu

Data	Source
Yearly ferry passenger numbers of Dong-Liu water route, 1996-2014	MOTC (2015)
Yearly ferry passenger numbers of Dong-Liu water route, 2001-2011	Pingtung County Government (2012b)
Yearly ferry passenger numbers of public ferry, 2001-2008	Pingtung County Government (2012a)
Yearly visitor numbers of Liouciou Scenic Area, 1996-2014	DBNSA (2015)
Number of register residents of Xiao-Liu-Qiu, 1996-2014	Pingtung County Government (2015)

Source: Compiled by author.

I. Calculation of the private ferry passenger numbers in 2001-2011

Step 1: The statistics of the total ferry passenger numbers of Dong-Liu water route and the private ferry passenger numbers in 2001-2011 are known. The official data were utilized to calculate the private ferry passenger numbers in 2001-2011. That is, the public passenger numbers in 2001-2011 are deducted from the ferry passenger numbers of Dong-Liu water route in 2001-2011 (Formula 1).

$$PRF_t = TFP_t - PUF_t \tag{1}$$

Where,

PRF_t: The private ferry passenger numbers in the years (t), 2001-2011 (Unit: person).

TFP_t: The total ferry passenger numbers of Dong-Liu water route in the years (t), 2001-2011 (Unit: person).

PUF_t: The public ferry passenger numbers in the years (t), 2001-2011 (Unit: person).

II. Calculation of the public and the private passenger numbers in, 1996-2000 and 2012-2014

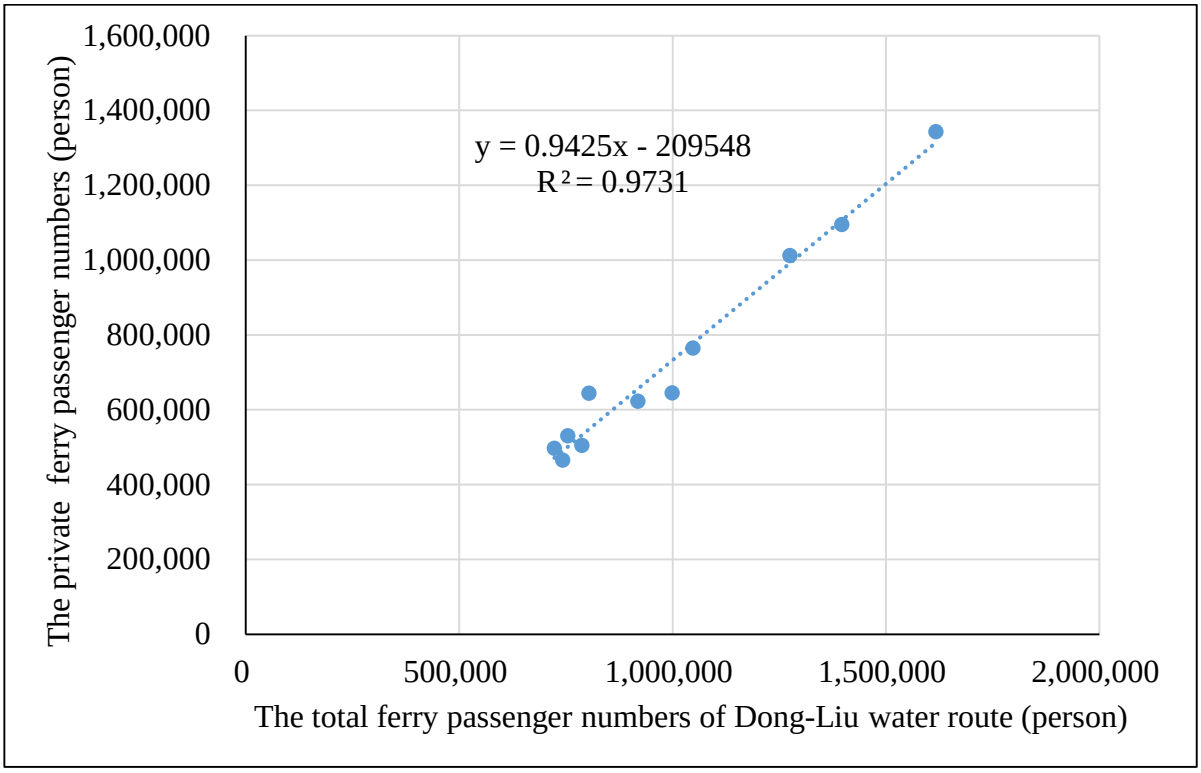
Step 2: The analysis period of this chapter is set up as 1996-2014. The total ferry passenger numbers of Dong-Liu water route and its components in 2001-2011 were calculated by Formula 1. Therefore, the target of step 2 is to obtain the ferry passenger numbers of Dong-Liu water route, including both the public and the private ferries, in the periods of 1996-2000 and 2012-2014.

Since 1996, the annual ferry passenger numbers of Dong-Liu water route have been increasing. Dong-Liu water route is operated by the public and the private ferry companies. Observed the results showed based on the Formula 1, the private ferry passenger numbers were also increasing in the period of 2001-2011. Therefore, a correlation analysis was conducted to explore the relationships between the total ferry passenger numbers of Dong-Liu water route and the private ferry passenger numbers.

Based on the correlation analysis in Figure 3.3, the trend showed that the ferry passenger numbers of Dong-Liu water route highly correlates to the private ferry passenger numbers in the years of 2001-2011 ($R^2 = 0.97$). The result demonstrated that the ferry market of Dong-Liu water route is dominated by the private ferry. The result is utilized to estimate the passenger

numbers of the private ferry first, and further to estimate the public ferry passenger numbers in the years of 1996-2000 and 2012-2014.

Figure 3.3 Simple correlation analysis of the ferry passenger numbers of Dong-Liu water route and the private ferry passenger numbers, 2001-2011



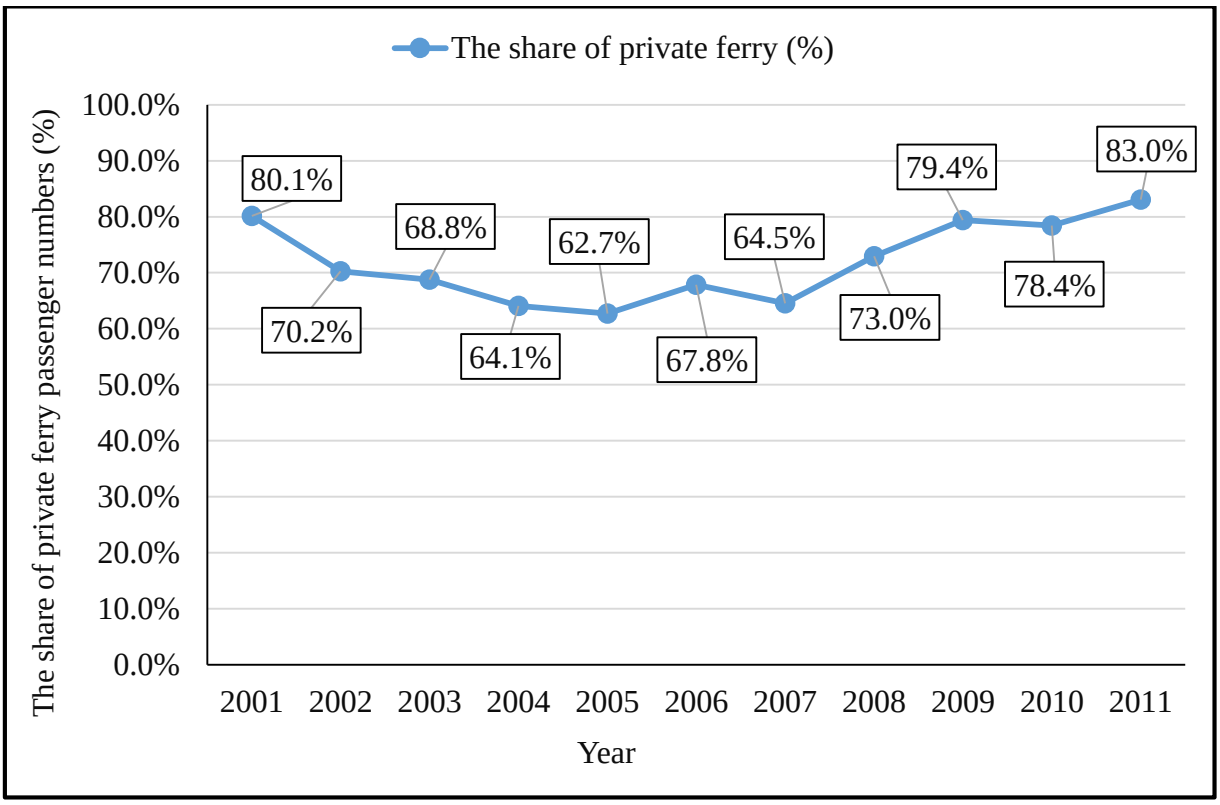
Source: Author's calculation based on the data of the Pingtung County Government (2012b) and the Ministry of Transportation and Communication (2015).

It has proved that the ferry passenger numbers of Dong-Liu water route and the private ferry passenger numbers had a strong relationship in the period of 2001-2011. Next, it is interesting to explore the changes of share of the private ferry passenger numbers in 2001-2011. The purpose is to observe if the trend appears valuable information for further estimation of the passenger numbers of the public and the private ferries in 1996-2000 and 2012-2014.

Figure 3.4 is the share of the private ferry passenger numbers for Dong-Liu water route in the years of 2001-2011. It showed that the private ferry occupied the major market for more than 60% in 2001-2011. However, the trend also appears that the share of the private ferry

passenger numbers in each year was not always stable, the percentages ranged from 62.7% to 83.0%. The information obtained from this calculation is considered for further analysis.

Figure 3.4 The share of private ferry passenger numbers for Dong-Liu water route, 2001-2011



Source: Calculated by author.

Since there was no influential incident caused to the economy and tourism development on Xiao-Liu-Qiu in the period of 1996-2014. I assumed that the share of the private ferry passengers in the years of 2012-2014 equaled the share in 2011 (83.0%), and the share of the private ferry passengers in the years of 1996-2000 equals the share in 2001 (80.1%). The private ferry passenger numbers in the years of 1996-2000 and 2012-2014 were estimated based on Formula (2) and Formula (3), respectively.

The official statistics of the total ferry passenger numbers of Dong-Liu water route in 1996-2000 are known. Adopted the assumption of 80.1% of the ferry passengers taking the private ferry in 2001, the estimates of the private ferry passenger numbers in 1996-2000 are calculated based on Formula (2).

$$PRF_t = TFP_t \times 80.1\% \quad (2)$$

Where,

PRF_t: The private ferry passenger numbers in the years (t), 1996-2000 (Unit: person).

TFP_t: The total ferry passenger numbers of Dong-Liu water route in the years (t), 1996-2000 (Unit: person).

80.1% indicates the share of the private ferry passenger numbers for Dong-Liu water route in 2001.

Similarly, the official statistics of the total ferry passenger numbers of Dong-Liu water route in 2012-2014 are known. Adopted the assumption of 83.0% of the ferry passengers taking the private ferry in 2011, the estimates of the private ferry passenger numbers in 2012-2014 are calculated based on Formula (3).

$$PRF_t = TFP_t \times 83.0\% \quad (3)$$

Where,

PRF_t: The private ferry passenger numbers in the years (t), 2012-2014 (Unit: person).

TFP_t: The annual ferry passenger numbers of Dong-Liu water route in the years (t), 2012-2014 (Unit: person).

83.0% indicates the share of the private ferry passenger numbers for Dong-Liu water route in 2011.

The private ferry passenger numbers have been estimated based on Formula (2) and (3). Then, the public ferry passenger numbers can be calculated since the total ferry passenger numbers and the private ferry passenger numbers in the periods of 1996-2000 and 2012-2014 are known. The public ferry passenger numbers in 1996-2000 and 2012-2014 are obtained based on Formula (4).

$$PUP_t = TFP_t - PRF_t \quad (4)$$

Where,

PUP_t: The public ferry passenger numbers in the years (t), 1996-2000 and 2012-2014 (Unit: person).

TFP_t: The total ferry passenger numbers of Dong-Liu water route in the years (t), 1996-2000 and 2012-2014 (Unit: person).

PRF_t: The private ferry passenger numbers in the years (t), 1996-2000 and 2012-2014 (Unit: person).

III. Decomposing the ferry passenger numbers of Dong-Liu water route by passenger type

Step 3: to decompose the total ferry passenger numbers of Dong-Liu water route in terms of the passenger types (i.e. resident and tourist), both the public and the private ferries.

The public ferry was constructed to provide commuting service to the island residents (Audit Office in Pingtung County, Ministry of Audit, 2013). Local people can buy a public ferry ticket in a cheaper price than the private ferry due to the government subsidy. However, the private ferry company can provide the more comfortable environment to passengers because the company operates by using the relatively new ferry boats. Besides, the travel time of taking the private ferry is shorter than that of the public ferry, and most tourist facilities are close to the private ferry port. Therefore, most tourists prefer to take the private ferry since there is not a considerable difference in price, comparing to the price charged by the public ferry.

i. Decomposing the public ferry passenger numbers by passenger type

Based on the official statistics, the average share of the public ferry passengers by month in the years of 2008-2011 was calculated. As mentioned earlier, the public ferry was construed to mainly provide commuting service to the locals, and the share of residents taking public ferry is calculated as 88.5%, based on Figure 3.5.

This value was used to estimate the public ferry passenger numbers in terms of different types in unknown years, 1996-2007 and 2012-2014.

a. Estimation of the resident numbers taking the public ferry in 1996-2007 and 2012-2014

Assuming the percentage of residents taking the public ferry is stable, then, the resident numbers taking the public ferry was obtained based on Formula 5.

$$PUR_t = PUP_t \times 88.5 \tag{5}$$

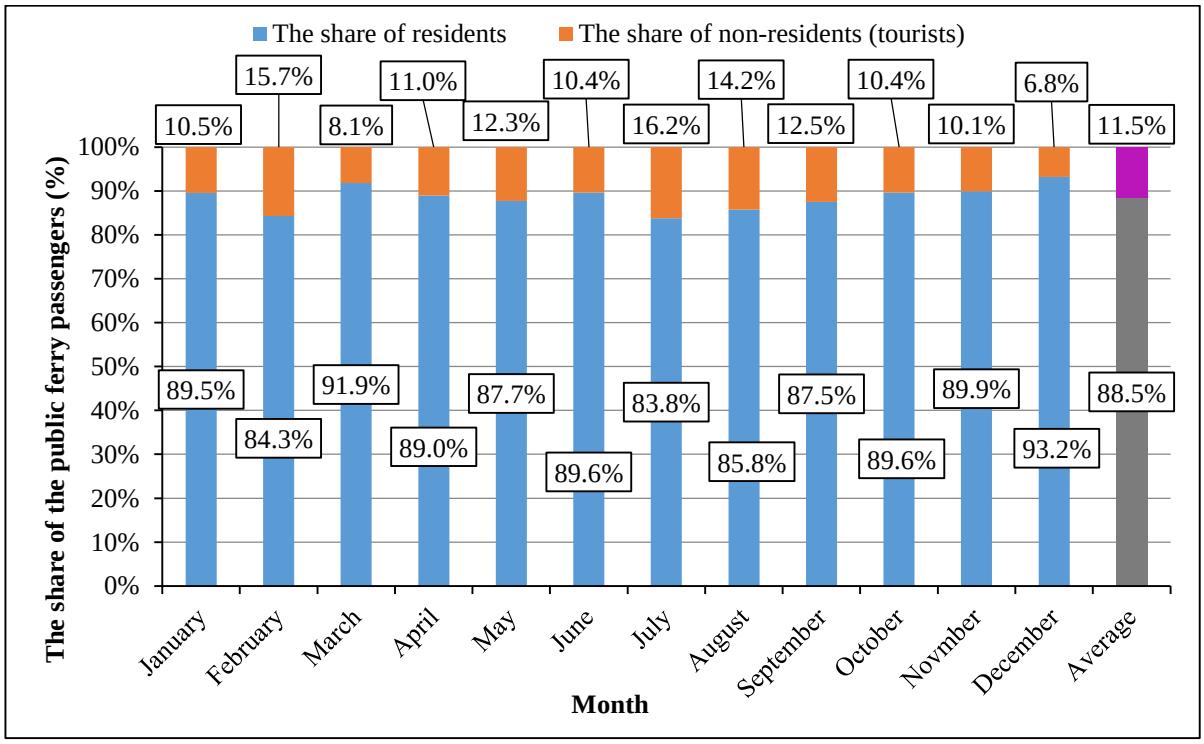
Where,

PUR_t: The resident numbers taking the public ferry in the years (t), 1996-2007 and 2012-2014 (Unit: person).

PUP_t: The public ferry passenger numbers in the years (t), 1996-2007 and 2012-2014 (Unit: person).

88.5% indicates the share of residents taking public ferry on average in 2008-2011.

Figure 3.5 The components of public ferry passengers of Xaio-Liu-Qiu, 2008-2011



Source: Author calculated based on the statistics by Pingtung County Government (2012a).

b. Estimation of the non-resident (tourists) numbers taking the public ferry in 1996-2007 and 2012-2014

Then, the number of non-residents (tourists) taking the public ferry can be calculated by Formula (6).

$$PUT_t = PUP_t - PUR_t \tag{6}$$

Where,

PUT_t: The non-resident (tourist) numbers taking the public ferry in the years (t), 1996-2007 and 2012-2014 (Unit: person).

PUP_t: The public ferry passenger numbers in the years (t), 1996-2007 and 2012-2014 (Unit: person).

PUR_t: The resident numbers taking the public ferry in the years (t), 1996-2007 and 2012-2014 (Unit: person).

ii. Decomposing the private ferry passenger numbers by passenger type

On the island of Xiao-Liu-Qiu, Liouciou Scenic Area was designated as a National Scenic Area by the government for the purpose of tourism development since 1990 (PTCG, 2010). However, very few tourism facilities were present on the island. Until 2000, Liouciou Scenic Area was incorporated into the administration of Da-Peng Bay National Scenic Area. The infrastructures and attractions for tourism started to be constructed since that time. With the development background, I assumed all tourists on Xiao-Liu-Qiu visited the entrance fee-charging spots in 1996 since only limited tourism facilities and attractions are built before 2000.

a. Estimation of the resident numbers taking the private ferry in 1996-2014

The tourist numbers of fee-charging spots of Liouciou Scenic Area were counted by the local government since 1996, in terms of the number of tickets sold. The tourist numbers of Liouciou Scenic Area are listed in Table 3.4. The total tourist numbers in 1996 was obtained under the assumption that the total tourist numbers of Liouciou Scenic Area equaled the total tourist numbers of Xiao-Liu-Qiu (see Formula 7).

$$TNX_{1996} = TNS_{1996} \tag{7}$$

Where,

TNX_{1996}: The total tourist numbers of Xiao-Liu-Qiu in 1996 (Unit: person).

TNS_{1996}: The total tourist numbers of Liuciou Scenic Area in 1996 (Unit: person).

The estimates of the passenger numbers were counted for the round-trip. Therefore, the tourist numbers taking the private ferry would be the double of the tourist numbers visiting Xiao-Liu-Qiu in 1996 (Formula 8).

$$PRT_{1996} = TNS_{1996} \times 2 \tag{8}$$

Where,

PRT_{1996}: The non-resident (tourist) numbers taking the private ferry in 1996 (Unit: person). It equals two times of TNS_t because it should be counted as round-trip journeys between the mainland of Taiwan and Xiao-Liu-Qiu.

TNS_{1996}: The total tourist numbers of Liuciou Scenic Area in 1996 (Unit: person).

While the total tourist numbers of Xiao-Liu-Qiu in 1996 is obtained based on the Formula (8), the numbers of non-resident (tourist) taking the private ferry in 1996 can be derived based on Formula (9).

$$PRR_{1996} = PRP_{1996} - PRT_{1996} \tag{9}$$

Where,

PRR_{1996}: The resident numbers taking the private ferry in 1996 (Unit: person).

PRP_{1996}: The total passenger numbers taking the private ferry in 1996 (Unit: person).

PRT_{1996}: The non-resident (tourist) numbers taking the private ferry in 1996 (Unit: person).

During the years of 1996-2014, the resident numbers stayed stable (see Table 2.5), and as mentioned earlier, the residents of Xiao-Liu-Qiu mainly relied on the public ferry. Under these two conditions, I assumed the demand for local people taking the private ferry remained the

same since 1996. The number of residents taking the public ferry was estimated according to Formula (10).

$$PRR_t = TRX_t \times PRR_{1996} \div TRX_{1996} \tag{10}$$

Where,

PRR_t: The resident numbers taking the private ferry in the years (*t*), 1997-2014 (Unit: person).

TRX_t: The registered resident numbers of Xiao-Liu-Qiu in the years (*t*), 1997-2014 (Unit: person).

PRP_{1996}: The total passenger numbers taking the private ferry in 1996 (Unit: person).

TRX_{1996}: The registered resident numbers of Xiao-Liu-Qiu in 1996 (Unit: person).

b. Estimation of the non-resident (tourist) numbers taking the private ferry in 1997-2014

Then, the non-resident (tourist) numbers taking the private ferry was obtained based on Formula (11).

$$PRT_t = PRF_t - PRR_t \tag{11}$$

Where,

PRT_t: The non-resident (tourist) numbers taking the private ferry in the years (*t*), 1997-2014 (Unit: person).

PRF_t: The private ferry passenger numbers in the years (t), 1997-2014 (Unit: person).

PRR_t: The resident numbers taking the private ferry in the years (*t*), 1997-2014 (Unit: person).

iii. Combining the estimates of the number of non-resident (tourist) passengers

Combined the estimates of the tourist numbers taking both the public ferry and private ferry, the total tourist numbers in the years, 1997-2014 were acquired (Formula 12). The passenger number was counted based on the round-trips. Therefore, to avoid double counting

of the total tourist numbers of Xiao-Liu-Qiu, the total number of tourists taking the public and private ferries should be divided by two.

$$TNX_t = (PUT_t + PRT_t) \div 2 \tag{12}$$

Where,

TNX_t: The total tourist numbers of Xiao-Liu-Qiu in the years (t), 1997-2014 (Unit: person).

PUT_t: The non-resident (tourist) numbers taking the public ferry in the years (t), 1997-2014 (Unit: person).

PRT_t: The non-resident (tourist) numbers taking the private ferry in the year (t), 1997-2014 (Unit: person).

Table 3.4 The breakdown of the ferry passenger numbers and the estimates of the tourist numbers, 1996-2014

Year	AFP*	PUP	PRP	TNS*	TRX*	PUR	PUT	PRR	PRT	TNX
1996	451,914	89,720	362,194	153,278	12,619	79,580	10,140	65,778	296,416	153,278
1997	613,894	121,878	492,016	151,100	13,800	108,104	13,774	71,934	420,082	216,928
1998	652,510	129,545	522,965	149,977	12,562	114,904	14,640	65,481	457,485	236,063
1999	691,896	137,364	554,532	131,193	12,472	121,840	15,524	65,012	489,520	252,522
2000	762,065	151,295	610,770 [a]	163,239	12,514	134,196	17,099	65,231	545,540	281,319
2001	804,019	159,624	644,395 [a]	152,143	14,485	141,584	18,040	75,505	568,890	293,465
2002	754,484	224,553	529,931 [a]	147,541	13,326	199,175	25,378	69,463	460,468	242,923
2003	722,994	225,901	497,093 [a]	133,538	13,215	200,371	25,530	68,885	428,208	226,869
2004	787,498	282,803	504,695 [a]	166,213	13,139	250,842	31,961	68,489	436,206	234,084
2005	742,023	276,709	465,314 [a]	112,348	13,289	245,437	31,272	69,270	396,044	213,658
2006	918,329	295,346	622,983 [a]	124,530	12,813	261,968	33,378	66,789	556,194	294,786
2007	998,932	354,331	644,601 [a]	140,306	12,652	14,286	40,045	65,950	578,651	309,348
2008	1,047,606	283,299	764,307 [a]	175,883	12,550	252,260	31,039	65,418*	698,889	364,964
2009	1,275,060	262,945	1,012,115 [a]	190,974	12,620	231,013	31,932	65,783*	946,332	489,132
2010	1,396,322	301,280	1,095,042 [a]	264,232	12,300	268,694	32,586	64,115*	1,030,927	531,756
2011	1,617,104	274,231	1,342,873 [a]	295,304	12,169	240,734	33,497	63,432*	1,279,441	656,469
2012	1,952,489	331,106	1,621,383	362,764	12,145	293,686	37,420	63,307	1,558,076	797,748
2013	2,036,805	345,405	1,691,400	378,791	12,415	306,369	39,036	64,715	1,626,686	832,861
2014	2,121,391	359,749	1,761,642	391,098	12,675	319,092	40,657	66,070	1,695,572	868,115

Note: "*" indicates official data, "a" indicates author's calculation, and the rest values are author's estimation based on the official data.
AFP: Annual Ferry Passengers; PUP: Public Ferry Passengers; PRP: Private Ferry Passengers; TNS: Tourist Numbers of Liouciou Scenic Area; TRX: Total Residents of Xiao-Liu-Qiu; PUR: Annual Residents Taking Public Ferry; PUT: Annual Tourists Taking Public Ferry; PRR: Annual Residents Taking Private Ferry; PRT: Annual Tourists Taking Private Ferry; and TNX: Tourist Numbers of Xiao-Liu-Qiu.
Source: Calculated and estimated by author.

3.3.3.2 Energy use and emissions factors of transportation and accommodation in 2012

Depending on the availability of data, two approaches are suggested by the GHG Protocol (2005) to measure the energy use and carbon dioxide emissions from mobility, including the distance-based approach and fuel-based approach. In this study, the fuel-based approach was utilized to estimate the energy use and carbon dioxide emissions from both water and land transportations, and the accommodation of Xiao-Liu-Qiu.

I. Water transportation (ferry)

Table 3.5 shows the variables, values and sources for estimating carbon dioxide emissions from water transportation (ferry). Based on the fuel-based approach, it is necessary to obtain the amounts of fuel consumed. However, the data is considered confidential by business, and it has been difficult to obtain the accurate consumption values from the ferry company. Instead of using primary data, the secondary data recorded from the official legal documents was utilized in this study.

Table 3.5 Variables, values, and sources for estimating energy use and carbon dioxide emissions from water transportation (ferry) of Xiao-Liu-Qiu

Variable (data year)	Value (unit)	Source
Fuel cost for per round-trip (2006)	10,000 (TWD/ per round-trip)	E. Y. Fair Trade Commission, R.O.C. (行政院公平委員會) (2006), and E. Y. Fair Trade Commission, R.O.C. (行政院公平交易委員會) (2006)
Fuel price per liter (2006)	23.7 (TWD/L)	CPC Corporation (2012)
Carbon dioxide emissions factor for fuel (2006)	2.6060 (kg-CO_2/L)	IPCC (2007)
Voyage numbers, Dong-Liu water route (2012)	17,342 (times)	MOTC (2015)
Passenger numbers of Dong-Liu water route (2012)	1,952,489 (person)	MOTC (2015)
Tourist numbers of Xiao-Liu-Qiu (2012)	797,748 (person)	Author’s estimation

Note: Fuel denotes diesel-oil.

Source: Compiled and estimated by author.

By utilizing the data listed in Table 3.5, Formula (13), Formula (14), and Formula (15) were used to estimate the energy use and carbon dioxide emissions from the ferry.

i. Estimating the fuel amounts used by ferry per round-trip journey in 2006

According to the information from the E. Y. Fair Trade Commission, R.O.C. (行政院公平交易委員會) (2006) and the E. Y. Fair Trade Commission, R.O.C. (行政院公平委員會) (2006), the ferry fuel cost for a round trip journey (Dong-Gang—Xiao-Liu-Qiu) was about 10,000 TWD in 2006.Assuming all ferries traveling the Dong-Liu water route consume the same amount of fuel, the amounts of fuel use can be estimated by combining the historical data of fuel price provided by CPC Corporation (2012). Formula (13) is utilized to calculate the fuel amounts used by ferry per round-trip journey in 2006.

$$PFU_{2006} = FUC_{2006} \div AFP_{2006} \tag{13}$$

Where,

PFU_{2006}: The fuel amounts used for the round-trip journey per voyage in 2006 (Unit: L).

FUC_{2006}: The fuel cost for a round-trip journey of ferry per voyage in 2006, considering the main fuel, diesel-oil, only (Unit: TWD).

AFP_{2006}: The average fuel price per liter in 2006 (Unit: TWD/L).

ii. Estimating the total fuel amounts used by ferry in 2012

Assuming the fuel amounts used for a round-trip journey per ferry voyage is fixed. In other words, the fuel amounts used for the round-trip journey per ferry voyage in 2006 was the same as in 2012, it is calculated as 421.9 liters of diesel-oil. Besides, the total passenger numbers of the Dong-Liu water route equals the double of the total tourist numbers because it indicates passenger numbers for the round-trip journey. Formula (14) is utilized to obtain the total fuel amounts used by ferry in 2012.

$$TFU_{2012} = PFU_{2012} \times TVF_{2012} \div 2 \tag{14}$$

Where,

TFU_{2012}: The total fuel amounts used for ferry in 2012 (Unit: Liter of diesel-oil).

PFU_{2012}: The fuel amounts used for the round-trip journey per voyage in 2012, it equals the fuel amounts used for the round-trip journey per voyage in 2006 (Unit: L).

TVN_{2012}: The total voyage numbers of Dong-Liu water route in 2012; the values divided by two is adjusted to be the number of the round-trip journeys (Unit: times).

iii. Estimating the carbon dioxide emissions from ferry in 2012

By using the estimates obtained from Formula (14), Formula (15) is utilized to estimate the carbon dioxide emissions from ferry in 2012.

$$CEF_{2012} = TFU_{2012} \times EEF \tag{15}$$

Where,

CEF_{2012}: The carbon dioxide emissions from ferry in 2012 (Unit: km).

TFU_{2012}: The total fuel amounts used for ferry in 2012 (Unit: liter of diesel-oil).

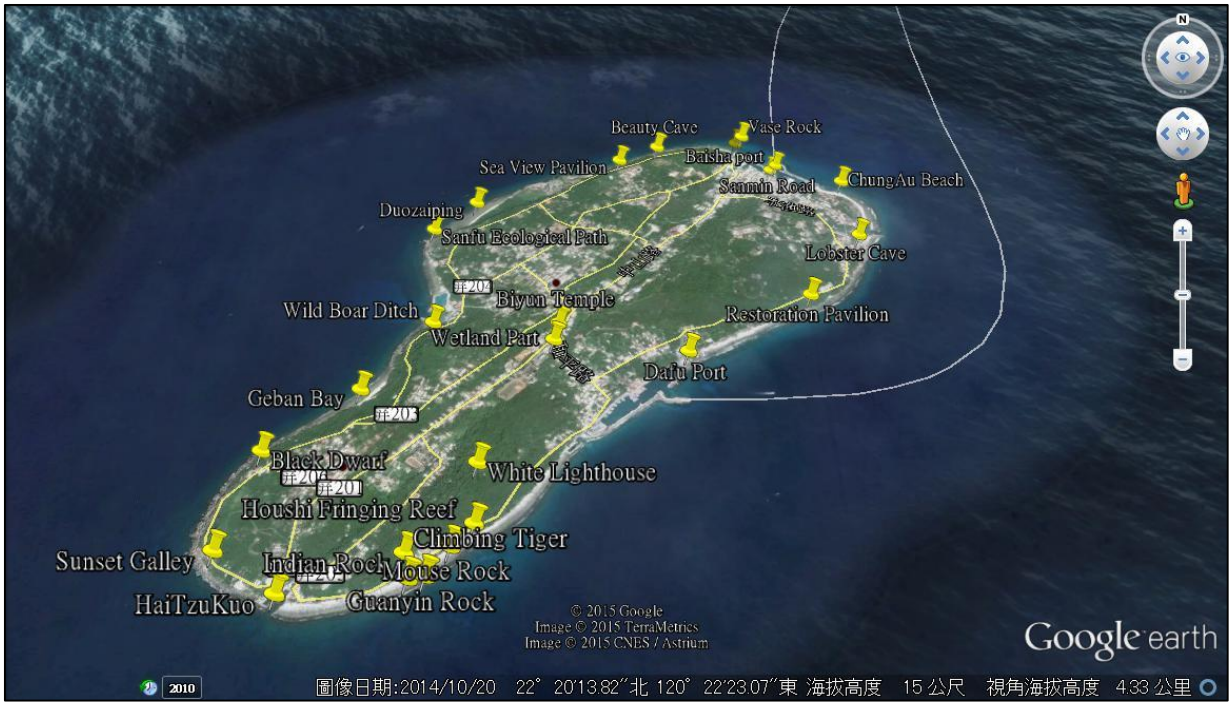
EEF: The emissions factor, generated from the diesel-oil burnt (Unit: km/L).

II. Land transportation (motorcycle)

Travel distance is one factor that affects the energy use and carbon dioxide emissions. For estimating the land energy use and carbon dioxide emissions, only the motorcycle was considered in this study because it is the main transport tool on Xiao-Liu-Qiu (Liouciou Township Ofiice, 2007). On the small island of Xiao-Liu-Qiu, the distance of the island ring road is 18 km and most attractions are located on this road (Figure 3.6).

Table 3.6 listed the variables, values and sources for estimating energy use and carbon dioxide emissions from land transportation for motorcycle. To consider the typical travel arrangement, the measurement unit is counted by distance multiplied by the magnitudes based on the length of stay. The estimates are calculated as 18 km for one-day tourists, 27 km for two-day tourists, and 45 km for three-to-five-day tourists. Besides, the load factor of land transportation is set as two people shared a motorcycle based on the information provided by the shop of the motorcycle rental on Xiao-Liu-Qiu.

Figure 3.6 The location of tourism attractions of Xiao-Liu-Qiu



Source: Google earth, modified by author.

Table 3.6 Variables, values, and sources for estimating energy use and carbon dioxide emissions from land transportation (motorcycle) of Xiao-Liu-Qiu

Variable	Value (unit)	Source/basis
Total tourist number in 2012	797,748 (person)	Author's estimation
Travel distance*	One day: 18 (km) Two-day: 27 (km) Three-to-five day: 45 (km)	Author's estimation
Load factor of transportation**	2 (people/ per motorcycle)	Author's design based on the typical trip arrangement
Energy efficiency (2011)	22.3 (km/L)	MOTC (2012)
Energy intensity***	0.04 (km/L)	Author's calculation
Caron dioxide emissions factor for gasoline	2.263 (kg-CO_2/L)	Environmental Protection Administration (2011) and IPCC (2007)

Note: * Perimeter distance=18 km, assuming magnitudes are one day=1; two-day=1.4, three-to-five-day=2.5.

** Based on two tourists sharing one motorcycle.

*** Energy intensity is the reciprocal of the energy of efficiency.

Source: Compiled and estimated by author.

For estimating the land energy use and carbon dioxide emissions, only the motorcycle was considered in this study because it is the main transportation tool on Xiao-Liu-Qiu (Liouciou Township Ofiice, 2007). The percentages of selecting gasoline motorcycles by length of stay are considered into the following estimation.

i. Estimating the total demand of motorcycle use in 2012

The amount of energy use and carbon dioxide emissions from motorcycle rely on the demand of motorcycle use and the travel distances within a year. It is necessary to calculate the demand of motorcycle use and travel distances by length of stay because tourists visited for different day of stay, the demand of motorcycle use and their travel distances would not be the same.

Formula 16 is utilized to estimate the total demand of motorcycle use in 2012.

$$TDM_{2012} = TNX_{2012} \times PTU_{2012}^{Di} \div 2 \tag{16}$$

$$TDM_{2012} = TNX_{2012} \times (PTU_{2012}^{D1} + PTU_{2012}^{D2} + PTU_{2012}^{D3}) \div 2$$

Where,

TDM_{2012}: The total demand of motorcycle in 2012 (Unit: number).

TNX_{2012}: The total tourist numbers of Xiao-Liu-Qiu in 2012 (Unit: person).

PTU_{2012}^{Di}: The proportion of tourist using motorcycle for land transportation by length of stay (Di) in 2012. The data is obtained based on author's survey (Unit: percentage). Based on the result of on-site survey in 2012, 86% of the one-day tourists (D_1), 95% of the two-day tourists (D_2), and 84% of the three-to-five day tourists (D_3) selected gasoline motorcycles for their land transportation.

2 indicates the load factor for a motorcycle, it is set as two according to the typical business plan (one motorcycle carries two passengers).

ii. Estimating the total travel distances by motorcycle users within Xiao-Liu-Qiu in 2012

Formula 17 is utilized to estimate the total travel distances by motorcycle users within Xiao-Liu-Qiu in 2012.

$$TTD_{2012} = PTU_{2012}^{Di} \times MTD_{2012}^{Di} \times 18 \quad (17)$$

$$TTD_{2012} = PTU_{2012}^{D1} \times MTD_{2012}^{D1} \times 18 + PTU_{2012}^{D2} \times MTD_{2012}^{D2} \times 18 + PTU_{2012}^{D3} \times MTD_{2012}^{D3} \times 18$$

Where,

TTD_{2012}: The total travel distances within Xiao-Liu-Qiu in 2012 (Unit: km).

PTU_{2012}^{Di}: The proportion of tourist using motorcycle for land transportation by length of stay (Di) in 2012. The data is obtained based on author's survey (Unit: percentage). Based on the result of on-site survey in 2012, 86% of the one-day tourists (D_1), 95% of the two-day tourists (D_2), and 84% of the three-to-five day tourists (D_3) selected gasoline motorcycles for their land transportation.

MTD_{2012}^{Di}: The magnitude given to set the travel distance by the length of stay (Di) in 2012. It is set as 1 for one-day visitors (D_1), 1.5 for two-day visitors (D_2), and 2.5 for the three days and over visitors (D_3).

18 indicates the peripheral distance in kilometer on Xiao-Liu-Qiu (Unit: km).

iii. Estimating the total amount of fuel use for motorcycles within Xiao-Liu-Qiu in 2012

Formula 18 is utilized to estimate the total amount of fuel use for motorcycles within Xiao-Liu-Qiu in 2012.

$$TFC_{2012} = AND_{2012} \times TTD_{2012} \times EIM_{2012} \quad (18)$$

Where,

TFU_{2012}: The total fuel amounts used for motorcycles in 2012, fuel denotes gasoline (Unit: L).

AND_{2012}: The annual demand of motorcycle in 2012 (Unit: number).

TTD_{2012}: The total travel distances within Xiao-Liu-Qiu in 2012 (Unit: km).

EIM_{2012}: The average energy intensity for a motorcycle in 2012 (Unit: L/km).

iv. Estimating the carbon dioxide emissions from motorcycles on Xiao-Liu-Qiu in 2012

Formula 19 is utilized to estimate the total carbon dioxide emissions from motorcycles within Xiao-Liu-Qiu in 2012.

$$CEM_{2012} = TFU_{2012} \times EEF \tag{19}$$

Where,

CEM_{2012}: The total carbon dioxide emissions from motorcycles in 2012 (Unit: kg-CO2).

EEF: The emissions factor, generated from the gasoline -oil burnt (Unit: kg/L).

III. Bed and Breakfast (B&B) Accommodations

Table 3.7 lists the variables, values and sources for estimating energy utilization and carbon dioxide emissions for accommodation. Based on this table, the total tourist numbers in 2012 was 797,748 people (the estimation in Chapter 2). In addition, the proportion of the length of stay for annual tourists of Xiao-Liu-Qiu was also obtained from the on-site survey by author.

Table 3.7 Variables, values, and sources for estimating energy use and carbon dioxide emissions for Bed and Breakfast (B&B) Accommodations of Xiao-Liu-Qiu

Variable	Value (unit)	Source
Total tourist numbers in 2012	797,748 (person)	Author's estimation
Length of tourist stay in 2012	One day stay: 38.6% Two-day stay: 56.1% Three-to-five day stay: 5.3%	Author's survey in 2012
Energy* use for B&B accommodations	39.45* (MJ/guest-night)	Huang (2011)
Carbon dioxide emissions for B&B accommodations	4.96 (kg-CO_2/MJ)	Huang (2011)

Note: * Energy denotes electricity.

** The value estimated by Huang (2011) is similar to the energy requirement amount per bed night suggested by Gössling, Hansson, Hörstmeier, and Saggel (2002): 30 MJ for simple guesthouses, 40 MJ for luxury guesthouses, 40 MJ for one to two star hotels, 70 MJ for three to four star hotels, 110 MJ for five star hotels, 50 MJ for self-catering, 30 MJ for private, and 40 MJ for boat.

Source: Compiled by author.

Considering Taiwan as a whole, the major energy use of the accommodation industry is electricity, share of 88% (Huang, 2011; Lin, 2011). In this study, it considered the main source of energy use and carbon dioxide emissions. The unit of accommodation use in this study is counted in terms of guest-night.

i. Estimating the total demand of B&B accommodations on Xiao-Liu-Qiu in 2012

Formula 20 is utilized to estimate the total demand of B&B accommodations on Xiao-Liu-Qiu in 2012.

$$TDA_{2012} = TNX_{2012} \times PTS_{2012}^{Di} \times LOS^{Di} \tag{20}$$

$$TTS_{2012} = TNX_{2012} \times PTS_{2012}^{D2} \times LOS^{D2} + TNX_{2012} \times PTS_{2012}^{D3} \times LOS^{D3}$$

Where,

TDA_{2012}: The total demand of B&B accommodations on Xiao-Liu-Qiu in 2012 (Unit: guest-night).

TNX_{2012}: The total tourist numbers of Xiao-Liu-Qiu in2012 (Unit: person).

PTS_{2012}^{Di}: The proportions of tourist numbers staying overnight by length of stay on Xiao-Liu-Qiu (Unit: day). The data is obtained based on the author's survey. Based on the result of on-site survey in 2012, 38.6% of the respondents stayed one-day (D_1), 56.1% of the respondents stayed two-day (D_2), and 5.3% of the respondents stayed three-to-five day tourists (D_3). One-day tourists are excluded in this estimation because they do not have accommodation demand.

LOS^{Di}: The length of stay in B&B accommodations on Xiao-Liu-Qiu (Unit: day). *Di* includes one-night stay for two-day tourists (D_2=1) and two-night stay for three-to-five day tourists[10] (D_3=2).

[10] Only 5.3% of the total respondents visited Xiao-Liu-Qiu for three-to-five days, and it is composed of 85% of them stayed for three days, 5% of them stayed for four days, and 10% of them stayed for more than five days. Because the shares of tourists who stayed more than three-day are small, I assumed a three-to-five day tourist stays two-night in B&B accommodation for unifying and simplifying the estimation.

ii. Estimating the energy use for B&B accommodations on Xiao-Liu-Qiu in 2012

Formula 21 is utilized to estimate the total amount of energy use for B&B accommodations on Xiao-Liu-Qiu in 2012, and Formula 22 is utilized to estimate the total carbon dioxide emissions from B&B accommodations on Xiao-Liu-Qiu in 2012

$$TEU_{2012} = TDA_{2012} \times EUP_{2012} \tag{21}$$

$$CDA_{2012} = TEU_{2012} \times EEF \tag{22}$$

Where,

TEU_{2012}: The total energy use for B&B accommodations on Xiao-Liu-Qiu in 2012 (Unit: MJ).

TDA_{2012}: The total demand of B&B accommodations on Xiao-Liu-Qiu in 2012 (Unit: guest-night).

EUP_{2012}: Energy use for B&B accommodations per guest-night on Xiao-Liu-Qiu in 2012 (Unit: MJ).

CDA_{2012}: The total carbon dioxide emissions generated from B&B accommodations in 2012 (Unit: kg-CO_2).

EEF: The emissions factor, generated from the electricity (Unit: kg-CO_2/MJ).

3.4 Estimates of energy use and carbon dioxide emissions, prediction of tourist numbers, and scenario analysis

3.4.1 Estimates of energy use and carbon dioxide emissions in 2012

This section shows the estimations of energy use and carbon dioxide emissions of the categories of water transportation (ferry), land transportation (motorcycle), and B&B accommodations used by tourists.

3.4.1.1 Water transportation (ferry)

Table 3.8 shows the results of energy use and carbon dioxide emissions of water transportation (ferry) used by tourists in 2012. The fuel consumption for a round-trip voyage was estimated as 421.9 liters based on the Formula (14). In 2012, the total amount of fuel consumption for ferry was estimated as 3,658,650 liters. It counted fuel consumption per passenger as 3.75 liters/per round-trip, and 2,989,702 liters of fuel use for the ferry for tourism purpose in a whole year.

Table 3.8 Energy use and carbon dioxide emissions from water transportation (ferry) of Xiao-Liu-Qiu, 2012

Variable	Value (unit)
Fuel* consumption for one round-trip	421.9 (L) ***
Total fuel consumption in a year	3,658,650 (L)
Fuel consumption one round trip per capita	3.75 (L)
Total tourism fuel use in a year	2,989,702 (L)
Total carbon dioxide emissions in a year	9,534,441 (kg-CO_2)
Carbon dioxide emissions per passenger	9.7664 (kg-CO_2 per capita)
Total carbon dioxide emissions from tourism	7,791,162 (kg-CO_2)
Average fuel consumption per capita-distance**	0.134 (L/person-km)
Average carbon dioxide emissions per capita-distance	0.3488 (kg-CO_2/person-km)

Note: * Fuel denotes diesel-oil.
** Distance counted is fourteen kilometers multiplying by two for a round-trip journey.
*** L denotes liter.
Source: Calculated by author.

Regarding the carbon dioxide emissions from the ferry, the total carbon dioxide emissions were measured as 9,534,441 kg-CO_2, and it converted to 9.7664 kg-CO_2 per capita. For the tourism purpose, it was counted as 7,791,162 kg-CO_2 in 2012. Taking the sea distance into account, the average fuel consumption per capita was counted as 0.134 liters/person-km with 0.3488 kg-CO_2/person-km.

3.4.1.2 Land transportation (motorcycle)

Table 3.9 shows the results of energy use and carbon dioxide emissions from land transportation (motorcycle) of Xiao-Liu-Qiu in 2012.

Table 3.9 Energy use and carbon dioxide emissions from land transportation (motorcycle) of Xiao-Liu-Qiu, 2012

Item \ The length of stay	1 day	2 days	3-5 days	Total
Total tourists* (person)	286,495	416,382	39,337	742,215
Total motorcycle users** (person)	246,386	395,563	33,043	674,992
Total motorcycle used (times)	123,193	197,782	16,522	337,496
Total travel distance (km)	2,217,470	5,340,105	743,476	8,301,051
Fuel use (L) ***	99,438	239,467	33,340	372,244
Carbon dioxide emissions (kg-CO_2)	225,028	541,913	75,448	842,389
Fuel use per capita (L/per capita)	0.40	0.61	1.01	0.67
Carbon dioxide emissions per capita (kg-CO_2/ per capita)	0.91	1.37	2.28	1.52
Fuel use per capita-distance	0.022	0.022	0.022	0.022
Carbon dioxide emissions per capita-distance (kg-CO_2/per capita-km)	0.051	0.051	0.051	0.051

Note: * The percentages were estimated as 39% for 1 day, 56% for 2 days, and 5% for 3-5 days based on the on-site survey.

** The percentages were estimated as 86% for 1 day, 95% for 2 days, and 84% for 3-5 days based on the on-site survey.

*** Fuel denotes gasoline (petrol-oil), and L denotes liter.

Source: Calculated by author.

The total number of tourists of Xiao-Liu-Qiu in 2012 was estimated at 742,215 people. Combined the results in Chapter 2, about 90.7%[11] of tourists using motorcycles for vehicles during their visits on Xiao-Liu-Qiu. The total motorcycle users in 2012 were counted as 674,992 people, and it required 337,496 times of motorcycle use as the load factor of 2. The total travel distance was measured as 8,301,051 kilometers. For the land transportation demand of tourists

[11] As the survey result showed in Chapter 2, the share of 90.7% is composed of 81.4% of the respondents used rental motorcycle and 9.3% of them used their owned motorcycle. The breakdown of the motorcycle use by the length of stay were 86.0% of one day tourists, 94.8% of two-day tourists, and 81.3% of three to five day tourists.

in 2012, the total fuel use for motorcycle was 372,244 liters, and it generated 842,389 kg-CO_2 of carbon dioxide emissions. The average fuel consumption per capita was estimated at 0.67 L/per capita, and the average of carbon dioxide emissions per capita was counted as 1.52 L/per capita. The fuel use per capita-distance was estimated at 0.022 kg-CO_2/per capita-distance, and the carbon dioxide emissions per capita-distance was measured as 0.051 kg-CO_2/per capita-km.

3.4.1.3 Breakfast and Bed (B&B) accommodations

About 156 units of accommodations were counted[12], mainly in the form of B&B accommodations. Table 3.10 shows the results of the energy use and the carbon dioxide emissions from B&B accommodations of Xiao-Liu-Qiu in 2012.

Table 3.10 Energy use and carbon dioxide emissions from B&B accommodations of Xiao-Liu-Qiu, 2012

The length of stay / **Item**	**1 day**	**2 days**	**3-5 days**	**Total**
Tourist numbers (person)	286,495	416,382	39,337	742,215
Accommodation demand (guest-night)	--	416,382	78,675	495,057
Energy use (MJ)*	--	16,426,287 (84.1%)	3,103,719 (15.9%)	19,530,006 (100.0%)
Carbon dioxide emissions (kg-CO_2)	--	2,065,257 (84.1%)	390,227 (15.9%)	2,455,484 (100.0%)

Note:* Energy denotes electricity.
Source: Calculated by author.

Excluding the one-day visitors, the total demand for B&B accommodations was counted as 495,057 guest-nights for the whole year, including 416,382 guest-nights from two-day tourists and 78,675 guest-nights from three-to-five-day tourists. The total energy use in accommodation industry of the island was measured as 19,530,006 MJ while it generated 2,455,484 kg-CO_2 of carbon dioxide emissions. The two-day tourists used 16,426,287 MJ of the total energy while it generated 2,065,257 kg-CO_2 of carbon dioxide emissions for the B&B

[12] The numbers of B&B accommodations is obtained through the on-site survey which is showed in Chapter 2.

accommodations. In total, it shared 84.1% of the total energy use and carbon dioxide emissions, the rest of 15.9% was generated by the three-to-five day tourists in 2012.

3.4.1.4 The overall energy use and carbon dioxide emissions for tourism purpose

Table 3.11 summarizes the overall energy use and carbon dioxide emissions for tourism purpose of Xaio-Liu-Qiu in original value in 2012. Regarding water transportation (ferry), the total fuel use was estimated as 2,989,702 liters, and it generated 7,791.162 ton-CO_2 in total for tourist demand.

Table 3.11 The overall tourism energy use and carbon dioxide emissions of Xiao-Liu-Qiu, 2012

Category / Item	Transportation		Accommodation	Total
	Ferry	**Motorcycle**	**B&B accommodations**	
Total energy use	2,989,702 (L)	372,244 (L)	19,530.006 (GJ)	--
Total carbon dioxide emissions	7,791.162 (ton-CO_2)	842.389 (ton-CO_2)	2,455.484 (ton-CO_2)	11,089.035 (ton-CO_2)
Energy use per capita	3.75 (L/ round-trip-per capita)	0.67 (L/ per capita)	39.45 (MJ/ per capita-night)	--
Carbon dioxide emissions per capita	9.77 (kg-CO_2)	1.52 (kg-CO_2)	4.96 (kg-CO_2/ per capita-night)	16.25 (kg-CO_2)

Note: The primary energy used are diesel-oil for ferry, petrol for motorcycle, and electricity for B&B accommodations.

Source: Calculated by author.

On average, the tourists consumed 3.75 liters of diesel-oil per capita, and it contributed 9.77 kg-CO_2. Regarding land transportation (motorcycle), the total fuel use was estimated as 372,244 liters, and it generated 842.389 ton-CO_2 in total for tourist demand. On average, the tourists consumed 0.67 liters of gasoline-oil per capita and contributed 1.52 kg-CO_2. Regarding B&B accommodations, the total fuel use was estimated as 19,530.006 GJ, and it generated

2,455.484 ton-CO_2 in total for tourist demand. On average, the tourists consumed 39.45 MJ/per person-night, and it contributed 4.96 kg-CO_2/per person-night.

Table 3.12 summarizes the converted values for total tourism energy use by length of stay in 2012, and Table 3.13 summarizes the corresponding carbon dioxide emissions. The total tourism energy use was estimated as 19,530 GJ, and it contributed 11,336 ton-CO_2 of the carbon dioxide emissions from tourism.

Table 3.12 The overall tourism energy use of Xiao-Liu-Qiu by length of stay, 2012

The length of stay / Type	1 day	2 days	3-5 days	Total (%)
Water transportation (ferry)	40,559 (92.6%)	58,947 (69.8%)	5,569 (55.7%)	105,075 (75.5%)
Land transportation (motorcycle)	3,245 (7.4%)	7,815 (9.3%)	1,088 (10.9%)	13,057 (9.4%)
B&B accommodations	--	16,426 (20.9%)	3,104 (33.4%)	19,530 (15.1%)
Total	43,804 (100%)	84,417 (100%)	9,993 (100%)	139,123 (100%)

Note: 1 L of diesel-oil=8,400 Kcal, and 1 L of gasoline oil= 7,800 Kcal; 1Kcal=0.004184MJ= 0.000004184GJ. The unit of energy use is GJ, and the values were converted based on the original values showed in Table 3.11.

Source: Calculated by author.

In terms of the length of stay, one-day tourists used 43,804 GJ of the energy, including 40,559 GJ (92.6%) for ferry and 3,245 GJ (7.4%) for motorcycle. To convert the energy use to carbon dioxide emissions, they generated about 3,232 ton-CO_2 of the tourism carbon dioxide emissions, including about 3,008 ton-CO_2 (93.0%) from ferry and about 225 ton-CO_2 (7.0%) from motorcycle.

Two-day tourists used 84,417 GJ of the energy, including 58,947 GJ (69.8%) for ferry, 7,815 GJ (9.3%) for motorcycle, and 16,426 GJ (20.9%) for B&B accommodations. To convert the energy use to carbon dioxide emissions, they generated about 6,978 ton-CO_2 of the tourism carbon dioxide emissions, including about 4,371 ton-CO_2 (62.6%) from ferry, about 542 ton-CO_2 (7.8%) from motorcycle, and about 2,065 ton-CO_2 (29.6%) from B&B accommodations.

Three-to-five-day tourists used 9,993 GJ of the energy, including 5,569 GJ (55.7%) for ferry, 1,088 GJ (10.9%) for motorcycle, and 3,104 GJ (33.4%) for B&B accommodations. To convert the energy use to carbon dioxide emissions, they generated about 879 ton-CO_2 of the tourism carbon dioxide emissions, including about 413 ton-CO_2 (43%) from ferry, about 75 ton-CO_2 (8.6%) from motorcycle, and about 390 ton-CO_2 (44.4%) from B&B accommodations.

Table 3.13 The carbon dioxide emissions from tourism on Xiao-Liu-Qiu by length of stay, 2012

The length of stay / Type	1 day	2 days	3-5 days	Total (%)
Water transportation (ferry)	3,007.4 (93.0%)	4,370.8 (62.6%)	412.9 (47.0%)	7,791.6 (68.7%)
Land transportation (motorcycle)	225.0 (7.0%)	541.9 (7.8%)	75.5 (8.6%)	842.4 (8.0%)
B&B accommodations	--	2,065.3 (29.6%)	390.2 (44.4%)	2,639.2 (23.3%)
Total	3,232.4 (100%)	6,978.0 (100%)	878.6 (100%)	11,335.8 (100%)

Source: Calculated by author.

Table 3.14 summarizes the converted values for tourism energy use and carbon dioxide emissions per capita. The average tourism energy use per capita was counted as 0.19 GJ, and it generated 17.63 kg-CO_2 on average. The breakdowns of tourism energy use per capita by the length of stay were counted as 0.15 GJ by per one-day tourist, 0.20 GJ by per two-day tourist, and 0.024 GJ by per three-to-five-day tourist. To convert the energy use to carbon dioxide emissions, carbon dioxide emissions from tourism per capita were calculated as 11.41 kg-CO_2 generated by per one-day tourist, 16.83 kg-CO_2 generated by per two-day tourist, and 22.70 kg-CO_2 generated by per three-to-five-day tourist.

Regarding the average tourism energy use per day per capita by length of stay, per one-day tourist used 0.15 GJ of tourism energy, per two-day tourist used 0.10 GJ tourism energy, and per three-to-five-day tourist used 0.09 GJ tourism energy, per day on average. To convert the energy use to carbon dioxide emissions, per one-day tourist generated 11.41 kg-CO_2 of carbon dioxide emissions, per two-day tourist generated 8.41 kg-CO_2 of carbon dioxide

emissions, and per three-to-five-day tourist generated 7.57 kg-CO_2 of carbon dioxide emissions, per day on average.

Table 3.14 Tourism energy use and carbon dioxide emissions per capita of Xiao-Liu-Qiu, 2012

Item	The length of stay / Category	1 day	2 days	3-5 days
Energy use (GJ)	Water transportation (ferry)	0.14	0.14	0.13
	Land transportation (motorcycle)	0.01	0.02	0.03
	B&B accommodations	--	0.04	0.08
	Total	0.15	0.20	0.24
	Average energy use per day	0.15	0.10	0.09
Carbon dioxide emissions (kg-CO_2)	Water transportation (ferry)	10.50	10.50	10.50
	Land transportation (motorcycle)	0.91	1.37	2.28
	B&B accommodations	--	4.96	9.92
	Total	11.41	16.83	22.70
	Average carbon dioxide emissions per day	11.41	8.41	7.57

Note: 1 L of diesel-oil= 8,400 Kcal, 1 L of gasoline oil= 7,800 Kcal, and 1Kcal= 0.004184MJ= 0.000004184GJ.

The figures are the converted value.

Source: Calculated by author.

3.4.2 The prediction of tourist numbers of Xiao-Liu-Qiu for 2015-2025

The other interest in this chapter is to forecast the tourist numbers and carbon dioxide emissions from tourism, and to further estimate the changes of carbon dioxide emissions from tourism under different mitigation strategies.

For forecasting the number of tourist arrivals, Stynes (1997b) suggested three approaches. They are: (1) Delphi Technique: the number of visitors is judged by a group of the professionals or experts in the specific field; (2) Historic trend/ time series methods: these assume the pattern of visitor arrivals in the past will remain steadily in the future, hence, once the time series function model is built, the tourist demand can be predicted; (3) Structural model: utilizing a

model that captures the relationship between the determinant factors (e.g. disposable income, GDP) and tourist visits.

Xiao-Liu-Qiu is an isolated island that can only be accessed by ferry, and it has the historic data on ferry passenger numbers. In addition, the tourism-related facilities (e.g. tourist ferry port, tourist service center, tourism sites) have almost been completed in the last decade. Considered these phenomena and data availability, the time series method is used to predict the tourist numbers for 2015-2025.

The concept of carrying capacity was utilized in order to obtain a reasonable estimate of predicted tourist number. According to Kurhade (2013), five types of carrying capacity are commonly used in tourism. They are physical carrying capacity, economic carrying capacity, social carrying capacity, biophysical carrying capacity, and environmental carrying capacity.

In this study, physical carrying capacity was taken. Water transportation is the only way to reach Xiao-Liu-Qiu. Therefore, the capacity of a ferry can be a suitable element to estimate the maximum tourist numbers because limiting the tourist numbers is one of the managerial concerns for the development of Xiao-Liu-Qiu, suggested by Pingtung County Government (2014).

As mentioned in Chapter 2, both Liu-Shin Company (the public ferry company) and Dong-Liu United Water Transport (the private ferry company) have arranged the departure time between Xiao-Liu-Qiu and Dong-Gang. Generally speaking, the ferries are operated following the timetable announced by the ferry companies. However, during the busy season, the private ferry company functions more voyages in order to provide the transporting services to the tourists. It may result in overloaded on Xiao-Liu-Qiu due to the large number of tourist arrivals. Formula 23 was used to estimate the maximum ferry passenger numbers per year. The estimate is used to examine whether the prediction of tourist numbers is reasonable.

$$MTP = NOV \times NPC \times ORP \times DOP \tag{23}$$

Where,

MTP: The maximum ferry passenger numbers in a year (unit: person).

NOV: The number of times of sea voyages per day in terms of the timetable announced by the public and private ferry companies. It indicates 19 times per day, including fourteen times run by Dong-Liu United Water Transport (the private ferry company)

and five times run by the public ferry company, Liu-Shin Company (the public ferry company).

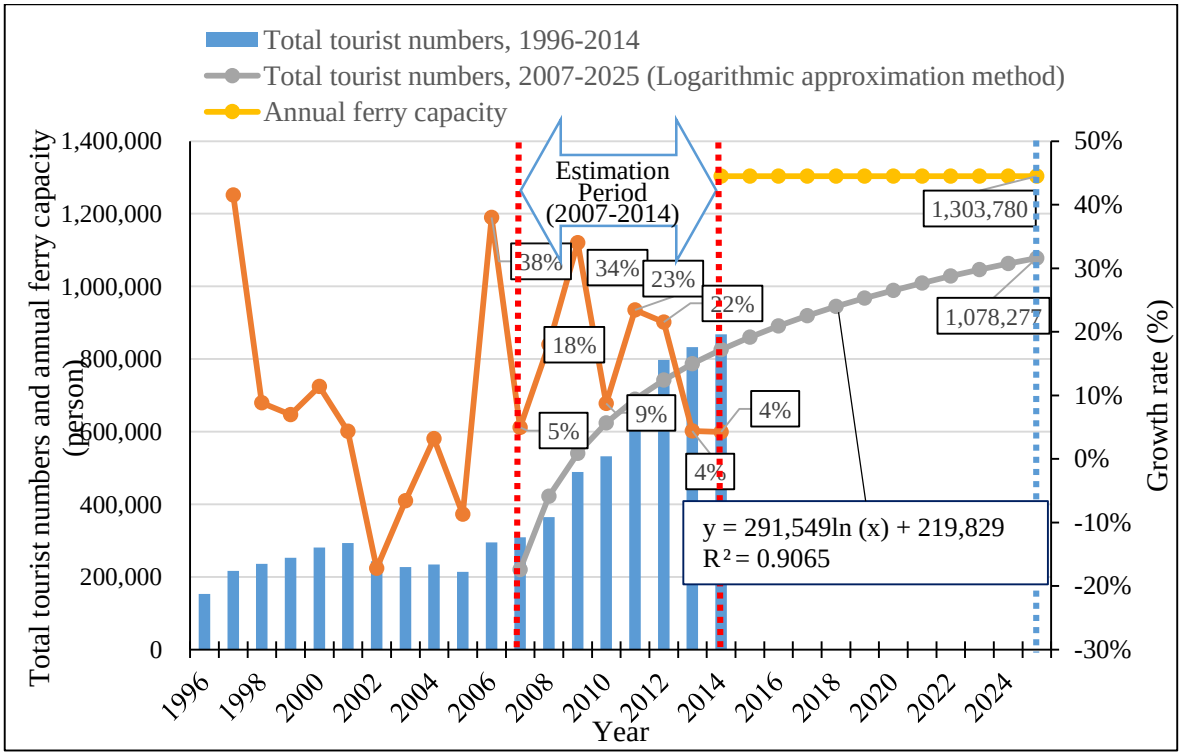
NPC: The number of passenger capacity per ferry boat. It indicates 188 people on average according to the ferry information showed in Chapter 2.

ORP: The occupancy rate of a ferry boat in percentage. It indicates 100% while the ferry boat is fully loaded.

DOP: The day of ferry boats in operation a year, it indicates 365 days.

Figure 3.7 shows the estimated tourist numbers and the growth rate in the years of 1996-2014, the forecasts of tourist numbers in the years of 2015-2025, and the volume of ferry capacity. The total tourist numbers in the years of 1996-2014 were extrapolated and described in the earlier section, and the historical trend was utilized to predict the tourist numbers in the years of 2015-2025.

Figure 3.7 The trend and forecast of tourist arrivals of Xiao-Liu-Qiu, 1996-2025



Source: Estimated by author.

Observed the trend of tourist numbers in 1996-2014, the tourist numbers kept increasing year by year since 2005. The historical growth rates in the years of 2006-2014 were calculated as 38%, 5%, 18%, 34%, 9%, 23%, 22%, 4%, and 4%, respectively. The annual growth rate was estimated at 14% in this period.

The growth rates in 2006, 2009, and 2012 were relatively higher comparing to in the other years, it was mainly affected by a triennial religious festival, Wang-Chuan Ritual at Xiao-Liu-Qiu. Therefore, the tourist numbers in 2006 was excluded in the prediction of tourist numbers in order to reduce the effect of the religious festival. Based on the trend of 2007-2014, Logarithmic Approximation equation is utilized to obtain the forecasts of tourist numbers of 2015-2025. According to the estimation results, it shows that the tourist numbers will reach to 1,078,277 people in 2025, under the maximum volume of ferry passenger numbers, 1,303,780 people. The figures obtained from the Logarithmic Approximation analysis will be utilized for the following analyses.

3.4.3 Scenario analysis

Alavalapati and Adamowicz (2000) suggested that tourism should be considered as an endogenous activity because the negative environmental impacts related to tourism may reduce the attractions of a site and the number of visits, thereby affecting the regional economy. Therefore, it is necessary to monitor the negative environmental impact in order to keep reaching the goal of economic sustainability, and it is the main goal of this chapter.

Carbon dioxide emissions was taken as an indicator to monitor the negative environmental impact of tourism on Xiao-Liu-Qiu. Energy use and carbon dioxide emissions focused on the tourism transportation and accommodations in 2012 have been explored. Besides, the measurements of carbon dioxide emissions from tourism in 2012 served as a basis, combined with the estimates of the trend in tourist numbers of 2007-2025, the prediction about tourism carbon on Xiao-Liu-Qiu has also been studied in the earlier sections of this chapter.

3.4.3.1 The background[13] of scenario setting

As Hertwich (2005) mentioned, "scenarios play an important role in the environmental policy, because they allow us to scope out possible future developments and evaluate alternative courses of action" (p. 4679). Scenarios are used to support policies or strategies, they are not aimed at obtaining forecasts but advocates the creation of alternative images of the future development of the external environment (Postmaa & Lieblb, 2005).

According to the official document by Pingtung County Government (2014), the directions in development of Xiao-Liu-Qiu should incorporate the development of low carbon industries and tourism, based on the basic principles of "Sustainable Energy Policy Convention" (永續能源政策綱領) established by the Executive Yuan, Republic of China (Taiwan)[14] and the "Demonstration Projects on Promoting the Green Island and Xiao-Liu-Qiu as Low Carbon Dioxide Emissions Tourism Islands" (推動綠島及小琉球低碳觀光島示範計畫) launched by the Tourism Bureau, Ministry of Transportation and Communications, Republic of China (Taiwan).

Besides, under the scope of coping with global climate change and island tourism development trend, the core planning principle on the strategy of sustainable island development on Xiao-Liu-Qiu is composed of the conceptual elements of the low-carbon energy, circular economy, ecological tourism, low-carbon community, and green transportation.

3.4.3.2 Current land transportation on Xiao-Lin-Qiu

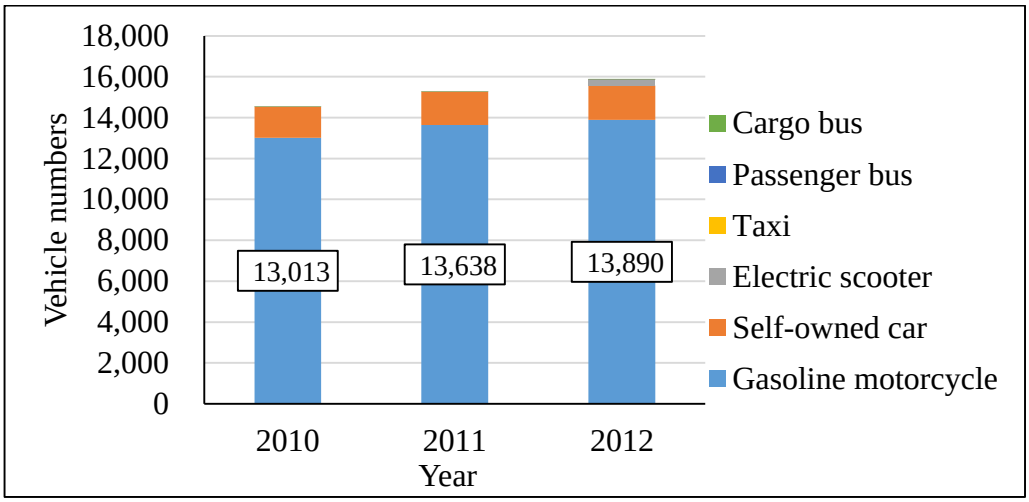
Figure 3.8 shows the number of vehicles by category on Xiao-Liu-Qiu in 2010-2012. There are six categories of land transportation used on this island. The total number of vehicles were increasing year by year, counted from 14,548 in 2010 to 15,875 in 2012. Gasoline motorcycle was the most common vehicle, the number of motorcycles increased from 13,013

[13] An extraction from "The 4th Phase (2015-2018) Implement Plan of the Offshore Island Comprehensive Development of Pingtung County (Approved version)" (屏東縣第四期 (104-107年) 離島綜合建設實施方案 (核定版)) instructed by Pingtung County Government (2014) and translated by author.

[14] The Executive Yuan (行政院) is the executive branch of the Republic of China (Taiwan) government. According to the Constitution, the Executive Yuan Council evaluates statutory and budgetary bills and bills concerning material law, amnesty, declaration of war, conclusion of peace and treaties, and other important affairs, all of which are to be submitted to the Legislature, as well as matters of common concern to various ministries and commissions. (http://www.ey.gov.tw/en/cp.aspx?n=95097CAF31185CC1).

in 2010 to 13,890 in 2012. It indicates that demand for motorcycles kept increasing for both residents and tourists in these three years.

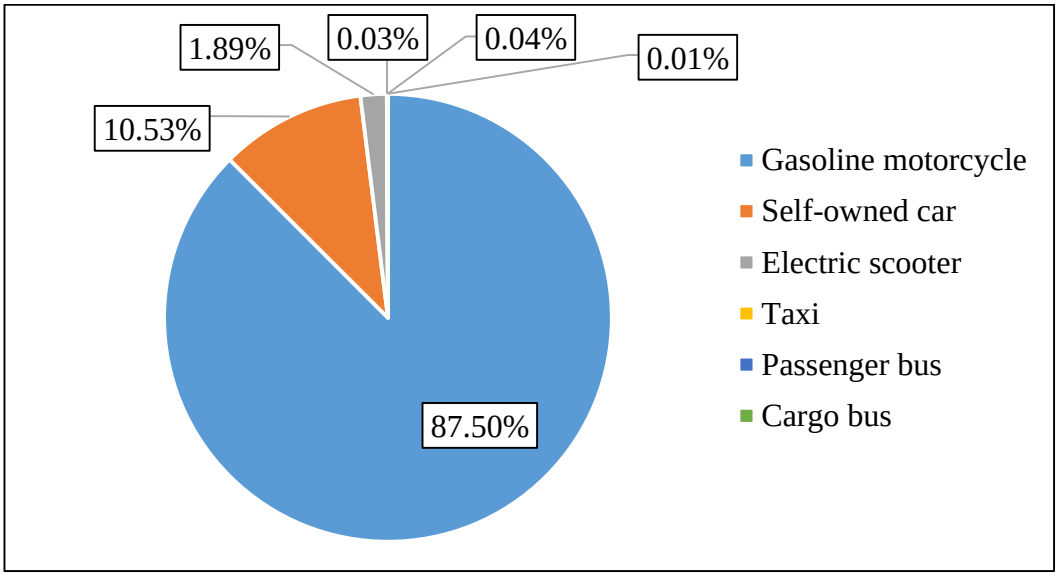
Figure 3.8 The number of vehicles on Xiao-Liu-Qiu by category, 2010-2012



Note: Electric scooter was introduced to Xiao-Liu-Qiu since 2012.
Source: Pingtung County Government (2014).

Figure 3.9 shows the vehicle numbers by category of Xiao-Liu-Qiu in 2012. About 87.5% of the land transportation is gasoline motorcycle, followed by 10.53% of self-owned cars.

Figure 3.9 The share of vehicle numbers by category on Xiao-Liu-Qiu, 2012



Note: Electric scooter was introduced to Xiao-Liu-Qiu since 2012.
Source: Pingtung County Government (2014).

As mentioned in Pingtung County Government (2014), the private vehicles are the main land transportations, and they cause disadvantage of the mitigation of carbon dioxide emissions. Although electric scooter only shared 1.89% of the total vehicles in 2012, it is the only green vehicle promoted by the government currently.

3.4.3.3 Mitigation scenario analysis of carbon dioxide emissions from land transportation

In the following part, the mitigation scenario analysis of carbon dioxide emissions from land transportation is conducted, and the setting of scenario is designed based on the policy statement mentioned.

Table 3.15 provides the setting and its corresponding governmental policy and plan of scenarios on carbon dioxide emissions from vehicles of Xiao-Liu-Qiu. Three scenarios are designed based on the concepts extracted from the corresponding policy and plans.

Table 3.15 The basis of scenario analysis on carbon dioxide emissions from vehicles of Xiao-Liu-Qiu

Scenario	**Setting**	**Corresponding governmental policy and plan**
Business as usual (BAU)	The original status without any adjustment.	--
Scenario 1: Improvement of technology efficiency	25% of improvement in private transportation efficiency in the years, 2015-2018. The annual growth rate of efficiency improvement is employed until 2025.	Sustainable Energy Policy Convention (永續能源政策綱領) launched in 2008.
Scenario 2: Replace gasoline motorcycle with electric scooter to increase the use rate of green transportation	Replace gasoline motorcycle with electric scooter to 70% of total vehicle use over the years of 2015-2018. Electric scooter use rate remains 70% of total vehicles in 2019-2025.	The 4th Phase (2015-2018) Implement Plan of the Offshore Island Comprehensive Development of Pingtung County (Approved version) (屏東縣第四期 (104-107年)離島綜合建設實施方案(核定版) launched in 2014.

(continued)

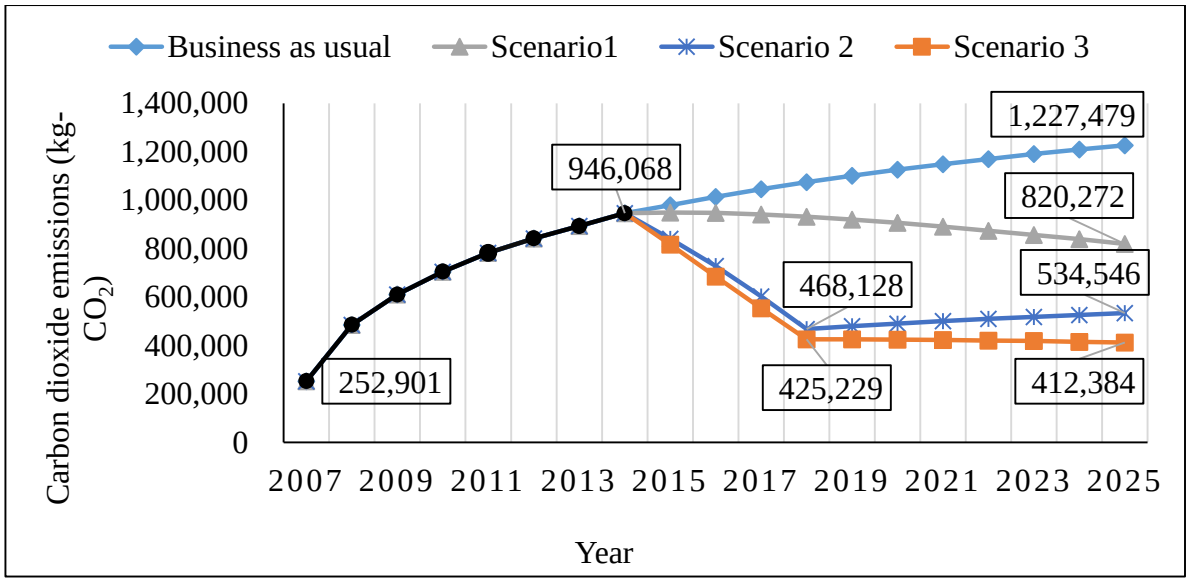
Table 3.15 The basis of scenario analysis on carbon dioxide emissions from vehicles of Xiao-Liu-Qiu (continued)

Scenario	Setting	Corresponding governmental policy and plan
Scenario 3: Replace gasoline motorcycle with electric scooter and improvement of technology efficiency on gasoline motorcycle	Replace gasoline motorcycle with electric scooter to 70% of total vehicle use over the years of 2015-2018. Electric scooter use rate remains 70% of total vehicles in 2019-2025. Meanwhile the annual growth rate of efficiency improvement in scenario 1 is utilized in 2015-2025.	Combined the idea in The 4th Phase (2015-2018) Implement Plan of the Offshore Island Comprehensive Development of Pingtung County (Approved version) (屏東縣第四期(104-107 年)離島綜合建設實施方案(核定版)) launched in 2014 and Sustainable Energy Policy Convention (永續能源政策綱領) launched in 2008.

Source: Compiled and designed by author.

Figure 3.10 showed the estimated trend of carbon dioxide emissions under the mitigation policy for land transportation on Xiao-Liu-Qiu in 2007-2025. Assuming the mitigation policies are applied on Xiao-Liu-Qiu during the forecasting period, 2015-2025. In the setting of business as usual (BAU), carbon dioxide emissions from the current use of vehicles will reach to 1,227,479 kg-CO_2 in 2025, from 252,901 kg-CO_2 in 2007 and 946,068 kg-CO_2 in 2014.

Figure 3.10 The estimated trend of carbon dioxide emissions under the mitigation policy for land transportation on Xiao-Liu-Qiu, 2007-2025



Source: Estimated by author.

In Scenario 1, there is no green transportation replacement applied but increase gasoline motorcycle efficiency. Assuming the gasoline motorcycle efficiency will increase 25%, compared energy efficiency in the years, 2015-2018. The annual growth rate was calculated as 3.8% of improvement per year, applied it to the years, 2016-2025. The annual carbon dioxide emissions will be reduced to 820,272 kg-CO_2 in 2025 from 946,068 kg-CO_2 in 2014 though the tourist numbers are increasing over the years.

In Scenario 2, the replacement of gasoline motorcycle with the electric scooter was employed. The purpose is to increase the use rate in green transportation, electric scooter. The target was that the electric scooter shared 70% of the total vehicle use rate over the years, 2015-2018. Therefore, the annual growth rate was counted as 17.5% in 2015, 35.0% in 2016, 52.5% in 2017, 70.0% in 2018, and 70% in 2019-2025. Based on the results showed in Figure 3.11, carbon dioxide emissions will reduce dramatically in the years, 2014-2018, from 946,068 kg-CO_2 to 468,128 kg-CO_2. However, carbon dioxide emissions will steadily increase after 2018, changed from 468,128 kg-CO_2 in 2018 to 534,546 kg-CO_2 in 2025. It may result from that the tourists keep increasing, but the use rate of electric scooter remains 70% of the total demand for land transportation.

In Scenario 3, the policy combined the replacement of gasoline motorcycle with the electric scooter, and the improvement of technology efficiency on gasoline motorcycle was adopted. Replace gasoline motorcycle with electric scooter to 70% of total vehicle use over the years of 2015-2018, Electric scooter use rate remains 70% of total vehicles in 2019-2025. Meanwhile, the annual growth rate of efficiency improvement in scenario 1 was utilized in 2015-2025. The trend showed that carbon dioxide emissions from tourism will be reduced obviously during 2014-2018, a decrease from 946,068 kg-CO_2 in 2014 to 425,229 kg-CO_2 in 2018. Thereafter, the change of reduction in carbon dioxide emissions will become steady decline, with the amounts of 425,229 kg-CO_2 in 2018 to 412,384 kg-CO_2 in 2025.

Table 3.16 The summary of the changes of reduction in carbon dioxide emissions

Setting / Year	Business as usual	Scenario 1	Scenario 2	Scenario 3
2015	-	-3%	-14%	-17%
2016	-	-7%	-28%	-33%
2017	-	-10%	-42%	-47%
2018	-	-13%	-56%	-60%
2019	-	-16%	-56%	-61%
2020	-	-20%	-56%	-62%
2021	-	-22%	-56%	-63%
2022	-	-25%	-56%	-64%
2023	-	-28%	-56%	-65%
2024	-	-31%	-56%	-66%
2025	-	-33%	-56%	-66%

Source: Calculated by author.

Table 3.16 summarizes the changes of reduction in carbon dioxide emissions by year under different mitigation scenarios. Compared to business as usual (BAU), the change rates in scenario 1 will decrease from 3% in 2015 to 33% in 2025. In addition, the change rates will reduce from 14% in 2015 to 56% in 2018 and thereafter in scenario 2, compared with BAU. The last, the change rates will reduce from 17% in 2015 to 66% in 2025, compared with BAU.

3.5 Discussions and Summary

The purpose of this chapter was to quantify energy use and carbon dioxide emissions from tourism-related transportations and accommodations in terms of the tourists' characteristics and activities choices. The main research question studied on what the environmental impact of an island tourism destination in terms of energy use and carbon dioxide emissions. A bottom-up approach was utilized to respond the objective of this chapter.

Tourist arrivals is the main factor to influence energy use and carbon dioxide emissions. For reaching the goal of this chapter, it is necessary to estimate the tourist numbers first since there are no statistics data at hand. By using the available secondary data (e.g. ferry passenger numbers) and official information, the trend of tourist numbers of Xiao-Liu-Qiu in the years 1996-2014 were extrapolated.

The trend of tourist numbers has been increasing, with the estimates from 153,278 tourists in 1996 to 868,115 tourists in 2014. Several factors (e.g. the trend of visitor numbers of the Liouciou Scenic Area) were taken into consideration in order to verify the reasonableness of the estimates. Besides, tourists' characteristics and their behavioral choices were taken into consideration since these are the factors that influence the amount of energy use and carbon dioxide emissions due to tourism. The results of the on-site survey (as the on-site investigation showed in Chapter 2) were also utilized in the analysis.

In 2012, the total tourism energy use in terms of transportation and accommodation was estimated as 139.123 GJ, and it generated 11,335.784 ton-CO_2 of carbon dioxide emissions. Generally, transportation constitutes the major tourism-related energy use, and while it is the main source of anthropogenic carbon dioxide emissions, its share is 60%-95% at the journey level (Gössling, 2002; Gössling et al., 2005; UNWTO, 2008). In the case of Xiao-Liu-Qiu, transportation consumed about 84.9% of total energy and generated around 76.7% of carbon dioxide emissions in the year of 2012. This included 75.5 % of the energy used for water transportation, and the rest (9.4%) was used for land transportation, motorcycle. This amount of carbon dioxide emissions from tourism transportation was 68.7% by ferry and 8.0% by motorcycle. Carbon dioxide emissions from the motorcycle was estimated at 0.051 kg-CO_2/ per passenger-km. Compared to similar studies, it is a bit lower than the study by Lin (2010), with the value of 0.054 kg-CO_2/ per capita-km, but it is relatively higher than the study by Tang et al (2015), with 0.0437 kg-CO_2/per capita-km. This mainly results from the different load factor of transportation and the energy efficiency of the motorcycles.

Taking the results of the on-site investigation on accommodation, and the factor of the length of stay into account, 156 units of B&B accommodations consumed about 19,530 GJ (15.1%) of the total energy for tourism and generated about 2,639.205 ton-CO_2 (23.3%) of the total carbon dioxide emissions. The majority of tourists stayed two days, and they consumed 60.7% of the total tourism energy while generating about 78.3% of the total carbon dioxide emissions in 2012.

In addition, it is not surprising that the longer tourists stay, the more energy is consumed, and the more carbon dioxide emissions is generated. However, taking the view of the whole trip, the fewer days stayed the more energy use and carbon dioxide emissions per day. In terms of different lengths of stay, the tourism energy use per capita was estimated as 150-260 MJ, and

the carbon dioxide emissions from tourism were estimated as 11.4-22.7 kg-CO_2 in 2012. The longer tourists stay, the higher tourism energy use per capita was used, and the more carbon dioxide emissions from tourism per capita were generated. In terms of different lengths of stay, the tourism energy use per day per capita was estimated at 90-150 MJ, and the carbon dioxide emissions from tourism were estimated to be 7.6-11.4 kg-CO_2 in 2012. The efficiency-performance ratios were counted as 73.7 kg-CO_2/GJ for per one-day tourist, as 82.6 kg-CO_2/GJ for per two-day tourist, and 87.5 kg-CO_2/GJ for per three to five-day tourist as combined carbon dioxide emissions from tourism generated per unit of energy. The measure of ecological footprint enables us to estimate the resource consumption and waste assimilation requirement of a defined human population or economy in terms of a corresponding productive land area. Ecological footprint can be adopted as an environmental indicator of sustainable development, as well in the tourism field (Hunter & Shaw, 2007).

Four scenario analyses were conducted to explore the change in carbon dioxide emissions under different mitigation strategies in land transportation. Carbon dioxide emissions will increase from 946,068 kg-CO_2 in 2014 to 1,227,479 kg-CO_2 in 2025 while no mitigation strategies adopted in the current situation. Under the scenario of increasing the energy efficiency of gasoline motorcycles by 25% in the years, 2015-2018. By adopting the strategy of the technology improvement of gasoline motorcycle, the annual carbon dioxide emissions will decrease, from 946,068 kg-CO_2 in 2014 to 820,272 kg-CO_2 in 2025, even though the tourist numbers are increasing year by year.

The replacement of gasoline motorcycle with the electric scooter was utilized in Scenario 2. The result showed that carbon dioxide emissions will be decreased hugely from 946,068 kg-CO_2 in 2014 to 468,128 kg-CO_2 in 2018. But, it should be noticed that carbon dioxide emissions will increase during 2018-2025, from 468,128 kg-CO_2 to 534,546 kg-CO_2. The last scenario combined the mitigation concepts of Scenario 1 and 2. The results showed that carbon dioxide emissions will have a significant reduction, from 946,068 kg-CO_2 in 2014 to 425,229 kg-CO_2 in 2018. During the years, 2018-2025, the reduction in carbon dioxide emissions will decline gradually, from 425,229 kg-CO_2 in 2018 to 412,384 kg-CO_2 in 2025.

To sum up the changes of reduction in carbon dioxide emissions by year, the results of Scenario 3 will generate a bigger reduction effect, compared the effects of Scenario 1 and 2.

The mitigation effect of Scenario 3 will reach to 66% in 2025, while Scenario 2 will reduce 56% and Scenario 1 shows 33% of reduction, compared to the scenario of business as usual.

CHAPTER 4

ESTIMATING TOURISM ECONOMIC CONTRIBUTION: A TWO-REGION INPUT-OUTPUT ANALYSIS

4.1 Introduction

4.1.1 Background

In many island communities, the tourism sector plays a leading role in regional development and is a key contributor to economic growth (De Villiers, 2005). In the case of Xiao-Liu-Qiu, there are several reasons that economic policy and the government put efforts into supporting tourism development. First, Xiao-Liu-Qiu has unique natural resources that form the main part of the tourism attractions. Second, the residents have mainly relied on the fishing industry to earn their income since the 1920s (H.-M. Chen, 2000), hence tourism can diversify the economic structure. Third, tourism can create other extra income, employment opportunities and government revenue. It is obvious that tourism has gradually become one of the pillars of the whole economy of Xiao-Liu-Qiu. However, although the importance of tourism has been increasing gradually, there has been no study to quantify its economic contribution and to confirm whether the profits earned from tourism remain locally or leak out of the island. Tourism is the combination of several industries; hence, the estimation of its economic impact is complex (Fletcher, 1989b). Nevertheless, the economic analysis of tourism can provide meaningful estimates of these economic interdependencies and a clear picture of the importance of tourism in a given region's economy.

4.1.2 Research objectives and questions

The aim of this chapter is to explore the economy of Xiao-Liu-Qiu and its economic connection with the rest of Taiwan within the context of tourism as a development strategy. The main research question is what the economic impact of tourism is on Xiao-Liu-Qiu as mentioned in Chapter 1. To that end, this study utilizes input-output analysis to answer the following sub-questions:

i. What are the inter-industry relationships in the economy of Xiao-Liu-Qiu?

ii. How are the economic multiplier effects regarding output, employment, and wage on Xiao-Liu-Qiu?

iii. Did the economic structure and the multiplier effects change between 2006 and 2011 on Xiao-Liu-Qiu?

iv. What are the trade effects within and between Xiao-Liu-Qiu and the rest of Taiwan, particularly regarding tourism characteristic industries?

4.1.3 Measure boundary

The industrial structure of Xiao-Liu-Qiu is much simpler than the rest of Taiwan, and it highly relies on importation from the mainland. Hence, the economic effects of the industrial structure of Xiao-Liu-Qiu, and between Xiao-Liu-Qiu and the rest of Taiwan are considered as a system while measuring the economic impact.

4.2 Literature review

4.2.1 Brief introduction to input-output analysis

In 1758, *Tableau Économique* was written by French economist Francois Quesnay, which has become the foundation of the Physiocratic sect[15]. This was used as the basis for Input-Output systems and modern general equilibrium theory. In 1923-1924, Dr. Wassily Leontief utilized the concept of *Tableau Économique* and compiled the first input-output table in the

[15] In *Tableau economists*, Quesnay set out three classes of society, which were landowners, the farmers and farmer-labourers, and others, called the "sterile class". In this publication, he showed how transactions flowed between them.

Soviet Union. Since that time, more and more researchers have used input-output analysis based on the seminal work of Leontief, and that some of them incorporated environmental issues into the analysis (Costanza, 1980; Daly, 1968; Hannon, 1973; Isard, 1972). Following a series of publications, Leontief was awarded the Nobel Prize in Economics for his work entitled *For the development of th*e *input-output method* an*d for its application to important economic problems* (Hara, 2012). Input-output analysis is a macroeconomic method, which demonstrates how the output of one industry becomes the input of other industries, and explains the inter-dependency of supply and demand along the production chain (Murray & Wood, 2010; Wiedmann, 2010). The analysis can be used to estimate models for local regions, a country or a group of countries (Stynes, 1999). The framework of input-output analysis has been employed not only in many science fields such as development economics, and regional science, but also in the tourism field (Hara, 2012). In the following section, case studies utilizing input-output analysis on tourism economics are reviewed.

4.2.2 Input-output analysis on tourism economic studies

Many studies have employed the input-output model to estimate tourism economic impacts (Archer, 1977; Haddad, Silva, Porsse, & Dentinho, 2012b; Polo & Valle, 2008). Reviewing the empirical studies that applied input-output model to measure tourism impact, the summaries are described as follows.

Lichy and Steinnes (1982) employed a general input-output model and a tourism-modified input-output model to estimate the multipliers for each industry and to measure the tourism impact in a small region of Ely. A questionnaire and the interviews were conducted to obtain firm-based and household-based data. The result showed that the average multiplier of non-resident spending in a given period equaled 2.23, and the average income multiplier was estimated at 1.67.

A study by Baaijens, Nijkamp, and Montfort (1997) attempted to demonstrate that meta-analysis could be regarded as a method for comparative and explorative research in the tourism field. They focused on regional tourist multipliers to measure the tourist spending effect on the regional economy. The results showed that the average tourist income multiplier had a positive relationship to population size, the number of visits in a year, the ratio of the tourist numbers to the population size, and the share of the most important country of origin in the total number of

tourists. They also transferred the comparative analysis result to the Greek island of Lesvos and estimated that the average tourist income multiplier comes out at 0.55 and 0.67, respectively.

A study conducted by Kweka, Morrissey, and Blake (2001), used input-output analysis to estimate the economic impact of tourism and assessed whether it is a key sector for the Tanzanian economy. The findings proved that tourism has a significant impact on output because of strong inter-sector and linkage effects, but the impact on tourism income was insignificant. However, tourism was identified as a key sector to enhance economic growth.

Fan and Oosterhaven (2005b) conducted an input-output table, a social accounting matrix, and gathered tourist expenditure data to estimate the international tourism impact on the Chinese economy. They found that only 1.64% of GDP, 1.40% of household income, and 1.01 % of total Chinese employment relied on international tourist expenditures. Compared to other industries, the tertiary industries have relatively low output multipliers, but have a higher contribution to GDP effect (55%) from international tourism. Although the size of the agricultural sector in China is large, its share of tourism impacts is quite small, and it needs 48% of the total employment, in order to satisfy international demand in China. International tourism in China mainly stimulates high value added in service industries.

Another study, conducted by Polo and Valle (2008), employed the standard input-output technique to provide the first assessment of the impact of tourism on the Balearic economy and to estimate the effects of a 10% decrease in tourism flows. The results showed that tourism has become the leading sector of the Balearic economy, and the economic performance of the island is tightly linked to tourism flows.

Regarding the tourism application of input-output analysis in a multiple site context, Haddad, Silva, Porsse, and Dentinho (2012a) explored the inter-island input-output system for the Azores, including the economy of the nine islands, considering twenty-five different economic activities. The results showed that the economic structure of those islands is quite different. Besides, the specific economic bases of those islands are also distinct and the biggest island not only captures an important part of the impact of external pushes completed on smaller islands, but it also constitutes a significant driver of smaller islands.

Soulié (2014) constructed an inter-regional input-output model to analyze the linkage and industry dependencies of a small island and the rest of Spain. The results not only proved that

tourism has a heavy specialization effect in Balearics, but revealed a high leakage effect due to the extraordinary dependency on supplies from the rest of Spain.

Khanal, Gan, and Becken (2014) studied the importance of economic linkages between the tourism industry and the rest of economy in Lao PDR by using input-output analysis. Their results revealed that the linkage between tourism and the rest of the economy was growing in recent years, and tourism was one of the dominant industries during the time period of 2003-2008. They also showed evidence that the tourism industries enhances the nation's economic growth.

Hanly (2012) utilized input-output analysis to examine the linkages between the Irish international association convention market and the rest of the economy. The findings showed that more than two-thirds of convention money was spent in backward-oriented industries, and one million Euros of convention money spent are estimated to create 15 full-time jobs.

Mazumder, Ahmed, and Al-Amin (2009) examined the Malaysian economic contribution made by the tourism industry in terms of the multiplier effects and also demonstrated the importance of the tourism industry by using the input-output technique. They found that international tourist spending can generate the biggest output effect. Besides, the secondary effect of tourist spending is higher in both output and value added effects. They concluded that tourism makes a significant contribution to enhancing economic growth in Malaysia now and in the future.

In current studies, input-output analysis was regarded as a suitable tool to quantify tourism impacts, industry linkages and multipliers (Cai, Leung, & Mak, 2005; Haddad et al., 2012a; Josaphat Kweka et al., 2001; Lichty & Steinnes, 1982; Polo & Valle, 2008). It not only can paint a picture of the economy that depicts the trade flows to and from industries within a specific region or even among certain regions, but it also can be a useful mean to evaluate the significance of different industries within an economy (Kay, Pratt, & Warner, 2007).

In addition, multiplier analysis has been considered as an approach for regional tourism impact assessment. Particularly in the regional input-output model, it provides comprehensive information on the consequences of tourist expenditure on the local economy(Baaijens et al., 1997; Surugiu, 2009). In most studies, the economic impact on employment, income, and output multipliers were estimated. Some of them focused further on the contribution of tourism

with other industries. Based on the results of those studies, all of them supported the fact that tourism development is useful to improve a specific economy.

4.3 Method

4.3.1 Industry category

Industry code, category, and the details of tourism related product are listed in Table 4.1. The name of each industry is given based on the standard industrial classification system of the Republic of China published by Directorate-General of Budget, Accounting, and Statistics, DGBAS (2011).

The economy on Xiao-Liu-Qiu is much simpler than Taiwan as a whole and relies highly on importation from the mainland. Therefore, it is necessary to take view both of the island and the mainland as a system. Besides, only 11 out of 14 industries appear on Xiao-Liu-Qiu. Electricity & Gas Supply (S4), Water Supply (S5), and Remediation Services (S6) are non-existent on the island. The services of energy supply (e.g. electricity, gas) and waste treatment (e.g. solid garbage) are provided by the Taiwanese mainland. However, the importance of energy supply and waste treatment cannot be ignored because tourism activities depend heavily on them. Therefore, 14 industries are retained and utilized in the following analysis.

Tourism characteristic industries identified in this study include Wholesale & Retail Trade (S8), Transportation and Storage (S9), Accommodation (S10), Food Service (S11), Support Services (S13), and Entertainment & Recreation (S14). The basis of categorization of tourism characteristic industries are listed as follows: first, the standard of categorization refers to the category in the Taiwan Tourism Satellite Account and OECD glossary; second, the products of these industries are mainly sold to tourists; and third, by citing the concept of Okubo and Planting (1998), the revenues of industries would be affected dramatically if tourism characteristic industries were not present.

Table 4.1 Industry category

Category	Sub-category (code)	Description
Primary	Agriculture, Forestry, & Animal Husbandry (S1)	Growing of Cereals (Except Rice), Growing of Fruits and Vegetables
	Fishing (S2)	Marine Fishing, Marine Aquaculture
Secondary	Mining, Quarrying & Manufacturing (S3)	Manufacture of Fish, Crustaceans and Mollusc Products
Tertiary	Electricity & Gas Supply (S4)	Electricity and Gas Supply
	Water Supply (S5)	Water Supply
	Remediation Services (S6)	Remediation Services
	Construction (S7)	Construction
	Wholesale & Retail Trade* (S8)	Retail Trade (including souvenir sales to tourists)
	Transportation & Storage* (S9)	Water Transportation (mainly passenger ferry from mainland of Taiwan to Xiao-Liu-Qiu) and Postal Activities
	Accommodation*(S10)	Short Term Accommodation Activities
	Food Service* (S11)	Food and Beverage Service Activities
	Other Services (S12)	Information and Communication; Financial and Insurance Activities; Professional, Scientific and Technical Activities; Human Health and Social Work Activities; and Other Personal Service Activities
	Support Services* (S13)	Rental and Leasing Activities, mainly motorcycle rentals to tourists (primary transportation tool on the island)
	Entertainment & Recreation* (S14)	Amusement and Recreation Activities (providing water recreation activities and operating equipment rental services to tourists, e.g. snorkeling, scuba diving, banana boating)

Note. * denotes tourism characteristic industry. Electricity & Gas Supply (S4), Water Supply (S5), and Remediation Services (S6) are non-existent on Xiao-Liu-Qiu.

Source: Compiled by author.

4.3.2 Data and analytical process

The data was obtained from the government statistics at the regional and national levels. As for unavailable data about Xiao-Liu-Qiu, I employed statistical data of both the Pingtung County and national sources in order to make estimations based on the role of proportionality. Table 4.2 provides the description of data employed in this study.

Table 4.2 Data collection for this study

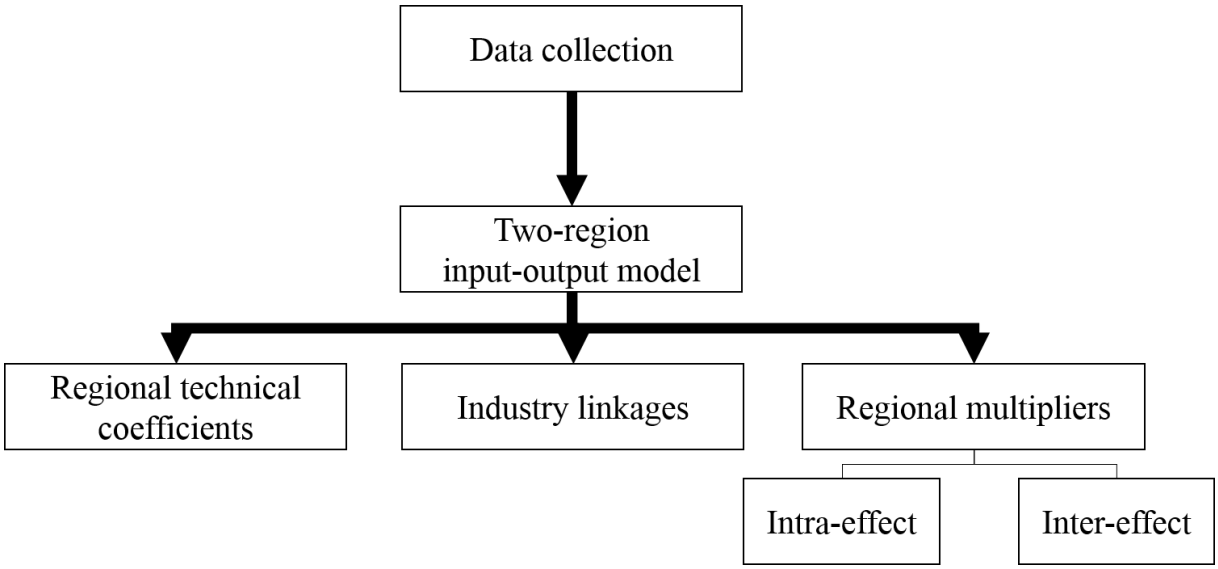
Data source	Data year	Source	Description
Benchmark Input-Output Tables (166 by 166)	2006	DGBAS (2009)	Served as the basis tables to estimate two-region tables
	2011	DGBAS (2014)	
Agriculture, Forestry, Fishery and Animal Husbandry Census	2005	DGBAS (2007)	Obtained the year production value, labor force number by industry of Xiao-Liu-Qiu, and Pingtung County's and national data
	2010	DGBAS (2012)	
Pingtung County statistical yearbook	2006	PTCG (2007)	
	2011	PTCG (2012)	
Industry, Commerce and Service Census	2006	DGBAS (2008)	
	2011	DGBAS (2013)	
Agricultural Statistics Yearbook	2006	COA (2007)	
	2011	COA (2012)	

Note: DGBAS denotes Directorate-General of Budget, Accounting, and Statistics, Executive Yun, PTCG denotes Pingtung County Government, and COA denotes Council of Agriculture, Executive Yuan.

Source: Compiled by author.

Figure 4.1 shows the schematic flow of the analytic process. After collecting the necessary data, two-region input-output models for 2006 and 2011 were constructed. Regional trade and technical coefficients, industry linkages, and regional multipliers for 2006 and 2011 were analyzed based on the two-region input-output tables.

Figure 4.1 The schematic flow of the analytical process



Source: Drew by author

4.3.3 The fundamentals of input-output analysis

This section introduces the basis of the input-output analysis and also explains the estimation procedure to construct a two-region input-output table.

4.3.3.1 The basis of input-output analysis

Since 1981, input-output tables were only being constructed at the national level in Taiwan. Therefore, adopting the techniques of location quotients (LQ) and RAS procedure (a "bi-proportional" matrix balancing method), the regional trade and technical coefficients could be obtained in terms of the regional statistics data and the existing national input-output tables for 2006 and 2011. The economic ratios and regional multipliers are assumed to be stable over the evaluation period based on the characteristics of input-output analysis, including "homogeneous" and "fixed proportions" (Miller & Blair, 2009).

Kweka et al. (2001) described it as follows: (1) the economy is composed of N endogenous sectors producing N different commodities, and one exogenous sector (final demand); (2) each commodity is produced by one production sector; (3) there is a stable and linear relationship between inputs and the level of output of that sector; (4) there are constant returns to scale such

that there are no external economies or diseconomies, and (5) there is no substitution of intermediate inputs (p.5).

Table 4.3 presents a general overview of an input-output table. The core part of the input-output table is the intermediate transaction table, which depicts the production function of each industry and the production relationships in a whole economy as showed by elements z_{ij}. In this table, the column industries are buyers and the row industries are sellers. Each element in the matrix describes the output value that the seller (row industry) delivers to the buyer (column industry). The elements f_i describes consumption patterns, usually including consumer expenditure, government spending, gross private domestic investment, net exports of goods, and services, and those elements are grouped as the final demand. The row elements v_i represents value added in specific industry containing all primary inputs (i.e. labor, capital, and land), and imports. Finally, summing down the total columns of an industry, the element x_i represents the total gross output in a whole economy, and the same value can be found by summing up the total rows of an industry.

Table 4.3 The framework of a standard input-output table

	Industry 1	**Industry 2**	**Industry 3**	**Final demand**	**Total output**
Industry 1	z_{11}	z_{21}	z_{31}	f_1	x_1
Industry 2	z_{21}	z_{22}	z_{32}	f_2	x_2
Industry 3	z_{31}	z_{23}	z_{33}	f_3	x_3
Value added	v_1	v_2	v_3		
Total input	x_1	x_2	x_3		

Source: Modified by author based on Miller and Blair (2009).

In algebra, the standard input-output model is written as equation (1). Following the well-established matrix notation, the bold uppercase letters indicate matrices, and the lowercase bold letters indicate vectors in this study.

$$x_i = \sum z_{ij} + f \tag{1}$$

Where, x denotes the output of a given industry, Z denotes the intermediate transaction flow, and f denotes the final demand of a given industry.

Each column of the industry represents the inputs required for that industry to generate its total output, and it can be calculated by dividing all column elements in a specific industry by the total production value of that industry. Following this rule, a new matrix A named as input coefficients (technical coefficients), would be obtained. The matrix demonstrates that the relationship of input values from the other industries is required by a specific industry to produce one unit of its output.

$$A = Z\hat{x}^{-1} \tag{2}$$

$$Z = Ax$$

Then, substituting equation (2) into (1):

$$x = Ax + f \tag{3}$$

$$x - Ax = f$$

$$(I - A)x = f$$

$$x = (I - A)^{-1}f \tag{4}$$

$$x = Lf$$

Where $(I - A)^{-1}$ is the Leontief inverse matrix L, also called the multiplier matrix or total requirement matrix (Miller & Blair, 2009). It is the core element in the input-output model, and it describes the relationship between final demand and total output. In other words, the matrix shows when one unit of final demand changes, how many units of total production would be affected.

4.3.3.2 Estimation Procedure

A two-region input-output table follows the same structure as a standard input-output table, but decomposes every industry into two in terms of the geographic areas. Therefore, each industry appears twice in the table: the industries located within the focus region; and the industries located outside of the region but within the same country.

Putting equation (1) and (3) into an two-regional setting, including region s and region r, a two-region input-output table can be divided into several sub-matrices. Z^{rr} is the intraregional transactions matrix, which represents that outputs produced by industries located in the region r that are used in the same region by other industries as inputs. Z^{ss} is the other intra-regional transactions matrix, which shows that outputs produced by industries located in the region s are used in the same region by the other industries.

In this study, where regions r and s belong to the same country, region s can be regarded as outside of the region r or the rest of the country. Inter-regional trade flows are recorded in sub-matrices of Z^{rs} and Z^{sr}, and these matrices represent the transactions between region s and region r. Final demand can be also divided into two matrices, including F^r and F^s, where F^r means the final demand from the region r, and F^s represents the final demand from the region s. Similarly, value added is also split into V^r and V^s.

Following the same rule, the regional technical coefficient, a_{ij}^r, can be broken down to the sum of the regional input coefficient, a_{ij}^{rr} and import coefficient, a_{ij}^{sr}, and $a_{ij}^{rr} = a_{ij}^r - a_{ij}^{sr}$[16]. Both regional technical coefficients and the import coefficients depict trade patterns (Miller & Blair, 2009)(p.309).

Location quotients (LQ) is a method for estimating trade coefficients (Tohmo, 2004). The simple location quotients (LQ) is defined as equation (5) and is used to obtain both the intra-regional technical coefficients and the inter-regional import coefficients. Both the regional technical coefficients and the import coefficients depict trade patterns between and with the regions (Miller & Blair, 2009). In regional studies, LQ can be used to explore the concentrated industries of region r and the outside of the region (region s).

$$LQ_i^r = \left(\frac{x_i^r/x^r}{x_i^n/x^n}\right) \tag{5}$$

[16] For studies that concentrate on a specific region, where it is not necessary to use a superscript to design the particular region, the simpler notation $r_{ij} = a_{ij} - m_{ij}$ is often used for regional input coefficients, technical coefficients, and "import" coefficients (Miller & Blair, 2009)(p.309). Herein, "import" means "not produced in the region".

Where x_i^r denotes the total production value of industry i in region r; and x^r is the total production value of all industries in region r. x_i^n and x^n are data at the national level.

Similarly, data from region s were also used to measure industry concentration level. If the industry has $\mathrm{LQ}_i^r > 1$, it indicates that industry i has more concentrated development in region r than in the entire nation, and that it can satisfy the demands of other regions. In other words, the regional economy has a comparative advantage in those industries. By contrast, when the industry has $\mathrm{LQ}_i^r < 1$, it means that industry i is not more concentrated in region r than in the nation, therefore, it is not sufficient to drive the economy. These LQ coefficients are calculated to estimate the input-output coefficients from the national level to the regional level.

Combining the concepts of LQ and a two-region input-output table setting together, if industry i has more concentrated development in region r than in the nation ($\mathrm{LQ}_i^r > 1$), it is assumed that the national input coefficient (a_{ij}^n) is used as the regional input coefficient (a_{ij}^{rr}), and no adjustment is made for that industry. On the contrary, the industry with $\mathrm{LQ}_i^r < 1$, its regional direct input coefficients (a_{ij}^{rr}) has to be reduced and is estimated from the national coefficient (a_{ij}^n) and multiplied by LQ_i^r. The intra-regional input coefficients and inter-regional import coefficients are estimated based on equations (6) and (7), respectively.

$$a_{ij}^{rr} = \begin{cases} (LQ_i^r)a_{ij}^n, & if\ LQ_i^r < 1 \\ a_{ij}^n, & if\ LQ_i^r \geq 1 \end{cases} \tag{6}$$

$$a_{ij}^{sr} = \left(1 - \widehat{LQ}_i^r\right)a_{ij}^r = a_{ij}^n - a_{ij}^{rr} \tag{7}$$

Once the intermediate trade matrices representing the transactions of each goods between region s and region r are estimated, the structure of the intra-regional input coefficients and the inter-regional import coefficients are obtained in this step. Similarly, the final demands of each industry of inter-regions and intra-regions are estimated. Further, a new two-regional intermediate transaction table can be estimated based on equation (2). The vector of valued added of each industry in different regions is estimated based on the national census and regional industry statistics. Once the new matrices of the bi-regional intermediate transaction, the final demand and the vector of valued added are obtained, the combined matrix has to be adjusted to balance the supply and demand.

For balancing a two-region input-output table, three pieces of information for the target year and regions are needed: (1) gross outputs of each industry in different regions, x_i^r and x_i^s; (2) the value added of each industry in different regions, v_i^r and v_i^s, and (3) total final demand in different regions; $\sum f_i^r$ and $\sum f_i^s$.

Given an $(n+1) \times (n+2)$ matrix $ZF(0)$; and given the column marginal information as $\acute{c} = [x_i^r \quad x_i^s \quad \sum v_i^{r+s}]$; and the row marginal information as $r = [v_i^r \quad v_i^s \quad \sum f_i^r \quad \sum f_i^s]$, the new estimate is denoted as $ZF(1)$.

$$ZF(1) = \hat{r}^{ZF} ZF(0) \hat{s}^{ZF} \tag{8}$$

Following the criterion in Miller and Blair (2009), when the tolerance error ε, between the estimates and the target values is smaller than 0.001, a new balanced matrix is obtained. Furthermore, the Leontief inverse matrix of the two-region input-output model can be estimated after RAS adjustment.

$$\mathrm{A} = \begin{bmatrix} a_{ij}^{rr} & a_{ij}^{rs} \\ a_{ij}^{sr} & a_{ij}^{ss} \end{bmatrix};\ Z = \begin{bmatrix} z_{ij}^{rr} & z_{ij}^{rs} \\ z_{ij}^{sr} & z_{ij}^{ss} \end{bmatrix};$$

$$F = \begin{bmatrix} f_i^{rr} & f_i^{sr} \\ f_i^{sr} & f_i^{ss} \end{bmatrix}; v = [v_i^r \quad \dots \quad v_i^s]; x = \begin{bmatrix} x_i^r \\ \vdots \\ x_i^s \end{bmatrix} \tag{9}$$

4.3.4 Data analysis

The following section describes the basis of industry linkages, multiplier effects and the components for the analysis in this study.

4.3.4.1 The basis of industry linkages

In the input-output model, there are two types of economic effects in the economy. One is the forward linkage, which is utilized to point out the interconnection of a specific industry with upstream industries from which it consumes inputs, and the other is the backward linkage, which is utilized to point out the interconnection of a specific industry with the downstream industries to which it sells its production (Miller & Blair, 2009).

In the inter-regional form of the demand-driven input-output model, the Leontief inverse matrix shows that the change in final demand (F) per industry in a given region is completely met by the change in the total output (x) per industry in a given region, via direct input coefficient (A), which determines intermediate demand (Ax), per industry in a given region. Equally, the change in the intermediate demand is met by the change in total output.

$$x = Lf = (I - A)^{-1}f = (I + A + A^2 + A^3 + \cdots)f \tag{10}$$

It has known that $L = (I + A + A^2 + A^3 + \cdots)$, so $L - I = (A + A^2 + A^3 + \cdots)$ indicates the matrix of total direct and indirect backward linkages between the relationship of industries.

On the other hand, by using the same set of data based on supply-driven model, the Gosh inverse matrix shows the connection of industries total production to the primary inputs, that is, to measure per unit of value investing into the inter-industry system at the initial process (Miller & Blair, 2009). In the supply-driven model, instead of dividing the column of Z by the gross output of the industry related to the column, a direct output coefficients matrix, denoted as B, is suggested, dividing each row of Z by the total output of the industry related to that row.

Therefore, equation (4) can be rearranged as,

$$B = \hat{x}^{-1}Z \tag{11}$$

Then,

$$x' = v'G = v'(I - B)^{-1} = v'(I + B + B^2 + B^3 + \cdots) \tag{12}$$

Where the component v is the vector of value added, and $G = (I - B)^{-1}$ is the Gosh inverse matrix, also called the output inverse matrix. Both the Leontief inverse matrix and the Gosh inverse matrix are employed to measure the strength of the backward linkage and the forward linkage, respectively.

The components of the regional Leontief inverse matrix and the Gosh inverse matrix are shown as equation (13) and then used to describe the importance of the inter-industry system at the intra-and inter-regions.

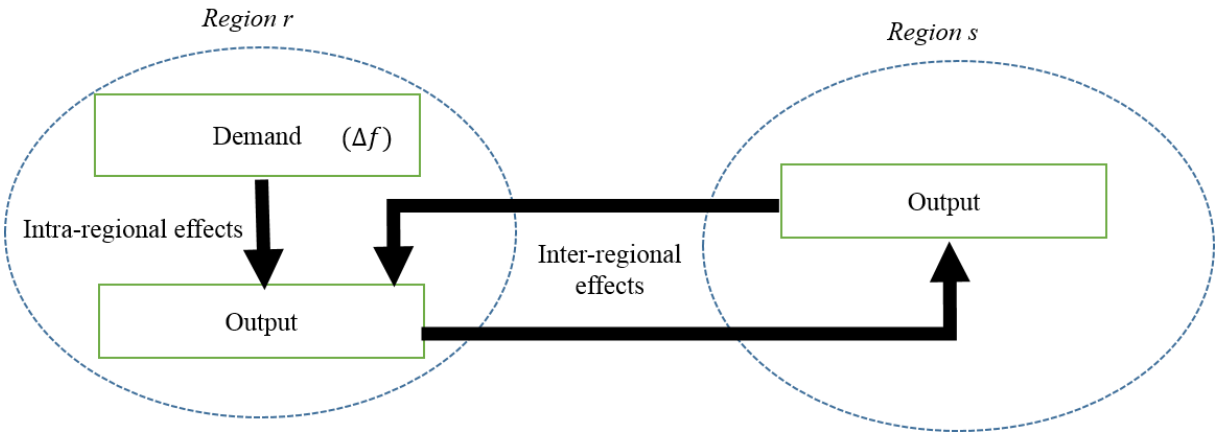
$$L = \begin{bmatrix} l_i^{ss} & l_i^{rs} \\ l_i^{sr} & l_i^{rr} \end{bmatrix};\ G = \begin{bmatrix} g_i^{ss} & g_i^{rs} \\ g_i^{sr} & g_i^{rr} \end{bmatrix} \tag{13}$$

The Leontief inverse matrix is the result of a matrix transformation through which multiplier coefficients can be estimated, as L is the Leontief inverse matrix, and G is the Gosh inverse matrix. Further, the simple output, employment, and wage multipliers can be calculated based on equation (14).

4.3.4.2 Multiplier effects and their compositions

The interest in this study is to decompose the effect which partly is caused by the inter-regional effects and which partly is caused by the intra-regional effects, when shock happens in the regional final demand for the particular products of a given industry. For this purpose, additive decomposition proposed by Stone (1985) is utilized to isolate net effects. The concept is showed as Figure 4.2.

Figure 4.2 The conceptual framework of inter- and intra-regional effects of economy



Source: Drew by author.

The Leontief inverse matrix of the two-region input-output model captures the changes in output production as a variation in final demand. Taking an example, if final demand of industry i changes by one monetary unit, the rows of corresponding industries within and outside the region would be affected. The effect comprises not only the direct effect between two industries, but the second, the third, and more round effects of all the inter-industry connections in the economy, including inter-regional trade. Therefore, when there is a demand change for the

products of a certain industry, a spillover effect outside of the region would also be generated.

The effect generated due to the variation in final demand is given by the Leontief inverse matrix, $x = Ax + f = (I - A)^{-1} = Lf$. In a two-region input-output model, the relationship can be written as;

$$\begin{bmatrix} x^r \\ x^s \end{bmatrix} = \begin{bmatrix} A^{rr} & A^{rs} \\ A^{sr} & A^{ss} \end{bmatrix} \begin{bmatrix} x^r \\ x^s \end{bmatrix} + \begin{bmatrix} f^r \\ f^s \end{bmatrix} = \begin{bmatrix} L^{rr} & L^{rs} \\ L^{sr} & L^{ss} \end{bmatrix} \begin{bmatrix} f^r \\ f^s \end{bmatrix} \tag{14}$$

With a view toward decompositions, the matrix A can be divided into intra-regional elements A^{ss} and A^{rr} and inter-regional elements A^{rs} and A^{sr}. In terms of the regional nature, let

$$A = \begin{bmatrix} A^{rr} & A^{rs} \\ A^{sr} & A^{ss} \end{bmatrix} = \begin{bmatrix} A^{rr} & 0 \\ 0 & A^{ss} \end{bmatrix} + \begin{bmatrix} 0 & A^{rs} \\ A^{sr} & 0 \end{bmatrix} \tag{15}$$

Define $A_{intra} = \begin{bmatrix} A^{rr} & 0 \\ 0 & A^{ss} \end{bmatrix}$ and $A_{inter} = \begin{bmatrix} 0 & \mathrm{A}^{rs} \\ A^{sr} & 0 \end{bmatrix}$, as these two matrices represent only intra-regional effects and only inter-regional effects, respectively. Assuming a standard input-output model only reflecting intra-regional effect by using matrix A_{intra}.

$$x = A_{intra}x + f = (I - A_{intra})^{-1}f \tag{16}$$

Let $\tilde{L} = (I - A_{intra})^{-1}$,

$$\tilde{L} = \left[\begin{bmatrix} I & 0 \\ 0 & I \end{bmatrix} - \begin{bmatrix} A^{rr} & 0 \\ 0 & A^{ss} \end{bmatrix}\right]^{-1} = \begin{bmatrix} I - A^{rr} & 0 \\ 0 & I - A^{ss} \end{bmatrix}^{-1} = \begin{bmatrix} (I - A^{rr})^{-1} & 0 \\ 0 & (I - A^{ss})^{-1} \end{bmatrix} \tag{17}$$

The matrix $\tilde{L}$ is said to capture an intra-regional effects, leaving out all inter-regional effects. Following the elements relationship of the Leontief inverse matrix in equation (10), equation (18) is obtained, only reflecting the intra-regional effect. Further, two independent systems would be obtained separately as equation (19).

$$\begin{bmatrix} x^r \\ x^s \end{bmatrix} = \begin{bmatrix} (I - A^{rr})^{-1} & 0 \\ 0 & (I - A^{ss})^{-1} \end{bmatrix} \begin{bmatrix} f^r \\ f^s \end{bmatrix} \tag{18}$$

$$x^r = (I - A^{rr})^{-1}f^r; \text{ and } x^s = (I - A^{ss})^{-1}f^s \tag{19}$$

The matrix $\tilde{L}$ represent the relationship between final demand change and total output under the only intra-regional effect structure. In other words, it is composed of the initial shock and the net intra-regional effect (M_R), therefore,

$$\tilde{L} = I + E_R \tag{20}$$

Since matrix A consists of submatrices of A_{intra} and A_{inter}, applying them to a basic input-output function as equation (3):

$$A = A_{intra} + A_{inter}$$

$$x = (A_{intra} + A_{inter})x + f = A_{intra}x + A_{inter}x + f$$

$$(I - A_{intra})x = A_{inter}x + f$$

$$x = (I - A_{intra})^{-1}(A_{inter}x + f)$$

It has known that $\tilde{L} = (I - A_{intra})^{-1}$, then it can be rearranged as,

$$x = \tilde{L}(A_{inter}x + f) = \tilde{L}A_{inter}x + \tilde{L}f \tag{21}$$

Equation (21) represents the combination of inter-regional effects, $\tilde{L}A_{inter}x$ and intra-regional effect, $\tilde{L}f$. Where $\tilde{L}A_{inter}x$ is the composition of the inter-regional spillover effects, M_s , and the inter-regional feedback effects, M_F. Where M_s mean the inter-regional spillover effect caused by a shock in a region to the other region; and M_F represents a close loop effect caused by these effects back to the original region, via the other region.

In order to isolate these two effects, the same operation recur. Therefore, equation (21) is rearranged as equation (22).

$$x = \tilde{L}A_{inter}\left(\tilde{L}A_{inter}x + \tilde{L}f\right) + \tilde{L}f = \left(\tilde{L}A_{inter}\right)^2 x + \tilde{L}A_{inter}\tilde{L}f + \tilde{L}f \tag{22}$$

Then, considering the whole economic system and the structure consistency with the equation (4) that $x = Lf$, the substitution is done as equations (23) and (24).

$$x = \left(\tilde{L}A_{inter}\right)^2 Lf + \tilde{L}A_{inter}\tilde{L}f + \tilde{L}f \tag{23}$$

$$x = (M_F + M_S + M_R + I)f \tag{24}$$

Therefore, three isolated net effects of the combined Leontief inverse matrix L are obtained as equation (25).

$$M_R = \tilde{L} - I;\ M_S = \tilde{L}A_{inter}\tilde{L};\ M_F = \left(\tilde{L}A_{inter}\right)^2 L \tag{25}$$

Under the assumption of the input-output model, L is constant in the short run and it becomes the key matrix that transforms the changes in final demand for the changes in total output. Calculating each column in the Leontief inverse, multipliers of output to each sector are gained showing the direct and indirect change in output sectors needed to meet one unit increase in final demand for this sector of output. Based on equation (4), the equation can be written as equation (26), where ΔX is the change of the total output, $\acute{\imath} = [1 \quad \cdots \quad 1]$ is a row vector to generate column sums; and Δf is the change of final demand of each industry.

$$\Delta X = \acute{\imath} L \Delta f$$

$$\text{Where, } L = (I - A)^{-1} \tag{26}$$

The simple output multiplier is defined as an initial monetary worth of a specific output of an industry required to satisfy an extra unit of the final demand. Thus, it is obtained by the ratio of the direct effect and the indirect effect to the initial effect (Miller & Blair, 2009). It is also signifies the column sums of the Leontief inverse matrix, so it is written as equation (27).

$$m = \imath\acute{L} \tag{27}$$

Combining equations (24) and (27), a simple output multiplier can be decomposed as three isolated multipliers as equation (28),

$$M = \acute{\imath}(I + M_R + M_s + M_F) = \acute{\imath}I + \acute{\imath}M_R + \acute{\imath}M_s + \acute{\imath}M_F \tag{28}$$

Based on the equation (10), $x = Lf = (I - A)^{-1}f$, the earnings multiplier can be estimated.

$$EM = E \times (I - A)^{-1} = E \times L \tag{29}$$

$$E = \widehat{W_J/X_J}$$

Where, E is a 14 by 14 matrix containing the direct earnings coefficient of industry j^{th} in its jth diagonal and zeros elsewhere; W_j is the vector of wage of industry j^{th}; X_j is the vector of total product of industry j^{th}; EM is the earnings multiplier matrix (14 by 14); L is the Leontief inverse matrix.

In addition, the employment multiplier can be estimated by using the total requirement table and direct employment coefficients as equation (30).

$$LM = LN \times (I - A)^{-1} = LN \times L \tag{30}$$

$$LN = \widehat{N_j / X_j}$$

Where, LN is a 14 by 14 matrix containing the direct employment coefficient of industry j^{th} in its jth diagonal and zeros elsewhere; N_j is the vector of labor number of industry j^{th}; X_j is the vector of the total product of industry j^{th}; LM is the employment multiplier matrix (14 by 14); L is the Leontief inverse matrix.

4.4 Two-region input-output analysis

4.4.1 Regional technical coefficients on Xiao-Liu-Qiu

In the national context, the technical coefficients matrix are used to indicate the production technology of each industry without considering the origin of inputs (materials). However, in the multi-regional context, the technical coefficients can reflect the information of the "regional input coefficients (intra-regional technical coefficients)" and the "inter-regional trade coefficients" (Miller & Blair, 2009). Regional technical coefficients represent the industry interconnection of the intermediate transactions within a specific economic scope. In other words, it shows that the amount of the input directly consumed to produce one monetary unit of output.

Table 4.4 and Table 4.5 represent the regional technical coefficients and the national technical coefficients for 2006 and 2011, respectively. These two tables included the regional input coefficients and the import coefficients of Xiao-Liu-Qiu as well. They showed the proportion of inputs (goods and services) of a given industry that are purchased from other industries within and between the regions to produce one unit of its own output. In general, the

regional technical coefficients (RTC) showed the similarity to the national technical coefficients (NTC). Most regional technical coefficients of the industries of Xiao-Liu-Qiu were slightly smaller than the national technical coefficients. Only a few industries showed the relatively higher regional technical coefficients, compared with the national technical coefficients. They were the industries of the Transportation & Storage* (S9) (RTC=0.67, NTC=0.62) and the Accommodation* (S10) (RTC=0.64, NTC=0.46) in 2006, and the industries of the Construction (S7) (RTC=0.89 NTC=0.73) and the Accommodation* (S10) (RTC=0.52 NTC=0.49) in 2011.

Table 4.4 Regional technical coefficients by industry for 2006

Code	Industry	RIC	%	IRT	%	RTC	NTC
S1	Agriculture, Farming, Forestry & Logging	0.18	39%	0.29	61%	0.48	0.54
S2	Fishery	0.14	25%	0.43	75%	0.56	0.62
S3	Mining, Quarrying & Manufacturing	0.11	14%	0.67	86%	0.78	0.80
S4	Electricity & Gas Supply	-	-	-	-	-	0.67
S5	Water Supply	-	-	-	-	-	0.43
S6	Remediation Services	-	-	-	-	-	0.54
S7	Construction	0.08	16%	0.44	84%	0.52	0.73
S8*	Wholesale & Retail Trade*	0.06	29%	0.15	71%	0.22	0.29
S9*	Transportation & Storage*	0.24	35%	0.44	65%	0.67	0.62
S10*	Accommodation*	0.24	17%	0.53	83%	0.64	0.46
S11*	Food Service*	0.11	21%	0.32	79%	0.40	0.49
S12	Other Services	0.08	22%	0.14	78%	0.18	0.29
S13*	Support Services*	0.04	19%	0.21	81%	0.26	0.31
S14*	Entertainment & Recreation*	0.05	23%	0.26	77%	0.34	0.34

Note: * means tourism characteristic industry; "-" represents which industry is not existent in the region. RIC: Regional input coefficient, IRT: Inter-regional trade coefficient, RTC: Regional technical coefficient, and NTC: National technical coefficient.

Source: Calculated by author based on the two-region input-output table for 2006 in current price.

The technical coefficient of the Mining, Quarrying & Manufacturing (S3) in 2006 was the highest, it was counted as 0.78. It means that the industry of the Mining, Quarrying & Manufacturing purchased 0.78 TWD worth of goods and services from the industries within

and outside of the region to produce 1 TWD worth of products. However, in 2011, the industry of the Wholesale & Retail Trade (S8) showed the highest regional technical coefficient among an entire industries of Xiao-Liu-Qiu, with the coefficient of 0.89. Regarding the industry with the lowest regional technical coefficients in 2006 and 2011 was the industry of the Other Services (S12), it estimated as 0.18 and 0.25, respectively.

Table 4.5 Regional technical coefficients by industry for 2011

Code	Industry	RIC	%	IRT	%	RTC	NTC
S1	Agriculture, Farming, Forestry & Logging	0.12	25%	0.36	75%	0.48	0.54
S2	Fishery	0.11	19%	0.47	81%	0.59	0.64
S3	Mining, Quarrying, & Manufacturing	0.07	9%	0.74	91%	0.81	0.80
S4	Electricity & Gas Supply	-	-	-	-	-	0.82
S5	Water Supply	-	-	-	-	-	0.47
S6	Remediation Services	-	-	-	-	-	0.56
S7	Construction	0.10	11%	0.79	89%	0.89	0.73
S8*	Wholesale & Retail Trade*	0.07	28%	0.17	72%	0.23	0.30
S9*	Transportation & Storage*	0.25	42%	0.35	58%	0.60	0.64
S10*	Accommodation*	0.07	13%	0.45	87%	0.52	0.49
S11*	Food Service*	0.04	13%	0.25	87%	0.29	0.49
S12	Other Services	0.05	18%	0.20	82%	0.25	0.30
S13*	Support Services*	0.05	16%	0.25	84%	0.30	0.31
S14*	Entertainment & Recreation*	0.05	17%	0.23	83%	0.27	0.35

Note: * means tourism characteristic industry; "-" represents which industry is not existent in the region. RIC: Regional input coefficient, IRT: Inter-regional trade coefficient, RTC: Regional technical coefficient, and NTC: National technical coefficient.

Source: Calculated by author based on the two-region input-output table for 2011 in current price.

Looking at the composition of the regional technical coefficients of Xiao-Liu-Qiu, it can be noticed that the inter-regional coefficients were very high, it shared 61%-86% in 2006 and 58%-91% in 2011 of the total regional technical coefficients of Xiao-Liu-Qiu. For instance, for one monetary unit of production in 2011 for the Accommodation industry (S11), 87% of input was imported from the rest of Taiwan and only 13% of inputs used was generated locally.

Taking another example, the industry of Transportation and Storage (S9) is a relatively high local-supply industry, even though 58% of demand was provided by industries from the rest of Taiwan.

4.4.2 Industry linkage

Table 4.6 summarizes the forward linkage coefficients (FL), backward linkage coefficients (BL), normalized forward linkage coefficients (NFL), normalized backward linkage coefficients (NBL) and the value added rate (VP) by industry for 2006 and 2011 of Xiao-Liu-Qiu. The measure and the meanings of the values are explained below, and the description correspond the information showed in Figure 4.3 and Figure 4.4.

Table 4.6 The backward linkage, forward linkage, and value added rate by industry for Xiao-Liu-Qiu, 2006 and 2011

Year / Code	2006					2011				
	FL	**BL**	**NFL**	**NBL**	**VP (%)**	**FL**	**BL**	**NFL**	**NBL**	**VP (%)**
S1	1.18	2.54	1.05	1.04	52.5	1.11	2.69	1.00	1.02	52.3
S2	1.05	2.99	0.94	1.22	43.6	1.05	3.22	0.95	1.22	41.4
S3	1.33	3.85	1.19	1.58	22.4	1.19	4.23	1.08	1.60	19.0
S4	-	-	-	-	-	-	-	-	-	-
S5	-	-	-	-	-	-	-	-	-	-
S6	-	-	-	-	-	-	-	-	-	-
S7	1.07	2.84	0.95	1.16	48.1	1.04	4.36	0.94	1.65	11.4
S8*	1.19	1.51	1.06	0.62	78.3	1.11	1.61	1.00	0.61	76.6
S9*	1.26	3.14	1.12	1.28	32.7	1.45	3.01	1.31	1.14	40.4
S10*	1.07	2.74	0.95	1.12	36.5	1.03	2.58	0.93	0.97	47.6
S11*	1.01	2.29	0.90	0.94	59.7	1.02	2.04	0.93	0.77	71.2
S12	1.10	1.45	0.98	0.59	82.1	1.06	1.68	0.96	0.63	75.1
S13*	1.05	1.73	0.94	0.71	74.4	1.07	1.93	0.97	0.73	69.7
S14*	1.03	1.80	0.91	0.74	65.9	1.01	1.76	0.91	0.67	72.6
Average	-	-	1.00	1.00	-	-	-	1.00	1.00	-

Note: * Denotes tourism characteristic industry. FL: Forward linkage coefficient; BL: Backward linkage coefficient; NFL: Normalized forward linkage; NBL: Normalized backward linkage; and VP: Value added rate.

Source: Calculated by author.

Figure 4.3 and Figure 4.4 visualize the position of each industry in the entire economy of Xiao-Liu-Qiu. The vertical axis denotes the normalized forward linkage, and the horizontal axis indicates the normalized backward linkage. The average of the original values is used for normalization. The purpose of normalization is to identify the linkage power of these industries across the whole economy and to identify the key industries in the entire economy.

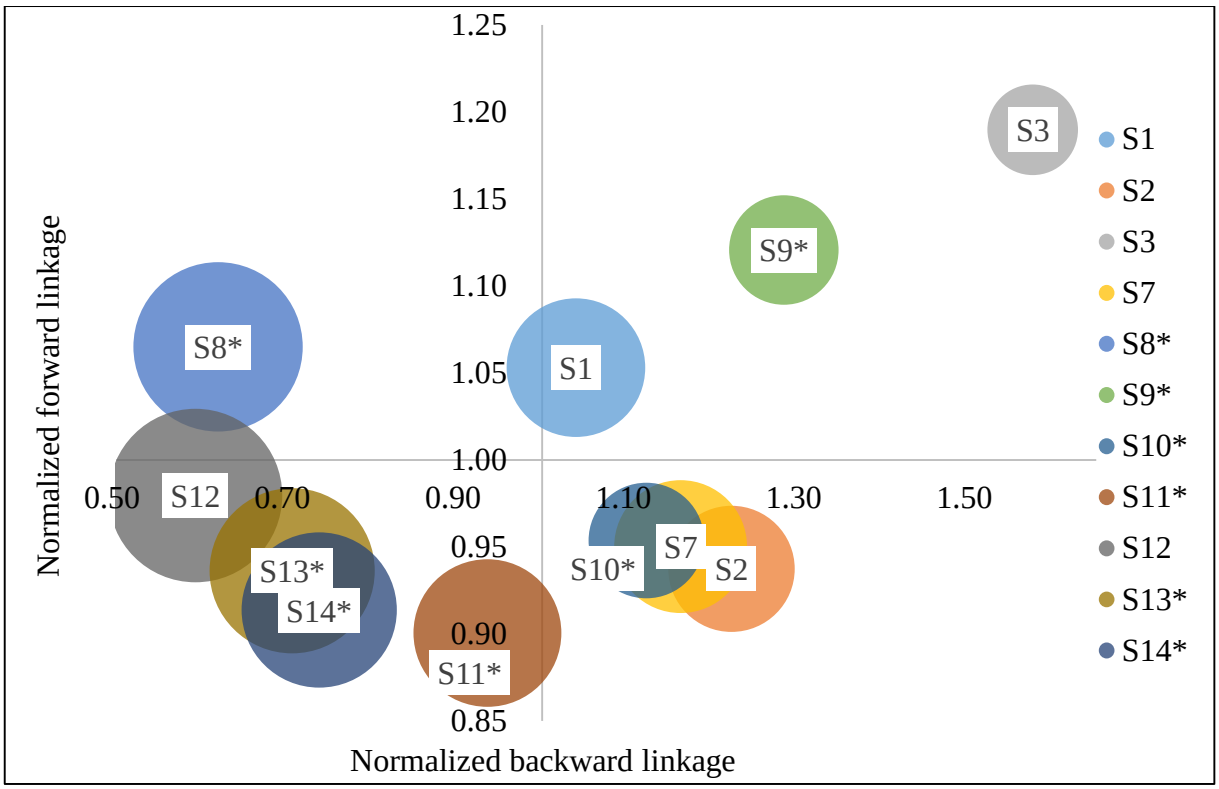
The normalized values higher than one represents above-average linkages (strong linkages). This shows that a dollar's worth of production in the particular industry would generate more benefit to the economy than other industries. On the contrary, the normalized values lower than one means below-average linkages (weak linkages). This means that the production in a particular industry produces smaller sales in downstream buying industries than in other industries. Four categories are classified in terms of forward and backward linkages in normalized form. They are (1) generally not strongly connected to other industries (both forward and backward linkage measures in normalized form less than 1), (2) generally connected to other industries (both forward and backward linkage measures in normalized form greater than 1, (3) dependent on interindustry supply (only backward linkage in normalized form greater than 1), and (4) dependent on interindustry demand (only forward linkage in normalized form greater than 1) (Miller & Blair, 2009).

Comparing the values between the years of 2006 and 2011, the overall relationship among these industries did not have significant changes. Some industries display high forward and backward linkage (both NFL and NBL >1); they can be classified as key industries. They are the industries of the Agriculture, Forestry, & Animal Husbandry (S1) ($NFL_{2006} = 1.18, NBL_{2006}$ =1.04; NFL_{2011} =1.00, NBL_{2011} =1.02), the Mining, Quarrying & Manufacturing (S3) ($NFL_{2006} = 1.58, NBL_{2006}$=1.19; NFL_{2011}=1.00, NBL_{2011}=1.02), and the Transportation & Storage (S9) ($NFL_{2006} = 1.28, NBL_{2006}$ =1.12; NFL_{2011} =1.31, NBL_{2011}=1.14).

The industry with higher forward linkage than the average and a lower backward linkage (NFL>1 and NBL<1) is defined as a forward-oriented industry. The industry of the Wholesale & Retail Trade (S8) was the only case ($NFL_{2006} = 1.06, NBL_{2006}$=0.62; NFL_{2011}=1.00, NBL_{2011}=0.61). Industry in this group is relatively highly dependent on the demand of inter-industries. It shows that the production of those industries is affected easily by other industries'

demand. Industry with both lower forward and backward linkages than the average (NFL<1 and NBL<1) is relatively independent of other industries. In 2006, they were the industries of the Food Service (S11) ($NFL_{2006} = 0.90$, NBL_{2006}=0.94; NFL_{2011}=0.93, NBL_{2011}=0.77), the Other Services (S12) ($NFL_{2006} = 0.98$, NBL_{2006}=0.59; NFL_{2011}=0.96, NBL_{2011}=0.63), the Support Services (S13) ($NFL_{2006} = 0.94$, NBL_{2006} =0.71; NFL_{2011} =0.97, NBL_{2011}=0.73), and the Entertainment & Recreation (S14) ($NFL_{2006} = 0.91$, NBL_{2006}=0.74; NFL_{2011}=0.91, NBL_{2011}=0.67). In other words, lower interconnection effect was generated in terms of an industry's demand or supply.

Figure 4.3 Industry linkage of Xiao-Liu-Qiu, 2006



Note: * Denotes the tourism characteristic industry. S4, S5, and S6 are missing because these industries are not existent on Xiao-Liu-Qiu.

Source: Calculated by author.

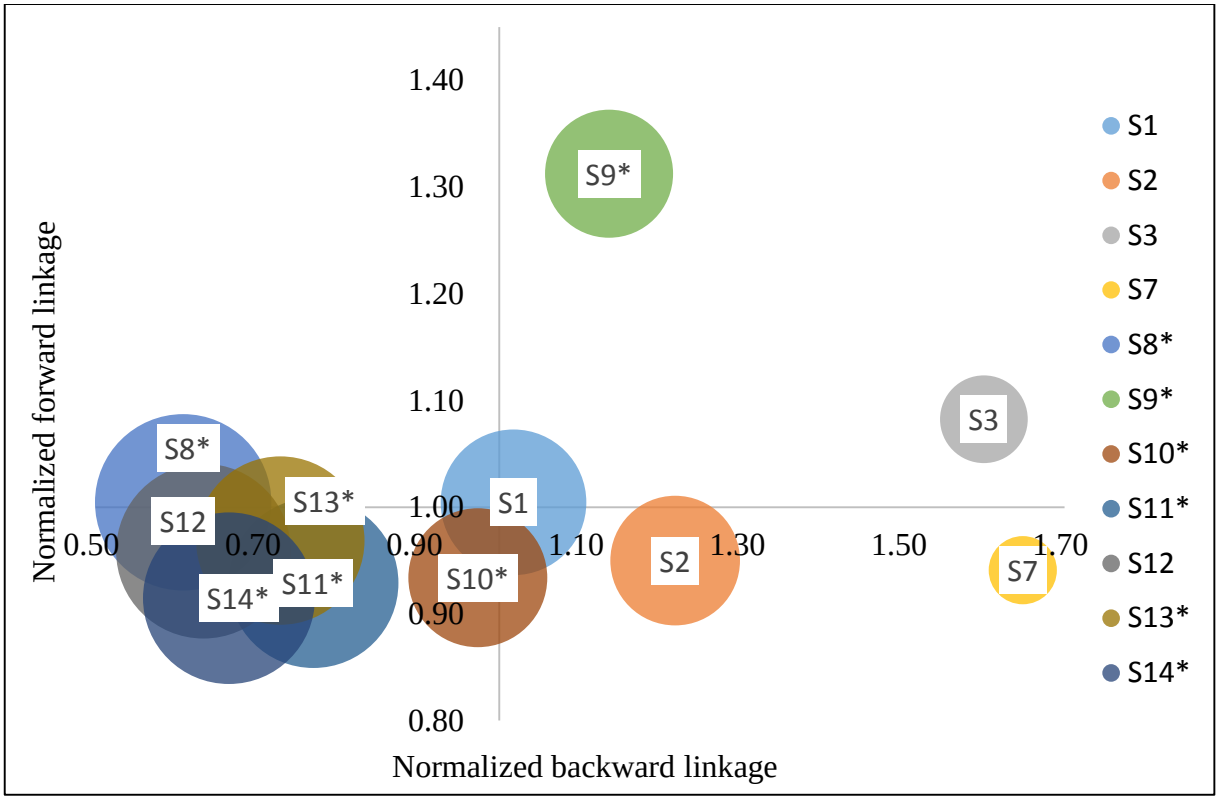
However, the industry of the Accommodation (S10) ($NFL_{2006} = 0.95$, NBL_{2006}=1.12; NFL_{2011}=0.93, NBL_{2011}=0.97) had a slight decrease in the backward linkage in 2011. It was categorized in the group with lower forward linkage and higher backward linkage (NFL<1 and NBL >1), denoted as backward linkage industry, in 2006. The industries of the Fishing (S2)

($NFL_{2006} = 0.94$, NBL_{2006}=1.22; NFL_{2011}=0.95, NBL_{2011}=1.22) and the Construction (S7) ($NFL_{2006} = 0.95$, NBL_{2006}=1.16; NFL_{2011}=0.94, NBL_{2011}=1.65) are categorized in this group both in 2006 and 2011. Those industries are relatively dependent on the supplies of other industries. It shows that the industries are not affected easily by the other industries, but they can play a leading role to improve the other industries' production.

The circle surface represents the size of value-added rate (%) of a given industry, which refers to the rate of value added to the production value of the industry in the same year multiplied by 100. It indicates the economic contribution by the specific industry to the whole economy. It is worth noting that the difference appears on the value added rate.

Four out six tourism characteristic industries present larger value added rates in 2011 than these in 2006. They were the industries of the Transportation & Storage (S9), the Accommodation (S10), the Food Service (S11), and the Support Services (S13).

Figure 4.4 Industry linkage of Xiao-Liu-Qiu, 2011



Note: * Denotes the tourism characteristic industry. S4, S5, and S6 are missing because these industries are not existent on Xiao-Liu-Qiu.

Source: Calculated by author.

4.4.3 Estimation of multipliers

A multiplier value reveals the size of the multiplier effect with respect to a given economy, and it rests on the difference between the initial effect of an exogenous change and the total effects of that change (Miller & Blair, 2009). As tourists consume goods and services and payments flow into the local economy, these payments would become the income and jobs for local people who provide tourism-related services. The effects of income, jobs and production value generated by tourism activity can be estimated by multiplier analysis. In this part, the output, earnings and employment multipliers (also named type I multipliers), with household treated exogenously, are analyzed and the results are described as follows.

Table 4.7 displays the effects of simple output, employment and wage multipliers of Xiao-Liu-Qiu for 2006 and 2011.The values of the simple output multipliers allow us to find the impact on a particular industry throughout the whole economy due to a dollar increase in final demand for this industry on the island. The average of simple output multipliers were estimated as 2.44 for 2006 and 2.65 for 2011.

For the economy of Xiao-Liu-Qiu in 2006, the industry of the Mining, Quarrying & Manufacturing (S3) showed the biggest effect (SOM=3.85), followed by the industries of the Transportation & Storage (S9) (SOM=3.14) and the Fishing (S2) (SOM=2.99). On the contrary, the industry of the Other Services (S12) showed the smallest effect (SOM=1.45), followed by the Wholesale & Retail Trade (S8) (SOM=1.51) and the Support Services (S13) (SOM=1.73).

In 2011, the biggest effect appeared in the industry of the Construction (S7) (SOM=4.36), followed by the industries of the Mining, Quarrying & Manufacturing (S3) (SOM=4.23) and the Fishing (S2) (SOM=3.22). In addition, the smallest effect appeared in the industry of the Wholesale & Retail Trade (S8) (SOM=1.61), followed by the industries of the Other Services (S12) (SOM=1.68) and the Entertainment & Recreation (S14) (SOM=1.76).

Looking at the tourism characteristic industries, the industry of the Transportation & Storage (S9) showed the biggest effect, with the figures of 3.14 and 3.01 in the year of 2006 and 2011, respectively. The industry of the Wholesale & Retail Trade (S8) appeared the smallest effect, with the figures of 1.51 and 1.61, in the year of 2006 and 2011, respectively.

Simple output multipliers can be utilized further to examine the employment and wage multipliers of each industry. Effects on employments and wages for the years 2006 and 2011

are listed in Table 4.7. The table shows the total change in employment and wages throughout the entire economy from 1 TWD change in final demand for a given industry, in physical and monetary terms, respectively.

In terms of the wage multipliers, it represents that how much worth of the new income would be earned by employees in a specific industry when an extra dollar of final demand for the output of this industry. The average of wage multipliers were estimated as 0.26 for 2006 and 0.24 for 2011. It means that when 1 TWD of the final demand for a given industry's output, 0.26 and 0.24 of the average new incomes would be generated by employees in 2006 and 2011, respectively.

In 2006, the industry of the Mining, Quarrying & Manufacturing (S3) showes the biggest effect (WM=0.42), followed by the industries of the Transportation & Storage (S9) (WM=0.41) and the Accommodation (S10) (WM=0.34). On the contrary, the industry of the Other Services (S12) shows the smallest effect (WM=0.10), followed by the Wholesale & Retail Trade (S8) (WM=0.13) and the Support Services (S13) (WM=0.14).

In 2011, the biggest effect appears in the industry of the Construction (S7) (WM=0.44), followed by the industries of the Mining, Quarrying & Manufacturing (S3) (WM=0.40) and the Transportation & Storage (S9) (WM=0.30). In addition, the smallest effect appears in the industries of the Wholesale & Retail Trade (S8) and the Other Services (S12), with the multiplier value of 0.13, respectively. Followed by the industries of the Food Service (S11) and the Entertainment & Recreation (S14), with the multiplier effect of 0.14.

Taking a look at the tourism characteristic industries, the industry of the Transportation & Storage (S9) shows the biggest effect, with the figures of 0.41 and 0.30 in the year of 2006 and 2011, respectively. The industry of the Wholesale & Retail Trade (S8) appears the smallest effect, with the figure of 0.13 for the year of 2006 and 2011.

Regarding the employment multiplier, it represents that when an extra dollar of final demand for the output of a specific industry, how many new job opportunities would be created in this industry. The average of employment multipliers are estimated as 0.71 for 2006 and 0.69 for 2011. It means that when 1 TWD of final demand for a given industry's output, 0.71 and 0.69 of average new jobs would be generated in 2006 and 2011, respectively.

In 2006, the industry of the Agriculture, Forestry, & Animal Husbandry (S1) (EM=2.50) shows the biggest effect, followed by the Mining, Quarrying & Manufacturing (S3) (EM=0.94)

and the industries of the Fishing (S2) (EM=0.89). On the contrary, the industry of the Other Services (S12) shows the smallest effect (EM=0.15), followed by the Wholesale & Retail Trade (S8) (EM=0.19) and the Support Services (S13) (EM=0.24).

Table 4.7 The output, employment and wage multipliers of Xiao-Liu-Qiu, 2006 and 2011

Category	SOM		EM		WM	
Year / Code	2006	2011	2006	2011	2006	2011
S1	2.54	2.69	2.50	2.31	0.26	0.24
S2	2.99	3.22	0.89	0.86	0.31	0.29
S3	3.85	4.23	0.94	0.93	0.42	0.40
S4	-	-	-	-	-	-
S5	-	-	-	-	-	-
S6	-	-	-	-	-	-
S7	2.84	4.36	0.55	0.78	0.29	0.44
S8*	1.51	1.61	0.19	0.20	0.13	0.13
S9*	3.14	3.01	0.78	0.70	0.41	0.30
S10*	2.74	2.58	0.55	0.49	0.34	0.27
S11*	2.29	2.04	0.73	0.62	0.22	0.14
S12	1.45	1.68	0.15	0.18	0.10	0.13
S13*	1.73	1.93	0.24	0.26	0.14	0.16
S14*	1.80	1.76	0.28	0.27	0.19	0.14
Average	2.44	2.65	0.71	0.69	0.26	0.24

Note. * denotes the tourism characteristic industry; SOM denotes the simple output multiplier, EM denotes the employment multiplier, and WM denotes the wage multiplier.
Source: Author's calculation.

In 2011, the biggest effect appears in the industry of the Agriculture, Forestry, & Animal Husbandry (S1) (EM=2.31), followed by the industries of the Mining, Quarrying & Manufacturing (S3) (EM=0.93) the industries of the Fishing (S2) (EM=0.86). In addition, the smallest effect appears in the industry of the Other Services (S12) (EM=0.18), followed by the industries of the Wholesale & Retail Trade (S8) (EM=0.20) and the Support Services (S13) (EM=0.26).

Taking a look at the tourism characteristic industries, the industry of the Transportation & Storage (S9) shows the biggest effect, with the figures of 0.78 and 0.70 in the year of 2006 and 2011, respectively. The industry of the Wholesale & Retail Trade (S8) appears the smallest effect, with the figures of 0.19 and 0.20 for the year of 2006 and 2011, respectively.

Table 4.8 The decomposition of net simple output multiplier by region, 2011

Region	**Xiao-Liu-Qiu**				**The rest of Taiwan**			
Effect / Code	M_R	M_S	M_F	M_T	M_R	M_S	M_F	M_T
S1	0.15	1.53	0.00	1.68	1.84	0.00	0.00	1.84
S2	0.10	2.00	0.00	2.10	2.19	0.00	0.00	2.19
S3	0.08	3.05	0.00	3.13	3.13	0.00	0.00	3.13
S4	-	-	-	-	3.15	0.00	0.00	3.15
S5	-	-	-	-	1.09	0.00	0.00	1.09
S6	-	-	-	-	1.55	0.00	0.00	1.55
S7	0.10	3.16	0.00	3.26	2.42	0.00	0.00	2.42
S8*	0.06	0.51	0.00	0.56	0.62	0.00	0.00	0.62
S9*	0.29	1.59	0.00	1.88	2.06	0.00	0.00	2.06
S10*	0.08	1.49	0.00	1.57	2.02	0.00	0.00	2.02
S11*	0.03	0.96	0.00	1.00	1.51	0.00	0.00	1.51
S12	0.03	0.62	0.00	0.65	0.71	0.00	0.00	0.71
S13*	0.06	0.88	0.00	0.93	1.10	0.00	0.00	1.10
S14*	0.03	0.65	0.00	0.68	0.84	0.00	0.00	0.84
Average	0.07	1.17	0.00	1.25	1.73	0.00	0.00	1.73

Note: * denotes the tourism characteristic industry, M_R denotes the intra-regional effect, M_S denotes the inter-regional spillover effect, M_F denotes the inter-regional feedback effect, and M_T denotes the net simple output multiplier.

Source: Author's calculation.

The decomposition of multipliers allows us to separately view how these effects affect the output variations within and between the regions when one monetary unit of change in final demand of the specific industry. Table 4.8 summarizes the decomposition of the net simple output multipliers, both on Xiao-Liu-Qiu and the rest of Taiwan. The total net multipliers (M_T) are obtained by excluding the initial shock. The decomposition of the multipliers includes the intra-regional net multiplier (M_R), inter-regional net spillover multiplier (M_S), and inter-

regional net feedback multiplier (M_F).

By comparing the multipliers of both geographical regions, the total net simple multiplier on Xiao-Liu-Qiu are significantly lower than in the rest of Taiwan. Each change of one unit in final demand on Xiao-Liu-Qiu creates an additional 1.25 monetary units of output. At the same time, an additional 1.73 monetary units of output would be generated in the rest of Taiwan under the same change in demand, on average. The comparison of the values is not meaningful because the values of their geographical sizes are very different. However, it may provide a hint about the relationship between geographical size and economic effects; the larger the size of the geographical region, the larger the economic impact may generate.

Regarding the intraregional multiplier (M_R), the average values are 0.07 on Xiao-Liu-Qiu and 1.73 in the rest of Taiwan. A possible explanation for the significant difference is that the composition of industry of Xiao-Liu-Qiu is relatively simpler than in the rest of Taiwan, which results in the smaller intra-regional effect. In addition, although tourism is an emerging economic activity on Xiao-Liu-Qiu, only Transportation & Storage (S9), with 0.29 of the intra-regional effect, can generate comparatively higher pulling effect to the other industries on Xiao-Liu-Qiu. The pulling effects of the other tourism characteristic industries are lower than the average value (0.07) except for Accommodation (S10).

In terms of the inter-regional effect, it includes the spillover effect (M_S) and feedback effect (M_F). The effect reflects the variation of the total output of the whole country caused by the final demand changes per monetary unit in each area. In Table 4.8, it summarizes how much Xiao-Liu-Qiu relies on the rest of Taiwan for its supply in terms of high value in spillover effects (M_S). The average of inter-regional spillover effect on Xiao-Liu-Qiu is 1.17. This means that one monetary unit increase in the final demand can generate 1.25 monetary units of total output, but 1.17 monetary units will flow to the rest of Taiwan. The high economic leakage results from high resource dependency on the rest of Taiwan. Additionally, it is clear to find that the supply dependence is not mutual between two regions in this case. In other words, the supply is unidirectional since the economy of Xiao-Liu-Qiu is much smaller than in the rest of Taiwan. In both regions, the feedback effect (M_F) is zero because the spillover effect is too weak for more round effects to be significant. A similar finding is supported by Soulié (2014).

4.4.4 An empirical analysis of tourism economic impact

Since tourism is not classified as a single industry in an economy (Fletcher, 1989a), collecting and adapting tourists' expenditures on per commodity groups into tourism impact analysis is necessary (Fan & Oosterhaven, 2005a). For estimating tourism effect, tourist spending in 2012 and tourist numbers in 2011 are utilized.

Based on Table 3.4 in Chapter 3, the estimation of tourist numbers of Xiao-Liu-Qiu was counted as 656,469 people. Assuming the economy was stable and the tourists' spending in 2011 was consistent in 2012. By using the same tourist spending pattern, the estimation of tourist spending in 2011 was calculated according to the equation (31).

$$ATS_t = \sum TNX_t^d \times TSC_t^{dp} \tag{31}$$

Where,

ATS_t: The annual tourists spending in a given year (*t*), 2011 (Unit: TWD).

TNX_t^d: The tourist numbers by the length of stay (*d*) in a given year (*t*), 2011. d denotes days of stay, including 1 day, 2 days, and 3-5 days (Unit: person).

TSC_t^{dp}: The amounts of tourists spending by the length of stay (*d*) in terms of the category of tourism products (*p*), in a given year (*t*), 2012. d denotes length of stay, including one day, two days, and three-to-five days, and *p* denotes the categories of Transportation (ferry), Accommodation, Food & Beverages, Leisure & Recreation service, Motorcycle rental, and Shopping (souvenirs) (Unit: TWD).

Table 4.9 shows the estimation of the annual tourist spending by length of stay by categories of tourism products in 2011.

Table 4.9 Annual tourist spending of Xiao-Liu-Qiu by length of stay by consumption category, 2011

The length of stay / Consumption category	1 day	2 days	3-5 days	Total
Transportation (ferry)	103.37 (30%)	148.43 (14%)	13.25 (9%)	265.05 (17%)
Accommodation	--	373.61 (35%)	71.69 (48%)	445.30 (28%)
Food & Beverages	79.42 (23%)	163.63 (15%)	23.47 (16%)	266.52 (17%)
Leisure & Recreation services*	23.45 (7%)	88.33 (8%)	9.31 (6%)	121.09 (8%)
Motorcycle rental	63.79 (18%)	157.48 (15%)	21.85 (15%)	243.12 (15%)
Shopping (souvenirs)	79.92 (23%)	141.91 (13%)	9.28 (6%)	231.11 (15%)
Total	349.95 (22%)	1,073.40 (68%)	148.85 (9%)	1,572.19 (100%)
Tourist numbers	252,123 (39%)	362,023 (56%)	32,323 (5%)	646,469 (100%)

Note: * Leisure and recreation services are the outdoor activities provided by the locals, it mainly includes scuba diving, snorkeling, intertidal zone tour, night land tour, and semi-submersible tour. The tourist spending by length of stay was captured from the author's survey in 2012 (Table 2.11) showed in the Chapter 2.
Unit: Million TWD.
Source: Estimated by author.

The total tourist spending in 2011 was estimated at 1,572.19 million TWD, including 349.95 million TWD (22%) contributed by one-day trip tourists, 1,073.40 million TWD (68%) by two-day trip tourists, and 148.85 million TWD (9%) by tourists who stay three-to-five days.

Regarding the spending by categories of tourism products, tourists spent 445.30 million TWD on accommodation, it shared 28% of the total annual tourist spending in 2011. The distribution of other tourist spending were counted as 266.52 million TWD for food and beverages (17%), 243.12 million TWD (15%) for motorcycle rental, 231.11 million TWD (15%) for shopping (souvenirs), and 121.09 million TWD (8%) for leisure and recreation services.

The economic effects contributed by a specific industry to an entire economy not only depends on its interrelationships with other industries but also is affected by the amounts of spending for its final demand. Utilizing the results of estimation of tourists spending by category for 2011 into the two-region input-output table for 2011, the economic effects

generated by tourism and the economic leakage between two regions were estimated (Table 4.10).

In 2011, the total tourist spending was 1,572.19 million TWD, and it generated 3,540.41 million TWD of the total economic effects. The total economic effects were composed of 32% from the Accommodation (S10), 23% from the Transportation & Storage (S9), 15% from the Food Service (S11), 13% from the Support Services (S13), 11% from the Wholesale & Retail Trade (S8), and the rest of 6% from the Entertainment & Recreation (S14).

Regarding the intra-regional and inter-regional effects, about 49% of the total tourism output effects, which counted as 1,739.82 million TWD, were remained within Xiao-Liu-Qiu while the rest of 51% of economic effects flowed to the rest of Taiwan, it was counted as 1,800.59 million TWD.

Table 4.10 The economic effects and leakage from tourism of Xia-Liu-Qiu, 2011

Industry		Wholesale & Retail Trade	Transportation & Storage	Accommodation	Food Service	Support Services	Entertainment & Recreation	Total
Code		S8	S9	S10	S11	S13	S14	
Tourist spending		231.1	265.1	445.3	266.5	243.1	121.1	1,572.2
%		15%	17%	28%	17%	15%	8%	100%
Total economic effect		372.1	796.7	1,147.0	542.7	468.8	213.1	3,540.4
%		11%	23%	32%	15%	13%	6%	100%
Multiplier		1.61	3.01	2.58	2.04	1.93	1.76	2.15
Intra-regional effect	S1	0.0	0.1	0.2	2.5	0.0	0.0	2.8
	S2	0.0	0.0	0.0	0.2	0.0	0.0	0.2
	S3	0.8	5.3	4.9	3.0	2.1	0.6	16.7
	S4	-	-	-	-	-	-	-
	S5	-	-	-	-	-	-	-
	S6	-	-	-	-	-	-	-
	S7	0.9	1.5	3.2	0.3	0.6	0.4	6.8
	S8*	232.1	1.7	4.9	2.2	1.7	0.7	243.2
	S9*	7.0	331.9	10.2	1.6	4.6	1.0	356.4
	S10*	2.6	0.8	446.1	0.1	0.6	0.5	450.6
	S11*	1.2	1.4	1.2	266.7	0.3	0.4	271.2
	S12	1.6	1.1	5.6	0.6	1.4	1.0	11.4
	S13*	2.3	5.4	4.3	0.5	245.1	0.7	258.3
	S14*	0.2	0.0	0.1	0.0	0.0	121.9	122.2
	Sum (%)	248.7 (67%)	349.3 (44%)	480.7 (42%)	277.6 (51%)	256.5 (55%)	127.1 (60%)	1,739.8 (49%)
Inter-regional effect	S1	1.6	7.5	9.3	4.4	3.2	1.2	27.1
	S2	0.0	0.2	0.2	0.1	0.1	0.0	0.6
	S3	69.9	339.4	418.0	199.2	145.6	51.8	1,223.9
	S4	6.7	12.7	48.7	12.3	5.9	4.9	91.2
	S5	0.4	0.5	7.4	0.5	0.2	0.3	9.3
	S6	0.6	2.3	3.3	1.3	1.4	0.4	9.3
	S7	0.8	1.9	3.6	1.1	1.1	0.5	9.1
	S8*	8.4	28.5	45.6	20.0	15.8	5.8	124.2
	S9*	1.3	4.8	6.9	2.8	2.3	0.9	19.1
	S10*	0.3	1.0	1.5	0.6	0.5	0.2	4.1
	S11*	0.4	1.1	1.8	0.6	0.6	0.3	4.7
	S12	27.3	32.5	104.3	18.1	29.2	17.5	228.9
	S13*	5.7	14.7	15.2	3.8	6.2	2.1	47.7
	S14*	0.1	0.3	0.6	0.2	0.2	0.1	1.4
	Sum (%)	123.5 (33%)	447.4 (56%)	666.3 (58%)	265.1 (49%)	212.3 (45%)	86.0 (40%)	1,800.6 (51%)

Note: * denotes tourism characteristic industry; "-" represents that the industry is not existent in the region. Unit: Million TWD. Electricity & Gas Supply (S4), Water Supply (S5), and Remediation Services (S6) are non-existent on Xiao-Liu-Qiu.

Source: Calculated by author.

In terms of each tourism characteristic industry, the Wholesale & Retail Trade (S8) owned the biggest intra-regional effect, with the share of 67%, followed by the Entertainment & Recreation (S14) (60%). The Accommodation (S10) and the Transportation & Storage (S9) were the industries with the smallest intra-regional effect, only 42% and 44% of the total economic effects remained. That is to say, the economic leakage in the Accommodation (S10) and the Transportation & Storage (S9) were relatively significant among all tourism characteristic industries, though they were the industries had the bigger multiplier effects and received the most tourist spending.

In addition, there is no energy and waste management industries on Xiao-Liu-Qiu, about 6% of interregional impact, including 91.15 million TWD for the industry of Electricity & Gas Supply (S4), 9.29 million TWD for Water Supply (S5), and 9.33 million TWD for Remediation Services (S6) were flowed to the rest of Taiwan due to the tourism demand on Xiao-Liu-Qiu.

4.5 Discussions and Summary

The most important reason to develop an area as a tourism destination is to gain or increase the extra economic benefits from the development, in particular in regional economies (Baaijens et al., 1997). The aim of this chapter was to explore the economy of Xiao-Liu-Qiu and its economic connection with the rest of Taiwan, within the context of tourism as a development strategy. The main research question was about the economic impact of the tourism development. To respond to the research question, two-region input-output models for 2006 and 2011 were utilized, and four parts of analysis were conducted.

First, the regional technical coefficients (RTC) shared the similarity of the national technical coefficients (NTC), though their component of industries were not completely the

same. Most regional technical coefficients were lower, compared to the national technical coefficients. Only some industries showed a relatively higher in regional technical coefficients than in national technical coefficients. In 2006, they were the Transportation & Storage* (S9) and the Accommodation* (S10), with the figures of RTC=0.67, NTC=0.62, and RTC=0.64, NTC=0.46, respectively. In 2011, they were the Construction (S7) and the Accommodation* (S10), with the figures of RTC=0.89 NTC=0.73, and RTC=0.52 NTC=0.49, respectively. In which, both the Transportation & Storage* (S9) and the Accommodation* (S10) were the industries related to tourism activities on Xiao-Liu-Qiu. On the entire economy of Xiao-Liu-Qiu, the highest regional technical coefficients appeared in the Mining, Quarrying & Manufacturing (S3) (RTC=0.78) in 2006, and the Wholesale & Retail Trade (S8) (RTC=0.89) in 2011. On the contrary, the lowest was the Other Services (S12), with the RTC=0.18 in 2006 and RTC=0.25 in 2011, respectively.

To decompose the component of regional technical coefficients of Xiao-Liu-Qiu, the inter-regional coefficients were very high, they shared 61%-86% and 58%-91% of the total regional technical coefficients in 2006 and 2011, respectively. This phenomenon happens when the diversity of economic structure is relatively low, so many goods have to be imported. A similar finding was seen in Baaijens, Nijkamp, and Montfort (1997), it results from the small size of the island, and its high accessibility in the case of Xiao-Liu-Qiu. Besides, as Lichy and Steinners (1982) mentioned, when an economy with little or no manufacturing activity exists, attention should be paid to the relationship of trade flow, rather than production. Therefore, the other main focus on this part is to show the spatial industry dependence between Xiao-Liu-Qiu and the mainland of Taiwan. Xiao-Liu-Qiu as a small island with a relatively simple industrial structure has eleven out of fourteen industries but with very limited production. These local

industries are not able to produce sufficient materials for their market or the other local industries' production needs.

Second, regarding the interrelationship of industries, the overall relationship among the industries stayed similarly in 2006 and 2011. Four categories were identified in terms of the normalized forward linkage (NFL) and the normalized backward linkage (NBL) of the industries in 2006 and 2011.

The key industries of Xiao-Liu-Qiu were composed of the Agriculture, Forestry, & Animal Husbandry (S1), the Mining, Quarrying & Manufacturing (S3), and the Transportation & Storage (S9). They were the industries with higher forward linkage and backward linkage in the entire economy. As Kay et al. (2007) suggested, these industries display a potent combination of forward and backward linkages, and they can play an influential role in supporting economic activity within the entire economy. In other words, when the final demand in these industries increases, these industries stimulate the demand or supply to the other industries because of their stronger linkage powers. On the contrary, the Food Service (S11), the Other Services (S12), the Support Services (S13), and the Entertainment & Recreation (S14) were the industries with the lower interconnection effect in terms of an industry's demand or supply.

The third, three types of multiplier were estimated in this chapter. In terms of the simple output multiplier, the average figures of the economy of Xiao-Liu-Qiu were estimated as 2.44 for 2006 and 2.65 for 2011. The Mining, Quarrying & Manufacturing (S3) showed the largest effect (SOM=3.85) in 2006, and the Construction (S7) (SOM=4.36) appeared the biggest effect in 2011. The most likely explanation rests on the increase in housing construction in the past years for satisfying lodging demand.

On the contrary, the lowest were the Other Services (S12) (SOM=1.45) in 2006, and the Wholesale & Retail Trade (S8) (SOM=1.61) in 2011. Regarding the tourism characteristic industries, the Transportation & Storage (S9) showed the biggest effects, with 3.14 and 3.01 in 2006 and 2011, respectively. This result can be explained by the fact that the shipping industry is essential to the whole economic development. It plays the role of mobility facilitator, such as conveying goods, services, and even people from the mainland of Taiwan to the island.

Adopting the concept by Galloway (2015), output multipliers indicate how deeply-rooted an industry is in a given region. Deeply-rooted industry can reproduce profit through the regional economy during a period before it leaks out to other regions. On the other hand, industries with very small multiplier effects are usually owned outside of the region. Therefore, the profit is lost soon, and goods are bought mostly from outside the region as well. This is called as a shallow-rooted industry. Therefore, the industries that can be regarded as relatively deeply-rooted industries are Agriculture, Forestry, & Animal Husbandry (S1), Fishing (S2), Mining, Quarrying and Manufacturing (S3), Transportation & Storage* (S9), Accommodation*(S10) in 2006, and Agriculture, Forestry, & Animal Husbandry (S1), Fishing (S2), Mining, Quarrying & Manufacturing (S3), Construction (S7), Transportation & Storage* (S9) in 2011.

In terms of the wage multiplier, the average of wage multipliers were estimated as 0.26 for 2006 and 0.24 for 2011. In 2006, the industry of the Mining, Quarrying & Manufacturing (S3) showed the biggest effect (WM=0.42), and the Other Services (S12) showed the smallest effect (WM=0.10). In 2011, the biggest effect appeared in the industry of the Construction (S7) (WM=0.44), in which the construction was indirectly related to tourism development because of the rapid expansion of tourism lodging and it contributed significantly to the growth of

household wages. Looking at the tourism characteristic industries, the Transportation & Storage (S9) showed the biggest effect (WM=0.41 in 2006 and WM=0.30 in 2011).

Regarding the employment multiplier, the average values were estimated as 0.71 for 2006 and 0.69 for 2011. The Agriculture, Forestry, & Animal Husbandry (S1) (EM=2.50 in 2006 and EM=2.31 in 2011) showed the biggest effect. On the contrary, the Other Services (S12) showed the smallest effect (EM=0.15 in 2006 and EM=0.18 in 2011). For the tourism characteristic industries, the Transportation & Storage (S9) showed the biggest effects (EM=0.78 in 2006, and EM=0.70 in 2011).

In addition, although the agricultural industry can provide more job opportunities, it does not generate a correspondingly high effect on wages. One possible explanation for this result could be the labor intensity; but low wage level in this industry. Tourism development indeed diversified the economic activities on the island and created jobs and brought new income to the locals. However, as Horváth and Frechtling (1999) and Wall (1997) proposed, the tourism earnings multiplier tends to be lower in a smaller region where earnings leak out of the economy through importing goods and services to satisfy tourism demand. In the case of Xiao-Liu-Qiu, only transportation could generate comparatively higher multipliers in employment and wages while the other tourism characteristic industries did not have significant effects.

The fourth, the high economic leakage results from high resource dependency on the rest of Taiwan. Additionally, it is clear to find that the supply dependence is not mutual between two regions in this case. In other words, the supply is unidirectional since the economy of Xiao-Liu-Qiu is much smaller than in the rest of Taiwan. In both regions, the feedback effect s are zero because the spillover effect is too weak for more round effects to be significant. A similar finding is supported by Soulié (2014).

As Baaijens et al. (1997) mentioned, tourists' spending can be regarded as a certain final demand since the money would be paid to the goods and services provided by the local firms. In the open economy of Xiao-Liu-Qiu, when the tourism demand increases, extra imports would be generated to support it. These imports can be regarded as an economic leakage. Direct output for an area is defined as the total amount of tourist expenditure. As internal businesses buy and sell to each other in response to the direct output, indirect output is generated. Also, when a tourist industry employee and his/ her household spend their income, induced output is created. These secondary effects, namely the indirect and induced effects, are calculated by multiplying the direct effects by multipliers of the region because of inter-industry dependencies. In these, the multiplier is often used to measure the secondary effects of tourism expenditure and show the wide range of sectors in a community that may benefit from tourism (Stynes, 1997a).

Tourism is a composite product of various industries. The expansion of tourism not only relies on production within the tourism characteristic industries but also other industries. As Kweka et al. (2001) mentioned, the industries gaining profits from tourism expansion should be taken into consideration because they probably can indirectly improve the growth of tourism impact. The total tourist spending in 2011 was estimated at 1,572.19 million TWD, and it generated 3,540.41 million TWD of the total economic effects. The Accommodation (S10) and the Transportation & Storage (S9) contributed more than 50% of the total economic effects, with the share of 32% and 23%, respectively. Only about 49% of the economic effects remained in the economy of Xia-Liu-Qiu, in which the Wholesale & Retail Trade (S8) contributed the highest intra-regional effect (67%), among the tourism characteristic industries. The result reflects that even the tourist expenditure spent in the local firms and generated the big economic effects in general, about 50% of profits would not remain in this island because of the heavily dependence on the mainland for its supplies. As Baaijens et al. (1997) mention that if products

are imported from other regions, the economic effects chain will come to a standstill; then, the money will not contribute to the regional economic growth. Similar finding is shown in the case study in Balearics island by Soulié and Valle (2014).

CHAPTER 5

CONCLUSIONS

5.1 Introduction

This study aimed to provide insights into the effects of tourism expansion on the environment (carbon dioxide emissions) and the economy of an island tourism destination, Xaio-Liu-Qiu, Taiwan. This dissertation is composed of five chapters. Chapter 1 introduced the background, conceptual framework, research objectives and questions. Chapter 5 summarized the findings of this study, gave policy implications, and academic contributions and limitations based on the findings. Chapter 2 through 4 were analytical chapters. The research objectives and questions of each chapter are described as follows.

In Chapter 2, two main research questions in Chapter 2 are: what the global agreement trends and national policy of island tourism development of Taiwan are; and what the current situation of island tourism development is on Xiao-Liu-Qiu. Under the main question, three sub-questions were raised.

1. What is the trend of island development agreement relating to tourism at the global and national levels?
2. What are the current tourists' characteristics and spending patterns on Xiao-Liu-Qiu?
3. What are the current tourism developments and business models on Xiao-Liu-Qiu?

To respond the sub-question 1, I reviewed the agreement trend of global island development and the policy of island tourism development in Taiwan because the international consensus, and the national policies laid the foundations of the developmental policies and strategies of the offshore islands of Taiwan. Besides, the current developmental outcome of Xiao-Liu-Liu was examined. In addition, on-site survey and investigation were utilized to respond the research sub-questions 2 and 3.

Chapter 3 quantified the energy use and the corresponding carbon dioxide emissions due to tourism expansion, especially focused on the aspects of the transportation and the accommodation. Tourists' characteristics obtained in Chapter 2 was utilized to explore the breakdown of the tourism energy use and carbon dioxide emissions on Xiao-Liu-Qiu.

The main research question of Chapter 3 is what the environmental impact of the tourism expansion of an island tourism destination is in terms of the energy use and carbon dioxide emissions on Xiao-Liu-Qiu. Under the main question, three sub-questions were addressed.

1. How much tourism-related energy is consumed on Xiao-Liu-Qiu?
2. How much carbon dioxide emissions are attributed to tourism activities of Xiao-Liu-Qiu?
3. How much carbon dioxide emissions can be mitigated through the green transportation policy implemented for land transportation?

To that end, both the primary data (i.e. tourists' characteristics) and the secondary data related to environmental factors for tourism on Xiao-Liu-Qiu were employed to respond the research questions. Besides, tourist numbers of Xiao-Liu-Qiu were forecasted. Meanwhile, the mitigation effects of carbon dioxide emissions from land transportation were also explored based on the scenario analysis.

Chapter 4 explored the economy of Xiao-Liu-Qiu and its economic relationship with the rest of Taiwan within the context of tourism as a development strategy. Tourist spending of Xiao-Liu-Qiu investigated in Chapter 2 was employed to examine the economic effects of tourism on Xiao-Liu-Qiu. The main research question of Chapter 4 is what the economic impact of tourism is on Xiao-Liu-Qiu. Four sub-questions were addressed under the main question.

1. What are the inter-industry relationships in the economy of Xiao-Liu-Qiu?
2. How are the economic multiplier effects regarding output, employment, and wage on Xiao-Liu-Qiu?
3. Did the economic structure and the multiplier effects change between 2006 and 2011 on Xiao-Liu-Qiu?
4. What are the trade effects within and between Xiao-Liu-Qiu and the mainland of Taiwan, particularly regarding tourism characteristic industries?

To that end, a two-region input-output analysis was employed to answer the research questions. The industry linkages of Xiao-Liu-Qiu were analyzed. In addition, the economic effects regarding the creation of production value, employment, and wage were studied. Besides, the leakage of economic effects to the mainland of Taiwan, in particular from tourism, was studied as well by utilizing the data of tourist spending and the length of stay.

5.2 Summary of findings

To respond to the research objectives and questions, this dissertation utilized different approaches for each chapter and summarized the findings as follows.

In Chapter 2, the first finding from the international conferences and agreements revealed that the world has paid attention to the island countries and communities on their development since about 25 years ago. In particular, tourism has become one of the priority issues because more and more island countries and communities started to rely on it to bring extra economic profits. Since 1994, sustainability has been emphasized as the core concept while considering the developmental issues of islands.

The second finding showed that the tendency of international agreements laid the basis for the establishment of the offshore island development policy of Taiwan. Three stages of the projects implementation plans of the Offshore Island Development can be identified in terms of the developmental objectives. The three stages were the Pioneer Stage (2000-2004), the Developing Stage (2004-2009), and the Maturity Stage (2009-present). The Offshore Island Development Fund was established based on the Offshore Island Development Act. The Fund was distributed to six inhabited offshore islands of Taiwan by nine categories in general. Overall, it mainly invested in the category of infrastructure (48.1%) during 2001-2010.

Take a look at the government spending on Xiao-Liu-Qiu by period, ten categories were invested. During the years of 2003-2006, 57.3% of the investments went to the construction of infrastructure, and it transferred to the categories of infrastructure (29.9%) and tourism (19.3%) in 2007-2010. In recent years, the Fund invested in the categories of social welfare and education were increasing. That is to say, the investment of the Fund was gradually shifting from the hardware facilities to the software facilities. In terms of the category of tourism, it shared 9.3% of the total spending in 2003-2014, and it ranked as the fourth major investment. In particular, the investment on the category of tourism raised to 19.3% of the total spending during 2007-2010, it ranked as the third largest investment.

The third finding was that the pressure on the environment and socio-culture system of the host may have increased in terms of the tourist-resident ratio. The tourist arrivals grew rapidly, particular in the recent years. The ratio of tourist to resident were about 12.1-24.5 to 1 during 1996-2007, but it increased to more than 50 to 1 since 2011

The fourth finding suggested that the seasonal variation in tourist numbers was obviously large. Looking at the tourist arrivals of each month, April to October were the relatively high season (the index was higher than the average). Starting from January to March and from November to December were the comparatively low seasons (the index was lower than the average) in a year. Besides, the gap between the lowest and the highest month was calculated at 3.88 times difference[17]. The variation of tourist numbers within a year may affects the local's economy directly in terms of the employment and income, and it also influences the environment of the community, such as the environmental degradation caused by the intensive tourism disturbance in a certain period. Besides, in the summer season, May-August, a quarter of the year, the scenic area handles 46.8 % of all tourists on average. The high season of Xiao-Liu-Qiu is mainly in summer, it may result from the long summer vacation and warm climate to enjoy outdoor attractions and activities.

The fifth finding was the tourists' characteristics based on on-site survey: About 93.2% of respondents arranged their trips by themselves, and 53.9% of them were in the age range of 18-25 years old. Besides, two-day trip was considered as a typical journey type on Xiao-Liu-Qiu, it shared about 56.1% of total tourists. The majority of respondents selected B&B accommodations for their accommodation (87.6%) and about 90.7% of them used motorcycle

[17] The monthly average index of tourist numbers in 2012-2014 was 100. June is the busiest time, its index was calculated at 163. On the contrary, January is the month with lowest tourist numbers on average, the index was calculated at 43.

for their land transportation. 68.2% of visitors responded that it was their first visit, and about 46.3% of visitors were from the southern Taiwan.

In addition, regarding tourist spending, three types of the length of stay were categorized according to the survey results: 56% of the respondents spent two-days with the average expenditure of 2,965 TWD; 39% of visitors had a one-day tour with an average expenditure of 1,388 TWD; and only a few tourists stayed three to five days with a 4,605 TWD expenditure on average. For tourists who stay overnight, their expenditure for the accommodation shared the biggest amount of the total expenditure, about 34.8% for two-day tourists and 48.1% for three to five-day tourists.

The sixth finding was that the tourism business system was formed by the locals, for providing all-inclusive services to the tourists. The cooperation can simplify the tourists' traveling arrangement, besides, it also ensure the tourism profits would distribute and benefit to the community. In other words, it is a win-win situation for the tourism business owners and tourists.

In Chapter 3, energy use and carbon dioxide emissions can be regarded as the costs of tourism development. The amount of energy use and carbon dioxide emissions are mainly determined by the number of tourists and their choices. The first finding showed that the tourist numbers were growing in the past years. Total tourist numbers were estimated at 153,278 in 1996 to 868,115 in 2014. The average annual growth rate of tourists was calculated as 10.1%.

The second finding revealed that the energy use for tourism was estimated as 139.123 GJ, and that it generated 2,639.205 ton-CO_2 of carbon dioxide emissions in terms of transportations and accommodation in 2012. The transportation contributed 84.9% of the total tourism energy and 76.7% of carbon dioxide emissions for tourism in 2012. It is composed of 75.5% of the

total energy used by ferry and 9.4% of the total energy used by rental motorcycle for tourism purpose. To convert the energy use to carbon dioxide emissions, 68.7% of carbon dioxide emissions were generated from ferry and 8.0% from motorcycle. The B&B accommodations required 15.1% of the total energy used and they generated 23.3% of the total carbon dioxide emissions.

The third finding was that the longer tourists stay, the higher tourism energy use and carbon dioxide emissions per capita were contributed. The tourism energy use per capita was estimated as 150-260 MJ, with the generation of carbon dioxide emissions at 11.4-22.7 kg-CO_2. However, if the energy use and carbon dioxide emissions per day per capita were examined, the longer tourists stay, the less tourism energy use and carbon dioxide emissions per capita were estimated. In terms of the different length of stay, the energy use per day per capita was estimated at 90-150 MJ and the carbon dioxide emissions from tourism were estimated to be 7.6-11.4 kg-CO_2. The longer tourists stay, the less energy per capita was used, and the less carbon dioxide emissions from tourism per day per capita were generated. The reason is mainly because the energy use by and carbon dioxide emissions generated from water transportation (ferry) were diluted when tourists stayed more days.

The last finding based on the scenario analysis, carbon dioxide emissions will become 1.30 times larger in 2025, compared the amount in 2014 when no mitigation strategy used. Assuming the technology improvement in gasoline motorcycle, the annual carbon dioxide emissions will become 33% smaller than if no mitigation policy applied in 2025. Besides, assuming the policy implication of the replacement of gasoline motorcycle with the electric scooter, the result of scenario appears 56% of the reduction in carbon dioxide emissions in 2025. The biggest mitigation effect of carbon dioxide emissions showed in the scenario which combined the idea of replacement of gasoline motorcycle with the electric scooter and the increase of the energy

efficiency of gasoline motorcycle. It will reduce 66% of the carbon dioxide emissions in 2025, comparing to the result of scenario without any mitigation strategy.

Chapter 4 explored the economy of Xiao-Liu-Qiu and its economic inter-connection with the rest of Taiwan, particularly the economic effects from tourism were focused. The two-region input-output analysis for 2006 and 2011 were utilized to conduct four part of analyses in terms of the regional technical coefficients, interindustry linkage, multipliers, and the economic effects of tourists' expenditure of Xiao-Liu-Qiu.

The first finding showed the comparison of technical coefficients. In terms of the structure, the regional technical coefficients (RTC) of Xiao-Liu-Qiu showed the similarity of the national technical coefficients (NTC). However, in terms of the values of technical coefficient, the regional technical coefficients of Xiao-Liu-Qiu were relatively smaller to the national technical coefficients. Three industries showed the higher values in technical coefficient on Xiao-Liu-Qiu than that in the national region. They were the Transportation & Storage* (S9) (RTC=0.67, NTC=0.62) and the Accommodation* (S10) (RTC=0.64, NTC=0.46) in 2006, and The Construction (S7) (RTC=0.89 NTC=0.73) and the Accommodation* (S10) (RTC=0.52 NTC=0.49) in 2011.

The second finding was regarding the key industries of Xiao-Liu-Qiu. It showed that the Agriculture, Forestry, & Animal Husbandry (S1) ($NFL_{2006} = 1.18, NBL_{2006}$ =1.04; NFL_{2011}=1.00, NBL_{2011}=1.02), the Mining, Quarrying & Manufacturing (S3) ($NFL_{2006} = 1.58, NBL_{2006}$=1.19; NFL_{2011}=1.00, NBL_{2011}=1.02), and the Transportation & Storage (S9) ($NFL_{2006} = 1.28, NBL_{2006}$=1.12; NFL_{2011}=1.31, NBL_{2011}=1.14) were identified as key industries in the economy of Xiao-Liu-Qiu, in terms of the higher effects on the normalized forward linkage (NFL) and the normalized backward linkage (NBL).

The third finding indicated that the simple output multiplier, the Mining, Quarrying & Manufacturing (S3) showed the largest effect (SOM=3.85) in 2006 and the Construction (S7) (SOM=4.36) appeared the biggest effect in 2011 among eleven industries, in the economy of Xiao-Liu-Qiu. In terms of the tourism characteristic industries, the Transportation & Storage (S9) showed the biggest multiplier effect (SOM=3.14 in 2006 and SOM=3.01 in 2011).

In addition, the wage multiplier (WM) and employment multiplier (EM) were estimated. In terms of wage multiplier, the Mining, Quarrying & Manufacturing (S3) (WM=0.42) showed the biggest effect in 2006, and the Construction (S7) (WM=0.44) showed the biggest effect in 2011. Regarding the employment multiplier, the biggest effect appeared in the Agriculture, Forestry, & Animal Husbandry (S1) (EM=2.50 in 2006 and EM=2.31 in 2011). In terms of the tourism characteristic industries, the Transportation & Storage (S9) showed the biggest effects in both wage multiplier (WM=0.41 in 2006, and WM=0.30 in 2011) and employment multiplier (EM=0.78 in 2006, and EM=0.70 in 2011).

The fourth finding showed that the average net simple output multiplier was estimated as 1.25. However, 1.17 monetary units of effect will distribute to the rest of Taiwan. The high economic leakage results from the high dependency on the resources imported. Besides, the supply dependence is not mutual between Xiao-Liu-Qiu and the rest of Taiwan because the economy of Xiao-Liu-Qiu is much smaller than that in the rest of Taiwan. Additionally, there is no feedback effect since the spillover effect is too little to generate it.

The last finding indicated that the Accommodation (S10) and the Transportation & Storage (S9) were the biggest economic contributors among the tourism characteristic industries, and that their contributions were estimated as more than 50% of the total economic effects. However, in terms of the economic leakage, only 49% of the economic effects generated by tourism activities can be remained on Xiao-Liu-Qiu, while the other 51% of the economic effects would

distribute to the rest of Taiwan due to the high importation. Especially, the leakage of money out of Xiao-Liu-Qiu from the Accommodation (S10) and the Transportation & Storage (S9) were comparatively significant, even the most tourist spending went to these two industries and they were the industries with the stronger multiplier effect.

Overall speaking, Xiao-Liu-Qiu has become a popular island tourism destination that received more and more tourists in the past years. It not only resulted in high pressure on its socio-culture system due to the larger and larger tourist-resident ratios year by year and a big gap in seasonal variation of tourist arrivals, it also raised the awareness of environmental issue in terms of the tourism carbon dioxide emissions. It is unavoidable that more carbon dioxide emissions would be generated year by year on Xiao-Liu-Qiu because the increase of tourist arrivals and most tourism activities require energy use. However, if the mitigation policies and strategies of carbon dioxide emissions can be implemented, the negative environmental effects from tourism would be reduced, but the local economic benefits would increase while the tourist arrivals are growing. In other words, the development of tourism on Xiao-Liu-Qiu would be more sustainable in terms of carbon dioxide emissions and economy.

5.3 Policy implications

The future development of this island depends on the direction of the tourism since tourism has been flourishing on Xiao-Liu-Qiu. As Martín-Cejas and Sánchez (2010) suggested, it is necessary to consider a trade-off between the economic gains and environmental impacts. For example, constructing a new tourism facility may promote the destination business, but the environment may be changed. In particular, when tourist growth and tourism facilities are not well managed. In terms of the environmental aspect, three possible directions are proposed:

One is to implement the eco-friendly alternatives for tourism. At the beginning, the environmental conservation funds for replacing the conventional tourism facilities and services with the green alternatives are suggested. For example, to replace the gasoline vehicles with the electricity powered ones. The other example is to increase the amount of energy generated by renewable energy (e.g. solar power, combined heat and power). This may also enhance the communities' and tourists' environmental awareness and responsibilities. Meanwhile, the policy for mandatory carbon dioxide emissions reduction should be implemented gradually in order to minimize the environmental impact.

Another direction is to control the tourist numbers. Based on the result of seasonality of the tourist visitation of Liouciou Scenic Area, the gap of tourist numbers between high season and low season on Xiao-Liu-Qiu were big. In other words, the tourist visits are concentrated in certain months. To reduce the seasonal fluctuations in tourist numbers, price control of tourism is suggested to implement. For example, to set up the tourism tax or to increase the price of using tourism facilities and services in the busy time.

The other direction is to extend the length of tourists' stay. The typical tourism type on Xiao-Liu-Qiu is of a short-stay. As Croes (2007) stated, the short length of stay contributes in particular to the increasing number of traffic movements. This causes the higher energy use and carbon dioxide emissions. Based on the finding of the study, it can reduce the carbon dioxide emissions per day per capita from tourism. Therefore, the strategic plans to extend the length of stay by increasing tourism attractions are recommended. For example, holding the green events and festivals. The green events are expected to attract the tourists who have a deeper environmental awareness to Xiao-Liu-Qiu. The benefit of organizing the green events and festivals may enhance the environmental awareness of the other tourists and the locals.

Tourism business is boosting on Xiao-Liu-Qiu. However, as Polo and Valle (2008) suggested, the local economy should find a way to increase local production and be aware of tourism crisis. One example is a traditional cookie called Mahua or fried dough twist (麻花捲) has become a popular local snack food for souvenir in recent years. More and more shops were opened by the locals and each shop has their own recipes. The owners try to create different flavors of Mahua in order to give more options to their customers. Making Mahua has become a unique business on Xaio-Liu-Qiu and it brings the extra economic benefits to the locals due to the tourism expansion. The economic benefits not only include the generation of sales revenue but also the creation of job opportunities, especially for the females who could not find any job on Xiao-Liu-Qiu in previous year. Taking this experience, it is recommended to develop the higher value added products locally. The government can play the role of supporting the creation and innovation in local products. Based on the finding of the economic effects in this study, the government can implement the industry-promotion strategies in the Wholesale & Retail Trade (S8) and Entertainment & Recreation (S14) because these two tourism characteristic industries show the higher intra-regional effects in multiplier. In other words, the more economic profits can be created and remained on Xiao-Liu-Qiu.

Although tourism expansion has enhanced the economy of the island, it is important to note a high economic leakage to the mainland of Taiwan. The local industries on the island should be aware of the high risk that may result from large supply dependence on the rest of country. When the tourism demand on Xiao-Liu-Qiu increases, the extra imports will be generated to support it. As Reis and Rua (2006) stated, the higher the import dependence is, the lower the industry linkages in a given area will be. In other words, when a region relies on more importation of goods and services than using local production, the more profit leaks to the supplier regions and ends up having a smaller impact on the local economy. A similar idea is

described in the study by Gravino (2012). The strategic alliance between industries with a higher output multiplier could be considered in order to generate larger profits from tourism income. Besides, the strategy of local production for local consumption should be implemented, especially the products regarding the industries of the Transportation & Storage (S9) and Accommodation (S10) because they are the industries with the higher effects in economic leakage.

5.4 Academic contribution and limitations

This study contributes a procedure to evaluate both environmental (e.g. carbon dioxide emissions) and economic impacts from tourism. Regarding the environmental aspect, this study took the advantages of the bottom-up approach from the viewpoint of tourist and the top-down approach from the perspective of industry chain. It provides a more comprehensive picture while studying tourism impacts on the island. In terms of the economic aspect, this is the first study to discuss the economic structure within Xaio-Liu-Qiu and between Xiao-Liu-Qiu and the rest of Taiwan, especially focusing on the economic contribution of tourism on Xaio-Liu-Qiu based on a two-region input-output analysis. This study not only focus on the intra-regional effects on Xiao-Liu-Qiu, but also concerning the inter-regional effects between Xiao-Liu-Qiu and the rest of Taiwan.

The limitation of this research is that the results only concern Xiao-Liu-Qiu. It will be interesting to replicate the analyses on other islands. In addition, the research period of this study did not allow to investigate the tourists' characteristics and their choice behaviors for each month. It will represent a more comprehensive insight on this matter if the tourists' characteristics and their choices in terms of the seasonality are investigated. Besides, this study only focused on the major land transportation choice, therefore, another issue requires further

comprehensive research exploring the effectiveness of another green tourism facility alternatives. Additionally, due to very limited data accessibility, this study was only able to analyze data for 2006 and 2011. Tourism has become a primary strategy for enriching local development. Therefore, a long-term analysis observing the economy of the island is suggested for further policy making.

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Appendices

Appendix 1 Offshore Island Development Act

Announced Date 2000. 04. 05

Amended Date 2015. 06.10

Article	Content
Article 1	This Act is specially targeted at promoting the developmental construction, enhancing the industrial development, protecting the natural environment, preserving the cultural features, improving the quality of life, and augmenting the welfare of residents of Offshore Islands. Matters not provided for in this Act shall be governed by the provisions of other laws.
Article 2	An Offshore Island as referred to in this Act means an island that is detached from the main island of Taiwan and is under the governing jurisdiction of the Republic of China.
Article 3	A major construction plan as referred to in this Act means a major industrial investment plan recognized by the central competent authority or a public works project assigned for undertaking by a private entity.
Article 4	The competent authorities for this Act are the Executive Yuan at the central government level, municipal governments at the special municipality level, and county (city) governments at the county (city) level. The central competent authority may establish a Steering Committee for Offshore Islands Development, under the convenership of the President of the Executive Yuan (“the Premier”), to review, supervise, coordinate and guide the development of Offshore Islands. The main responsibilities of the above-mentioned Steering Committee shall be to review schemes for implementing the overall development of Offshore Islands, and to coordinate matters concerning the implementation of major construction projects on Offshore Islands. Directions on the establishment of the Steering Committee shall be prescribed by the Executive Yuan.

(continued)

Appendix 1 Offshore Island Development Act (continued)

Article	Content
Article 5	County (city) competent authorities shall, according to the integrated development plan of each county (city), formulate four-yearly implementation schemes for the integrated development of Offshore Islands, containing as follows: 1. Targets of the scheme and scope of implementation. 2. Implementation strategies. 3. Development of infrastructure. 4. Development of industry. 5. Development of education. 6. Development of culture. 7. Development of transport and communications. 8. Development of medical facilities 9. Development of tourism. 10. Development of police administration. 11. Development of social welfare. 12. Prevention and mitigation of natural disasters, and improvement in respect of improper land use for burial, cultivation and construction. 13. Yearly implementation plans and division of work. 14. Yearly financial requirements and sources of funds. 15. Other matters.
Article 6	Implementation schemes for the integrated development of Offshore Islands shall be implemented only after having been reviewed and approved by the Steering Committee for Offshore Islands Development and then reported to and approved by the Executive Yuan. The county (city) competent authority shall comprehensively review the above-mentioned implementation scheme once every four years, or amend the scheme as necessary to match revision of the integrated development plan of the county (city); and such amendment shall be carried out in accordance with the procedure stipulated in the preceding paragraph.

(continued)

Appendix 1 Offshore Island Development Act (continued)

Article	Content
Article 7	To encourage the development of industries on Offshore Islands, in the case of investment projects recognized as major construction projects by the central competent authority, the review procedure for land-use alterations, from submission of application through to the conclusion of review for land use segmentation or alteration of use, shall be completed within a timeframe not exceeding one year. The standards for the recognition of major construction projects as aforesaid shall be drawn up by the Steering Committee for Offshore Islands Development and reported to the Executive Yuan for approval. When a major construction project involves alteration of land use for an urban planning master plan or for non-urban land, and the alteration of land use has been approved by a county (city) government, it shall not be subject to the restrictions imposed by the Urban Planning Act, non-urban land use control regulations or other related laws and decrees.
Article 8	Where land required for a major construction project on an Offshore Island is publicly owned, the governing authority of the target enterprise may, after carrying out the allocation for use, set a time limit for the provision of the land for use by a private entity by means of lease, setting of surface rights, trust, or the use of royalty or rent for the land as financial contribution, without being limited by Article 25 of the Land Act, Article 28 of the National Property Act, or laws and decrees concerning the management of public property by local governments. Where a major construction project on an Offshore Island is a public work assigned for undertaking by a private entity, and the land required for the project is privately owned, the governing authority of the target enterprise or the private entity shall negotiate with the landowner to purchase the land at a regular price, and if the negotiation is unsuccessful or cannot be conducted, the governing authority of the target enterprise may execute expropriation. The expropriation plan shall clearly state that the land is provided for a private entity to carry out development, construction and operation by means of joint development, commissioned development, cooperative business operation, lease, setting of surface rights, trust, or the use of royalty or rent for the land as financial contribution, without being limited by Article 25 of the Land Act, Article 28 of the National Property Act, or laws and decrees concerning the management of public property by local governments. To help private entities acquire land needed for major construction projects on Offshore Islands, the governing authority of the target enterprise or the county (city) government may select a suitable location and, after obtaining approval from the central competent authority, directly execute sectional expropriation. After the scope of the sectional expropriation is determined, the land allocated for investment by private entities may be sold by tender in advance, without being limited by Article 53 or Article 55-2 of the Equalization of Land Rights Act.

(continued)

Appendix 1 Offshore Island Development Act (continued)

Article	Content
Article 9	In the areas to which this Act is applicable, where a piece of land was registered as public-owned due to expropriation, purchase, or compulsory purchase before the termination of battleground administration, or after the termination of battle administration period occupation, and the land administration authority has ceased to use or has in fact abandoned use of the land, the whole amount shall be publicly announced at the latest within two years from the date of the coming into force of the amendment of this Act on December 20, 2013; and the original owner of the land or his heir may, within 5 years of the public announcement, apply to the said land administration authority to buy back the land at the price calculated according to the current land value announced in the year in which the application is submitted. However, where the price paid for expropriation, purchase or compulsory purchase exceeds the land value as thus calculated, the price for buying back the land shall be the original expropriation, purchase or compulsory purchase price. After receipt of an application, the land administration authority shall reply to the applicant within 30 days. Where the application is found upon review to comply with the requirements of this Act, the land administration authority shall notify the applicant to pay the purchase price within 30 days, and if payment is not made within this time limit, the application shall be cancelled. Where the application is rejected as not complying with the requirements of this Act, the applicant if dissatisfied with this decision may submit a request for mediation to the county (city) government of the area in which the land is situated. The time periods stated in the preceding paragraph may, when necessary, be extended by one month. The county (city) government mediation referred to in Paragraph 2 may be conducted under the mutatis mutandis application of the provisions of Article 59 of the Land Act. Where land in the Kinmen area was registered as public land without the procedure for eminent domain or purchase, before the termination of battleground administration, and where there is sufficient proof of the pre-existence of a building or tomb on the land, the original owner or his heir or the original occupier may, within five years from the date of the coming into force of the amendment of this Act on December 20, 2013, apply with submission of related evidential documents to the authority in charge of the land to collaborate with the land administration authority in conducting a site inspection, and where the claim is confirmed as factual and there is no public use of the land, the area occupied by the land or tomb may be calculated, and the land sold at the current land value announced at the time of the application. Where land in the Matsu area, since 1949, was registered as public land without the procedure for eminent domain or purchase, causing the original land owner or person deemed as owner under the provisions of

(continued)

Appendix 1 Offshore Island Development Act (continued)

Article	Content
Article 9	Article 9 of the Enforcement Act of the Part of Rights in Rem of the Civil Code, or that person's heir, to lose ownership right, and where the authority in charge of the land no longer has need to use it, the land shall be returned according to law upon application by the original owner, deemed owner or such person's heir within five years from the date of the coming into force of the amendment of this Act on December 20, 2013; and where the authority in charge has continuing need to use the land, it shall conduct expropriation, purchase or lease of the land from the original owner, deemed owner or such person's heir according to law. Where a request submitted under the Safety and Assistance Act for Kinmen, Matsu, Dongsha and Nansha has previously been rejected, a further application may be submitted under the provisions of this Act. Regulations for implementing the return of land as referred to in the preceding paragraph shall be prescribed by the Executive Yuan. Applications to repurchase land under Paragraph 1, applications to sell land under Paragraph 5, and applications for the return of land under Paragraph 6 shall not be subject to limitations imposed by Articles 52 or 53 of the Urban Planning Act, Article 25 of the Land Act, Articles 28, 33 or 35 of the National Property Act, or local government public property management ordinances. The foregoing provisions of this Article shall apply with similar effect to any land in the Penghu area not expropriated, purchased or compulsorily purchased by government authorities under legally stipulated procedure.
Article 9-1	Where an application was made for the return of a piece of land to which this Act is applicable during the applicable period of Article 14-1 of the Safety and Assistance Act for Kinmen, Matsu, Dongsha and Nansha, but the land could not be returned because it was under use by the government or had been transferred to a private party, the applicant may, within two years from the date of amendment of this Act coming into effect, request the competent land administration authority or the authority that made the original disposal to pay compensation according to the land value at the time of the application for return, as determined in accordance with the provisions of Article 30 of the Land Expropriation Act. Regulations governing the conditions, time limit for application, requisite supporting documentation, and other matters concerning compensation as referred to in the preceding paragraph shall be prescribed by the Executive Yuan.
Article 9-2	In the areas covered by this Act, where, prior to the termination of battleground administration, an application to cultivate idle land in Kinmen or Matsu was made and approved and cultivation commenced in accordance with restrictions, but subsequently cultivation could not be continued or ownership obtained due to military reasons, the applicant or his heir may, within two years from the date of amendment of this Act coming into effect, request the competent land administration authority to pay compensation for the costs of commencing cultivation.

(continued)

Appendix 1 Offshore Island Development Act (continued)

Article	Content
Article 9-2	Where the applicant had acquired the right to cultivate, compensation shall be calculated according to the term of the right and the current land value announced at the time of application. Regulations governing the conditions, time limit for application, requisite supporting documentation, amount of compensation, and other matters concerning compensation as referred to in the preceding paragraph shall be prescribed by the Executive Yuan.
Article 9-3	An original obligee before laying mines on April 30, 1971, or a possessor or his/her heir(s) by adverse possession according to Civil Code, of a land that locates within a minefield in the areas of Kinmen and that is registered as public land without following a remunerative procedure such as expropriation or procurement may, within five years after the amendment of this Article coming into force on May 26, 2015, apply to local Land Administration for the return of the land. Those applying for the return in accordance with the preceding Paragraph should present one of the following relevant certified documents that demonstrate the ownership of the land, or acquisition of the land by adverse possession in accordance with Civil Code, prior to laying landmines: 1. Certified documents of the land title prior to laying mines. 2. A certificate issued by the local District office or other government authorities. 3. Certified documents provided by at least two surrounding neighbors, or a certificate issued by the chief of the village (li, or neighborhood). The neighbor attesters or the chief described in the Subparagraph 3 of preceding Paragraph should have, during the period of occurrence to be proved, had registered as permanent residents at address(es) located in, or the village adjacent to, the land to be returned and had the capacity of a natural and juridical person. In addition, they should in conjunction with the obligee be present at the scene to survey and verify the limits. The application for the return of the land should be dismissed, if any certifier did not present after being notified twice by the local land administration. The certificates described above should specify that the area of the land has been approximately measured and that the results are facts of each attester's personal observation, rather than speculations. If an attester's household register had been relocated to other place during occupancy certified by the attester, the applicant should seek another attester to make up the deficiency.

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Appendix 1 Offshore Island Development Act (continued)

Article	Content
Article 9-3	If certified documents to support the application for return of land described in Paragraph 1 are insufficient, the local land administration who supervises the related land should give notices to the applicant and request the applicant to provide amendment and complement to the insufficiency within three months. If the applicant cannot, or does not, provide amendment and complement to the insufficiency, the application should be dismissed. After having been verified by the local land administration, announced to the public for six months, and notified land managing authorities, without anyone raising any objection by the expiration of the announcement, the ownership of the land should be transferred by the local land administration supervising the related land. If the original land managing authorities have the need to continue using the land, the managing authorities should, according to law, apply to the landowner for a land tenure, procurement, or expropriation. The local land administration should review the case described in preceding Paragraph in conjunction with the local county government, the land managing authorities, and relevant authorities. During the period of announcement, if someone raises an objection, the matters should be mediated, mutatis mutandis, in accordance with Paragraph 2, Article 59 of the Land Act. The application for the return of land specified in Paragraph 1 is not subject to the restrictions of Article 52 and 53 of the Urban Planning Law, Article 25 of the Land Act, Article 28, 33, and 35 of the National Property Act, or administrative legislation of public property specified by the local government. An applicant when he applies for the first registration of an unregistered land that he had acquired to the real property by adverse possession but later lost the possession due to being enclosed in a minefield described in Paragraph 1 should be deemed to have uninterrupted possession of the land. The provisions of Paragraph 3 and 4 should apply, mutatis mutandis, to the requirements of the registration, such as the amendment and complement to insufficient evidence for review, the period of announcement, attester's eligibility, etc.
Article 10	Goods sold and delivered locally or services provided locally by business operators in the Penghu, Kinmen, Matsu, Ludao (Green Island), Lanyu, and Liuqiu areas shall be exempted from business tax. Merchandise imported and sold locally by business operators in the Penghu, Kinmen, Matsu, Ludao (Green Island), Lanyu, and Liuqiu areas shall be exempted from customs duties. The items exempted and the method of implementation shall be prescribed by the Ministry of Finance.

(continued)

Appendix 1 Offshore Island Development Act (continued)

Article	Content
Article 10-1	To promote tourism in Offshore Islands, persons establishing Offshore Island duty-free shopping stores in the Penghu, Kinmen, Matsu, Ludao (Green Island), Lanyu, and Liuqiu areas shall, after obtaining approval from the competent authority of the local county (city) government, apply to the customs authorities for registration to conduct the sale to visitors of goods to be taken out of the Offshore Island area. Goods imported and stored for sale by Offshore Island duty-free shopping stores shall be bonded and stored in bonded warehouses in accordance with the provisions of the Customs Act. Goods sold by Offshore Island duty-free shopping stores shall be subject to a zero rate of business tax. Goods purchased from abroad or from a bonded area that are brought in and stored for sale by an Offshore Island duty-free store, sold to a visitor within the range of a certain monetary value or quantity, and taken by the visitor out of the Offshore Island area, shall be exempted from customs duty, commodity tax, tobacco and alcohol tax, and the health and welfare surcharge on tobacco products. Domestically manufactured goods that are brought in and stored for sale by an Offshore Island duty-free store, sold to a visitor within the range of a certain monetary value or quantity, and taken by the visitor out of the Offshore Island area, shall be exempted from commodity tax, tobacco and alcohol tax, and the health and welfare surcharge on tobacco products. Regulations concerning the qualifying conditions, application procedures, registration of and changes in the establishment of Offshore Island duty-free shopping stores, the monetary values and quantities as referred to in the preceding two paragraphs, the persons to whom sales may be made, the customs clearance procedures, the management of the delivery of goods, and other matters requiring compliance, shall be prescribed by the Ministry of Finance. If an Offshore Island duty-free store violates the regulations concerning application for or change or re-issuance of registration, the monetary value and quantity of sales or persons to whom sales may be made, customs clearance procedures, the management of the delivery of goods, or other matters requiring compliance, as referred to in the preceding paragraph, the customs authorities may issue a warning and require correction within a specified time or impose a fine of between NT$6,000 and NT$30,000. A fine may be imposed for each violation. A shop that has been fined three times but has still failed to make the requisite correction may be punished by suspension of business for between three months and one year.

(continued)

Appendix 1 Offshore Island Development Act (continued)

Article	Content
Article 10-1	Where the quantity or monetary value of goods sold to a visitor by an Offshore Island duty-free store exceeds the limits as referred to in Paragraphs 4 and 5 above, the buyer may not take the goods out of the Offshore Island area until after making supplementary payment of customs duty, commodity tax, tobacco and alcohol tax, the health and welfare surcharge on tobacco products, and business tax, as calculated in accordance with the provisions of the Customs Act, the Commodity Tax Act, the Tobacco and Alcohol Tax Act, and the Value-added and Non-value-added Business Tax Act.
Article 10-2	Before an Offshore Island may be opened to the establishment of tourist casinos, a local referendum thereon must be held in accordance with the Referendum Act, and more than half of the valid votes cast in the referendum must be votes of approval. However, the validity of the referendum result shall not require votes to have been cast by at least half of the eligible voters in the county or city. Tourist casinos as referred to in the preceding paragraph shall be established within international tourist resort zones. The facilities in international tourist resort zones shall also include international tourist hotels, tourism and travel facilities, international conference and exhibition facilities, shopping malls and other service facilities related to developing tourism. Applications for plans to invest in international tourist resort zones shall be submitted to the central government authority in charge of tourism. The time schedule, review and approval standards, related procedures and other matters in respect of such applications shall be decided by the central tourism authority and publicly announced after submission to and approval by the Executive Yuan. Application procedures, establishment standards, license issuance, license fees, special gaming tax, relevant supervision and administration, and other such matters concerning tourist casinos shall be separately prescribed by law. The provisions of the Offenses of Gambling Chapter of the Criminal Code shall not apply to the legally authorized operation of tourist casinos and engagement in gaming activities in accordance with the preceding paragraphs.
Article 11	Subject to the principle of not impeding national defense or the military security of Offshore Islands, the armed forces or military units stationed on Offshore Islands shall actively cooperate with all construction projects on the Offshore Islands, and shall constantly review their military defenses and improve military control measures that are out of keeping with the times.

(continued)

Appendix 1 Offshore Island Development Act (continued)

Article	Content
Article 11	For the purpose of handling matters as referred to in the preceding paragraph, the Executive Yuan shall convene regular yearly review and discussion meetings of the Ministry of National Defense, related ministries and commissions, representatives of local public opinion, and persons of standing in society, to come up with concrete measures in support of Offshore Island construction and development.
Article 12	The Ministry of Education shall allocate a budget to subsidize the textbook expenditure and miscellaneous expenses of students who receive national compulsory education on Offshore Islands. Where the lack of a school on an Offshore Island necessitates a student going to the main island of Taiwan or another Offshore Island to receive compulsory education, his two-way travel expenses shall be subsidized from a budget allocated by the Ministry of Education. But when, due to transportation and communication factors, a student is unable to return the same day to the Offshore Island on which he resides, he may use this travel allowance to pay the necessary living expenses for staying in the area in which his school is situated.
Article 12-1	A teacher who has entered into initial employment to teach at a senior secondary school, or a lower level, on any outlying islands should serve at least actual six years in such a position before the teacher may apply for a teaching engagement on the mainland Taiwan, in order to guarantee the right to education of students who inhabit on outlying islands. The actual year limits of service described in the preceding Paragraph should deduct each the seniority in a position retained without pay, in addition to the seniority during parental leave without pay or a position retained without pay due to being conscripted. The seniority is limited to actual years of service at the school the teacher is currently serving.
Article 13	To maintain the safety and health of the residents of Offshore Islands, the Executive Yuan shall allocate a budget for subsidizing the establishment of medical institutions, nursing institutions, long-term care institutions, and other medical institutions on Offshore Islands, and for recruiting doctors in specialist departments that are under-staffed in Offshore Island areas, and shall prescribe regulations for the provision of special incentives and assistance. The self-payment requirement of National Health Insurance premiums for residents of Offshore Islands aged 65 and over shall be paid from a budget allocated by the central government. The central competent authority shall subsidize the two-way travel costs of acutely or severely ill patients who urgently need to be transferred from Offshore Islands to the main island of Taiwan for hospitalization, and of accompanying medical personnel.

(continued)

Appendix 1 Offshore Island Development Act (continued)

Article	Content
Article 13	The central competent authority shall allocate a budget to subsidize expenses of physically and mentally disabled and elderly persons who have need for receiving long-term care services. To protect the dignity and health of elderly persons on Offshore Islands, the central competent authority shall provide each senior citizen with a two-yearly physical examination that is comparable to health checks provided for civil servants, and the central competent authority shall allocate a budget to subsidize the difference in cost between such physical examination and the health checks provided for senior citizens by the competent authorities of special municipalities and counties (cities) in the current year under the Senior Citizens Welfare Act.
Article 14	Charges for water and electric power consumption on Offshore Islands shall be levied at the average rates applicable on the main island of Taiwan. Reasonable losses sustained by utility operators in consequence of the setting of such rates shall, after review and approval by the central governing authorities of the target enterprises, be subsidized from budgets allocated for such purpose. However, charges for the electric power consumption of the self-use residences of the residents of the Lanyu area shall be exempted from collection.
Article 15	The central government shall allocate a budget exclusively for Offshore Island development expenditures pursuant to this Act. If such budget is insufficient, it may be supplemented from the Offshore Islands Development Fund.
Article 15-1	To promote fast and convenient external transportation for residents of Offshore Island areas, all charges for transportation between Offshore Islands and the main island of Taiwan shall be subsidized from a central government budget allocated for this purpose, and ticket subsidies shall not be less than 30 percent of ticket prices. Regulations for ticket subsidies as referred to in the preceding paragraph shall be drawn up by the Ministry of Transportation and Communications and submitted to the Executive Yuan for approval.
Article 16	To speed up the development of Offshore Islands, the central competent authority shall establish an Offshore Islands Development Fund with a total fund of not less than NT$30 billion, obtained from the following sources: 1. Allocation from the ten-year budget compilation or financial sources designated by the central government. 2. Allocation from the budget compilation of county (city) competent authorities. 3. Interest on the fund. 4. Donations from individuals or organizations. 5. License fees from tourist gaming enterprises. 6. Other income. Regulations on receipts and expenditures, custody and utilization of the Offshore Islands Development Fund shall be prescribed by the Executive Yuan.

(continued)

Appendix 1 Offshore Island Development Act (continued)

Article	Content
Article 17	Regulations on the subsidies referred to in Articles 12 to 14 shall be drawn up by the Steering Committee for Offshore Islands Development in consultation with the central competent authorities of the target enterprises, and reported to the Executive Yuan for approval. Education and culture in the Penghu, Kinmen, Matsu, Ludao (Green Island), Lanyu, and Liuqiu areas shall be guaranteed, and the Ministry of Education in consultation with other authorities concerned shall draw up regulations on student admission recommendation, to support and promote the cultivation of talents in these areas.
Article 18	To promote the development of Offshore Islands, prior to the comprehensive opening of transport links between the main island of Taiwan and the Mainland area, transport links between the Kinmen, Matsu and Penghu areas and the Mainland area may be opened on a pilot basis. Residents of the Taiwan area may, with due approval, use the pertinent entry/exit certificates, after checks, to enter the Mainland area from the pilot areas, or to enter the pilot areas from the Mainland area, without limitation by the Act Governing Relations Between the Peoples of the Taiwan Area and the Mainland Area or other laws or decrees. Regulations on the implementation thereof shall be prescribed by the Executive Yuan.
Article 19	Enforcement rules for this Act will be prescribed by the central competent authority.
Article 20	This Act will take effect as of the date of promulgation.

Appendix 2 Brief introductions of tourism attractions of Xiao-Liu-Qiu

Type	Attraction	Description
Natural attraction	Vase Rock	A coral formation looks like a vase, it is the landmark and the most famous tourism attraction.
	Chung-Au Beach	One of the main beaches which is mainly composed of fragments of coral reefs and shells.
	Lobster Cave	A destination has plenty of small platforms with potholes and ditches formed by being eroded by the sea.
	Houshi Fringing Reef	A coral formation stretches along the coast and eroded by the sea, with rough and uneven surfaces.
	Mouse Rock	A coral formation eroded by the sea, the rock looks like a mouse standing still.
	Guanyin Rock	One of the coral formations eroded by the sea, and it looks like Guanyin (Goddess of Mercy) stands on the coast protecting the islanders' fishing boats on the sea.
	Indian Rock	Another coral formation standing nearby with banyan trees on its top, and it looks like an Indian people.
	Climbing Tiger Rock	A coral formation standing nearby with Houshi Fringing Reef, and it looks like a tiger climbing on the rock.
	Black Dwarf Cave	One of the scenic spots which has a historical legend. There are two big clam fossils embedded in the rocky wall on a slope near the site. The two fossils are about one meter in diameter and hundreds of thousands years old and worth academic research.
	Geban Bay	The largest sand beach on the island, it is about 230 meters long. Tourists enjoy picking up shells and star sand or playing in the water, and enjoy watching a beautiful sunset.
	Wild Boar Ditch	One of the scenic spots which is composed of cliffs. The ditch is dangerous, deep, curved and about 400 meters long and has a variety of wild plants in it.

(Continued)

Appendix 2 Brief introductions of tourism attractions of Xiao-Liu-Qiu (continued)

Type	Attraction	Description
Natural attraction	Beauty Cave	One of the scenic spots which was built in 1075. The main attractions of this spot includes limestone walls, eroded cliffs, collapsed coral cliffs, sea terraces and sea caves.
	DuoZaiPing	It is about 1,600 meters long and 200 meters distant from the coast. It is the best place to watch fishes around coral reefs, sea cucumbers, sea urchins, starfish, hermit crabs and various fiddler crabs.
Artificial attraction	Sanfu port	It has a uniquely eroded coastal landform with a variety of features such as column-shaped coral formations, small caves and potholes. It is one of the common places for local people's gathering, particularly it can be seen that children enjoy swimming in the sea near the port in summer.
	Sanfu Ecological path	It is rich in geological sights, especially the potholes which can be seen only here. The potholes on the eroded platform are formed by being continuously eroded by the waves and salt, so people can see salt crystals around some of them.
	Baisha port	It is the main port for tourists to get in and out of Xiao-Liu-Qiu. It is the best place to enjoy a fascinating night view.
	Dafu Port	One of the main ports on the island. As a main parking area for many deep-sea fishing boats, it has a typical feature of fishery industry.
	Lingshan Temple	It is the most magnificent one of the temples on the island, is dedicated to Sakyamuni Buddha and the deities Linshuifuzen, Chenjinggu and Wufugiansui and attracts a continuous procession of worshippers.
	Sanmin Road	San-Min Road is the earliest street developed on Xiao-Liu-Qiu, and most old shops are located on this street.
	Restoration Pavilion	It was originally a landfill and it has been cleaned and turned into a conservation place by the District authority. This is in-line with the rise of environmental protectionism in the country.

(Continued)

Appendix 2 Brief introductions of tourism attractions of Xiao-Liu-Qiu (continued)

Type	Attraction	Description
Artificial attraction	White Lighthouse	It is 11 meters high from the bottom to the top and 88 meters high from sea level to its top. It is equipped with a flashing light which can reach objects 20 nautical miles distant. In addition, White Lighthouse is an international lighthouse guiding the ships traveling on the Taiwan Strait and the Bashi Channel.
	Sanlung Temple	The residents believed that the king boat sailed out of their lands and took away the plague. Most of the king boats sank in the sea while few of them floated onto foreign lands. People believe that they should build a temple for the king boat on the coast or put more offerings onto the king boat and put it back to the sea. Otherwise, disasters would happen to you.
	Biyun Temple	A temple was built in 1936 and named Guanyin Pavilion. As it is said the Buddha of the Biyun Temple would satisfy people's praying, the temple attracts many worshippers.
	Wetland park	An ecosystem pond which was built of coral stone and surrounded by a bamboo forest. It is enjoyable to listen the sound of babbling spring and see the stars in the night sky.
	HaiTzuKuo port	It stands in the middle of sightseeing route around Liuqiu, many tourists stop here to take a rest and watch the magnificent coastal coral reefs.
	Sunset Galley	It is one of the best places on the island to watch a spectacular sunset, and a good place for tourists to take a break and enjoy a sea breeze and a magnificent sea view.
	Sea View Pavilion	Occupying a commanding position, people can see the coastal cliffs, coastal fringing coral reefs and net-cage fish farming very well.
	Net cage	It is very suitable for net-cage fish farming because Black Tide flowing along both sides of the island. Currently, the fish farm becomes one of the tourist attractions on the island.

Source: Compiled by author based on the information from Liuqiu Township Office (2009).

Appendix 3 Questionnaire of on-site survey

【第一部份】遊客消費調查

※若您此次行程是旅行社套裝行程(請跳答表 A)　　自行規畫遊程(請跳答表 B)

【表 **A**】若您此次是參加旅行團套裝行程**…**

1. 請問您此次停留天數：□一日來回 □兩天一夜 □三天二夜 □四天三夜 □五天以上。

2. 請問您此次行程的團費為：_____元/人；如有額外自費部分，請提供各項消費總額：

交通	□已含在套裝行程費用，無自費部分。 船票(含人+車)：_____元/人；島上租車：_____元/車；島上公車_____元/人
住宿	□已含在套裝行程費用，無自費部分。 住宿：_____元/人；導覽解說：_____元/人
餐飲	□已含在套裝行程費用，無自費部分。 早餐：_____元；午餐：_____元；晚餐：_____元；零食/小吃/飲料：_____元
活動/娛樂	□已含在套裝行程費用，無自費部分。 景點門票：_____元/人；水上活動：_____元/人；其他：_____元/人
購物	□已含在套裝行程費用，無自費部分。 伴手禮/紀念品：_____元；油資：_____元/車(島上)；其他：_____元

【表 **B**】若您此次是自行規畫遊程**…**

1. 請問您此次停留天數：□一日來回 □兩天一夜 □三天二夜 □四天三夜 □五天以上。

2. 請提供您此次於小琉球消費的各項總金額：

交通	船票(含人+車)：_____元/人；島上租車：_____元/車；島上公車_____元/人
住宿	住宿：_____元/人；導覽解說：_____元/人
餐飲	早餐：_____元；午餐：_____元；晚餐：_____元；零食/小吃/飲料：_____元
活動/娛樂	景點門票：_____元/人；水上活動：_____元/人；其他：_____元/人
購物	伴手禮/紀念品：_____元；油資：_____元/車(島上)；其他：_____元

【第二部分】個人資訊

1. 性別：□男 □女。
2. 年紀：_____歲。
3. 教育程度：□國小 □國中 □高中職 □大學(專科) □研究所以上。
4. 個人平均月收入：□20,000 元以下 □20,001~30,000 元 □30,001~40,000 元 □40,001~50,000 元 □50,001~60,000 元 □60,001~70,000 元 □70,001 元以上。
5. 居住地：□北部(台北、桃園、新竹、苗栗) □中部(台中、彰化、南投、雲林) □南部(嘉義、台南、高雄、屏東) □東部及離島(宜蘭、花蓮、台東、澎湖、金門、連江縣)。
6. 職業別：□公務人員 □軍警人員 □教職人員 □經商 □農漁牧 □服務業 □自由業 □待業中 □退休人員 □家庭主婦 □學生 □其它_____。

【第四部分】旅遊型態量表

1.	請問您是第幾次到小琉球旅遊：□第一次　□第二次　□第三次　□第四次　□五次以上。
2.	請問您此次選擇何種交通工具至東港(搭船處)：□飛機 □高鐵 □台鐵 □客運 □小客車 □機車 □其它_____。
3.	請問您此次選擇何種交通船至小琉球：□公營船(欣泰號) □公營船(吉祥如意輪) □民營船(東信、眾益、飛馬、東昇)。
4.	請問您此次於小琉球島上活動的交通工具為：□出租汽車 □自家汽車□出租機車 □自家機車 □出租自行車 □自備自行車 □島上公車 □遊覽車、遊園車 □步行 □其他_____。
5.	請問您此次的住宿選擇：□ 沒有住宿 □飯店、旅館(名稱：_____) □民宿(名稱：_____) □露營(名稱：_____) □親朋/好友家　□其他(說明：_____)。
6.	請問您此次於小琉球從事哪些遊憩活動：(可複選) □自然風景欣賞(賞日落、海景、地質景觀) □生態體驗(如賞鳥、賞綠蠵龜、植物景觀) □動力船舶活動(如觀光玻璃船、香蕉船、水上摩托車) □游泳戲水 □浮潛 □重裝潛水 □潮間帶導覽 □騎自行車 □攝影 □其它_____。
7.	此次您曾造訪或參觀的有(可複選)： □美人洞 □山豬溝 □烏鬼洞 □龍蝦洞 □肚仔坪潮間帶 □杉福潮間帶　□中澳沙灘 □蛤板灣潮間帶 □厚石群礁 □杉福漁港 □大福漁港□海子口港 □白沙觀光港 □爬山虎 □紅番石 □觀音石 □老鼠石 □花瓶石 □白燈塔 □復育涼亭 □落日亭 □望海亭 □三民老街 □靈山寺 □三隆宮 □碧雲寺 □碧雲寺竹林生態溼地公園
8.	請問您此次造訪小琉球的整體滿意度：□非常滿意 □滿意 □普通 □不滿意 □非常不滿意。
9.	請問您目前或曾經是否為保育團體會員(如動物、自然資源、環境保育組織)：□是 □否。
10.	小琉球為一珊瑚礁島嶼，生態資源相當豐富，並設有綠蠵龜重要棲息環境及杉福潮間帶管制區，連同當地極富特色的漁村廟宇文化，均為小琉球觀光發展的重點。因此，為了小琉球發展生態觀光的永續考量前提下：
	□我願意，捐贈 _____元(單次/月)支持當地生態保育。 捐贈 _____元(單次/月)支持當地人文保育。 □我不願意捐贈任何費用做為當地保育基金，因為… _____

* 問卷結束，感謝您的耐心填答 *

Appendix 4 Leontief matrixes of the two-region input-output tables for 2006 and 2011

Leontief matrix of the two-region input-output table for 2006

		Xiao-liu-qiu														The rest of Taiwan													
		S1	S2	S3	S4	S5	S6	S7	S8*	S9*	S10*	S11*	S12	S13*	S14*	S1	S2	S3	S4	S5	S6	S7	S8*	S9*	S10*	S11*	S12	S13*	S14*
Xiao-liu-qiu	S1	1.14	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S2	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S3	0.03	0.05	1.07	0.00	0.00	0.00	0.05	0.01	0.04	0.03	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S4	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S5	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S6	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S7	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.01	0.01	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S8*	0.03	0.03	0.02	0.00	0.00	0.00	0.02	1.01	0.03	0.02	0.03	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S9*	0.01	0.02	0.01	0.00	0.00	0.00	0.01	0.01	1.16	0.02	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S10*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	1.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S11*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S12	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	1.01	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S13*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S14*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
The rest of Taiwan	S1	0.02	0.03	0.04	0.00	0.00	0.00	0.03	0.00	0.03	0.02	0.02	0.00	0.01	0.01	1.26	0.04	0.06	0.03	0.01	0.02	0.04	0.01	0.02	0.02	0.06	0.01	0.01	0.01
	S2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S3	1.02	1.42	2.14	0.00	0.00	0.00	1.36	0.23	1.34	0.98	0.85	0.23	0.44	0.37	1.00	1.38	3.23	1.77	0.37	0.86	1.68	0.24	1.05	0.95	0.90	0.31	0.55	0.33
	S4	0.03	0.06	0.07	0.00	0.00	0.00	0.04	0.02	0.05	0.12	0.06	0.01	0.02	0.05	0.03	0.06	0.08	1.15	0.06	0.04	0.04	0.02	0.04	0.11	0.06	0.02	0.02	0.04
	S5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.29	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
	S6	0.01	0.01	0.02	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.02	0.01	0.00	1.18	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.00
	S7	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.02	0.02	1.01	0.01	0.02	0.03	0.01	0.02	0.01	0.01
	S8*	0.09	0.12	0.16	0.00	0.00	0.00	0.11	0.02	0.11	0.09	0.08	0.02	0.04	0.04	0.18	0.21	0.22	0.13	0.04	0.12	0.20	1.04	0.15	0.15	0.16	0.05	0.09	0.06
	S9*	0.02	0.02	0.03	0.00	0.00	0.00	0.02	0.01	0.02	0.02	0.01	0.00	0.01	0.01	0.03	0.05	0.05	0.04	0.02	0.02	0.06	0.03	1.21	0.04	0.03	0.02	0.03	0.01
	S10*	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	1.01	0.00	0.01	0.01	0.01
	S11*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	1.00	0.01	0.00	0.01
	S12	0.10	0.13	0.19	0.00	0.00	0.00	0.15	0.13	0.19	0.31	0.13	0.11	0.12	0.21	0.12	0.14	0.22	0.16	0.10	0.14	0.21	0.18	0.17	0.38	0.16	1.18	0.19	0.24
	S13*	0.01	0.02	0.03	0.00	0.00	0.00	0.02	0.02	0.08	0.04	0.02	0.01	0.02	0.02	0.02	0.02	0.04	0.02	0.02	0.03	0.03	0.02	0.09	0.05	0.02	0.02	1.03	0.03
	S14*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01

Source: Calculated by author.

Leontief matrix of the two-region input-output table for 2011

		Xiao-liu-qiu														The rest of Taiwan													
		S1	S2	S3	S4	S5	S6	S7	S8*	S9*	S10*	S11*	S12	S13*	S14*	S1	S2	S3	S4	S5	S6	S7	S8*	S9*	S10*	S11*	S12	S13*	S14*
Xiao-liu-qiu	S1	1.08	0.01	0.01	-	-	-	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S2	0.00	1.05	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S3	0.02	0.03	1.04	-	-	-	0.04	0.00	0.02	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S4	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S5	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S6	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S7	0.00	0.00	0.00	-	-	-	1.00	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S8*	0.02	0.02	0.01	-	-	-	0.02	1.00	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S9*	0.01	0.03	0.01	-	-	-	0.04	0.03	1.25	0.02	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S10*	0.00	0.00	0.00	-	-	-	0.00	0.01	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S11*	0.00	0.00	0.00	-	-	-	0.00	0.01	0.01	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S12	0.00	0.00	0.00	-	-	-	0.00	0.01	0.00	0.01	0.00	1.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S13*	0.00	0.00	0.00	-	-	-	0.00	0.01	0.02	0.01	0.00	0.00	1.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S14*	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
The rest of Taiwan	S1	0.03	0.04	0.06	-	-	-	0.06	0.01	0.03	0.02	0.02	0.01	0.01	0.01	1.24	0.05	0.08	0.06	0.01	0.02	0.04	0.01	0.03	0.03	0.07	0.01	0.02	0.01
	S2	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S3	1.22	1.66	2.54	-	-	-	2.58	0.30	1.28	0.94	0.75	0.37	0.60	0.43	1.20	1.63	3.54	2.56	0.55	0.98	1.90	0.31	1.35	1.15	1.12	0.36	0.67	0.46
	S4	0.04	0.07	0.09	-	-	-	0.08	0.03	0.05	0.11	0.05	0.02	0.02	0.04	0.04	0.07	0.09	1.19	0.08	0.05	0.06	0.03	0.05	0.13	0.07	0.02	0.03	0.04
	S5	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.31	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
	S6	0.01	0.01	0.02	-	-	-	0.02	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.02	0.02	0.00	1.22	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00
	S7	0.01	0.01	0.01	-	-	-	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.01	0.02	0.02	1.01	0.01	0.02	0.03	0.01	0.02	0.01	0.01
	S8*	0.13	0.16	0.20	-	-	-	0.23	0.04	0.11	0.10	0.08	0.04	0.07	0.05	0.19	0.21	0.23	0.18	0.06	0.11	0.22	1.05	0.14	0.18	0.16	0.06	0.10	0.07
	S9*	0.02	0.02	0.03	-	-	-	0.04	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.03	0.05	0.05	0.04	0.02	0.04	0.05	0.03	1.23	0.04	0.02	0.02	0.03	0.02
	S10*	0.00	0.00	0.01	-	-	-	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	1.01	0.00	0.00	0.01	0.01
	S11*	0.00	0.00	0.01	-	-	-	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	1.01	0.01	0.01	0.01
	S12	0.08	0.09	0.13	-	-	-	0.18	0.12	0.12	0.23	0.07	0.14	0.12	0.14	0.09	0.10	0.14	0.13	0.10	0.12	0.16	0.15	0.15	0.35	0.12	1.16	0.16	0.19
	S13*	0.02	0.02	0.04	-	-	-	0.04	0.02	0.06	0.03	0.01	0.01	0.03	0.02	0.02	0.03	0.04	0.04	0.02	0.03	0.04	0.04	0.09	0.06	0.03	0.02	1.04	0.03
	S14*	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02

Source: Calculated by author.