



LUND UNIVERSITY

School of Economics and Management

**Master program in Economic Growth,  
Innovation and Spatial Dynamics**

## **Stone weirs on Chipei Island, Taiwan**

**Landesque capital and ecologically unequal exchange**

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*Abstract:* This thesis focuses on the development of stone weirs on Chipei Island. Chipei is one of the offshore islands of the Penghu archipelago in Taiwan. Stone weirs on Chipei Island have been in use for more than three centuries. The islanders developed a social structure based on building and utilizing stone weirs for fishing. Stone weirs are central to the legacies of every family on Chipei. Nowadays, most people still hold shares in stone weirs. The development of stone weirs on Chipei Island is examined from the perspective of historical-political ecology, more specifically drawing on the concepts of landesque capital and ecologically unequal exchange.

Three phases were carried out in the use of stone weirs, 1) pre-1940s, stone weir as landesque capital, when the KMT took over 2) from the end of the 1940s to the 1970s ecologically unequal exchange occurred in the stone weirs and Chipei Island 3) from post-1970s, tourist industry became the most important sector that stone weirs become a destination of tourists.

*Key words:* stone weir, Chipei Island, landesque capital, ecologically unequal exchange

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## Content

### Introduction

5

Purpose and the Scope 5

Research question 10

### Theoretical structure

11

Overview 11

Landesque capital 11

Ecologically Unequal Exchange 13

### **Methodology 14**

Interviewees 16

Limitation 21

### **Research reviews on stone weirs 21**

### Research location

24

Overview on Penghu archipelago and Chipei island 24

Physical geography of Penghu archipelago 28

Economy of Penghu archipelago 30

**Structural Change given 1970 as a benchmark.....30**

Chipei Island 32

## Stone weirs on Penghu archipelago and Chipei Island

33

What is a stone weir? 33

The geographical distribution of stone weirs 35

Development of stone weirs on Chipei 36

Development of stone weirs in shape 40

### **Stone weir as landesque capital 42**

Overview 42

How were stone weirs constructed? 43

How do fishermen catch fish in the stone weirs? 45

The social meaning of Stone weirs 48

Summary 48

### **Stone Weirs in Ecologically Unequal Exchange 50**

Overview 50

Ecological Footprint 52

Impact of technologically improved fishing measures 53

Application of Chemicals 55

Extraction of Coral reefs 56

Summary 57

### **Economic alternative 58**

Tourism boom 58

Negative consequence to ecology 59

**Damage to coral reefs and the underwater ecosystem....59**

**Threat to sea cucumbers and sea snails.....60**

**Offshore fishery became prosperous..... 63**

Summary 63

**Conclusion 64**

**Literature 66**

## **Appendix I**

**68**

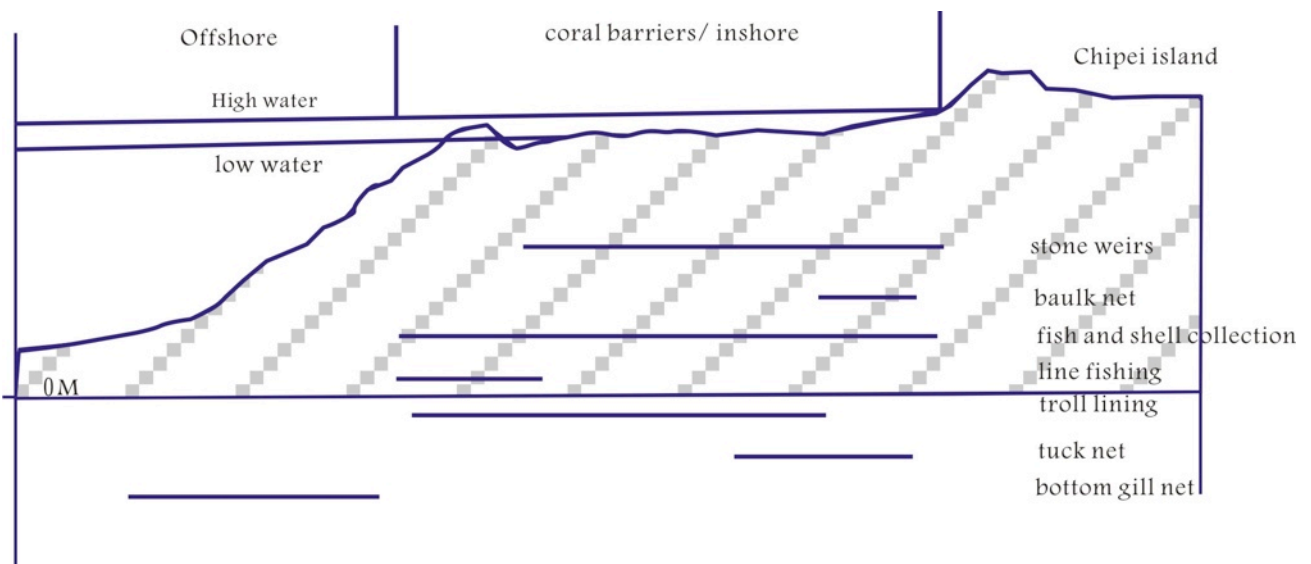
***Population in Chipei during 1688 to 2007 68***

## Introduction

### Purpose and the Scope

The following thesis is focusing on the development of stone weirs on the Chipei Island. Chipei is one of the offshore islands of Penghu archipelago governed by Taiwan. Stone weirs in Chipei Island has been using for more than three centuries. The islanders developed a social structure and a system when building stone weirs, it is a legacy of every family in Chipei as well. Nowadays, most people still hold the shares on stone weirs. Therefore, Chipei was selected as a research location as a case of the landesque capital and ecologically unequal exchange. The development of stone weirs on Chipei Island is in the following examined with the help of the historical-

Figure 1 Landscape and the corral barriers of the Chipei Island



Source: drawing based on Chen(1996)

political ecology as a theoretical framework. Further on landesque capital and ecologically unequal exchange were included as two main concepts.

Landesque capital is a product made by past human labours that people invest in the land for increasing the capacity and productivity, examples are terraces, ditches and irrigation system in agriculture. Thus, it is a concept related to human activities and their environment, "...labour to

be environmentally banked through stone walls, terraces, drainage and irrigation systems, raised fields, or other landscape infrastructure.”<sup>1</sup>

Unequal exchange, the second main concept means “ moving accumulated capital from politically weak regions to politically strong regions.”<sup>2</sup> “ Ecologically unequal exchange results in ecological impoverishment in some places, and material overload with high levels of pollution in other places, while the most ‘successful’ societies are able to ‘export’ these environmental consequences of their own consumption, and are left largely with problems related to transportation and waste

Table 1 The development of stone weirs

<b>Stone weirs as Landesque capital (~ end of 1940s)</b>	<b>Event</b>	<b>Participants</b>
First record of stone weirs was in 1771		
Before 1940s, Stone weirs was mainly use	Since the lack of equipments, only dried fish was exported to Tainan city in Taiwan island	Islanders
<hr/>		
<b>Ecologically Unequal Exchange (1940s~ 1980s)</b>		
New technologies and innovations introduced (non-sustainable fishery)	shipped fresh fish directly to Magong city in the main Penghu island  coral reefs extraction	Islanders Outsiders
<hr/>		
<b>New solutions for living (end of 1970s~ now)</b>		
Stone weirs for tourism		
New Dishes were innovated		
Even more fish were caught offshore		

Source: The table made by the result of the research

<sup>1</sup> Mats Widgren, (2007) Precolonial landesque capital: a global perspective

<sup>2</sup> Wallerstein, (2004) World-systems analysis: an introduction. Durham, Duke University Press

*Stone weirs on Chipei Island, Taiwan*

management.”<sup>3</sup> Thus, the extractive economies of the periphery would suffer from ecological degradation due to resources extraction or production activities while in the productive economies of the core regions, by accessing those resources, are commonly more successful societies. The distant markets only bear the environmental consequences.

The case of development of stone weirs in Chipei Island is a vivid example fitting in these concepts, where islanders exchange their harvests to Magong city, located in the main Penghu Island, and Taiwan Island. The case of Chipei is not only on the land, but it extends to the tidal flats, and the inshore area where human perform their economic activities for hundreds of year.

A cross-section of the landscape of Chipei and its surrounding coral barriers is given in figure 1. Different fishing methods were used depending on the landscape. The stone weirs, the protagonist of the paper is located in the inshore/ coral barriers. When the tide rises, the inshore area will be covered by water. Thus, we could imagine that the area of the island changes with the tide. In Chipei, when tide rise, the area is 3.0508 km<sup>2</sup> while the tide fall the area is 3.6430 km<sup>2</sup>. The shoreline is 9,937 m. Thus, the story of stone weirs on Chipei island will take place not merely on the Chipei island, but extends to the sea area (coral barriers/ inshore).

The development of the stone weirs on the above island can be divided into three time periods (see table 1) and are based on the conducted research which is later on described in more detail.

The first period, concerning the time period before the 1940s, is characterized by the use of stone weirs as a landesque capital for more than two hundred years. People lived ordinary lives and caught fish by using simple equipments. It was a sustainable fishing method which keeps fishery stock in a sustainable status. People invest in labour forces, capital and

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<sup>3</sup> Eric Clark & Huei-Min Tsai (2008) Ecologically unequal exchange, landesque capital and landscape change: on the historical-political ecology of Kinmen Island.

several years of time to build a stone weirs. Thus, stone weirs could be classified as landesque capital which people invest labour forces for improving productivity. The islanders traded dried fish during this first phase when stone weirs as landesque capital.

However, when innovations were introduced from 1940s onward, people found an easier way of fishing with new nets and modern technologies (such as using complicated nets or high-toxic inorganic compound). This second period is characterized by an over-exploitation of fishery resources for ecologically unequal exchange to Taiwan and Magong city from the end of 1940s. At the same time, they ignored the underwater ecosystem. Fishery's equilibrium was at risk since islanders could transport and sell large amount of fresh fish directly instead of exporting only dried fish. When machine boats were introduced, people could even sail to the offshore area to maximize their harvests. Fishing in the coastal or inshore stone weirs was not the sole option anymore. Meanwhile, coral reefs were extracted and exported to Japan with a considerably high demand. Stone weirs on Chipei started to face the environment load displacement. Unfortunately, the villagers didn't pay attention to the problem. They kept extracting as much as they could from the valuable resources near them in order to obtain maximum profits.

From 1980s to 1990s, fishing boats from mainland China started fishing within Taiwan's territorial water by using bottom drag nets. The bottom drag nets they used did irreversible destruction to underwater ecology. The activity damaged coral reefs and largely reduced the amount of creatures in the sea. Both mainland fishers and Chipei islanders exploited the resources in the offshore area, thus, it underwent a significant declination in fishery stocks. The general decline in fishery means that there were fewer fish swimming into the inshore or coastal areas. With the threatening decline in fishery stocks in stone weirs, Chipei people figured out other solutions to sustain their revenues and profits Ecologically unequal exchange and underwater degradation are the result of this exploitation. In



## **Historical-Political Ecology**

The analysis on the regional and global inequalities which results in the process of landscape change

### **Landesque capital**

“investment in land with an anticipated life well beyond the that of the present crop or crop cycle”

(Blaikie & Brookfield 1987)

### **Ecologically Unequal Exchange**

Material flows from politically and economically weak to strong regions, entailing ecological degradation in the weak region

Source: Drew by the author

fact, the problem became too severe to be neglected. In seek of a solution, the islanders started to develop tourism and further focused on offshore fishery.

In the third period tourist industry of Chipei boomed from the 1970s onwards. Structural change on the island and Penghu was obvious. The labours reallocated to the service sector from the agricultural sector. Before tourists came to Chipei, islanders made a living by fishing. Later, when tourist industries became more prosperous, the main income source shifted from fishery to tourism related sectors. Restaurants, hostels, water activities companies, local tours and tourists experiencing Chipei lifestyle mushroomed within one decade. Innovating new dishes in restaurants and walking in stone weirs were the new choice for tourists. Also, more and more fisheries were caught in offshore followed with the modern machineries and technologies and changed the previously established sustainable fishery. However, when the modern technologies went into the island, people applied the new methods which is easier and more efficient for exporting and extracting fisheries which stone weirs lose its old meaning but become an unsustainable fishery status. The stone weirs developed

followed this three steps, from 1) landesque capital to 2) ecologically unequal exchange. When they catch nothing from the stone weirs, they 3) sought other livelihoods such as tourism. However, it hurt the environment even harder from the first step to the third. Stone weirs were no more sustainable fishery in present days.

## **Research question**

Several researches in Taiwan had investigated on stone weirs on Chipei island in the fishery methods, tourist industries, construction, and comparative analysis with other villages. Despite that fact the role of stone weirs plays in Chipei historical-political ecology was rarely discussed. In this thesis the main question is how these two concepts, landesque capital and ecologically unequal exchange can be applied in the case of Chipei. Moreover, not like most of the case studies on landesque capital, it is commonly on the land rather than underwater. Stone weirs on Chipei is a special example that people built up stone weirs in tidal flats which would be covered underwater when tide rises. Only when tide falls, people go to stone weirs and started working, a sustainable method.

In this paper, three questions will be explored,

- How were stone weirs built up?
- What forces drove the change to a usage of stone weirs?
- What is the process and material flow between regions and between places?

## Theoretical structure

### Overview

The concept of this thesis is based on the perspective of Historical-political ecology which is a framework that analyzes the process of material flow, landscape change, and the political influence on the distribution of resources. The two main concepts are *landesque capital* and *ecologically unequal exchange*. They are all about the authority, so to say, power, which drive the material flows from one place to another.

*Landesque capital* is mainly about human and environment. People invest time, capital or labour power onto the land, for improving productivity. *Ecologically unequal exchange* occurred when core regions, productive in its economy import a large amount of raw material or resources from the weak region, extractive economies. Those weak regions, politically or economically, exported their resources to those “rich” places, or “core” regions. Land or ecological degradation takes place following with over-exploitation of resources. It leads land devaluated and decreased in capacity in periphery regions.

### Landesque capital

**Landesque capital** could be conceptualized as a carpet of investments covering the surface of the earth<sup>4</sup>.

*Landesque capital* was built upon the relationship between human and natural. *Landesque capital* as “ the capital-intensive human-made environments have a long history of human investment in land.”<sup>5</sup> This has two effects according to Widgren: on the one hand, *landesque capital* is a formation through which human beings improve the conditions of nature into a more secure and stable future which could increase surplus for future

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<sup>4</sup> Mats Widgren 2007, pre-colonial *landesque capital*

<sup>5</sup> Håkansson and Widgren (2007) *Labour and landscapes: the political economy of landesque capital in nineteenth century Tanganyika*

and on the other hand landesque capital can be developed into different forms in terms of geographical variation. People had different investment on landesque capital over time and space since there are different conditions in the land such as climate and soil.

Landesque capital was used as early as 1960s, which is coined by Amartya Sen. And he regards the concept as a production-oriented one. In his article on choice of agricultural techniques, he gave a definition on landesque capital and labouresque capital. He entails capital goods ” which replace labour(e.g., tractors) and those which replace land(e.g, fertilizer)”<sup>6</sup>, the former is labouresque capital and the latter refers to landesque capital .

Later on, Blaikie & Harold Brookfield developed the concept as ” investment in land with an anticipated life well beyond that of the present crop or crop cycle.”<sup>7</sup> The concept is no longer limited by the capital goods which replace land, but explains investments in land. In short, people invest in land for improving natural conditions.

“ the creation of landesque capital involves substantial ‘saving’ of labour and other inputs for future production” which is not only about the production but “includes a wide variety of properties of use.”<sup>8</sup> Thus, terraces, ditches, dams, wells, irrigation systems or stone walls are classified as landesque capital.

As Widgren<sup>9</sup> 2007 pointed out “ altering conditions for future sustainable use for the better, and not only for the worse, as is often the unproven assumption in much writing on environmental history.” which

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<sup>6</sup> Amartya Sen (1959) The choice of agriculture techniques in underdeveloped countries, *Economic Development and Culture Change*.

<sup>7</sup> Blaikie, P & Brookfield, H(1987), *Land degradation and society*

<sup>8</sup> Brookfield, H (2001) *Intensification and alternative approaches to agricultural change, Asia Pacific Viewpoint*

<sup>9</sup> Widgren, M.(2007) *Precolonial landesque capital: a global perspective*. In A Hornborg, J.R, Mcniell & J. Martinez-Alier (eds.) *Rethinking environmental history: world-system history and global environmental change*. Lanham, AltaMira Press. pp61-77

describes the concept. However, is landesque capital sustainable and increase the capacity for future? Or, does it also result in degradation?

## **Ecologically Unequal Exchange**

Unequal exchange is “moving accumulated capital from politically weak regions (the periphery) to politically strong regions (the core)”<sup>10</sup> . Ecologically unequal exchange is the concept departs from the value and the exchange of currencies and goods, focusing instead on material flows and its environmental consequence. It entails” moving the ecological footprint of politically and economically strong regions to politically and economically weak regions.”<sup>11</sup>

Hornborg<sup>12</sup> carried out the footprint in the cotton fields in the mid 19th century about British overseas trade. He asserts that in the beginning of British industrial revolution, few were imported from overseas. They were rather self-sufficient. Thus the more developed places such as Yorkshire and Lancashire tend to extract coal from the closest periphery. As textile industry developed, they not only had capital accumulation but technology development, they started to “extract” land and labour from somewhere else while they had serious problem with the shortage of land and labour in those former colonies or its neighbor countries. Which elaborated as “The rationale of machine technology is to (locally) save or liberate time and space, but crucially at the expense of time and space consumed elsewhere in the social system.”<sup>13</sup>

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<sup>10</sup> Wallerstein, I. (2004) *World-system analysis: an introduction*. Durham, Duke University Press

<sup>11</sup> Hornborg, A.(1998) *Towards an ecological theory of unequal exchange: articulating world system theory and ecological economics*, *Ecological Economics*

<sup>12</sup> Hornborg, A.(2006) *Footprints in the cotton fields: the industrial revolution as time-space appropriation and environmental load displacement*, *Ecological Economics*

<sup>13</sup> Hornborg, A.(2006) *Footprints in the cotton fields: the industrial revolution as time-space appropriation and environmental load displacement*, *Ecological Economics*

## Methodology

Several thesis and researches have been carried out evaluating the stone weir's usage, construction process, re-using as a tourist spot and apply as a heritage from UNESCO. By doing reviews on previous papers and researches, it will be the basic knowledge on the development of stone weirs and fishery industries.

Two main methods will be applied in this thesis which will be presented as follow.

First of all, secondary analysis, which will be used by collecting information and data from Penghu official websites, previous researches, administrative data, books, year books and journals.

Administrative data is a way to explain a phenomena or being the background knowledge of getting to know the island. Accessing to meteorology data from Central Weather Bureau to show the rainfall, temperature and wind speed which are the most important factors might influenced fishery industry and agriculture in Chipei. Moreover, referring to year books from 1951 to present days, the classification altered through time, thus, when we looked at the catalogs of fishery nets and harvests, it would be easy to identify the technology development and in how far did fishermen applied it. Yet, there are some limitations as well. Since Chipei is a small village in Penghu, it is difficult to obtain its data. Sometimes by avoiding high tax, people would report less harvest than reality. Or, fishing is part of living, it is hard to count how much they caught each time, they caught it only for self-sustaining. So the real harvest, and the exactly export are impossible to obtain.

As for coral reefs, administrative data is unavailable either. In the interviews, people said there were many coral reefs but they were mainly exported from private traders to Japan during 1960s and 70s. However, the

figures are not possible to get from the private traders. They won't tell the exactly numbers without a trust relationship. Thus, the description on coral reefs is mainly based on interviews.

Population growth is the main reason that people started to build stone weirs, thus population and GDP per capita are important. By accessing to the website of Taiwan Directorate-General of Budget, accounting and Statistics<sup>14</sup> and Penghu county government<sup>15</sup>, the data of population growth and GDP per capita of Penghu county or Chipei island could be downloaded from the website.

Further on the National Land Surveying and Mapping Center, Ministry of the Interior, aerial photogrammetry and urban planning surveying will be obtained which could distinguish the location of stone weirs and land use in the village.

Moreover, in the Chi-pei stone weir culture museum some information on stone weirs is collected. They not only found professional elderly to rebuild stone weir but also collected information and stories through oral history, made videos and published several books. So a lot of data and pictures are published. The guides of the museum are islanders, some of them hold share on stone weirs. They also know many people who had the experiences on using and building stone weirs, thus it is a good path get to know people in the village and do interviews.

Besides, "the structure plan of rural landscape management" which was directed by Executive Yuan<sup>16</sup> had been done a complete survey in 2006 which includes physical and human geographical information and several maps such as the distribution of stone weirs, geology maps of Penghu and

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<sup>14</sup> Taiwan Directorate-General of Budget, accounting and Statistics, <http://www.dgbas.gov.tw/mp.asp?mp=1> (2009, April)

<sup>15</sup> Penghu county government, <http://www.penghu.gov.tw/> (2009, April)

<sup>16</sup> which is the executive branch of government of Taiwan.

Penghu archipelago' land use, thus leading to the usage of the survey for the solution of the research questions.

Secondly, field work and interviews will be the main method used in this thesis for testing if theory matched with for the selected case.

Field trip took place during 22<sup>th</sup> to 27<sup>th</sup> of April in 2009. The author spent two days in Magong and rest of days were in Chipei Island fishing with people and doing interviews.

As for interviewees, several experts from different contexts and multiple disciplines were interviewed for a qualitative research. Those interviewees were selected since they are highly-sensitive on the changes on Chipei and had participated in the local events for several years. They are from different institutions and background. While the local interviewees were selected randomly in the village. Some are owner of restaurants, guest houses, or shops. The questions were related to the use of stone weirs, the harvest in it, and the use of machine fishing boats. By interviewing both experts and local people, it is easier to filter the truth and the development of fishery industry in Chipei island. It is a way to solve the problem when the data was impossible to obtain.

## **Interviewees**

*2009, April 23<sup>th</sup>. At Ke, Jin-Duo's place on Chipei Island.*

Lin Wen-zhen<sup>17</sup> is the stone weir expert who has been dedicating to study on stone weirs for seven years. Lin is a retired Literature and History high school teacher in Magong high school, who graduated from Dept. of Chinese, NTNU<sup>18</sup>. He is the pioneer of investigating stone weirs

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<sup>17</sup> Lin, Wen-zhen, the founder of "Chi-pei stone weir cultural museum", as well as a member in the Zai Feng cultural organization in Penghu which is mainly carried out big projects related to Penghu. He dedicated to preserve and start to collect information and data on stone weirs by grouping those elderly professional stone weir constructors and keep maintain stone weir from 2005

<sup>18</sup> NTNU, National Taiwan Normal University, which is a teacher school since 1940s.



and protecting the valuable data and equipments for catching fish or building stone weir. Several books had been published by collecting information from oral history, making video and published by council for cultural affairs in Penghu. In addition, he is a inhabitant in Penghu, thus he knows more about the way people living on the Penghu archipelago than others and he also observes the changes from time to time in Penghu.

*2009, April 27<sup>th</sup>. In a penda cafe in Magong.*

Hung, Kuo-Hsiung<sup>19</sup> is a retired biology high school teacher. After retirement, he is now work in NGOs<sup>2021</sup> in Penghu. Mr. Hung carried on the stone weirs in Penghu. He also put a big effort on illustrating the pollution and damage in tidal flats and the fishery industry in Penghu archipelago as well as the upheaval in fishery stocks due to exploited catching, using and technology development. In terms of stone weirs, he had spent three years collected the shareholders on stone weirs all over Penghu archipelago and marked the location on maps with the correct scale in “The Stone Tidal weir in the Penghu islands”<sup>22</sup>. By highly concerns with the environmental problems and ecosystem , he published several books<sup>23</sup> on the creatures in tidal flats in Penghu. As an islander in Penghu, he feels more than us, and write down the change through time.

*2009, April 24<sup>th</sup>. In National Penghu University, at the department of tourism and leisure management.*

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<sup>19</sup> He is a retired Science teacher in high school, graduated from Department of Biology, NTNU, in late 1960s

<sup>20</sup> Penghu Cai Feng cultural organization, which is a institution on protecting the treasure of history sites and trying to contain the ancient sites or building in a complete condition.

<sup>21</sup> Penghu Kung Sheng Zao institution was founded in August, 1990, which concern about environment issue , coral reefs, and birds.

<sup>22</sup> Hung, Kuo-Hsiung,(1999) “The Stone Tidal weir in the Penghu archipelago”, Bureau of Culture of Penghu County

<sup>23</sup> Hung, Kuo-Hsiung, (2008) “Tidal flat noting down Penghu”, Agriculture and fishing bureau of Penhu County another book published in the same year with same publisher, “Cherish the Heritage of the sea”

Yu, Xi- Liang is a professor at the Department of Tourism and Leisure Management of National Pengu University. Yu has devoted himself to work with Chipei stone weirs for three years and further on he knows a lot about the development of tourism on Chipei island and the overall development in Penghu archipelago. Also, he analyze the case of establishing casino in Penghu island which might have a big impact on the islanders' living and fishery industries (local culture and living style). He is familiar with the issues which is related to tourism.

*2009, April 22<sup>th</sup>, Phone interview*

Also a researcher that focuses on crab and coral reefs was introduced but the personal wish of not being named is respected here. But given his important position as well as his outstanding research in this area, his answers are still considered.

*During 2009, April 23<sup>th</sup> to 27<sup>th</sup> on Chipei Island*

Interviewing elderly inhabitants in the villages and those were held a share of stone weir. They are sensitive to the shift on the use of stone weir over time and the stories from their grandparents or they had experienced, additionally, some of them had experiences in building stone weirs in their childhood. Interviewing them is easier to construct a complete picture of development and transformation.

There is a common phenomena that in Chipei, most islanders had worked in Taiwan Island or immigrated to Taiwan for a long time (People around sixty to seventy years old, they mostly worked in Kaohsiung during the end of 1960s to 2000). When they retired from the company, they went back to their hometown and live like they used to before - fishing, diving or going to the stone weirs. However, since the fishery stocks declined, people

go back when the tidal was big, or around harvest days<sup>24</sup>. The youth and the age groups between 30 to 40 came back because they were fired or they couldn't afford the living costs in the big cities in Taiwan. Few people would like to stay and fish in their whole live. Not only researchers were interviewed, also local people have been interviewed to get a deep insight in the daily life. The following lists are the local interviewees.

*2009, April 24<sup>th</sup>, at Interviewees' house on Chipei Island*

Jang, Ching-Hai is the director-general in "Chipei Ai Shiang organization"<sup>25</sup> who had been observing the change in ecology for a decade since he retired from Kaohsiung<sup>26</sup>. Moreover, he had wrote many articles about Chipei Island according to what he is remembering about the stories told by his grandparents and villagers when he was a child. After the retirement, he went back to Chipei, and participated in the local events, and started to write down everything he knew from the old stories and combined these with his own observations and published it as a book - "The Stone weirs on Chipei island".

*2009, April 23<sup>th</sup>. At Ke, Jin-Duo's place on Chipei Island.*

Ke, Jin-Duo, born in 1954, is an islander in Chipei. Mr. Ke did not work in Kaohsiung, he has been fishing with his father and uncles since he was a child. He is proud of his talent for innovating new methods of fishing. Since he had always be around his father and uncles, he learnt a lot, and

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<sup>24</sup> It could be forecasted by lunar calendar. On first, second and fifteenth, sixteenth of each month the range of tidal will be the biggest. During low water period, the water retreat for a longer time and the tidal flat will be drier than another days. There will be more fishery in the stone weir or near tidal flats. People always go inshore and set their nets when high water period and wait until low water period for harvesting.

<sup>25</sup> The organization is a private local institution which care about the rights on Chipei. They also published some journals and brochures which in related to the history and development in Chipei island.

<sup>26</sup> Kaohsiung is the second biggest city in southern Taiwan where its economy mainly focus on heavy industries and logistic. There is the biggest harbor in Taiwan which play an important role in East Asia.

knew many stories. Thus, he provides many information about the change through time.

*2009, April 25th, In the northeast coast of Chipei Island.*

Ke, Jin-Kui is about seventy years old, a islander who retired from Kaohsiung. He moved back to Chipei and devotes himself to the local culture and history for several years.

Owners of sea food restaurant who had ran their restaurant and guest house for more than ten years, and are the pioneers of tourist industry were further on also interviewed. The sea food served in the restaurants were mostly caught by themselves. However, if we told them that we are doing a investigation on stone weirs, they would say something positive, or avoid saying the truth. Thus, when interviewing them, we only chatted and talked. They would show off everything they are proud of, such as how do they catch lobsters, fishing on the ships.

*2009, April 23th, In Agriculture and fishing bureau of Penghu County in Magong.*

Mr Wang is responsible for giving advises and assisting fishermen about the new knowledge and newly applied regulations in Agriculture and fishing bureau of Penhu County. He gave the information about the fishery market and also introduced the major of Baisha Township, Mr. Hsu, to the author. Mr. Hsu gave a brief introduction about the fishery industry in Baisha, however, he informed that there are some difficulties on the fishery harvest in every single villages, thus there only the aggregate estimated figure were obtainable.

In the trip, the author also caught fish in stone weirs with several fishermen for a week, experiencing the ancient wisdom and the way they live. The week we visited the island were the harvest days and the largest tides, thus people fishing and diving everyday. When tides fall, they walked from Chipei island to another island for picking sea snails and catching fish.

By learning the way they fish and experiencing the way islanders live, it is easier to imagine the ancient time and how Chipei shifts from time to time.

## **Limitation**

This paper was constrained by some factors. First of all, the historical data was gone, it is hardly completely collected. Secondly, the issues about the over-exploitation of the resources, such as the methods of fishing, the coral reefs extraction and harvest are sensitive topics for islanders, it takes time to get the information. Thirdly, some papers carried out research on stone weirs, but rarely on the ecological and environmental change in Chipei, thus the data collection was mainly from interviews. Finally, the administrative data is not complete, some of them are the estimated figures as a whole township rather than a village. This leads to the fact that interviews become the main source of this paper and are seen as the most adequate method to solve the previously formulated research question. In this field, there is a limitation on the research which is the lack of the discipline on biology. It could constrain the explanation on the ecological degradation and the food net under water.

## **Research reviews on stone weirs**

In terms of previous researches, there are some useful papers in Chinese.

Huang<sup>27</sup>(2007) put a lot of effort on finding out how stone weirs were constructed by using interviews and field work as leading methods. Huang discussed the development of stone weir through time by giving sufficient background of Chipei island. Moreover, Huang pointed out how those elderly people applied material resource and their experiences to construction which is always influenced by its natural and social environment. It provides useful information about attaining the resources for stone weir, and the process of constructing stone weir. By obtaining those

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<sup>27</sup> Huang, Sheng-Min, 2007, investigation into dry-stone-wall construction experience applies in Penghu chipei islet

information, I could examine the formation of landscape capital and ecologically unequal exchange.

Lu<sup>28</sup>(1998) used in his paper the “Social Mechanisms of Environment Degradation in Peripheral Areas-A Case Study of Coastal Landscape Degradation in Peng-Hu Taiwan” the perspective of political ecology to examine the factors of land degradation in the Penghu coastal area. In the researches of political ecology, they argued land degradation is due to poverty on the islands. However, Lu argued that the theory could not fully explained the reason why the coastal area was destroyed. Lu took the local politics and culture into account and explains the processes and factors attributed to coastal landscape. It is a good example on exploring the case study in the island where there always have been so many complex factors affecting the island.

Yan<sup>29</sup>(1989) in his“Case Study on Space Structure of Fishery in Chi-pei and Chi-kan Village” based on the geography theory man-land relationship carried out in different ways in the two villages. Yan made many interviews with elderly people who have sufficient experiences fishing in stone weir. She also collected valuable information about fishery surplus and how stone weir used to be. By comparing the fishery methods and the development of two villages in Bai sha township, she made a very complete picture on the fishery industry in these two villages. Her paper provides complete information on the development of nets thus it is a good source to examine the application of new technology and ecologically unequal exchange.

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<sup>28</sup> Lu, Jing-Chein, (1998), social mechanisms of environment degradation in peripheral area-A case study of coastal landscape degradation in Peng-Hu Taiwan

<sup>29</sup> Yan, Xiu-Ling, (1989), Case study on space structure of fishery in Chi-pei and Chi-kan village

Chen & Lin<sup>30</sup>(1996,2002) carried on how ancient islanders work on stone weirs and how do people harvest in the stone weirs. Also the development of stone weirs, and its distribution all over the world, there are several countries such as Australia, Japan, Korea, Philippine and Taiwan were catching fish by means of stone weir which was mentioned in papers and history. Some of them remain in coast in some countries, yet, most of them were abandoned for years. Moreover, fishery industry is the main sector in Penghu archipelago, however, it changes through time. The papers made a complete description on it.

Chen<sup>31</sup>(1991, 1992, 1996) takes a closer look in his research on the fishery industry in Penghu archipelago. Two of them were about stone weirs. Chen made a delicate illustration on the development and the construction of stone weirs. He is the pioneer of investigating stone weirs in Penghu and two specific villages (which had common characters and share a fishery area, Chipei and Chikan village). The paper analyzed the development of technology innovations and equipment applied in fishing. The traditional way was changed with the introduction of new equipments. The progress was almost the same throughout those selected villages, or those villages which mainly use stone weirs as the tool of fishing. With geography discipline as his context, these papers were presented with a geographical perspective, the interaction of human and their environment. In terms of historical perspective, the author had written a clear timeline and pattern on fishery in selected islands.

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<sup>30</sup> Chen, Hsien-ming & Lin, Wen-zhen, (2002), Culture of agriculture and fishery in Penghu, Bureau of culture of penghu county

<sup>31</sup> Chen, Hsien-Ming, (1996), Investigation into the stone tidal weirs in the penghu archipelago, geographical research No 25

Chen, Hsien-Ming, (1992), An ecological approach to the fishing community of a coral island: Study of Niao Yu, the Penghu Islands, Geographical Research, No18

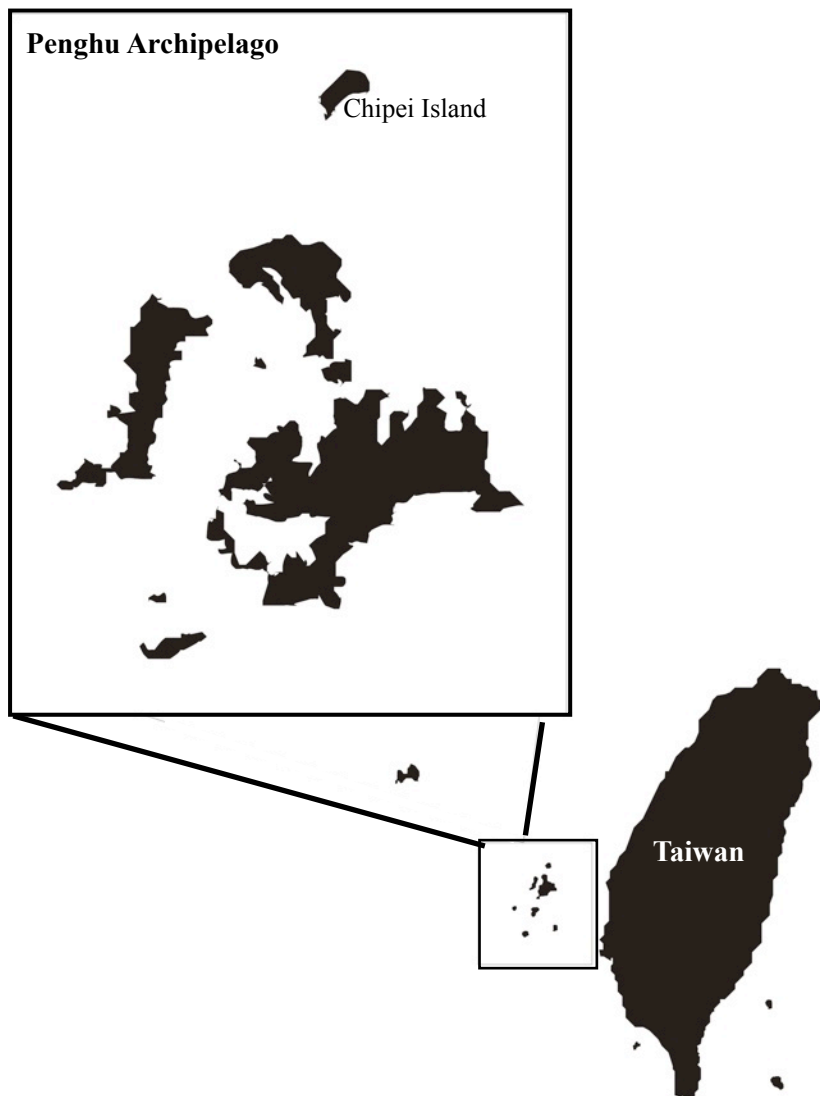
Chen, Hsien-Ming, (1991), Territorial regulation of seaweed gathering in the uninhabited islands of Northern Penghu, Geographical Research, No17.

## Research location

### Overview on Penghu archipelago and Chipei island

Chipei is one of the inhabitable islands in the Penghu archipelago. Before introducing Chipei, it is better to know something about Penghu archipelago. The Penghu archipelago is offshore islands of Taiwan Island, which is surrounded by the Taiwan strait <sup>32</sup>(see Figure 2). In terms of the administration division on Penghu county, there are one city and five

Figure 2 The map of Taiwan and Penghu archipelago



Source: Drew by the author, based on the aericl photogrammetry of Taiwan

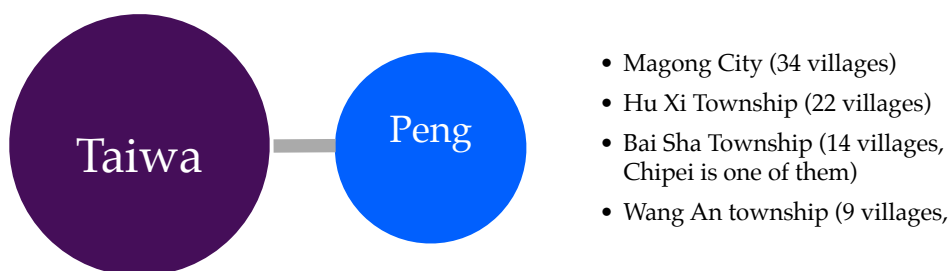
<sup>32</sup> Taiwan Strait is in the southeast of China, and west of Taiwan. Which connect to South sea and China east sea.



*Stone weirs on Chipei Island, Taiwan*

townships. And several villages under township. Chipei Island is as one out of fourteen villages in Bai sha township ( see Figure 3).

Figure 3 Penghu county



Source: drawing based on the data of Penghu county government

The majority of population worked as fishermen before 1970s. However, due to the economy boom on Taiwan Island during the 1970s, and the downturn of fishery stock, large amount of Penghu islanders migrated to Taiwan Island and abandoned the way they had been living for centuries.

The economy boom and the construction of a cross-island bridge<sup>33</sup> connected two of the main islands in 1970s. Tourism industries were set up at that time. Penghu gradually became a tourist destination where people enjoy the beach and water activities. This led then to a change of the industry structure from primary industries to service industries.

A tourism industry report, presented by Penghu County Government, made an analysis on the total productivity by shift share from 1981-1996<sup>34</sup>. As table 2, 3, 4 elaborate, fishery sector had a negative growth rates in industrial growth. While business, transportation and service sectors showed an upward trend which could be understood as that Penghu in the

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<sup>33</sup> The bridge was named “ Penghu kua hai da ciao”. When it was completed in 1970, it was a East Asia first deep sea bridge. It is 2494 meter which connect BaiSha island and Xiyu island.

<sup>34</sup> [http://www.phhg.gov.tw/CHINESE/DEPART/scheme/develop/part/05/05\\_2-2.htm](http://www.phhg.gov.tw/CHINESE/DEPART/scheme/develop/part/05/05_2-2.htm). (2009 April, 13<sup>th</sup>) The table was translated into English as table 2,3,4

Table 2 Total productivity by shify share (1981-1986)

		1981-1986			
		National growth	Industrial growth	Regional growth	Total Growth
Total		27.82	-5.59	-15	7.24
Primary Industries	Agriculture and farming	2.69	-2.04	-1.91	-1.26
	Fishery	14.18	-1.6	-11.88	0.69
Mining		0.13	-0.13	0.04	0.04
Manufacture		1.82	0.27	-1.52	0.57
Construction		2.96	-2.25	1.18	1.88
Water, Electricity supply		0	0	0.02	0.02
Wholesale and retail		3.54	-0.1	-1.45	1.99
Transportation, Logistic		0.9	0.3	-0.49	0.7
Financial and insurance					
Business Service					
Social and Personal Service					

Table 3 Total productivity by shify share (1986-1991)

		1986-1991			
		National growth	Industrial growth	Regional growth	Total Growth
Total		37.4	0.31	-17.53	20.18
Primary Industries	Agriculture and farming	2.33	-1.82	-1.47	1.36
	Fishery	17.09	-14.24	-5.72	14.22
Mining		0.18	-0.12	0.7	0.76
Manufacture		2.51	-0.69	-0.45	1.37
Construction		0.02	-0.02	0.01	0.01
Water, Electricity supply		4.7	7.47	-4.16	8.01
Wholesale and retail		5.46	4	-3.54	5.92
Transportation, Logistic		1.51	0.2	-0.71	1
Financial and insurance		1.04	1.53	-1.48	1.08
Business Service		0.05	0.13	0.61	0.78
Social and Personal Service		2.5	4	-1.44	5.06

Table 4 Total productivity by shify share (1991-1996)

		1991-1996			
		National growth	Industrial growth	Regional growth	Total Growth
Total		47.47	-5.08	-10.78	31.61
Primary Industries	Agriculture and farming	-0.6	-0.46	0.3	
	Fishery	-10.4	-4.83	-1	
Mining		0.64	-0.69	-0.08	-0.12
Manufacture		3.22	-0.8	-2.63	-0.22
Construction		9.4	-2.84	4.27	10.83
Water, Electricity supply		0.02	0.01	-0.06	-0.03
Wholesale and retail		8.84	4.86	-6.61	7.1
Transportation, Logistic		2.04	0.06	0.3	2.4
Financial and insurance		1.67	1.18	1.65	4.5
Business Service		0.56	0.63	-0.48	0.7
Social and Personal Service		5.49	3.51	-1.84	7.15

1980s had a significant structural change<sup>35</sup>, in terms of labour reallocation

<sup>35</sup> "Structural change" is a concept that the country or a region that had went through the transformation from one sector to another, in terms of labour force, it could results from new labour force introduced into the sector or reallocation of employees. On the other hand, new technology and FDI might be another factor of the consequence of structural change. By this process of transforming, a new industry could be developed or become prosperous. During 1970s, Taiwan island had experienced structural change since the shift from heavy industries to high-tech industries. It resulted in the economy boom in 1970s.

Figure 4 1971-2008 average precipitation (mm)

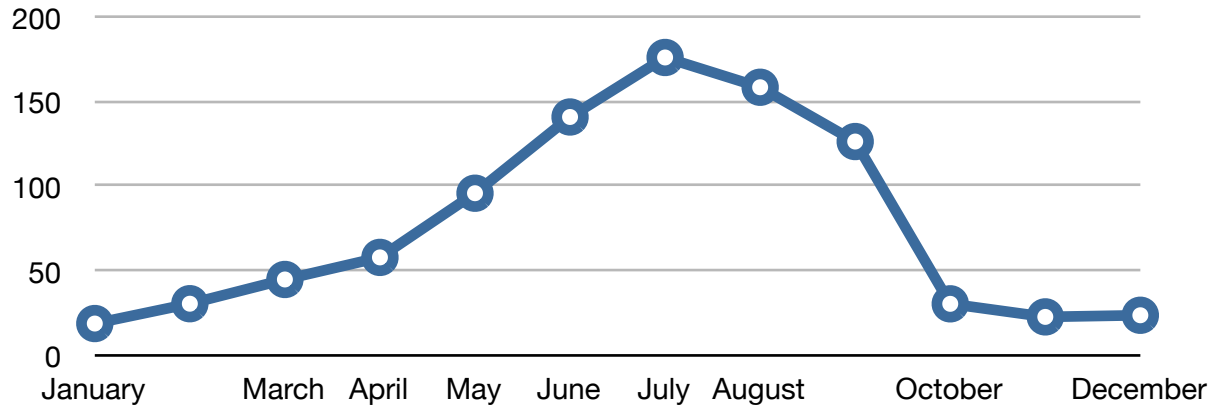


Table 5 1971-2008 average precipitation in Penghu archipelago (mm)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
19.61	31.32	45.63	58.66	96.55	141.56	176.69	159.11	127.06	31.25	23.54	24.5

Figure 5 1971-2008 average temperature (°C)

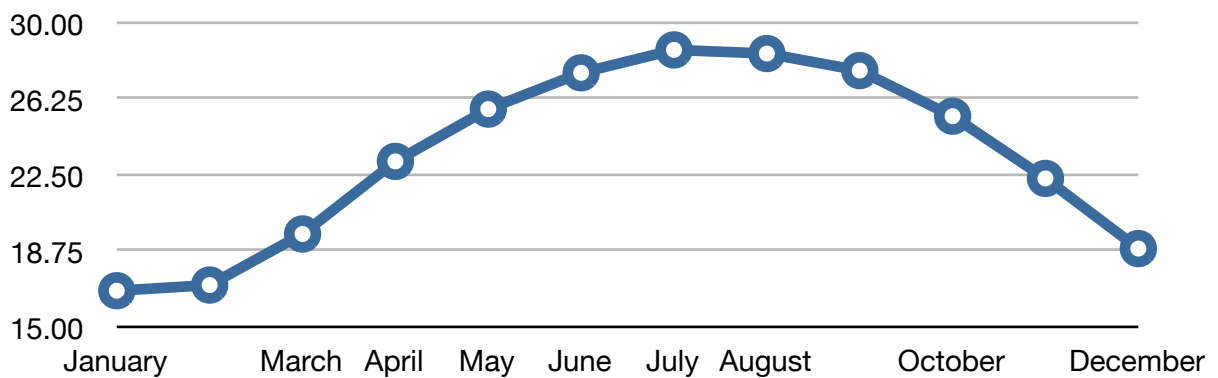


Table 6 1971-2008 average temperature in Penghu (°C)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
16.85	17.13	19.65	23.23	25.81	27.6	28.73	28.55	27.71	25.46	22.39	18.93

Figure 4, 5 and table 5, 6 were calculated by the author based on the data from Central weather bureau

from fishery or primary industry to service sector and the productivity shift from sector to sector.

## **Physical geography of Penghu archipelago**

Penghu archipelago is a county of Taiwan located in the southeast corner of Taiwan Strait<sup>36</sup>, composed of ninety large and small islands. Most of them are uninhabitable, only twenty of them are inhabitable.

The size of Penghu archipelago is approximately 127 km<sup>2</sup> with 94000 inhabitants having a GDP per capita in 2007 of 24803.35 USD. Geographically speaking, Penghu is located between Taiwan and Mainland China, it gains its advantage with dock and harbor This why. Penghu has been a military key post and a very important stepping stone for migration over timeline. Further on is it one of the earliest developed areas in Taiwan regarding its history, culture and relics.

Regarding the climate, Penghu is classified as monsoon and trade-wind costal which has abundant rainfall in summer due to the migration of ITCZ<sup>37</sup>. The figure 4 and 5 show the average precipitation and temperature from 1971 to 2008. During summer, monsoon climate is characterized by rainfall concentrated. During winter, powerful northeast monsoon was the reason that people could not cultivate or grow plants. Taken September, 2008 as an example, the maxium wind speed was 14.6 m/s<sup>38</sup>. The wind erosion was strong thus the soil-cap was eroded badly. This type of climate influences the way people live as well as their working lives.

As far as geology was concerned, the Penghu archipelago were formed by volcanic activity. In the Miocene epoch, the volcano erupted and formed basalt based islands. The landforms are simple and flat with marine platforms as a common characteristic. The highest mountain, so to speak, is 70m on an island in the south of Penghu archipelago while the highest in Chipei is 18m. After the Miocene epoch, only the Holocene epoch can be

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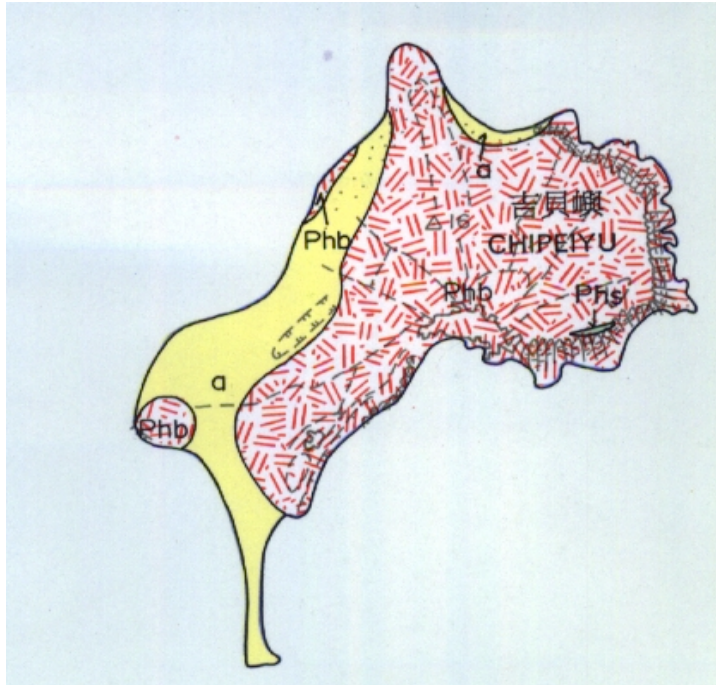
<sup>36</sup> Taiwan Strait is in the southeast of China, and west of Taiwan. Which connect to South sea and China east sea.

<sup>37</sup> ITCZ stands for "Intertropical convergence zone" which migrate from south to north during high-sun season.

<sup>38</sup> Central weather bureau, <http://www.cwb.gov.tw/V6/index.htm>(2009, April 15<sup>th</sup>)

found which is a layer formed as sediment layer by sand mud, boulders, and detrital. Geologist could not find the other layer in between these two layers.

Figure 6 Geology map of Chipei



**Miocene Epoch**

- Phb** basalt
- Pht** sandstone, mudstone, thin-bedded sandstone and mudstone in alternation
- Pfs** Volcanic tuff-breccia

**Holocene**

- a** sand mud, boulders, and detrital

Source: The geological map of Taiwan (1:50000)  
- Penghu Islands

The geology map of Chipei (see figure 6) shows that the land is mostly covered by basalt. Coral reefs fringe the Chipei island where Coral reefs are exposed to a low tide and covered by water during high tide. The landforms we can see are tidal flats, bar, basalt cliff and spit.

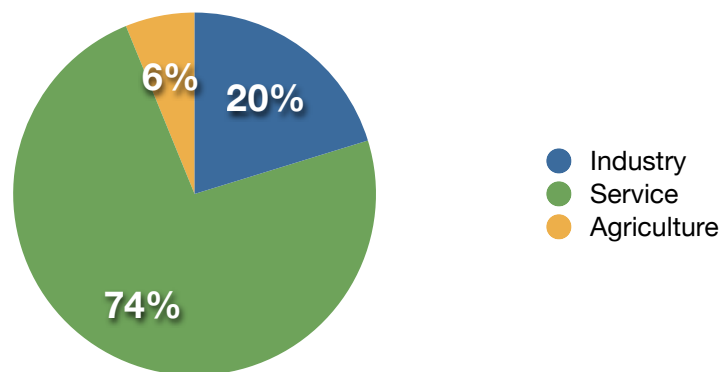
In the winter the strong northeast monsoon takes place, it leads to the cultivation difficulty and lack of plants and vegetation. With the lack of vegetation and the flat of Penghu, the lands had a very low ability to resist strong wind erosion. In terms of cultivation difficulty, both climate and the landscape were involved. Rainfalls concentrated in summer is the characteristic of Penghu, thus it constrains the cultivation only in the summer. Sweet potato and peanut are the farm crop but also some economic crops, such as papaya, pumpkin and vegetables are planted.

In the past, the main source of income on most islands in Penghu archipelago is fishing in tidal flats, while in present days, some people still do so. Generally speaking, the area when tide falls, is 164 km<sup>2</sup> in Penghu archipelago which is 1.3 times more than during the high water period. By having a large tidal flats and sufficient fish, sea snails and aquatic life, tidal flats is the most important area that people depend on in everyday life.

## Economy of Penghu archipelago

### *Structural Change given 1970 as a benchmark*

Figure 7 2007 Employment in Penghu County- Occupation



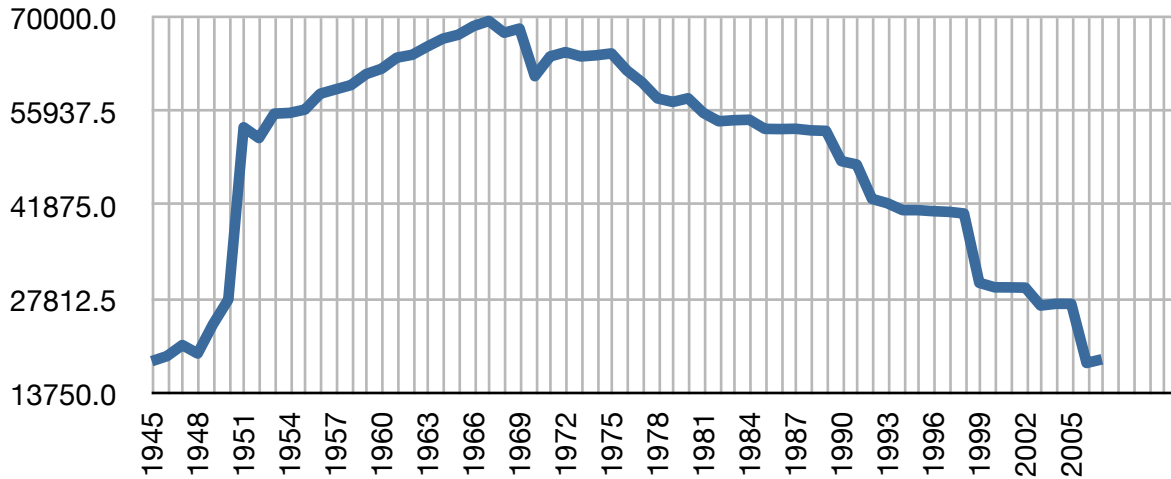
Source: drawing based on the data from Penghu county year book, 2007

In the employment distribution 74% of the employees are employed in the service sector. Since Penghu archipelago is an offshore island of Taiwan surrounded by the sea, compared to Taiwan island, there are less heavy industries or factories. Referring to Penghu county year book in 2007, see figure 7, the service sector accounts for 74% in aggregate, while 3% of labour work as official servant were grouped into service sector as well. The industrial structure had been slowly shifted from first sector to service sector during 1970s<sup>39</sup>.

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<sup>39</sup> Refer to Penghu year book from 1930s, to 2007s, there were no figures on industrial sector and service sector. They only showed the fishery population, household, fishery harvest, and the value of the whole fishery stocks. Until 1990s, they presented the percentage of employment in three sectors, however, fishery and the first sector was the majority, which accounts for 40.4% of employment, while public and official servants represented 24.9%, service sector had 18%, 16.7% of employment was in industries and manufacture.

Figure 8 Population in fishery industry from 1945 to 2007



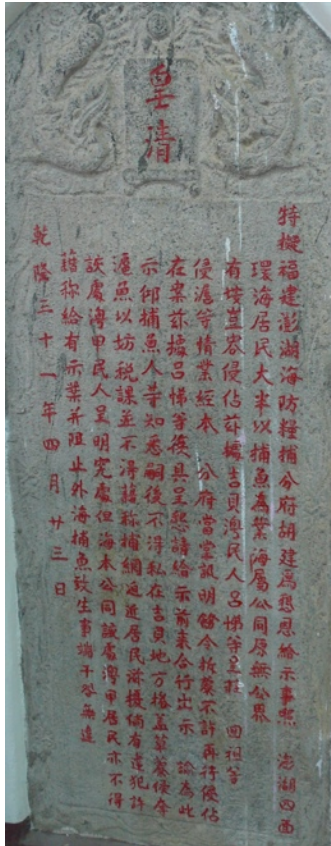
Source: The figure was drawn by the author, by collecting data from year books (1950-2007)

In the agriculture sector, regards to agriculture, fishery and forestry. Fishery was the largest part among them from 1940s. However, from 1970 onward to 2007, the amount of fishermen decreased by 80%, from about 70000 to around 14000. It had similar pattern in Chipei island. According to the line chart (figure 8), the amount of the fishermen shows an upward trend since 1945. 1965 marks the peak of the numbers but also a turning point—since 1965 a downward trend until the present days is observable.

The structural change in Penghu could be understood as a result of the economy boom in Taiwan that took place in the 1960s and 1970s. The increase in demand of labours became a pull force in Taiwan Island and led many islanders to immigrate to Taiwan Island and to abandon their traditional life. Moreover, as the application of new technologies started, the catching of fish is much more easier and efficient. This led to the establishment of other industries, namely the Tourist Industry then became the main sector within the Penghu economy. This confronted Penghu with a structural change during the 1970s and a shifting from the primary sector to the service sector as the predominant sector.

## Chipei Island

Figure 9 The stone stela approved Chipei fishery right



Source: The picture took by the author during field trip

Chipei was the first island exploited by Chinese people seven hundred years ago. Its history was earlier than Taiwan and other Penghu archipelago. Geographically speaking, Chipei is closer to the coastal of China, besides, there are two main fishery spots around Chipei island. Chinese would catch fish nearby and took a rest on Chipei in the past. Until the 17th century, some immigrants started to settle down on Chipei island. Then in the 18 century, the Qing<sup>40</sup> empire gave a stela (Figure 9) which approved Chipei as its own fishery area where no others could catch fish within. The fishery industry has been developing for more than four hundred years.

The area of Chi-pei is only 3.1 km<sup>2</sup>, which accounts for 104 out of 550 stone weirs in Penghu archipelago. As for the distribution and the numbers of stone weirs in the world, there are some six hundred stone weirs around the globe.

Most of them are located on Japan, Okinawa (Japan), and some pacific islands. However, stone weirs in Japan and other countries were mostly abandoned or destroyed through time. Yet, some islanders on Chi-pei are still using stone weirs until the present day and also found the new value on stone weirs for the present.

The islanders on Chipei are using stone weirs for more than 250 years now. They built the stone weirs which remained until the present days. Moreover, they developed a social structure and a system when building

<sup>40</sup> The last ruling dynasty in China. The empire had been governing from 1644-1912.

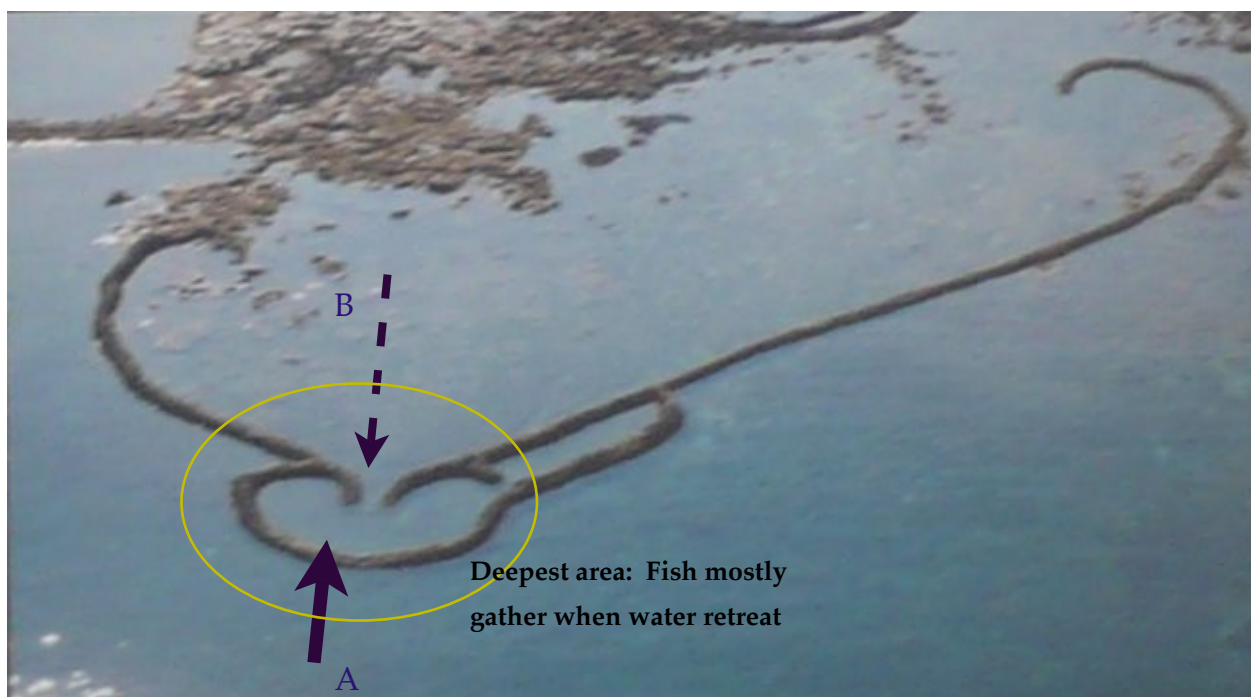


*Stone weirs on Chipei Island, Taiwan*  
stone weirs, it is a legacy of family in Chipei as well. Most people still hold the shares on stone weirs. Therefore, Chipei was selected as a research location. And the case of the landesque capital and ecologically unequal exchange.

## Stone weirs on Penghu archipelago and Chipei Island

### What is a stone weir?

Figure 10 Picture of stone weir when water was retreating



A: direction of current

B: direction of retreat

Source: The picture took in Chi-pei stone weir culture museum. Edited by the author.

In Chipei, the area of the island changes with the tides. When the tide rises, the area is 3.0508 km<sup>2</sup> whereas when the tide falls the area is 3.6430 km<sup>2</sup>. The shoreline is 9,937m. By having these environmental factors, the economic activities on the island are taking place in the tidal flats or the

fringing reefs. Moreover, when the tide falls, islanders can walk from one island to another for fishing or picking sea snails. Thus, tidal flat is the most important place for living before machinery boats and new technologies were introduced. The question that is important to answer for the solution of our research is how the islanders efficiently catch the fish along the coastal or in the inshore area and will be answered further on.

Stone weirs were introduced at least 250 years ago which improve the productivity in coastal area. However, no one knows the exactly time when stone weir were first used. Stone weirs is a traditional way of fishing built by limestone and basalt stone in tidal flats. It has a semi-circular wall of stacked-up stone. “ it is a man-made replica of the natural hollow found in a rock or coral reef which fill itself with water during ebb-tide.”<sup>41</sup>. The function is similar to a natural fish trap.

Catching fish by stone weirs uses the principal of tidal currents. When tide rises, the stone weir is covered by water, so that the fishes can swim into the stone weirs with tidal currents and move from deep sea to shore. When tide falls the bank of stone weir is higher than the water level that fish could not swim out of stone weir. Some deeper places in stone weirs would become small ponds that fish gather in it. The design of a stone weir is semi-circular because the eye of fish could only see straight line, thus leading to no possibility for the fish to swim out of the stone weirs. When the tide then falls, fishermen are going to their stone weir to harvest.

There are four factors that should be concerned when building a stone weir. First of all, the wave and wind should be strong enough and the area of tidal flats should be large, moreover, basalt and limestone are accessible. Finally, the tidal range should be large.

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<sup>41</sup> Chen, H-M (1996) Investigation into the stone tidal weirs in the Penghu Islands, Geographical Research No25

## **The geographical distribution of stone weirs**

There are around six hundred stone weirs all over the world, placed on some pacific islands Japan, Korea, Philippine, Australia and Taiwan(both found in Taiwan Island and Penghu archipelago). The history of stone weirs in Chipei is impossible to trace back, the earliest that we could find is a book about Penghu which was published in 18 century during Qing dynasty.

As for the numbers of stone weirs, some twenty stone weirs were recorded in 1720. In 1957, there were 192 registered stone weirs and the number rose in to 1999 up to more than 574 stone weirs to be found in Penghu. Among the Penghu archipelago, Chipei accounts for 104 stone weirs<sup>42</sup> in a area of 3.1 km<sup>2</sup>, which has the highest density of stone weirs around the world.

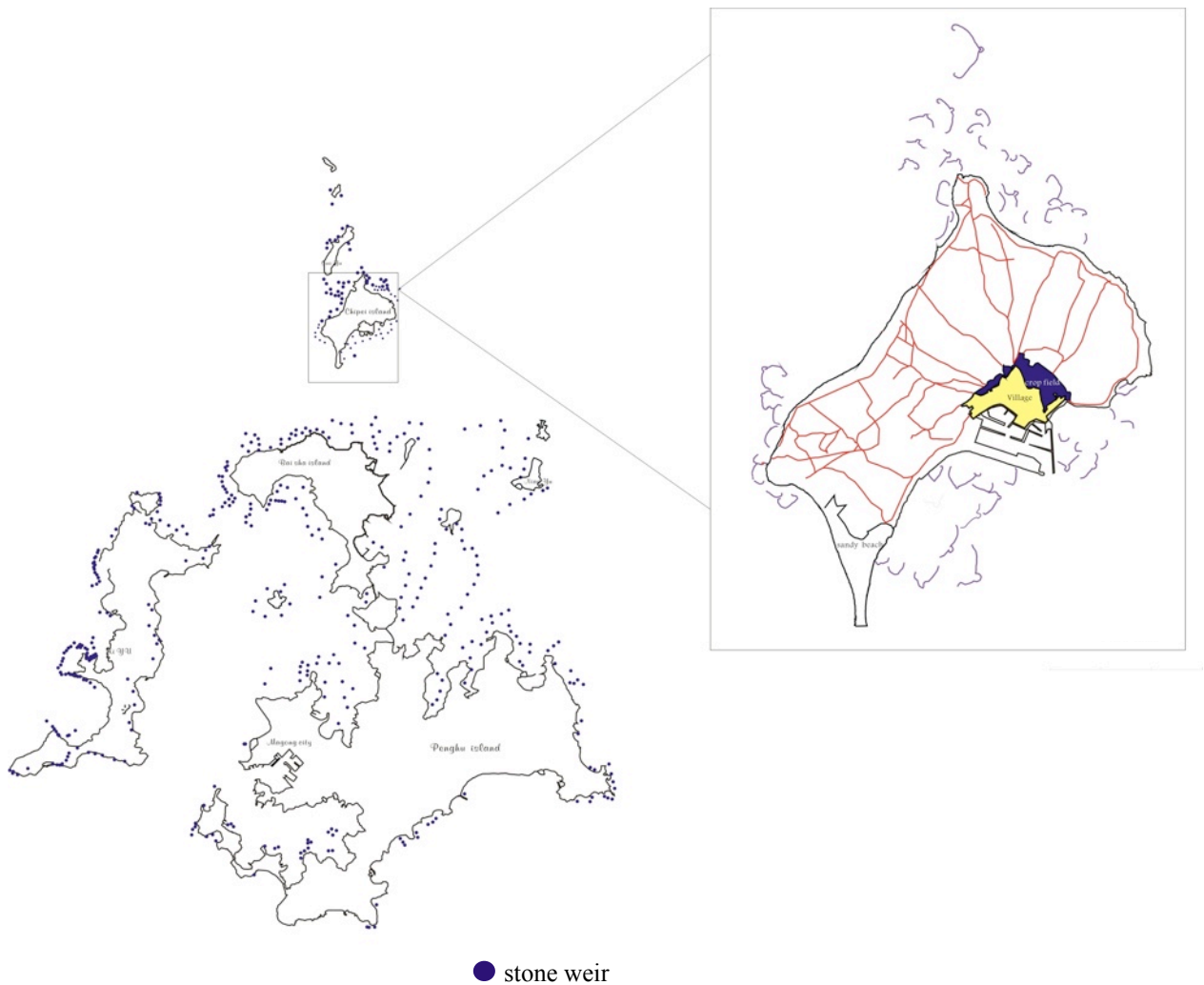
Penghu archipelago is common in its geology and undersea environment, thus we could find most of the islands had stone weirs as figure 11 shows. Most islands were surrounded by the fringing reefs, thus the tidal flats is considerable. The area of Penghu during the low water period is 164 km<sup>2</sup>, while during the high water period, the area is 127 km<sup>2</sup>. The length of sea line is 320 km. Furthermore, since Penghu was formed by volcano, it is sufficient in basalt and limestone. These natural gifts were the strength that islanders could build up stone weirs and make a living along coastal area.

In Figure 11, it illustrates the distribution of stone weris on Penghu archipelago and in Chipei Island. Each purple dot represent a stone weirs, because of the shapes and the length of stone weirs are totally different, it could not be corrently drawn on the map. Only Chipei was drawn in detailed based on aerial photogrammetry 2008. (The photogrammetry were taken when the tide was rising, thus some of stone weirs could not be distinguished)

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<sup>42</sup> 104 was the lastest number that were counted by Lin, wen-zhen

Figure 11 The distribution of stone weirs on Penghu archipelago and Chipei Island



Source: Drawing based on the aerial photogrammetry and the book “ the structure plan of rural landscape management in Penghu”

### Development of stone weirs on Chipei

According to the ancient book<sup>43</sup> which includes the first record on stone weirs, stone weirs are used for at least 250 years. No records could trace back to when did people first used stone weirs nor where the first stone weir is located. There are several legends about the first application of stone weirs. Some said the idea of building stone weirs is coming from weaving

<sup>43</sup> "p'eng hu chi lueh" is the first ancient book which had records of stone weirs tax. It was an official record published by Qing empire

Figure 12 The weaving vine: Hou Teng



Source: The picture took by the author during field trip

*Stone weirs on Chipei Island, Taiwan*  
vine rope. In the past, they weave vine<sup>44</sup> as a rope and put in the sea as a curve to trap fish. When the tide rises, fish would swim into the rope area, whereas when the tide falls, fish would be frightened by the shadow of the rope. Thus, fish would swim around the curve and get lost. Islanders could go

to the selected location and catch fish. After a while, people figured out it was even more durable by stacking up stones.

Chipei is widely covered by the vine “Hou Teng”. It is easily to access the weaving vine along the coastal area. Some people still remember that their grandparents had used this method before.

Another said, these techniques might be learned from the southeast coastal of China, the hometown of ancient migration. Others said, it might developed from self-learning, since people caught fish in the sea everyday. They were all familiar with tidal currents, fisheries habits and landscapes. They knew where and how to surround fish by stones, thus, starting to take the advantage of their natural resources, limestone and basalt for building stone weirs.

In 1720, the official records from Qing Dynasty presented there are two large stone weirs, and twenty small stone weirs. In 1771, the numbers increase up to two large stone weirs and sixty-nine small ones. At that time, Chipei had one large and four small stone weirs which account for 7% among Penghu archipelago.

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<sup>44</sup> It is called” Hou Teng” Chinese, which could be easily found along coast

Given the period of Japanese colonialization<sup>45</sup>, which contributed by the development of tools and technology, islanders started to build stone weirs in the further shore. The numbers of stone weirs significantly increased and the size was larger than before. In 1917, the total stone weirs on Penghu archipelago had raised to 314. Between 1900 and 1930, the numbers surged up to 70 within thirty years. Thus, up to the 1930s, most villagers hold shares on stone weir and had a harvest. In this period, people in Chipei lived a rather rich life compare with other islands.

There was a famous story that people like to tell when talking about the harvest in stone weirs. On the 21<sup>st</sup> of June 1945, during World War Two, when Mr. Yang<sup>46</sup> was twenty years old, his house was damaged by a bomb, killing his mother and grandmother who were in the house at that time. Luckily, his family got a share on a productive stone weir. On the 7<sup>th</sup> of October in 1945, he went to the “chuan zi tou” stone weir and found more than nine hundred “mian yu<sup>47</sup>”, which were about nine kilogram individually. When he went to the stone weirs again when tide fell in the evening, he caught another 4200 kilogram “ding xiang<sup>48</sup>”. After selling the harvest, he had enough money to rebuild his house. This is the story perfectly tells that stone weirs is a high productive equipment in the sea.

After 1935, even though there were more and more mechanical power fishing boats and new equipments introduced to Chipei, inshore fishery was still prosperous. In 1950, according to the Penghu year book, stone weir still accounts for 77.4% of the total harvest. From 1960 onward, people started to emigrate to Taiwan for working, in addition, the fishery stocks shrank dramatically. These two reasons result in abandoned stone weirs.

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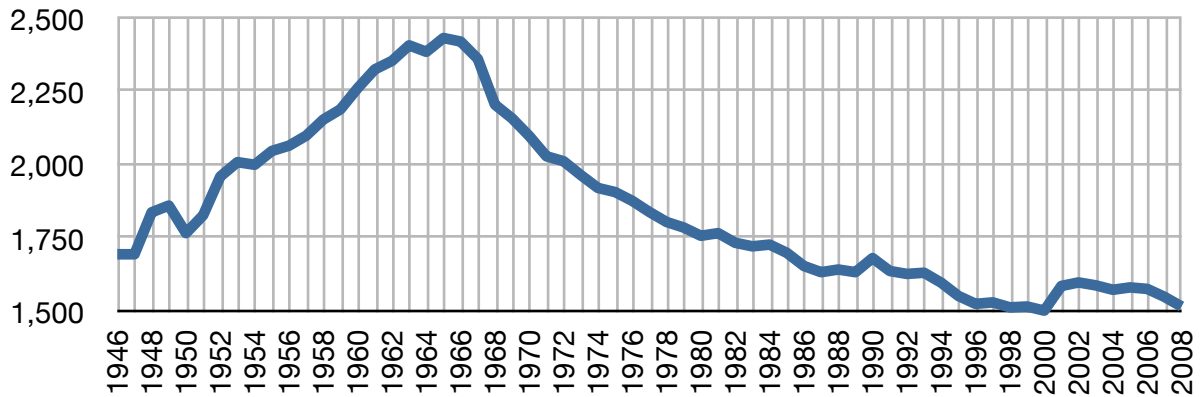
<sup>45</sup> Taiwan was a Japanese colony from 1895 to 1945.

<sup>46</sup> Mr. Yang, Shug-Liang, who is one of villagers in Chipei, who is 88 years old in 2009. He hold a share of “chuan zi tou” stone weir.

<sup>47</sup> a high economic value fish. It's scientific name is “*Miichthys miiuy*”, the market price is 420NTD/kg (13USD/kg)

<sup>48</sup> It's scientific name is, *Spratelloides gracillis*

Figure 13 Population in Chipei(1946-2008)



Source: The chart is drawn based on the figures in year book.

The declination in the use of stone weirs started in the end of 1960s until the present day. Still, people hold the shares nowadays but people are reluctant to care about the stone weirs. Although some people fish in their stone weirs in the harvest days, they won't try to repair the ruinous part. Only picking sea snail, catching fish, or collect coral reefs and shell as souvenirs in the stone weirs.

The abandon of stone weir is a result of several reasons. First of all, it is related to the population in Chipei Island. When the youth moved to Taiwan during 1960s and 1970s, population aging became a serious problem. Figure 13 illustrates the trend from 1946 to 2008. The 1960s is the turing point that population had a downturn trend since then.

Secondly, fishery stocks shrinks almost 9/10 compared to thirty years ago<sup>49</sup> since innovations were introduced in Chipei since 1940s. Thirdly, the economic structure shift from the costal and inshore fishery to offshore and the tourist boom change the economic sector from a fishery to a service.

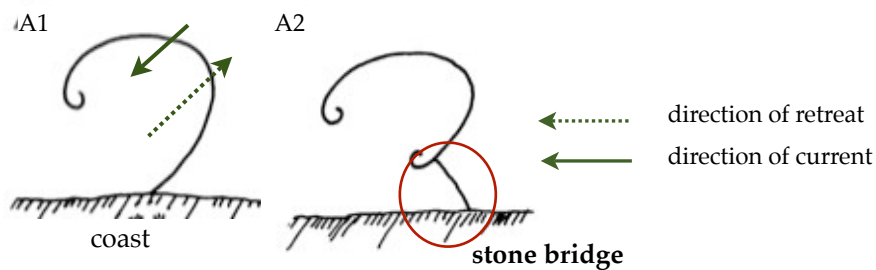
<sup>49</sup> According to the elderly people, they said in the past, why it was low water period. Stone weirs were full of fish that they hardly see the water. Sometimes, the fish in stone weirs would be too crowded to die. The harvest once could be more than six hundred Kilogram. However, in the present time, it is hardly see fish in stone weirs, the only thing you can see were dead reefs, and few fish. Today, if you want to have better harvest only when the tidal range were large and the wind were strong.

The development of technology thus is the main reason that people changed their fishing hobby because the offshore area is easier to access than before. In addition, it makes fishing more efficient with mechanical boats and new fish nets.

## **Development of stone weirs in shape**

As for how the shape and function of stone weirs has been developed since the 18th century, there is a sharp distinction in the shape of stone weirs, regarding the difference of the landscapes and the fishing areas.

Figure 14 Basic type of stone weir



Source: Drawing based on Chen(1996)

Referring to figure14, A1, A2 are the basic type of weirs. They were built in shallows. When tide falls, the water level in stone weirs were low or dry. Only deeper places have water where fishermen can catch fish. The arrow in A1 is the direction of current when tide rises and the dotted line is the direction of water retreat when tide falls. In A2, the stone bridge was built when the stone weir was in further shore.

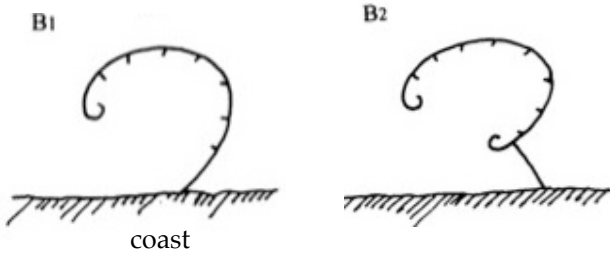
The principle of constructing stone weirs is parallel to the direction of water retreat. Fish will swim with water when retreat, and stuck in the stone weir.

In figure 15, B1 and B2 were developed around the 19th century. (Chen 1996) In the basic ones, the fishing rights only for one person per day. However, there are more than seven people that building the stone weirs cooperatively, so they built small stone plates (it is called Hu-ya) for



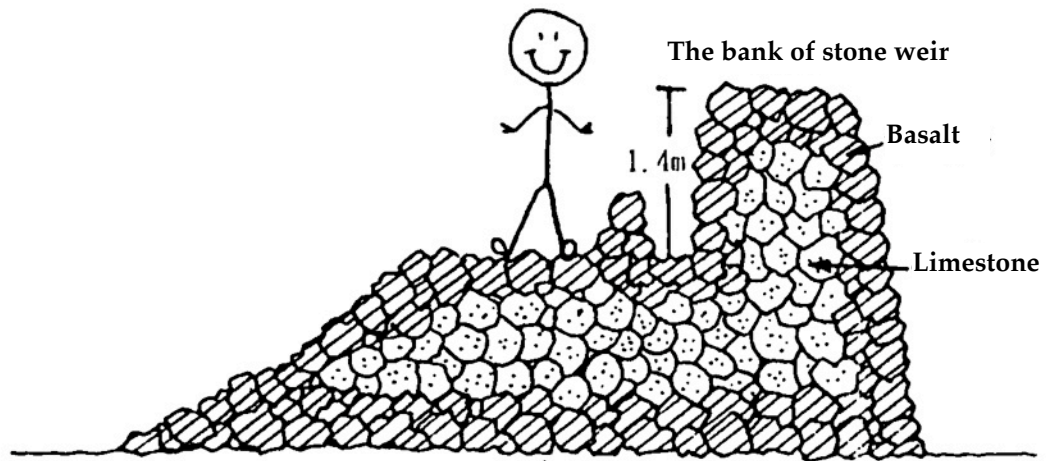
Stone weirs on Chipei Island, Taiwan giving everyone the rights to fish everyday in their fishing area. When they caught small fish in their place (which refers to the figure 16), the harvest belonged to their family. However, the fish that was found in the middle of the stone wier, was shared.

Figure 15 Stone weir with stone plates



Source: Drawing based on Chen(1996)

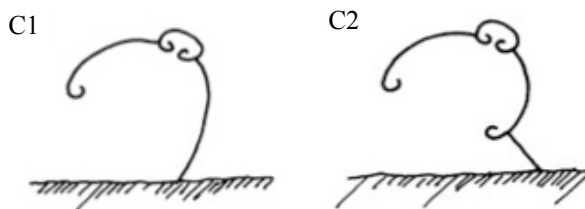
Figure 16 Illustration of fishing on Hu-ya



Source: Edited based on Chen(1996)

The plate in stone weir

Figure 17 Stone weir with Hufang



Source: Drawing based on Chen(1996)

In the 20<sup>th</sup> century, new shape of stone weirs were developed in Chipei which are more advanced. The figure illustrates that there is a room-like area, the deepest area in the stone weir. This type of stone weirs were mostly built in the further shore, when the tide falls, the water level is high until the waist. If there is no special equipment, it will be difficult to catch the fish. Thus, they innovated the

room-like area (it is called Hu-fang) that the fish will swim into it when the water retreated. This is the most difficult but also the most important part in building a stone weir. The right place with the correct direction of the water flow needs to be selected. Since it is the deepest area in the stone weir, it is very difficult to construct. For the most cases, it takes three or more years to complete a Hu-fang. When a Hu-fang is completed, they would divided the banks of stone weirs into several parts and respond individually. Only 15 out of 104 stone weirs have a Hu-fang in Chipei because it is a newly developed type that brings a lot of difficulties when constructing.

## Stone weir as landesque capital

### Overview

Each stone weir has its own name, just like a person. It could be named after the character, location, or the main fishery. The length of a stone weir is several meters to one kilometer long and it is difficult to estimate how much stones do they use. Furthermore, the size, shape and deep vary. It is stacked up by basalt rocks outside, and limestone inside. Collaboration is the most important when working and apprenticeship is applied in building. The professional elders are always responsible for stacking up the stones. Apprentices are learning by doing from extracting, e.g. by transporting the right stones to the professional elders. Thus, it is a labour-intensive work.

Population <sup>50</sup> growth is the main reason that stone weir started widely built and used. As the history records, before the 16<sup>th</sup>, 17<sup>th</sup> century, Chipei was a place where fishermen rested. There were no permanent inhabitants on the island. The southeast coastal fishermen always traveled between two places from seasons to seasons. Until the Qing dynasty, the population on Chipei doubled and the ancient record showed that there were twenty-two stone weirs in 1720 in Penghu. The more labours a family could offer in building stone weir, the more shares they could get from it. Some families

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<sup>50</sup> Population in Chipei during 1688 to 2007 refer to Appendix I

had fewer people so they could buy a small share from one of the shareholders and traded by working with their shareholder. Also, like a company, there is a leader who has to organize everything from preparing tools and boats to the arranging of the praying ceremony<sup>51</sup>.

### **How were stone weirs constructed?**

Building up a stone weir is just like setting up a new company which has several shareholders. On the one hand, there is an obligation of building and maintaining the stone weir in a good condition and on the other hand, they all have fishery rights in their stone weir. Besides, they sign a contract that people would clearly understand their obligation, the rights of catching fish and the shares in the stone weir. The relationship between shareholders were mostly relatives, or close friends. In most cases, stone weirs are owned by very closed parties. Despite of being a landesque capital, stone weirs also had a strong relationship that connect every villager on the island.

When someone wants to build up a stone wier, he would find some shareholders mainly from his relatives or sometimes close friends. After grouping people, they would select the location by their preference. It depends on how many people do they have and what kind of fish do they want to catch. Mostly, when there are more shareholders, they could build a stone weir further away from the coast where the water is deeper and more valuable fish would appear. Thus, collecting experiences such as the tidal currents, wind and the habits of fish from each other were important. They would have a discussion before breaking the ground.

Signing a contract is important, which describes the rights and obligations in their stone weirs. Every shareholders should apply a specific

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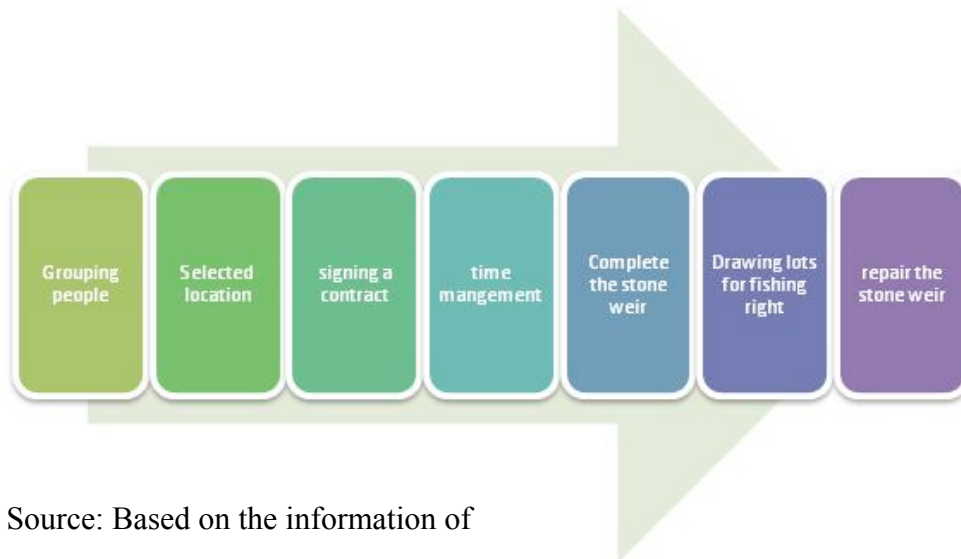
<sup>51</sup> In Taiwan, when we pray to a god, we have to prepare food for them. People believe the more they prepare the happier the god will be. Since they are poor in the past, it is expensive to held a praying ceremony.

numbers of labours<sup>52</sup> during working, if not, they will get fined. Moreover, while they complete the stone weir, they would draw lots. An order of fishery rights will be followed which will be recorded in the contract.

The process of building one stone weir takes a long time, it could be three to ten years depending on how difficult or how large the stone weir is. Without any advanced equipment, people build stone weirs from finding stones or, extracting and, transporting to stack up stones with their bare hands. Figure 18 explains the process of building stone weirs.

Building a stone weir needs a lot of basalt stones and limestones, they have to extracted stones nearby or further places. Before the 20<sup>th</sup> century, they didn't have any equipment for extracting stones from mountains, outcrops, or rock foundations. They had only basic steel tools which was easier to leave and take out stones by using the principle of lever. They would find coffin board<sup>53</sup> from the mountains for transporting the more

Figure 18 The process of stone weir



Source: Based on the information of

<sup>52</sup> Women, Children, Elders, Illness people would not allow to work in the stone weirs. As the elders said, forty years ago, people were so poor that they had few clothes. When they were working, they would not let their clothes wet so as underwear. Thus, they were always naked when they were working. When they finished working, they put on their clothes on the beach and go home. It is why women could not work with them.

<sup>53</sup> Why do they use coffin board is because on Chipei island, it is hardly find a "tree". Moreover, people were too poor to afford a transporting raft. Therefore, people went to the mountains and find the abandoned coffin wood board as a small raft.

distant rocks when the tide rises. After extracting the stones, they put on the floor, waiting until the high water is taking use of buoyancy. The stones are lighter than before, thus they can easily move and stack up.

As far as working time management was concerned, not all seasons in the year are good time to build stone wier. Only summer is the best time, while in winter the temperature is too low and the northeast monsoon is too strong to work. Yet, there are some limitations during summer time. During the high water period, people extract basalt along the coastal area. While the water falls, they transport rocks to their selected location. Working is only possible during the low water period, in other words that there are only three to four hours each day during which work is possible.

When the stone weir is complete, they would cast lots on the 15th of July (according to the Chinese lunar calendar). The leader of stone weir has to responsible for gathering everyone to cast lots. Drawing lots is to decide the orders of fishing rights in the stone weirs in the following year. Once the order is decided, the leader put everyone's name on the calendar. Everyone would follow the order until the next July. The people who are getting a fishing right that day will be the "host" in the stone weir and therefore could own most of the fishery stocks on that day. When the host is finishing the catching in the stone weirs, others could go to the stone weirs and share the rest of fishery stocks.

Since they draw lots in advance, people would know how does the harvest look like in the year by referring to the lunar calender. However, when the host family of the stone weir could not catch fish by themselves, someone who helps them would get some portions of the harvest from the host.

### **How do fishermen catch fish in the stone weirs?**

Catching fish in stone weirs is not bare handed, they had multiple equipments for it. The equipment also developed with time. In the past, when people considered stone weirs as their main income source, they

would put on a headscarf, fold a bamboo weaving bag on the waist, bring an acetylene torch(see figure 19), fishing nets, and put on straw weaving shoes before they head to stone weir. They made everything by themselves. The fishery in stone weirs were diversified, some of them in habited in the crack of rocks in the back of stone weirs, some of them in the bottom of the stone weirs, others might be on the water surface. Thus, there are several ways of catching fish, multiple fish nets and methods that can be chosen from could be selected for different kinds of fish.

Figure 19 Acetylene torch



Figure 20 Fishing spear

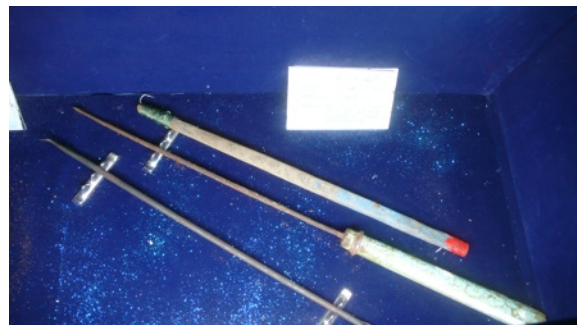


Figure 21 Fishing Cage



Source: These pictures took by the author during field trip in Chipei stone weir cultural museum

A fishing spear(see figure 20) is another useful tool when working in a stone weir. Once a fish is found in the crack between rocks, they would stick the spear into the crack. Torch light net and fishing spear are useful when they are catching sea eel<sup>54</sup>, puff fish<sup>55</sup>and “xiang yu”.

<sup>54</sup> Its scientific name is *Plotosus lineatus*

<sup>55</sup> It's scientific name is *Diodon holocanthus*

Fishing cage (see figure 21) is made of metal. There are some holes in the bottom of the cage that light will go through it. When the cage was put into the water, phototaxis fish would swim into the cage.

When people went to stone weirs in the early morning and late evening, they bring an Acetylene Torch(see figure 19) as part of their equipment with them. The Acetylene Torch is composed of two different parts as the figure shows. The right part is filled with water and the other part is for acetylene. The right part will be dipped into the water with the left part of container, thus acetylene will light up.

When catching fish on the water surface like “ding xiang”, they use hand operating dip net<sup>56</sup> or hand operating nets(see figure 22, 23).

Another method people use in stone weirs is called “bao dun”. Fishermen heap up a small mound with basalts or rocks when the tide rises in the stone weir. While the tide is falling, fishermen go into the stone weirs, then people besiege the rock mound with nets and when they move the rocks away, fish will swim out of the rocks. When people are trying to catch fish on the surface of sea, they would use hand operating dip net<sup>57</sup> such as “ding xiang.”

Figure 22 hand operating net



Figure 23 hand operating dip net



Source: These pictures took by the author during field trip

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<sup>56</sup> It is called as “cha shou wang”

<sup>57</sup> It is called as “cha shou wang”

In the past, buffalo was a helpful animal when transporting fishery, however, the islanders were too poor to afford one so they had developed a way to share their capital. Normally, people should have at least thirty thousand “zai<sup>58</sup>” to afford a buffalo which is nearly impossible to own. Thus, people always gathered some money from several families for buying one. Buffalo became a common capital between several families, and people would help each other cultivating the farm. Whenever someone had a harvest in a stone weir, they would bring their buffalo to transport. As the elderly people said, forty years ago, when the day of harvest came, they went to the stone weirs. It was hardly to see the water, the stone weirs were covered by fish and tens of creels of fish would be caught. It is hard to be transported since the harvest need to be moved from coast to the village. So the buffalo was an important animal for transporting and cultivating in the past.

### **The social meaning of Stone weirs**

Stone weirs is not only an equipment of fishing but also a symbol of the rank within the society. As we know that stone weirs are qualified as landesque capital due to the fact that stone weirs secure future life. Thus, when a man holds a share of a stone weir, especially a high productive stone wier, the social meaning is that he has the possibility to start a family and is prestigious within the society. The other meaning of the stone weir is that it could be divided into families or geographically close friends. Shareholders who have the same family name were preferred, sometimes neighbors or friends would be invited if no one else is found.

### **Summary**

Stone weirs are just like farms in the sea that people cultivate and waiting for the time for a harvest. Not only is the stone weir a tool for making a living but it also means a lot in their social organizations. The stone weirs

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<sup>58</sup> “zai” is a special units that used only in Chipei. It measures how many land could you cultivate sweet potato. Normally, sweet potato were cultivated in a square, each square is one Zai. A zai is approximately 60 cm\*60 cm.

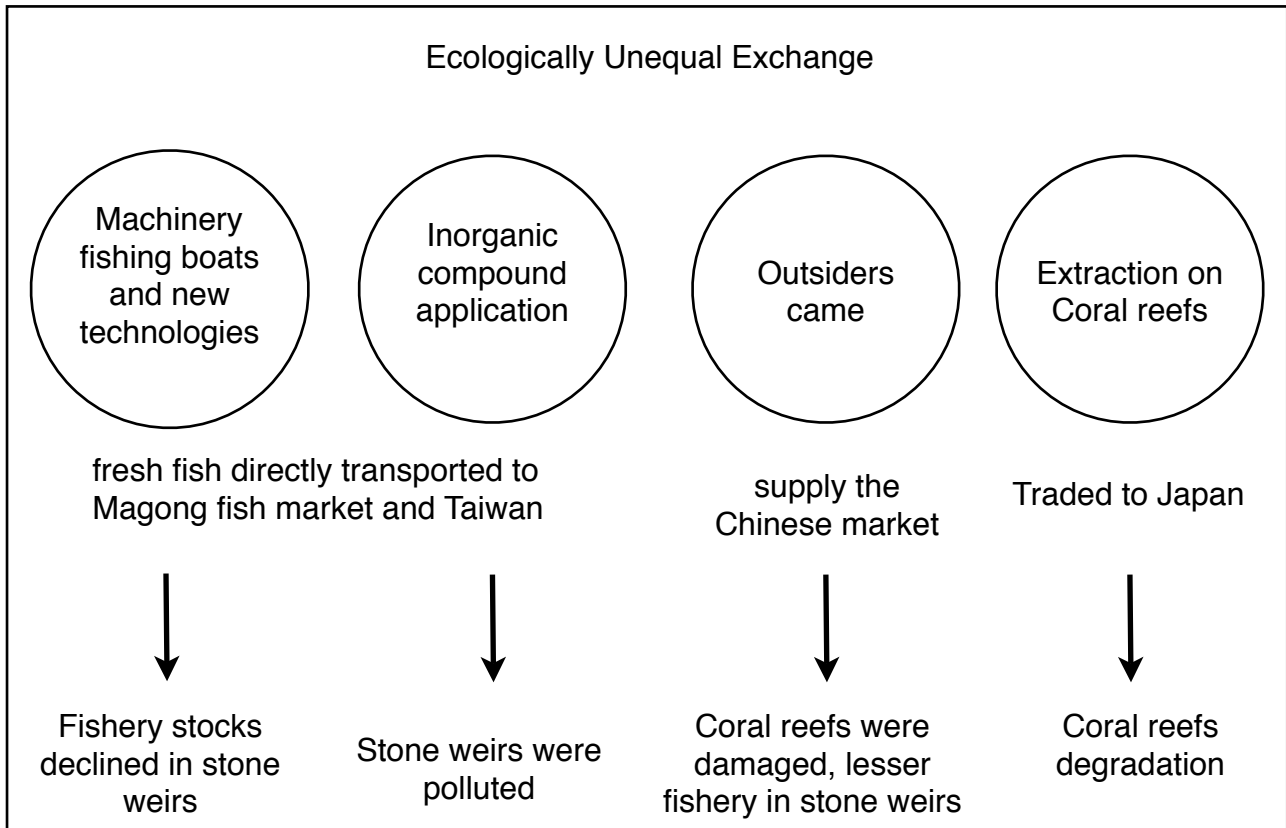


are always built by selected groups of people which might be relatives or neighbors. The process of building is exhausting that is why people build this facility cooperatively. When one dies, the share will be the legacy of his son. So when it comes to three or four generations, the shares are complicated that quarrels would take place in the long run. It is another reason that stone weirs were abandoned.

As people put a big effort on the complex process of building stone weirs. Organizing a group of people, details like choosing the location, how do they build and cooperate within the process of building the stone weirs until the end of building, the people established a system and a principle of having fishing rights. They found a way of moving rocks from low productive mountains or coastal areas to tidal flats. So they improve the productivity of tidal flats and also construct a “green”, “environmentally friendly” way of fishing. Stone weir is a perfect example which created upon human activity and environment that could be classified as landscape capital.

## Stone Weirs in Ecologically Unequal Exchange

Table 7 Ecologically Unequal Exchange in stone weirs and in Chipei Island



Source: Based on the information from interviews

### Overview

During the period of Japanese colonization, the numbers of stone weirs notably increased. Until 1931, there were sixty stone weirs in Chipei, whereas in the 1900s there were five. Stone weirs kept the fishery in a sustainable status when people only used simple nets and equipment before the 1940s. The harvest would be dried in front of the temple (which is the center of the village, geographically and spiritually) in summer. Some dried fish are feed on animals in winter, others are transported to the wholesaler in Taiwan (this will be discussed later on).

In the end of 1940s when the KMT took over Taiwan, new technologies were introduced in Chipei, people had more efficient measures of fishing. Machine fishing boats, echosounder, fix-nets, purse seine, gill

net, banding line and drift nets were gradually used. More and more fisheries were caught in both inshore and further shore (where only takes one day return).

In the past, when fishermen don't have advanced equipments, stone weirs were significantly used all year round. However, after the 1940s, new technologies enlarged the fishing area, changed the way villagers traded their harvest.

Until the 1940s, people worked depends on the tide rises and falls. When tide falls, they went to the stone weirs for fishing, while tide rises, they cultivated their fields, or made their fishing equipments, such as creels, nets, and shoes. Their economic activities were contrained by lacking of machine fishing boats, or advanced nets. In that period, people transported dried fish as livelihood to wholesalers in Tainan <sup>59</sup> city.

From the end of the 1940s, the machine fishing boats were gradually applied. Fishing no longer limited by the tides, they started going further shore for fishing with new nets. As well as they started to use new nets in stone weirs for catching more fish. Moreover, in the early phase of applying new technologies, people still fishing in the stone weirs because the fish stocks were considerable before the 1960s. Meanwhile, people mostly fished in stone weirs in winter and went further shore in summer. In terms of trading, fishermen shipped fresh fish directly to Magong fish market and sometimes to Taiwan Island instead. Thus, ecologically unequal exchange started from the end of the 1940s when the new, speedy boats and other new methods were introduced.

Coral reefs extraction during the 1970s to the 1990s was a result of the introduction of new technologies. However, no official figures about the

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<sup>59</sup> Tainan is a south ancient city where were occupied by Dutch in 17 century. In 1920s, Japanese constructed channel which could directly go from Taiwan strait to Tainan city. Thus, those ships from Penghu or Chipei could unload merchandise in the city. However, the channel had deposited severely that was not useful as before. Until Kaohsiung Harbor was started to use in 1955, the Tainan channel and harbor were abandoned.

harvest, trading and the amount of coral reefs underwater were accessible. The empirical evident can be traced back to some twenty years ago, there was a street in the central of village with several stores selling small stuffs made out of coral reefs, as well as colored coral reefs as the works of art. In the present days, since the government banned from extracting coral reefs, the signboards remained but the stores are gone.

In Magong city, there was a street where especially sell aragonite and coral reefs twenty years ago. Tens of hundreds tons of coral reefs were sold to tourists and exported to Japan each year. After 1990s, Taiwanese government seted a law, barred the capture of coral reefs and coral sands from beach. Thus, those stories disappeared. Since the lack of official data, interviewed both local people and the experts were the main source of informations.

## **Ecological Footprint**

Ecologically unequal exchange implies relocating the ecological footprint from politically and ecologically strong regions to weak regions.

During the time of Japanese colonization, there was a Japanese store named “Gong Qi”. By using wooden box and ice they traded fresh fish directly to Japan. Only steamer ships were used in this period. The main fisheries were “Diao Yu”<sup>60</sup>, “Que Yu”<sup>61</sup>. However, the numbers were not significant in Chipei Island.

In 1949, when KMT took over Taiwan, the living standard in Chipei was poor. Sweet potatos and some crops were the only crops grew on Chipei Island, however, it hardly satisfied the needs. Thus, people dried fish the caught and sold them to Tainan city for exchanging crops and groceries from Taiwan. Wholesalers would purchase dried fish from Chipei. The lack of technologies and facilities were the constraints on trading between Chipei

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<sup>60</sup> It's scientific name is *Holacanthus venustus*

<sup>61</sup> It's scientific name is *Lethotremus awae*

*Stone weirs on Chipei Island, Taiwan*

to Magong city and Taiwan Island. Thus, the only thing they could do was dried fish and delivered to Tainan.

Up to 1950s, some people had accumulated fortunes from previous harvest that could afford to have a boat or new fishing equipments. Or, some cases were like this: one owned a smaller boat which is the legacy from their parents or family. They sold a small one and bought a larger. They could buy a more horse power fishing boat, drum-type line hauler or marine refrigerating plant. Since much people went further shore with their better function boats, people said they could earn more than before (when they catch fish in the stone weirs, they have to share with others who help you with catching.) However, futher shore fish had more economic value than in stone weirs. Consequently, people started to fish in further shore, stone weir became the ancillary revenue. Stone weirs fishery industry was prosperous only in winter, since the large amount of spratelloides gracilis (which had a rather good price<sup>62</sup>) could be caught. With more and more fisheries were caught and traded to Taiwan island, fishery stocks were declined since then.

### **Impact of technologically improved fishing measures**

Fishing nets were another important equipment in fishing, such as fix-net<sup>63</sup>, beam trawler, torch light net<sup>64</sup> and so on. Those methods had a serious impact on fishery stocks in stone weirs as well.

Fix-net is used for hundreds of year. The material changed over time, and the functions were improved. However, after the 1940s, fix-nets developed into the type which composed of three layers into one net. The three layers are made of large, medium and small nets in one. It is always

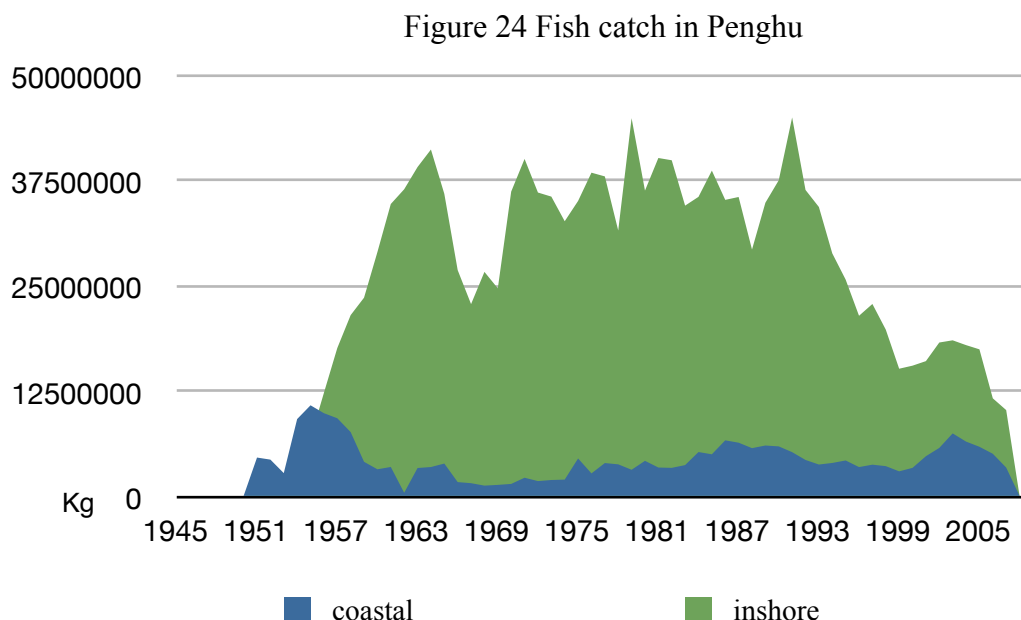
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<sup>62</sup> The price averagely were two USD per kilogram.

<sup>63</sup> Fix-net was one of the most harmful equipment in coastal and in tidal flats. The fix-net had three layers composed of three different sizes of nets. thus whenever the stuff come by, it will stock by the nets. Coral reefs, all kind of fishery, aquatic life, even green lever and stones were hardly escape from the nets.

<sup>64</sup> This fishing method was most common seen in inshore or coastal fishing. It is composed of three different parts of small boats. One of them is the net, another is light that could lit up during the night and fishery will come out, the third is for transportation.

used in the inshore or costal area which is near or in stone weirs. Everything in the water can be caught by three-layer fix-net when the water retreated in a low water period. Sometimes, when water flows through, coral reefs would stuck on the net as well. Therefore, coral reefs would be hurt or destroyed when fishermen use three-layer fix-net.



Source: The chart is drawn based on the figures in year book.

According to the Penghu year book (1951-2007), the fishery harvest grouped with two catalogs, coastal and inshore. By the definition of the year book, coastal fishery was collected by non-machinery boats which includes stone weir fishery, the inshore fishery by machinery boats. Figure 24 illustrates the trend of coastal and inshore fishery from 1950 to 2005. According to the chart, the inshore fishery became the main income since the mid-1950s all over the Penghu archipelago. However, there is no data on the same statistics for Chipei. Comparing with other villages in Penghu, Chipei was a rich village during the 1950s to 1970s. Thus the development should be similar to Penghu. The trend of using machinery boats in inshore area has been widely use until 2000. In addition, there were almost no records on the offshore fishery until 2000.

In the nearly ten years, the islanders are not the only party participated in exploiting fish resources. The outsiders (both Taiwanese and Chinese boats) also involved in the activities, they used even harmful and powerful boats fishing in Taiwanese territorial waters. Large fishing ships in the offshore catch more fish but they are more harmful to the underwater ecosystem, especially the coral reefs. TAs records show, during 1992 to 2001, there were some 8,000 Chinese roller danish trawlers were expelled and about 73,000 Chinese fishermen were caught because of illegally fishing in Taiwanese territorial waters. Thus, Penghu government forfeited their equipment and harvest.

According to the story, it can imagine how many roller danish trawlers fished in Taiwanese territorial waters every year. It could say roller danish trawler was a woe of coral reefs. When it drags its nets from the sea floor, coral reefs immediately die into pieces. The particles of coral reefs flow with currents, and the evidence on the Chipei Island is a three kilometer long inshore island were deposited by those pieces of coral reefs. The island is located in the northeast of Chipei. The particles of coral reefs are also deposited in the stone weirs. Therefore, the stone weirs are out of use when they deposit by the pieces of coral reefs.

### **Application of Chemicals**

Catching fish by using poisonous plants has been occurred for a long time. It is the easiest method with the lowest cost. Poisonous plants<sup>65</sup> was the first measure people used before the introduction of those chemical inorganic compound. It is easy to access the poisonous plants from mountain area. People can pick the poisonous plants and grind them into powder. When they see a fish spot, they would spread the powder in the water where fish gathered. The fish would be gradually fainted and listless, therefore, it is easy to pick up the fish and put into the creel. It was a game that children played after school, it is not necessarily to be the economic activity.

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<sup>65</sup> *Tephrosia purpure* is the most popular plants for poisoning fish

Tephrosia purpure is not so harmful due to the fact that it is not so toxic. Its toxic could be washed out with the sea current.

From the 1950s and 1960s, rotenone (derris extract) was applied which is more toxic than the previous poison. People started to use the chemical instead of poisonous plants. In the 1980s, new poisons were applied, such as potassium cyanate (KCNO) and potassium cyanide (KCN). KCNO and KCN are highly toxic, most of the people on Chipei abused using this poisons at that time. The reason people applied is because it is the easiest way and lower cost than buying other equipments. Not until when Taiwanese government embargoed on using it, people halted to use inorganic compounds.

Some said by applying those poisons, they could easily catch high economic value fish. In addition, the cost was lower than buying other equipments so they prefer to abuse by using these poisons. It results in all kinds of creature underwater were dead. People say sometimes they see dead fish floating on the water surface. In addition, the ecological degradation underwater is significant with the application of poisons.

Poisoning fish was banned during 1990s, however, yet some people still use KCN secretly.

## **Extraction of Coral reefs**

Figure 25 Coral reefs in stone weir



Source: These pictures took by the author during field trip

Penghu island was known for its coral reefs and aragonite. They all banned from extraction in nearly ten years.

Chipei sold coral reefs everywhere on the street twenty



years ago. Since it is easy to harvest coral reefs by diving, people extracted a lot from 1970s onwards until the government banned it.

Before the government embargoed the extraction, people extracted coral reefs and put it into a glass box for selling. They traded coral reefs to Japan and Magong city. There are many shops selling a variety of coral reefs and aragonites. Some were sold on Chipei Island as well. As the researcher said, the situation of coral reef was getting worse and worse these days, compared with thirty years ago. Harvesting coral reefs was one of the reasons that led to the degradation of the coral reefs ecosystem.

## **Summary**

In sum, technology makes fishing easier and more efficient. However, since they can earn more from extraction the resources, people gradually forget the virtue of conservation or carrying the ancient wisdom with them. The extraction and exploitation of coral reefs and fish stocks heavily hurt the balance of ecosystem and results in the underwater ecological degradation.

The ecological consequence that the Chipei islanders bore was the smaller individuals of fish both in the stone weirs and inshore area, fishery stocks slumped and coral reefs were damaged. Since the damage of coral reefs, the aquatic life would no longer live soundly in the tidal flats or in the stone weirs.

## Economic alternative

From 1970s, the islanders abandoned the use of stone weirs, since the loss of fishery stocks and some of the stone weirs were deposited by the dead coral reefs. Thus, people rethought the use of stone weirs and they found their ways out. Tourism is newly developed industry as the most important economic sector on Chipei Island in present days. Islanders tried hard to attract tourists by innovating new dishes, and started with stone weirs tours. Moreover, they started to fish offshore for even higher economic value fisheries with the more advanced ships.

The boost of tourism industry from the end of 1970s onwards let some three million of tourists<sup>66</sup> flourish into Chipei every year since the 1990s. Given that fact of having too many people traveling to Chipei, the land is over loaded by keeping giving things out and waste itself. It has been losing most of the coral reefs<sup>67</sup> since then. For satisfying the tourists, government replaced a natural fishery spot and stone weirs to construct concrete harbor and new buildings.

### **Tourism boom**

As the local government knows, only constructing new buildings or a concrete harbor could satisfy tourism. Making use of the natural sandy beach and the surroundings are the main ways for local development. The islanders were happy with having many tourists. Yet, the natural harbor once

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<sup>66</sup> According to Penghu county year book, during these thirty years, the number of tourists were around four million flow into Penghu every year. The official estimated number, 75% of tourists would go to Chipei island for experiencing water activities and the tidal flats (when it is in low water period, people can walk from north of Chipei island to another uninhabited island "Guo Yu". It only takes two to three hours return by walking), enjoying the most beautiful white sand beach in Penghu archipelago.

<sup>67</sup> There were no records on coral reefs in the official year book. However, according to the mid-age fishermen, they said coral reefs were everywhere, whenever you went into the stone weir, you can see coral reef. They showed scar on their legs. They traded coral reef to Japan during Japanese colonized period, in 1930s. Not until 1980s, Taiwanese government banned extracting coral reefs. In the present days, it is hardly see a group of coral reefs. Only local people could point out the location of coral reefs. Twenty years ago, it is easy to reach coral reefs. Coral reefs were everywhere.

*Stone weirs on Chipei Island, Taiwan*

were the gate of Chipei island, in 1970s the government filled the wetlands, ruined several stone weirs, and destroyed the coral reefs to start with a concrete harbour. Also a road directly to the sandy beach which did not even get into the village was built. When tourist came to Chipei, the bus sent them straight away to the beach. Tourists did not stay on Chipei, only went to the beach for water activities for some hours then leave. It did not benefit the local people but those cooperations and government. The new entertainment facilities and harbor only brought waste to Chipei Island. And the water activities disturbed the equilibrium of ecosystem These exploitation results a negative impact on the environment

## **Negative consequence to ecology**

### **Damage to coral reefs and the underwater ecosystem**

Coral reefs are just like a mother who feed on and give a shelter to fish, and aquatic life. It plays an important role for the undersea ecosystem. Not to mention, it insures the fishery stocks in a sufficient status. However, people started to abuse it when the boost of tourism.

Coral reefs were once, easily access to or be seen around Chipei island. When it comes to coral reefs, the islanders were sighed, talking about where could they see coral reefs in the past. However, in nearly decades, there were so many factors that coral reefs were heading to the fate of dying. Tourist industry boom is one of the main reason in these three decades. For getting profit and earning more money, fishermen started to catch as much fish as they could for. Moreover, they cut the coral reefs into pieces, and get sea snails or fish they are looking for. The purpose of doing so is for selling the harvest to restaurants and tourists.

In terms of tours in stone weirs, the tourist guide always bring their guests to the stone weirs, and let them walk in the water, pick aquatic life in it. After having a trip to stone weir, restaurants would cook the seafood that customers caught as their dinner, therefore, it becomes a incentive make people pick more. However, sometimes tourists caught uneatable creatures

only for fun, thus, large amount of aquatic life would die. The ecosystem were disturbed by the large number of tourists.

Tourists were like bacteria that spread out the island. They totally change the way islanders life as well as the way resource distributed. Villagers expected to be more prosperous on tourists and tried to make maximum profits, however, this trading of resources to those people had a negative ecological consequence on their lands and sea in return. The damage of undersea coral reefs is dreadful that some of the species were endangered or nearly extinct.

### **Threat to sea cucumbers and sea snails**

Eating for East Asian is one of the biggest pleasures. Thus, for tourists from Taiwan or China, when they go traveling, they definitely want to try local specialities. With this cultural context, the islanders try their best to catch fish, or innovate new cuisines to attract customers.

When the author was on Chipei island, she ate multiple kinds of seafood she had never eaten in Taiwan island before. The sea food restaurants served is mostly caught by the owner himself. Almost every mid-age people in the village are good at swimming, diving, and fishing. During summer, they dive for catching lobster<sup>68</sup> or go offshore with boats for shark-hunt and some large size fishery. Fishermen would keep part of the harvest for themselves or sell to tourists. By having those fish and aquatic life, they started with innovating dishes for keeping tourists flourishing in on the island.

In this section, two aquatic life are made as dishes recetly which are sea cucumber and sea snail.

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<sup>68</sup> As fishermen said, April, May and June are the best month for catching lobster. They have to dive under the sea in the mid night, when everything was dark around. Lobster is phototaxis, thus fishermen will use flashlight under the sea, lobster will appear. They could easily catch them.

A special kind of sea cucumber<sup>69</sup>(Dàng Pí Shēn<sup>70</sup>) is the newly innovated dish that villagers were proud of. Not only do they serve it in restaurants, they also sell to the fishery market.

In the recent two years, there was a household caught sea cucumbers and earned about 120,000 USD a year with that. The market price is approximately 0.5 USD per sea cucumber. Thus, it is estimated that the household caught two hundred sea cucumbers last year. This is a story most villagers know about. When they know this is a profitable business, many people would imitate the same way of catching. Assume that everyone had the same productivity, sea cucumber would disappear in few years.

Figure 26 Women pick sea snail in tidal flats



Source: These pictures were taken by the author during a field trip.

Sea snail is one of the most popular dishes in Chipei. Referring to the picture (figure 26), there are so many women picking sea snail in the stone weirs when the tide falls. The story of sea snail is going to be told below.

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<sup>69</sup> Sea cucumbers are echinoderms, there are approximately 1250 known species. (The sea cucumber they caught was a toxic one "Dàng Pí Shēn" is what we call it) Sea cucumbers feed on tiny particles, waste and sand, then break down those inputs into even smaller pieces which could feed bacteria, and get into the ecosystem again.

<sup>70</sup> In China, it is used as Chinese medicine.

Chipei is known for its sea snail <sup>71</sup>, and it is one of the specialties of the local dishes. Mid-age women pick sea snails everyday when tide falls. It is easy to find sea snail in most of every local restaurant. Averagely speaking, one plate of sea snail is 3 USD which is around fifty sea snails in one plates. There are millions of tourists flourished into Chipei each year, it is hardly estimated how much sea snails would be caught.

According to the islanders, those women who pick sea snails everyday, they averagely earns 30 USD per day, it is about tens of hundreds of sea snails are caught everyday per person. In addition, tourists also pick sea snails for their dinner. Therefore, it is impossible to calculate how many sea snails were picked every year and how much people are there picking sea snails everyday. The sea sanils could not only serve in the restaurant as a dish, but also be sold to the fish market in Magog or to the local venders.

The local guides also lead their group experiencing picking sea snails. Enormous amount of sea snails are taken away from stone weirs every single day which damages the land and ecosystem gradually.

Lead a good life is the most important thing fir the islanders. Being one of the small offshore islands in Taiwan they are relatively in a “periphery” position including poverty, low standards of living, the lack of advanced technologies, the shortage of infrastructure and medical caring. What they could do is taking the best use of their resources. With the talent of swimming, diving and fishing, the only way for making a living on the island is by combining that with the tourism industry. Being over-exploited both on the land and underwater for more than three decades, most people feel the changes on their environment. The bio-diversity is fewer, the individual fishery is smaller than before and the coral reefs are dead into pieces. Stone weirs were gradually deposited by sand and small pieces of coral reefs. Only 5% of fishery stocks remained in stone weirs compare to thirty years ago.

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<sup>71</sup> Sea snail in Chipei is mostly Trochidae which is called” Zhong luo” in Chinese. It feed on hard substrate species graze on algae, algal spores, detritus or bacteria.

## **Offshore fishery became prosperous**

Niao Yu village<sup>72</sup> as well as a village in Bai sha Township as Chipei, he mentioned 1980 as a turning point in Niao Yu because of the application of echosounder, net drums and two-way radio for detecting the fish spots and torch light nets were replaced by boat seine nets which could find new fish spots. The case in Chipei Island is almost the same as in Niao Yu. People started to go offshore for fishing from that time. Referring to the year book, the records on offshore fish catch in Penghu started at mid-1980s, which means that people expanded their fishery spots from inshore to offshore from the 1980s.

## **Summary**

In the post-1970s, since the economic boom in Taiwan, and the cross-island bridge in Penghu archipelago were built. Penghu became a new destination for tourists. Chipei is one of the most popular island in Penghu archipelago. Thus, tourism became the most important sector in Chipei Island from the 1970s. For satisfying millions of tourists, guest houses, restaurants, shops mushroomed and harbor, roads were exploited. A serious damage in the underwater ecosystem takes place when tours go to stone weirs, pick up the aquatic life and step on the coral reefs. Moreover, dishes that restaurants served and the motivation to catch more fish and lobsters are threatening the bio-diversity as well. As much as local people extract, as harmful as the underwater will be. Tourism is no longer believed as a green industry, but results in the ecological degradation in Chipei Island.

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<sup>72</sup> Chen, H-M (1992) An ecological approach to the fishing community of a coral island: study of Niao Yu, the Penghu Island, Geographical Research, No18

## Conclusion

The story of stone weirs hasn't ended. For over three centuries stone weirs forms part of the backbone of local economy on Penghu. However, from the 1940s the story took a dramatic turn when modern technologies were introduced and new innovations were applied. For three decades, extraction of fish stock intensive as stone weirs become less significant for the economy. Over-extraction resulted in devaluated of the sea. From the 1970s, the tourist industry became the main economic activities.

As offshore island, Chipei had been placed as a “periphery” for a long time. People had relatively poor living standard compared with Taiwan island. The islanders was keeping a subsistence based economy, based primarily on stone weir fishery for livelihood. However, the land on Chipei was hardly cultivated because of the infertile soil and climate. By taking advantage of basalt and acquainting with the surroundings sea, they transported rocks from unproductive land to coastal where had sufficient resource to support them, heaping up the rocks to improve the productivity of the tidal flats.

Stone weirs is the wisdom of the ancient islanders, which by definition, as a landesque capital which could be productive if the fishery stocks were not reduced in nearly decades. Material flow occurred when they were building a stone weir by moving rocks from the unproductive place to the coast. They pile up the rocks cooperatively as a stone weir and develop a complete principle and system.

However, in the end of 1940s, ecologically unequal exchange was taken place on the island when new technology was introduced, such as freezer equipment and machinery boats in 1950s. The main places with which Chipei engaged on trade to are Magong city and Taiwan Island. Thus, ecologically unequally exchange took-off when the “core” and “periphery” were established between regions or islands. The ecological consequence,



the significant shift is a reduction of fishery stocks. Moreover, ecological degradation under water and the death of coral reefs were a dramatic aftermath. If people continue exploiting the resources of the sea, it will be not sustainable anymore.

Technological innovations played an important role on the development of fishery industry and the economy of Chipei island. Chipei is dependent on trade for satisfying a variety of needs. They don't have any trees, the soil is not fertilize, there is no manufacturing and a lack of infrastructure. Most of what they need is imported from Taiwan or Magong by exchanging fish. Thus, the more harm caused by the ecologically unequal exchange, the more dependent the island becomes on the core regions.

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# Appendix I

## Population in Chipei during 1688 to 2007

Year	Population	Note
1688	6000	Qing dynasty
1736	13417	Large amount of immigration pour into Penghu
1762	24050	
1767	25843	
1838	59128	
1893	67541	1895 Japan took over Taiwan
1905	56327	
1906	55352	
1907	54388	
1908	54597	
1909	55423	
1911	55883	
1923	60315	
1935	67601	
1943	70842	Taiwanese government took the power back from Japan
1951	80731	
1961	100502	
1971	118774	
1981	105674	Immigrate to Taiwan island for jobs
1991	95346	
2001	92268	
2007	91950	