



Environmental changes and building resilient community in Penghu Islands

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Abstract The world today is facing the impact of the environmental changes, resulting in changes to the ecological environments and threats to the human living space. Thus, how the communities facing with those changes, revive the environment, and maintain the sustainable development of society and economy is an important direction for governmental policy around the world. With rich fishing resources, Penghu Islands has a long history of fisheries. However, faced with the impact of environmental changes and under the ecologically unequal exchange patterns of fishery and tourism, Penghu Islands has to rely on the main island of Taiwan for resources.

This study aims to investigate the unequal exchange behavior of early fishery and recent tourism development of Penghu Islands. By reviewing the implementation of the policy of developing a low-carbon island, this study summarizes the resilient community construction pattern, which is very important to sustainable development, and expects that Penghu Islands can be constructed into an eco-tourism, environmental education, scientific research and living experience area, as well as an example of sustainable island.

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Introduction

Global environmental changes, ecological conservation, and the sustainable use of natural resources are important issues of Agenda 21st Century. In the trends of global changes, how to promote ecological conservation and sustainable use of natural resources to maintain the sustainable development of human society and the economy is an important policy

direction for governments around the world. For Taiwan, which is an island country, the rich fishery resources make fisheries become the economic lifeline of the island, and related industries have led to the prosperity of the local economy, marine environment maintenance and the conservation and utilization of marine resources. Fishery is the foundation of sustainable development.

Penghu is a remote offshore island in the Taiwan Strait. Although its inclusion in the social and economic system has reduced its solidarity, it is still a peripheral island. Despite of the diverse fishery technologies on the island, the development of fishery and agriculture is still limited. Recently, due to the depletion of fishery resources in coastal waters of Taiwan,

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Penghu's unequal exchange behaviors become increasingly serious. After a large number of fishery catches have been sold to the main island of Taiwan, the traditional fishery industry of Penghu started to rapidly decline since 1990. Although the development of tourism has led to the rapid prosperity of the tourism industry in Penghu, the unequal exchange behavior is ongoing. Such a development model is unfavorable to the sustainable development of the island. Therefore, focusing on marine industries, this study expects to identify the problems and solutions for the local residents by the historical discussion of island environmental changes. The purposes of this research are as follows:

- 1.1. To understand the environmental changes of Penghu Islands;
- 2.1. To understand the unequal exchange of Penghu;
- 3.1. To propose relevant suggestions for the island resilient community development.

Literature review

Introduction to Penghu

Located in the middle of the strait between Mainland China and Taiwan at latitude 23 ° 12' to 23 ° 47' and longitude 119 ° 19' to 119 ° 43', Penghu Islands consists of more than 90 islands. The Tropic of Cancer at 23 ° 27' goes through the southern part of Huching Islet of the islands. The Far East island: Chamu Islet, the far west island: Hua Islet, the far south island: Qimei Islet, and the far north: Darao Islet. Islands in this range are collectively known as Penghu Islands. Penghu County has five townships and one city. Magong City and the land part of Huhsi Township are collectively known as the island of Penghu with an area of approximately 65.41 square kilometers (Penghu County Government, 2009).

The natural environment of Taiwan Strait where Penghu Islands are located is complex as the north-south coastal currents dominate in winter and the south-northward warm currents and the tributaries of Kuroshio from the Pacific rule in summer. The confluence of warm and cold water makes Penghu rich in fishery resources. However, as Penghu is surrounded by sea, it is relatively affected by northeast monsoon. As a result, the development of the early stage industry (fishery) and the current industry (tourism) is restricted.

Environmental change

The impact of environmental change has no empirical proof (Wan et al., 2000). However, it can be established that environmental change will bring about political, economic, social and cultural impact. These shocks will result in changes in industrial development, such as human activity and the increase of exchange that may cause impact and the damage to the landscape resources, ecological resources, agricultural land resources, supply services, regulating services and cultural services and other functions (Tsai, 2009; Wang and Chang, 2009). As islands mostly rely on the ocean as the economic lifeline, the fishery economy will be affected in the first place in environmental changes, so is the case of Penghu Islands.

Unequal exchange

Unequal exchange refers to the transition of cumulative capital from politically weaker region to the stronger area (Wallerstein, 2004). While the concept of ecologically unequal exchange (EUE) focuses on material flows of trade, especially in terms of embodied labor, embodied land and environmental degradation. This process will result in the environmental degradation of the politically weaker area. Some successful societies transferred or output the environmental costs caused by the consumption behavior to politically weaker consumed area (Hornborg, 1998, 2001; Clark and Tsai, 2009, 2012). As Penghu Islands are geographically located in the remote area, the development model has been riddled with unequal exchange behavior. As a result, its economy tends to be disadvantaged and the resources are dwindling.

Resilient community

Huang and Guo (2012) pointed out that community recovery resilience is the preparation of the community before the occurrence of the disaster, the response and capabilities or capacities of the community after the occurrence of the disaster, in particular, the community is able to learn how to adjust response during the process of disaster, and thus it does not need to totally depend on others, governments and NGOs. Namely, the resilient community should have self-preparation and responsiveness and does not need the excessive dependence on external resources. The network resources of establishing the resilient community include: economic development, social capital, information communication and community capacity (Norris et al., 2008). Namely, the resilient community can: (1) explore a variety of community resources; (2) in the method of community seeking process, promote the community residents to perceive and identify the tribulation pressure sources; (3) understand how the community responds to disaster pressure.

In summary of the above, environmental change and unequal exchange behaviors result in the impact of declining economy of the island. There are 96 villages and communities in the area of Penghu Islands, faced with declining economy and environmental disaster, communities should learn how to strengthen themselves to become self-supportive resilient community. Furthermore, the resilience of the entire area can be established step by step, which is very important to the realization of sustainable island.

Methods

This is a qualitative study based on literatures. Research methods of systematic and subjective definition, evaluation and summarized verification are used to confirm the authenticity and conclusions of past events, and gain an understanding to rebuild the past, explain the present and infer the future (Yeh and Yeh, 2002). The researchers reviewed journals, books, theses and dissertations, websites and governmental publications such as county chorography, official statistical data, anthology and newspaper relating to the research topic to gain further knowledge of the research topic.

County chorography

County chorography is the confluence of local literature covering a wide range. It can be geographic description, political evolution, economic development, educational direction, changes in transportation and the activities of the people.

Official statistical data

Data relating to the agriculture and fishery of Penghu are included in Penghu Statistical Abstract, for example, the increase and decrease of fishery households, the production of agriculture and fishery, changes in farming area, the increase or decrease of a forestation, which helps very much in the understanding of the changes in agriculture and fishery.

Collected works

Books relating to the agricultural and fishery industries of Penghu can help understand the changes in the agricultural and fishing industries of Penghu.

Newspaper

In addition to relying on statistical information, as for fisheries data, the Fisheries Annual Reports have been faithfully recording the changing process of fisheries of Penghu for decades.

Results and discussion

Japanese colonial period of enlightenment

During the Japanese Occupation Period, the coastal fishing activities of Penghu mainly include: stone weir fishing, shore seine fishing and gill net. The coastal fishing activities started to flourish in 1920s and faced with problems of fishing boat equipment and damaged harbor after the “Pacific War” of World War II. It indirectly resulted in the decline of coastal fishing activities. Since then up to 1945, coastal fishing activi-

ties dominated Penghu, supplemented by offshore fishing activities (Penghu County Government, 2005).

The flourishing period of 1950s-1990s – from coastal fisheries to offshore fisheries

The flourishing of Penghu fisheries depended on three elements: (1) the emergence of powered fishing boats, the implementation the “fishing boat program” from 1953 to 1972 to achieve the goal of “fishermen with fishing boats” (Chen, 2009); (2) new fishery technology with the introduction of purse-seine and deposited net fisheries (purse seine and rod granted seine), drag net fishery (single vessel bottom trawl and grilled net) and improved fixed shore net technology; (3) the construction of fishing ports from 47 in 1970s to 69 in 1990s ranking the first in Taiwan (Council of Agriculture, 1993).

As shown in Fig. 1, in early 1950s, coastal fisheries still dominated in Penghu. Since the implementation of the policy of “fishermen with fishing boats” in 1952 by the Penghu County Government, coupled with introduction of fishing technology and construction of ports, the number of powered fishing vessels gradually increased. The production of offshore fisheries of Penghu gradually increased. In 1960s, the production of offshore fisheries exceeded the production amount of coastal fisheries and the benchmark of 30,000 tons. Afterwards, in 1970s, with the continuous growth of powered fishing boats, the production of offshore fisheries reached the level of 39,971 tons. On the contrary, the production of coastal fisheries decreased as the focus of fisheries of Penghu was shifted to offshore fisheries; during the period of 1980s to the end of 1980s, it was the peak of powered fishing vessels of Penghu. However, the production of offshore fisheries had not made any breakthrough. Since then, the production of coastal fisheries started to decline. The government was actively promoting and the industry continuously strengthened investment with the active efforts of the academic units. However, due to resource limitations, the coastal and offshore fisheries of Penghu were not further developed. On the contrary, since 1990s, the powered fishing vessels of Penghu and the production of offshore fisheries started to decline.

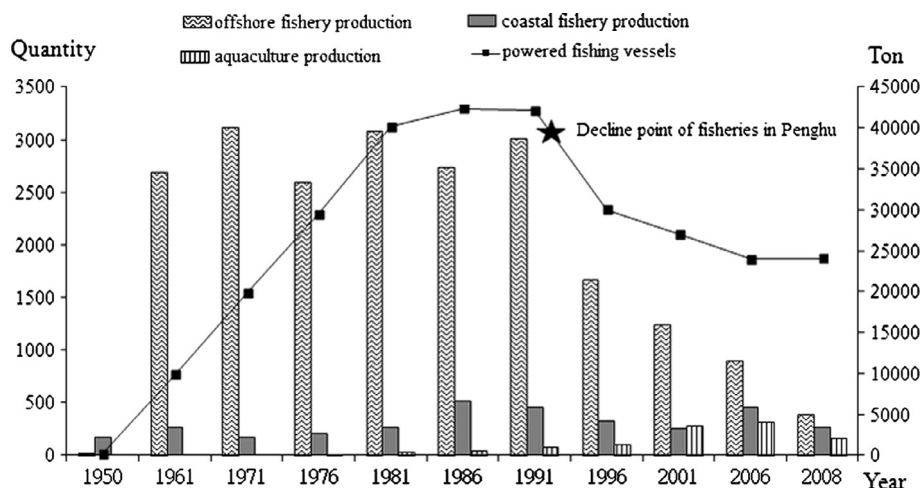


Fig. 1 Offshore, coastal aquaculture production and number of powered fishing vessels of Penghu in 1950–2008.

Decline period

The decline of Penghu fisheries resources can be attributed to the following elements: (1) overfishing, the newly introduced fishing methods increase fishing catches and result in the depletion of marine resources; (2) illegal fishing, the rampant poisoning, electrifying and bombing fishing; (3) aging population, unstable income to prompt the relocation of young population; (4) climatic change and temperature is on the rise.

Transition

The traditional fishing activities of Penghu cannot satisfy the economic benefits of Penghu. In 1992, the aquaculture output was 896tons and the average per ton value was about 249,000 NTD; on the contrary, the output of offshore fisheries in 1992 was 36,292tons, and the average per ton value was about 51,000 NTD. Therefore, since the formulation of “Recreational Fishery Administrative Methods” by the government in 1993, Penghu County started to move from the traditional fishery economy to the new industry. The traditional fishing activities of Penghu were being combined with tourism to become the recreational fishery.

Unequal exchange

Fishery unequal exchange

In the early era of imperfect organization, the sales of goods were mainly of retailing, and fishery is no exception. With the rise of the organizational operation, labor division of major wholesaler, medium wholesaler and downstream distribution started to emerge. In this study, we summarized the annual data of Fisheries Agency. As the data have shown, even after the introduction of the new industry, the unequal exchange of fishery resources still existed. However, in Penghu, due to geographic location, some fishing vessels do not return to the port but directly sail to the neighboring ports of Taiwan. Therefore, we believe that the amount of fishing catches recorded in the annual reports is actually lower than the real amount. Nevertheless, it can sufficiently reflect the flow of resources.

Fishing goods supply. The sources of fishing goods of Penghu Magong fish market can be divided into local and other regional supplies. As the statistical data of fishing goods in

early period depend on oral communication without detailed records. However, the supply of Penghu has been always local. As the annual report data since the inclusion of fishing goods supply by the Council of Agriculture 2005, 100% of the fishing goods supply of Penghu County comes from local suppliers (Fig. 2).

Sales of fishing goods. According to Fig. 3, 100% of catches on the Magong fish market come from the local suppliers. Only 40% of the catches are consumed in the local region including 10% for direct sales including: sales to the public, restaurants; 30% of the catches are locally processed including: dried fish, products for vacuum-packed sales; most of the fishing catches, 60%, are sold to other places.

Fishing goods percentage. With the modernization progress and the establishment of organization, the sales of fishing goods are mostly conducted via fish market in Penghu. In the summary of the statistical data of the annual reports of Fisheries Agency, it can be clearly seen from Fig. 4, in recent years, in the area of Penghu Islands, 60% of fishing catches are sold to Taiwan, and the market share in Taiwan is only 2.61%-3.44%, suggesting that fish market of Penghu lacks in competitiveness. In addition, the comprehensive development plan of Penghu County proposed by the Penghu County Government in 1997 records that the market share of catches from Penghu was 4.12% in 1995. It thus can be seen that the market share of fishing catches from Penghu gradually declined.

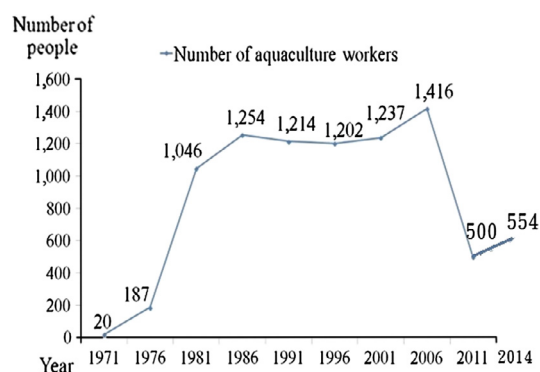


Fig. 3 Number of aquaculture workers of Penghu from 1971 to 2014.

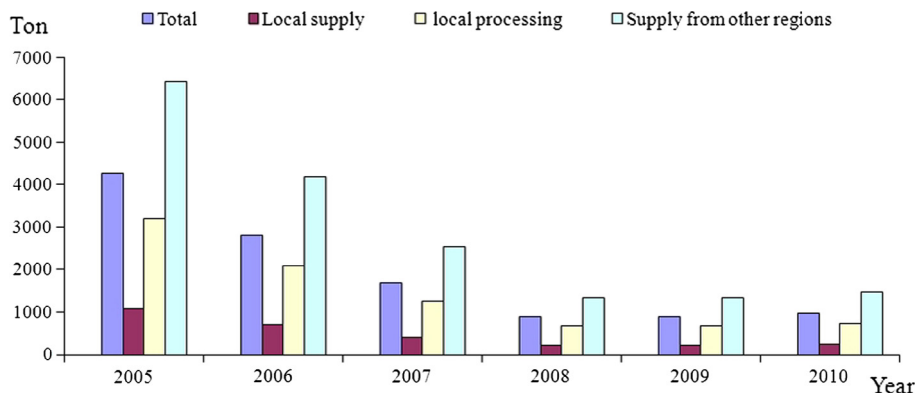


Fig. 2 Fishing goods of Penghu county in 2005–2010 (summarized from the 2005–2010 fisheries agency annual reports).

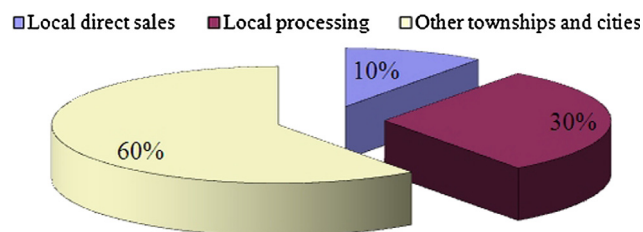


Fig. 4 Penghu County fishing goods sales (summarized from 2005 to 2010 Fisheries Agency annual report).

Number of aquaculture workers of Penghu from 1971 to 2014 reflects the rise and fall of Penghu fishing (Fig. 3).

Tourism industry unequal exchange

Although recreational fishery opens new source of income, the income is actually obtained by unequal exchange such as: aragonite industry, water resources, and living quality. Namely, visitors to Penghu are most impressed by “water” such as “livelihood water” and ocean” followed by “transportation, which means the carbon dioxide produced by transportation vehicles, can damage the living quality. Tourist groups mainly use tourism vehicles and individual visitors rely mainly on motor cycles including tourists hiring vehicles by their own. Therefore, the unequal exchange behaviors of tourism industry can thus be further explored.

Aragonite industry. The land and ocean industries of Penghu flourished side by side, forming the “aragonite industry”. It lasted till 1961. However, with no recognition of conservation, the aragonite industry started the mechanical processing. By 1971, in 10 years, poor sales of the aragonite industry start to emerge due to excessive mining of aragonite. The lack of changes in processing of aragonite cannot attract the attention of customers and general customers have no idea of restoring aragonite in addition to the loss of color of aragonite (Yu and Fang, 2005).

Although Penghu County Government issued ban on mining after 1991, the aragonite resources of Penghu have been depleted. In the following 20 years up to the present, the aragonite of banning has not recovered the previous resources. The rise and fall of aragonite is the most conspicuous ecological unequal exchange behavior of the development of tourism industry of Penghu. To develop tourism and get income, a large amount of aragonite resources were mined and sold. Moreover, the government encouraged the establishment of

aragonite processing factories, resulting in the rapid depletion of aragonite resources. As a result, the market is full of products of inferior quality to destroy the reputation of aragonite, accelerating the decline of aragonite resources and decomposition of the industrial structure (See Table 1).

Water resources. According to the “Water Supply Improvement Plan for Regions outside Taiwan Island” by Water Resources Agency (2007), the daily water requirement of each visitor to the destination is 226 liter. This study estimated the water amount required by Penghu visitors in 2010, assuming visitors to Penghu would stay at least for a single day and the cost of water purification by seawater distillation plants is about 30–40 NTD per ton. By the calculation of cost of 40 NTD per ton, the estimation results are as shown in Table 2.

According to the results as shown in Table 2, at present, the seawater distillation plants on Magong can satisfy the water demands of tourists. In the high season of July, only the First Seawater Distillation Plant of Wukuan can satisfy tourist demands. By the water purification cost, it can be found that the amount for water purification of Penghu can be up to about 6 million NTD. As we assumed that tourists only stayed

Table 2 2010 estimated water consumption of tourists.

Month	Number of tourists	Monthly water requirement (tons)	Water purification cost (NTD)
1	10,562	2,378	95,120
2	15,223	3,440	137,600
3	13,069	2,954	118,160
4	62,376	14,097	563,880
5	81,663	18,456	738,240
6	75,096	16,972	678,880
7	137,496	31,074	1,242,960
8	102,676	23,205	928,200
9	64,225	14,515	580,600
10	20,429	4,617	711,018
11	17,351	3,921	156,840
12	16,753	3,786	151,440

Sources: ¹2010 monthly number of tourists: Penghu County Government Statistics Abstract; ²The water requirement for residence of tourists is 226 liters by referring to the “Water Supply Improvement Plan for Regions outside Taiwan Island” by Water Resources Planning Institute in 2007; ³Water purification cost of sea water distillation plant (including building factory, land, pipelines, operation, feedback, equipment renovation, interest rate of 6%, 20 years of life service) is about 30~40 NTD/ton.

Table 1 Production and value of coastal, offshore and aquaculture fisheries of Penghu in 1992–2014.

Year	Offshore fisheries		Coastal fisheries		Aquaculture	
	Output	Value (thousand NTD)	Output	Value (thousand NTD)	Output	Value (thousand NTD)
1992	36,292	1,861,370	4,259	147,806	896	223,356
1995	25,656	2,281,221	4,198	263,961	1,195	298,273
1998	19,722	1,563,008	3,526	284,035	2,735	545,809
2001	15,984	1,778,152	4,702	639,188	3,530	692,850
2004	18,453	2,004,887	7,409	954,707	7,884	1,708,669
2008	10,177	1,252,013	3,357	325,815	4,847	1,229,278
2010	5,127	743,414	777	67,163	3,657	816,993
2014	4,955	544,225	1,424	136,445	3,630	824,544

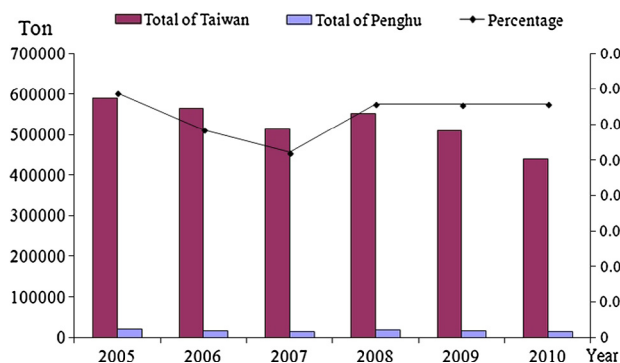


Fig. 5 Supply percentages of Penghu (Magong) fish market and Taiwan in 2005–2010 (summarized from 2005 to 2010 Fisheries Agency annual reports).

for one day, if they stayed for 2 to 3 days, the water purification costs can be doubled.

Although tourists can bring about income to the local residents, they can consume a large amount of costs as the water purification cost of the seawater distillation plant is about per ton 40 NTD. The water supply company only charges 10 NTD per ton, and the rest part of the costs are taken by the government. The fiscal income of the government is not too much and cannot take care of the residents naturally. Therefore, the final loss will be returned to each resident. Therefore, the residents are exchanging their own “resources” with the current “income”.

Quality of life. Tourism can be divided into group tourists and individual tourists. In the area of Penghu, group tourists use passenger vehicles as the main transportation tool, and individual tourists mainly use motorcycles as the transportation tool including tourists hiring cars at some times. As shown in Fig. 5, the number of passenger vehicles of Penghu has been doubled as compared with the number in 10 years ago. The number of motorcycles has been reaching new records each year. The increase in number of vehicles is mainly because of visiting tourists. In recent 10 years, the increasing number of passenger cars and motor cycles can increase the carbon dioxide emissions of Penghu without doubt. Relatively, the air quality will be affected step by step without the knowledge of the residents.

Conclusion and suggestion

The wake-up thinking of fishery changes

Penghu fishery resources are very rich. However, fishermen have been overfishing without moderation, leading to serious overfishing. Coupled with illegal fishing behaviors, it creates worrying problems of marine resources. Bombing and poisoning fishing behaviors not only create pollution to the marine environment and water quality, the fish catches can have residuals of the toxic substances. The fishing resources reduce and the working environment of fishery become more difficult and dangerous, making people unwilling to engage in fishing activities. As a result, the population of Penghu is aging to accelerate the decline of fishery economy. Furthermore,

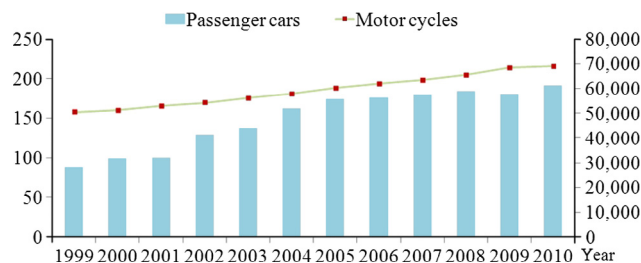


Fig. 6 Number of passenger vehicles and motorcycles of Penghu in 1999–2010 (summarized from 1999 to 2010 Penghu Statistics Abstract).

tourism is developed to replace the fishery to gradually become a new pillar industry of Penghu. It is expected the same mistake will not be repeated in business operation and management.

To improve unequal exchange model

This study found that fishery changes and unequal exchange behaviors exist in the area of Penghu, even if the economy has been transited to the development of tourism. Due to geographic limitations, the development of the island has many restrictions. If exchanging the resources with the current income continuously, the niche of sustainable development will be sacrificed. Therefore, for sustainable development, regardless of fishery supplemented with tourism in the past or the tourism supplemented with fishery in the present, it should be recognized that the current behavior is a kind of “resource unequal exchange behavior”. Such a development model should be improved before realizing the sustainable development of the island.

Building of resilient community

Regarding the implementation of habitat protection to strengthen fishery resource restoration, to arouse the sense of crisis of community residents of the depletion of fishery resources and to encourage the self-management of community in addition to the restoration of the community and the sustainable development of sea environments, the more important thing is how to realize “resilient community”. Resilient community realization is the reemergence by the strength or advantage of the community in the face of huge changes or hardship. For this reason, it need to think how to allow the community to integrate the traditional sustainable living patterns with new knowledge to rebuild the production culture of mutual help of fishing villages. To learn the sustainable living skills and self-reliable island economic pattern without depending on external resources is the way of survival of island fishing villages (Fig. 7).

In 2011, Ministry of Economic Affairs selected Penghu as the “Low Carbon Example Island” and is expected to invest nearly 8.1 billion NTD to create a “low carbon home” of Penghu. The policy has boosted Penghu suffering low development rate due to the impact of climate, and set the tone for the sustainable development of island and marine environment. In other words, the concept of “low carbon” is instilled in life to create Penghu as a home of “low carbon life” (Hsue,

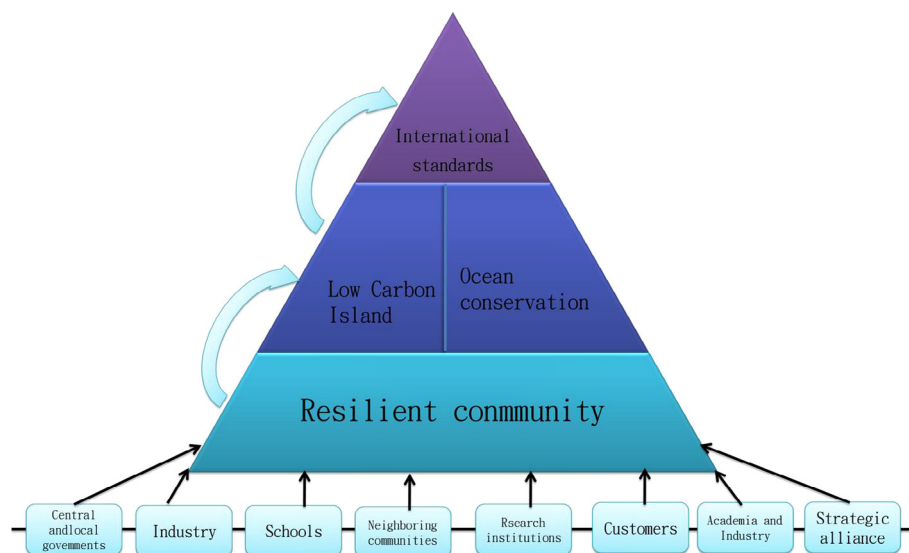


Fig. 7 Resilient community and island sustainable development (compiled in this study).

2011). The ultimate goal of the resilient community is to allow the community to have the self-for-profit space. In the future, the “open innovation theory” can be introduced to realize resilient community. Community resources are only one of the key factors driving the growth of the community. When residents convert resources into more valuable products or services, they create value for the community, interact, coordinate, communicate and make decisions. The process include the community product (service) development and training, market survey, budget, employee development, salary, and resource distributions. Comprehensive cooperation is the right way of building resilient community.

The basis of building resilient community requires the joint efforts of various parties starting from human resources including the industry, government, the academic and community residents. In this way, the foundation of resilient community can thus be built to support the promotion of low carbon island strategy in Penghu. Therefore, the building of resilient community is of considerable importance. It allows the community residents take advantage of the traditional living skills to have self-support capabilities. Moreover, it helps greatly the combination of land of Penghu (low carbon island) and waters (ocean conservation). The combination of land and sea can definitely conserve the resources for the full implementation of the membership of the Beautiful Bays of the World granted to Penghu in 2012 and meeting of the international standards. Finally, we can understand the demand of island residents on independent environmental governance to achieve the sustainable development of resilient island (Fig. 6).

References

- Chen, H.W., 2009. A Study on Fishery Changes and Social Development of Ling Yuan Township. Graduate Institute of Taiwan Culture. National University of Tainan.
- Clark, E., Tsai, H.M., 2009. Ecologically unequal exchange and landesque capital on Kinmen Island. *Center Asia-Pacific Area Studies* 44, 148–167.
- Clark, E., Tsai, H.M., 2012. Islands: Ecologically Unequal Exchange and Landesque Capital. In: Hornborg, A. et al. (Eds.), *Ecology and Power: Struggles over Land and Material Resources in the Past, Present, and Future*. Routledge, London, pp. 52–67.
- Council of Agriculture, Executive Yuan, 1993. Taiwan Fishery in 40 Years.
- Hornborg, A., 1998. Towards an ecological theory of unequal exchange: Articulating world system theory and ecological economics. *Ecol. Econ.* 25, 129–136.
- Hornborg, A., 2001. *The Power of Machine: Global Inequalities of Economy, Technology, and Environment*. Alta Mira Press, Walnut Creek.
- Hsue, H.G., 2011. Evaluation of Possibilities for Low Carbon Island: An Example of Wangan Island in Penghu (Master Thesis). National Taiwan Ocean University, Keelung.
- Huang, S.L., Guo, E.H., 2012. Relationship between community recovery resilience and rebuild of society after disaster. *J. Taiwan Community Works Res.* 2, 22–28.
- Norris, F.H., Stevens, S.P., Pfefferbaum, B., Wyche, K.F., Pfefferbaum, R.L., 2008. Community resilience as a metaphor, theory, set of capacities and strategy for disaster readiness. *Am. J. Community Psychol.* 41, 127–150.
- Penghu County Government, 2005. *Penghu County Chorography-Fiscal Book*. Penghu County Government.
- Penghu County Government, 2009. *Penghu County Statistics Abstract*. Penghu County Government.
- Tsai, H.M., 2009. Co-evolution and Beyond: Landscape Changes in the Penghu Archipelago (the Pescadores), Taiwan. *Asia-Pacific Forum* 44, 193–213.
- Wallerstein, I., 2004. *World-Systems Analysis: An Introduction*. Duke University Press, Durham, NC.
- Wan, G.H., Wang, G.C., Li, C.S., 2000. An analysis of the impact of global environmental changes on public health. *Chin. J. Public Health* 19, 20–32.
- Wang, S.H., Chang, L.F., 2009. Urban peripheral land use and ground surface coverage changes: driving forces and environmental change issues. *Urban Planning* 36, 361–385.
- Water Resources Planning Institute, Water Resources Agency (MOEA). *The General Report on Penghu Ground Water Resources Survey and Planning (2006-2007)*, 2007. Environmental Investigation and Analysis.
- Yeh, C.C., Yeh, L.C., 2002. *Research Methodology and Thesis Writing*. Shinning Culture, Taipei City.
- Yu, B.C., Fang, C.N., 2005. *Gem of Taiwan*. Yuantsu Cultural, Taipei.