EVALUATING LOCAL CLIMATE CHANGE ADAPTATION ALONG THE SOUTHWEST COASTAL AREA OF TAIWAN

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Submitted in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

January 2017

Abstract

In the context of research highlighting the mixed performance of coastal climate change adaptation elsewhere, this thesis developed a modified Analysis-Awareness-Action (AAA) framework to evaluate local climate change adaptation in four coastal townships along the vulnerable southwest coast of Taiwan in order to derive recommendations for local adaptation framework development. This mixed-method research included an assessment of socioeconomic vulnerability through the development of a socioeconomic vulnerability indicator framework (SVIF) (‘Analysis’). This included a face-to-face questionnaire survey with the public to evaluate public awareness of climate change (‘Awareness’), public participation and community engagement in adaptation actions; and an expert workshop and follow-up survey to identify the challenges in local adaptation framework (‘Action’).

Results of the study show that the AAA framework is not only a useful and relevant approach to contribute to local adaption in Taiwan, but can also serve as a reference for other threatened countries and people in Asia and non-member countries of the United Nations Framework Convention on Climate Change to respond to climate change. Results of the SVIF demonstrated that the SVIF was capable of judging location-specific susceptibility and resilience to climate change between different coastal communities. Results of the questionnaire revealed high levels of public concern about climate change, but generally public understanding is insufficient. Further scientific evidence and explanation is necessary to increase public understanding and knowledge of climate change. Many findings are consistent with the wider literature. For example, respondents favoured an emphasis on mitigation over adaptation; preventive and protection actions were seen as the most effective adaptation approaches and the immediate priority; potential cost and influence of specific govermental actions on communities may constrain participation. Additionally, cognitive, affective, and behavioural factors, which may influence local adaptation engagement, were identified. These suggest that a constructive dialogue and participatory process is needed with the public in order to increase community engagement in local adaptation.

Finally, specific challenges for local adaptation framework development, related to political, economic, social, technological, legal, and environmental (PESTLE) perspectives were identified. As a result, it was recommended that there is a need for a

range of improvements to the current system, including engaging other local organisations and private actors, developing specialist organisations, legislative acts, and considering multiple objectives in formulation of adaptation actions to eliminate the potential conflict of interest.

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank those people who have helped in making it possible for me to complete this work. Firstly, I give a huge and grateful thank you to me supervisor Dr Rhoda Ballinger for her support during the extensive production of the thesis. Secondly, I would also like to thank Dr Azmath Jaleel, Dr Wen-Hong Liu and Dr, Kuo-Huan Ding within the National Kaohsiung Marine University, both of whom were very helpful during this research. I am especially grateful to those interviewees who provided me with their valuable time, information and insight into the climate change and adaptation.

Within the Earth and Ocean Science Department at Cardiff, I have made many friends who have provided fruitful discussions and helps on many things. My thanks go to the Severn Estuary Partnership (SEP), Josh and Miros. Closer to home are of course the people outside of work; Moses's family, Fay and Pascal, who helped me keep perspective and provided useful suggestions to deal with the problems in my life in the UK.

I am of course thankful to all my family and friends in Taiwan, in particular to my mom, May Chang, for her constant support and encouragement. Finally, I wish to thank my girlfriend Jin Lin. She has been my partner in this process, providing support and her patience and caring, kind words and sharing. Thank you for keeping me on track and helping me to overcome the challenges and difficulties.

To my father Deng-Yi Jhan and uncle Ping-Chien Chang,

for inspiring and encouraging me

DECLARATION

This work has not been submitted in substance for any other degree or award at this or any other university or place of learning, nor is being submitted concurrently in candidature for any degree or other award.

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LIST OF ABBREVIATIONS

APF	Adaptation Policy Framework
CEPD	Council for Economic Planning and Development
COA	Council of Agriculture
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CVI	Coastal Vulnerability Index
CWB	Central Weather Bureau
DOH	Department of Health
EPA	Environmental Protection Administration
FI	Forest Index
GEI	Geographic Exposure Index
HDI	Human Development Index
IPCC	Intergovernmental Panel on Climate Change
ISDR	International Strategy for Disaster Reduction
MND	Ministry of National Defense
MOEA	Ministry of Economic Affairs
MOI	Ministry of the Interior
MOTC	Ministry of Transportation and Communications
NCCARF	National Climate Change Adaptation Research Facility
NCSD	National Council for Sustainable Development
NDI	Natural Disaster Index
NGOs	Non-Government Organisations
NSC	National Science Council
PDI	Population Density Index
SVIF	Socioeconomic Vulnerability Indicator Framework
TCCIP	Taiwan Climate Change Projection and Information Platform
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UKCIP	United Kingdom Climate Impacts Programme
WMO	World Meteorological Organisation
WRA	Water Resources Agency

Chapter One Introduction

1.1 Introduction

This introductory chapter gives an overview of the research which focuses on climate change adaptation in the southwest coastal areas of Taiwan. The purpose of this chapter is to introduce the issues and establish the rationale and focus of the research as well as to explain the research methods adopted. It also highlights the key terms used in the thesis. The associated rationale and justification are outlined in Section 1.2 and the research aim, objectives, and questions are presented in Section 1.3. A brief outline of the methodological approach, the Research Strategy Model and associated stages is presented in Section 1.4. Finally, Section 1.5 presents an overview of the thesis structure and details the aims of each chapter.

1.2 Rationale

1.2.1 Why do We Need a Climate Change Adaptation Framework?

The threats of climate change

Climate change is arguably one of the greatest environmental threats the entire world faces this century. Many researchers argue that the impacts of climate change have been influencing human livelihoods and ecological environment for some time and consider these effects will continue into at least the near future (see for example: Poortinga *et al*., 2006; Parry *et al*., 2001; Poortinga *et al*., 2011). Burton (1996) and Parry (1986) suggest that the nature of climatic impacts is multiple, and the impacts of climate change are potentially devastating and costly. These include loss of life, economic losses, and environmental degradation (see: Harley *et al*., 2006; Satterthwaite *et al*., 2009; Dowden, 2008). In order to reduce the undesirable effects and influences of climate change, numerous researchers have focused on two major topic areas/issues: one is related to possible scenarios of the climate condition itself (see: Dow and Downing, 2007; Parry *et al*., 2007; Moss *et al*., 2010), and the other is related to reducing potential influences of climate change on natural and human systems (see: Rayner and Malone, 1998; Yohe and Tol, 2002).

Vulnerability and adaptation to climate change

Over recent decades, as both academic writers and policy makers have recognised that the severity of climate change and associated risks and, as a consequence, they have highlighted climate change adaptation as an urgent issue for modern human society (see for example, Urwin and Jordan, 2008). Within this academic discourse, the relationship between natural disasters and human systems has been shown to depend on a number of key characteristics related to adaptability and vulnerability, including the geographic characteristics, economic and social circumstances of populations, and property of actions (for example: Cutter *et al*., 2000; Hall-Spencer *et al*., 2008; Vijaya VenkataRaman *et al*., 2012; Smith *et al*., 2011; Bormann *et al*., 2012), as the detail interpretation in Section 2.3 and 2.4.

As Grubler and Nakicenovic (2001) have noted, the understanding of these potential vulnerable characteristics and practical response actions is more important than guessing what disasters or climatic events are likely to occur. Adger *et al.* (2009) assert that individual and social characteristics and risk perception, subjective and mutable limits to adaptation that currently decrease society's ability to act. This complexity of characteristics and factors, implies that any effective and practicable adaptation policies and actions should be specific to the climatic context, the types of impacts, and the properties of the people who need to take action. Therefore, the detailed study, analysis and characterization of vulnerability and adaptation to climate change is critically important. Adger *et al*. (2005a) and Tang *et al*. (2013) go so far as to suggest that such detailed studies already have transformed our understanding of how human society should prepare for the impacts associated with a range of climate change projections.

Adaptation framework is needed

It has been argued by Burton *et al*. (2002), that there are many issues associated with climate change. These include the uncertainty of climate change, the inappropriate mismatch of scale between climate models and adaptation actions, and the design of impact assessments which do not consider a wide range of adaptation options. Therefore, a framework embracing an appropriate geographical/spatial scale and clear objectives is necessary to understand and collect specific information regarding the vulnerability and adaptation of specific local areas to climate change in order to inform effective local adaptation policies and actions.

1.2.2 How to Establish a Complete Adaptation Framework?

The components of the Adaptation Policy Framework

Planning to address the impact of climate change emerged in the middle 1990s as an important tool to respond to climate change (Wheeler, 2008). Within this period, the United Nations Development Programme (UNDP) proposed the Adaptation Policy Framework (APF) as a guideline for the design and implementation of adaptation action in all countries (Burton *et al.*, 2004). Figure 1.1 shows that this framework is comprised of five components: the scoping and design of an adaptation project; the assessment of current vulnerability; the assessment of future climate risks; the formulation of an adaptation strategy; and the continuation of the adaptation process. Moreover, this framework suggests that these components are supplemented by two cross-cutting processes: the engagement of stakeholders in the adaptation process, and the assessment and enhancement of adaptive capacity.

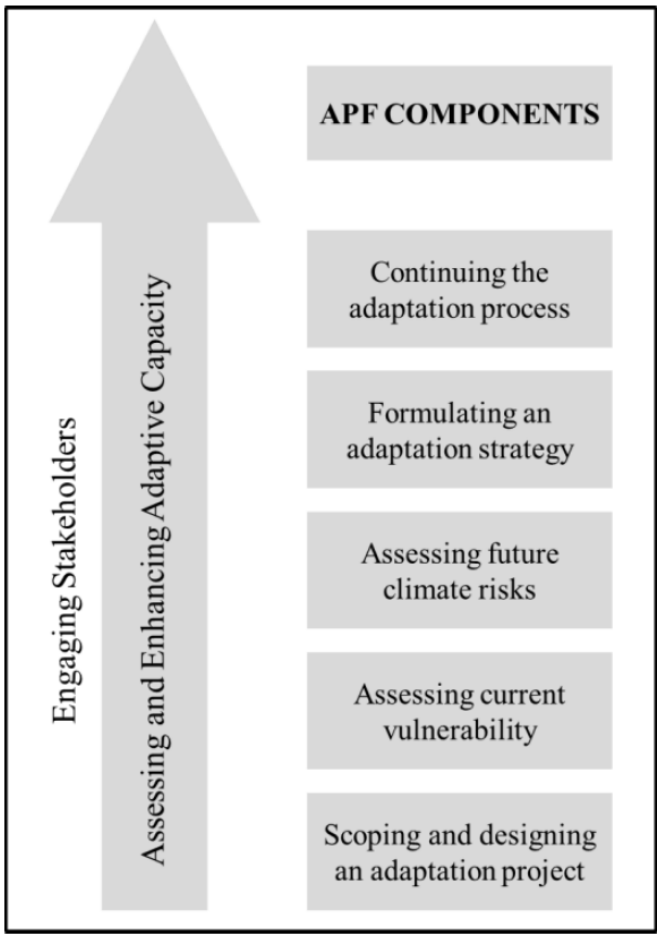


Figure1.1: The key components of APF

Source: Burton *et al.*, 2004

The cooperation between different governance levels for adaptation

The APF highlights that any adaptation mechanism should contain broad governance scales (international, nation, region and local) and stakeholder participation. McAnaney (2012) and Amundsen *et al*. (2010) have suggested that the central government should first develop the overarching policy framework and provide guidance for lower levels of the decision-making hierarchy (including local government) and identify areas of prioritization. In this context, Agrawal (2008) suggests that local governments have three roles in climate adaptation: 1. developing responses to local impacts; 2. mediating between individual and collective responses to vulnerability; 3. allocating the resources to facilitate adaptation. In this context, others such as Smith *et al.* (2009) and Ivey *et al.* (2004) suggest that the mandate of local government is expanding and local governments are the responsible for managing these impacts, due to the shifting of responsibility from higher levels to lower levels of authority.

As this review has shown, the local government can undertake in-situ adaptation actions in practical ways. Hall and Weiss (2012) suggest there is a need for a good interactive relationship between central government and local government for adaptation as, this may aid the engagement of a range of communities and areas. To summarise, the literature suggests an effective adaptation framework requires a multi-governance approach and a good interrelationship between central and local governmental actors.

Stakeholder participation and community engagement

The APF process has provided opportunities for local stakeholders to identify and share their interests and concerns with decision-makers (Ebi *et al*., 2005; Conde *et al*., 2005; Goven *et al.*, 2012). Alongside this, researchers have suggested adaptation practices should embrace the concept of community-based adaptation, which emphasises local participation and modifies the perception and enhances the knowledge of local communities (Ebi and Semenza, 2008). Lane and McDonald (2005) and Li (2002) provide reasons for this: they assert that local communities are more familiar with specific challenges and are therefore more able to inform the development of an appropriate, locally relevant planning process to adaptation. Therefore, stakeholder participation and community engagement are regarded as important within the adaptation process, in order to establish a more resilient and

adaptable society and enhance management efficiency (for example: Whitmarsh and Lorenzoni, 2010; Patel *et al*., 2007; Bormann *et al*., 2012; Dolan and Walker, 2004; Yohe *et al.*, 2007; Norman, 2009). Further related details are provided in Section 2.5.

1.2.3 Why do We Need to Adapt to Climate Change in Taiwan?

Threats of climate change to coastal areas and communities

Climate change and its related events have greatly amplified risks to coastal environments and ecosystems (for example: Lewsey *et al*., 2004; Diaz and Rosenberg. 2008; Halpern, 2008; Huang, 1997; Mortreux and Barnett, 2009; Tompkins, 2005; VijayaVenkataRaman *et al.*, 2012), socioeconomic development and security of coastal communities (for example: De Sherbinin *et al*., 2007; Yasuhara *et al*., 2012; Nicholls and Cazenave, 2010; Smith *et al.*, 2011; Hanson *et al.*, 2011; Tol *et al.*, 2006; Bosello *et al.*, 2012; Zanuttigh, 2011; Nicholls *et al.*, 2008; Barnett and Adger, 2007; Nicholls, 2004; Malone *et al.*, 2010; Chapman, 2012; Small and Cohen, 2004; Ehler *et al.*, 1997). Coastal communities are extremely vulnerable to ongoing climatic variability is particularly at risk in coastal areas as noted by Tribbia and Moser (2008) and Monirul and Mizra (2003). In a global context, it is well known that approximately 70% of major cities are located in such areas and 50% of the global population presently live within 60km of shorelines (Small and Nicholls, 2003). Also, most economic activities take place within 60 miles from coastline (Dow and Downing, 2007).

Of all coastal areas, small island states are amongst the most vulnerable to climate change impacts. Over the last twenty years, there has been a growing consensus that these states, such as those in the Pacific, are extremely vulnerable to external impacts which are triggered by natural events (for example: Field *et al.*, 2014; Tasi, 2000; Kelman and West, 2009; Huang, 1997; Pelling and Uitto, 2001). There has been growing recognition of a wide range of coastal problems in these islands (Barnett and Campbell, 2010). A number of studies (for example: Byrne and Inniss, 2002; Ratter, 2008; Parry *et al*., 2007; Bosello and De Cian, 2014; Field *et al*., 2012; Houghton *et al*., 1996; Capili *et al.*, 2005; Nicholls, 1995; Rosenzweig and Solecki, 2001) have noted that these problems include inundation, storm surge, erosion and salinisation of soil and groundwater; all these issues are likely to be aggravated by high intensity and frequency of climate variability and sea level rise.

The Southwest Taiwanese coastal communities and adaption to climate change

In Taiwan, with a coastline extending over 1,300 kilometers (MOI, 2006), there has been a dramatic increase in the population and economic development in the coastal areas over the last few decades. Taiwan regularly encounters a range of natural disasters including earthquakes and typhoons due to its geographical location and geological characteristics (Lu, 2010). In recent decades, climatic hazards have been exacerbated by climate change and have directly affected the inhabitants of coastal areas, especially in the southwest (Hsu *et al.*, 2011; Ko and Chang, 2012).

Studies in the last decade (Chiau, 2011; Lu *et al.*, 2009) have highlighted specific problems caused from overdevelopment (cross ref: 4.2.2) and vulnerable geography (cross ref: 4.2.1), particularly around western coastal area. These together with extreme weather events (cross ref: 4.2.3) have been exacerbating the impacts of natural hazards on southwest coastal communities, such as those around Pingtung County (Chien *et al.*, 2010). Indeed, the southwest coast has become the most hazard-prone area in Taiwan, and Wang *et al.* (2011) suggest that the communities who inhabit this area, particularly the stretch of coast from southwest Taiwan (Changhua, Yunlin, Chiayi, Tainan, Pingtung), may be amongst the first climate change refugees in the country. It should be noted, however, that despite such concerns, there has been little attempt to develop a community-based adaptation framework and engage the vulnerable communities in climate change adaptation in this area. For further details and specific interpretation of the South West coast's vulnerability to climate change reference should be made to Chapter Four.

This study was designed in the context of these concerns, particularly the need for Taiwan to address coastal adaptation to climate change at local levels. In the context of the literature on climate change adaptation, highlighted above, it was considered that this study should take into account the frequency of natural hazards, vulnerability of the environment, and the susceptibility of the socioeconomic structure of the coastal areas.

1.2.4 Is the Existing Adaptation Framework in Taiwan Capable of Improving Adaptation to Climate Change?

An insufficient understanding of socioeconomic vulnerability

The first point which this study will consider is the importance of the socioeconomic vulnerability in the adaptation framework. Previous studies (Laukkonen *et al*., 2009; Clark *et al*., 1998) suggest that the adaptive capability and vulnerability to climate change vary within different regions and communities as a result of geographic and socioeconomic variables. For these reasons, Burton *et al*. (2004) and Webb *et al*. (2013) have noted that any adaptation policy framework should embed the results of vulnerability assessment into the planning process.

Socioeconomic variables or characteristics are universally used to define the vulnerable communities and areas and to identify the specific vulnerability properties of a system (see: McLaughlin *et al*., 2002; Laksmono *et al*., 2008; Pawar, 2008; Thrush *et al*., 2005). Therefore, it was considered that this would be a potentially important aspect to consider for the southwest coast of Taiwan, because of the very different geographic features (estuary and wetland) and socioeconomic characteristics (industrial and population structure, and available resources) of coastal urban and rural areas (cross ref: Section 4.2). Although national and local frameworks have developed a set of adaptation policies and actions in Taiwan, the specific vulnerability of different local communities and areas rarely is taken into account. Therefore, the potential socioeconomic vulnerability to climate change is a primary concern of this thesis.

Lack of public awareness and participation in adaptation framework

The second issue which needs to be addressed in the Taiwanese adaptation policy framework is a lack of a process which is informed by knowledge about public perceptions and takes on board the need for local communities and stakeholders to be involved in developing and implementing adaptation actions (cross ref: Section 4.3). There is considerable agreement among researchers (for example: Adger and Kelly, 1999; Turner *et al.*, 2003; Aalst *et al*., 2008; Tompkins and Eakin, 2012; Urwin and Jordan, 2008) about the need for bottom-up perspective and place-based initiatives to enable adaptation to locally experienced climate change impacts. Community participation and engagement are essential for further understanding of public perception and for prioritising adaptation actions. However, relevant procedure lag behind those assessing climate impacts and risks (see: Subak, 2000; Van Aalst *et al*., 2008; Urwin and Jordan, 2008).

Although academics suggest that there is a requirement to understand public awareness of climate change and engage with the community in the adaptation process (see: Bormann *et al*., 2012; Alexander *et al*., 2012; Lorenzoni *et al*., 2007; Sutton and Tobin, 2011; Ebi *et al*., 2005), the Taiwanese national adaptation policy framework was based on top-down perspective (CEPD, 2012), and understanding of public perception and community engagement have not been adequately addressed in the associated adaptation frameworks (Hsu *et al.*, 2011). To overcome these shortcomings, this study will focus on public awareness and an understanding of public participation and community engagement in the adaptation process.

The constraints or challenges in adaptation framework

The APF was considered as a practical concept and framework by the Executive Yuan in 2010 (CEPD, 2012). This approach was adopted to inform the development of the Taiwanese national adaptation policy framework which was designed to enable the development and implementation of national climate change adaptation strategies. It was also developed to enhance adaptive capacity as well as minimise vulnerability and establish an implementation basis for policy structure and plan promotion (CEPD, 2012). Many local governments in Taiwan have subsequently developed their own individual local adaptation frameworks since 2012 in accordance with this national framework. Whilst, a number of previous studies elsewhere (Measham *et al.*, 2011; Amundsen *et al.*, 2010; Næss *et al*., 2005; Preston *et al.*, 2011) had suggested a wider range of unknown constraints or challenges (e.g. limited resources and lack of information, institutional frameworks, financial conditions, available technology and information) may associated with local adaptation. Therefore, the author was doubtful whether these problems would restrict the capacity of local adaptation frameworks at the outset of the research process.

1.2.5 The Rationale of This Research

The author asserts that an understanding of socioeconomic vulnerability, public awareness, community engagement and participation not only can translate into effective adaptation, but can also reduce bias and misunderstanding, particularly in the selection of practical policies. However, to date, the critical components for assessing the current vulnerability, public awareness, and stakeholder engagement have not been clearly or purposefully used in the adaptation framework in Taiwan. Furthermore, the

identification of potential constraints or challenges in local adaptation frameworks is necessary in Taiwan in order to improve the effectiveness of existing adaptation frameworks particularly for the vulnerable areas of the southwest. Therefore, this thesis addresses these concerns directly through a comprehensive research framework and a case study analysis of disaster-prone areas along the southwest coast. In this context, the rationale for this study has two main elements:

Firstly, whilst a considerable amount of literature concerns the role of socioeconomic profiles and public perception in adaptation planning (see: Sutton and Tobin, 2011; Tompkins and Eakin, 2012; Urwin and Jordan, 2008; Alexander *et al*., 2012; Adger *et al*., 2009), many studies have focused upon the evaluation of national adaptation frameworks and policy, with none have been specific to the local circumstances of Taiwan (Kuo, 2010; Hsu *et al*., 2011). From a practical perspective, an initial overview of the recently emerging adaptation framework in Taiwan during the early stages of this research also suggested a notable lack of consideration of public perception and specific vulnerability characteristics in adaptation framework process back in 2012 (when this study was being designed). It was therefore decided that an investigation was required to explore the influence of both the specific vulnerability characteristics and the awareness of specific coastal communities in climate change adaptation.

Secondly, in light of the recent adaptation framework of Taiwan, it was considered that a combination of a bottom-up and top-down perspective might be most effective. This idea came from study of the literature which suggested that stakeholder participation and community engagement should be an important and integral part of efficient and practical adaptation framework (see: Burton *et al*., 2004; Ebi *et al*., 2005; Whitmarsh and Lorenzoni, 2010; Lorenzoni *et al*., 2007; Bormann, 2012). In light of several of the points made above, therefore, an investigation is required to increase the understanding of public perception of adaptation actions, public response to climate change, and community engagement in local adaptation. Moreover, an investigation is also necessary to explore the critical issues of local adaptation frameworks from the top-down perspective. From this it was hoped it would be possible to determine the challenges constraining the implementation of local adaptation in Taiwan.

1.3 Research Aim and Objectives

This research is not an attempt to produce an ultimate adaptation framework to climate change, but rather a proposal for developing an operating framework that enables the evaluation of the current adaptation framework for Taiwan, based on current research thinking. It is also intended that the study should also contributes to the academic literature through providing considerable empirical evidence to inform the development of relevant theory. Following on from the rationale above, the outputs of the study therefore represent an analysis of socioeconomic vulnerability, an evaluation of public awareness of climate change and public participation in adaptation, as well as an assessment of key issues in the local adaptation frameworks. As a consequence this study should allow for the possibility of future improvements in the future climate change adaptation in the context of disaster-prone areas on southwest coast of Taiwan. Therefore, the research aims of the study are:

- **To develop and evaluate the Analysis-Awareness-Action Framework for coastal area of Taiwan.**
- **To discuss and recommend improvements for local adaptation framework development in Taiwan.**

The subsequent objectives and investigations are:

'Analysis - develop and undertake an analysis of community vulnerability to climate change with respect to socioeconomic factors' (Chapter 5)

1. Develop a specific socioeconomic vulnerability indicator framework;
2. Appraise the salient socioeconomic characteristics of individual communities to climate change;
3. Explain the role of socioeconomic vulnerability of communities in adaptation in the context of the SW coast of Taiwan.

'Awareness - evaluate and conceptualise public awareness of climate change' (Chapter 6)

1. Ascertain and illustrate public perception, concern, and understanding of climate change within relevant communities, and the significance of such findings for adaptation planning;

2. Construct a conceptual model of factors affecting public awareness of climate change in Taiwan.

'Action - identify factors influencing public participation and community engagement in local adaptation' (Chapter 7)

1. Investigate and illustrate the motivations for and limitations of existing public responses to climate change;

2. Validate the cognitional, affective and behavioural factors relevant to community engagement in climate change adaptation.

'Action - to derive recommendations for local adaptation framework improvement' (Chapter 7)

1. Identify the critical issues of the current local adaptation framework;

2. Make recommendations for improved local adaptation frameworks.

1.4 Methodological Approach

This study used a multiple method design to achieve these four research objectives. The research methodology employed both qualitative and quantitative data collection approaches. It comprised the development of an indicator framework and the conduct of a questionnaire with the general public along with an expert workshop and follow-up with a focus group. These elements were applied at different stages of the Awareness-Analysis-Action framework (the AAA framework).

The indicator framework incorporated the concepts of both susceptibility and resilience and was used to develop a measurable indicator framework to assess the potential socioeconomic vulnerability, as required in the 'Analysis' dimension. The research process and the development of the indicator framework was based on a thorough review of the literature and was based on available datasets related to the four selected cases.

In the context of the 'Awareness' dimension, the questionnaire with the general public, investigated public awareness of climate change (public concern, public perception, public understanding) and flood experience. This was conducted through a face-to-face quantitative survey (public questionnaire) with a large sample of the local population.

In the ‘Action’ dimension, this study investigated public response to climate change and the factors of community engagement in adaptation through a questionnaire. Then, an expert workshop was undertaken using a focus group with experts interested in or responsible for climate change adaptation. This workshop explored the potential problems and suggestions for the development of local adaptation frameworks and was informed by the issues raised by the public questionnaire, previously mentioned. The results from the expert workshop were then used to develop a follow-up questionnaire to ascertain the specific details of and evaluate the existing local adaptation framework by local executors in the counties of Yunlin and Pingtung, the two key counties along the coast of South West Taiwan.

Details of the rationale and application of methodological approaches in this study are provided in Chapter 3.

1.5 Thesis Structure

This thesis has three fundamental components which are organised into eight individual chapters. An overview of the thesis structure is delineated in Figure 1.2.

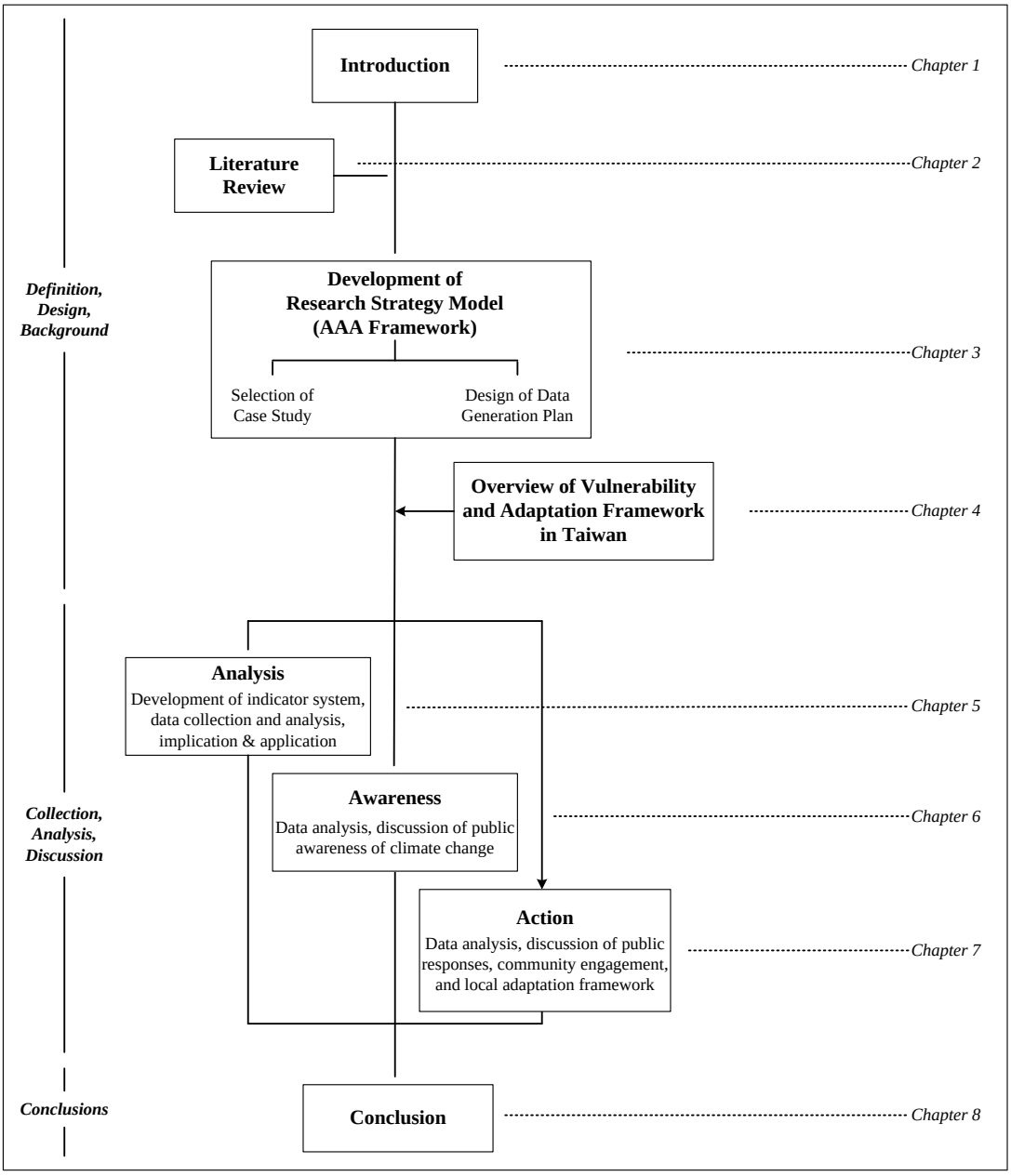


Figure 1.2: Thesis structure

This figure illustrates the relationship and consistency between these three fundamental components of the research and also highlights how these relate to the key chapters of the thesis. In particular it shows the location of each chapter within the broad thesis structure. To supplement a summary of the thesis structure follows:

Definition, design and background: Chapters 1-4

Chapters One, Two and Three address the definition and research design. After this current chapter, which provides an introduction to the research, Chapter Two presents the literature review, introducing the scientific framework of the study and focusing on

adaptation, vulnerability and stakeholder participation in climate change adaptation. Key terms used throughout the thesis are then defined and a modified Analysis-Awareness-Action framework is presented. Chapter Three then outlines an overview and detailed explanation of the research methodology. This explains and identifies the overall research methodology, and the techniques associated with the various stages of data collection in the Research Strategy Model (AAA framework) and the boundaries and limitations associated within the selected methods and instruments. Chapter Four illustrates the general background of coastal vulnerability, impacts of climate change and the existing adaptation framework in Taiwan.

Collection, analysis and discussion: Chapter 5-7

This part of thesis (Chapters Five, Six, and Seven) comprises the primary data collection related to the four case studies and presents subsequent analysis and discussions of the results. Chapter Five develops a unique vulnerability indicator framework and presents data and findings associated with the socioeconomic vulnerability of the four case studies. This chapter also discusses the role of the indicator framework in identifying susceptibility and resilience factors as well as its importance for adaptation. Chapter Six presents an analysis of public awareness of climate change in Taiwan, and provides some discussion of a conceptual model of public awareness. Chapter Seven presents and discusses the findings associated with the public participation related to climate change responses, as well as the key factors of community engagement, and related salient challenges and opportunities associated with each local adaptation framework.

Conclusions: Chapter 8

Chapter Eight concludes the thesis with a discussion of the theoretical, methodological and applied implications of this research for the South West coastal areas of Taiwan, drawing on results from the AAA framework. This chapter also explains the broader contribution of this research alongside suggestions for future research.

1.6 Important Definitions

Adaptation: Adaptation is defined as the ability to cope, respond, and recover from the impacts of climate change. It includes the short-term survival ability to urgent impacts

as well as long-term adjustment to changing conditions (Smit and Wandel, 2006, Adger *et al*., 2005a; Adger, 2001).

Vulnerability: Vulnerability refers to the exposure, susceptibility, and resilience, of people who live in hazardous areas where, the impacts of climate change are felt (Cutter, 1996; Adger and Kelly, 1999; Klein and Nicholls, 1999). This thesis is focused on the socioeconomic susceptibility and resilience of exposed communities to climate change impacts.

Public perception: Public perception is defined as people's understanding, feeling, experience, and concerns (Teka and Voge, 2010; Grothmann and Patt, 2005; Brody *et al*., 2008; Crona *et al*., 2009; Spence *et al*., 2011; Taylor *et al*., 2014a; Taylor *et al*., 2014b; Whitmarsh, 2009a; Whitmarsh, 2009b). This thesis is interested in these factors in relation to climate change.

Community engagement: This thesis has used the definition outlined by Lorenzoni *et al*. (2007) which suggests that community engagement involves a personal state of connection with climate change, and also includes cognitive, effective and behavioural dimensions.

Chapter Two Literature Review

2.1 Introduction

This chapter frames the research in the light of a number of fields and disciplines relating to adaptation, vulnerability, and stakeholder participation in climate change adaptation. Therefore, the predominant areas of literature that have been reviewed relate to the scientific framework for topics related to these areas.

The chapter is divided into several sections, commencing with an overview of the scientific framework for climate change adaptation. The theoretical framework and relevant components are introduced in Section 2.2. In Section 2.3 adaptation is reviewed. Section 2.4 then provides an overview of vulnerability and identifies the critical factors concerning the vulnerability assessment framework. Section 2.5 reviews literature regarding stakeholder participation and community engagement. In conclusion (Section 2.6), a synthesis of these key factors is presented and coordinated with the three critical dimensions of the adaptation framework.

2.2 Theoretical Underpinning and Research Strategy Model

2.2.1 Theoretical Underpinning

Strauss and Corben (1998) suggest that theory can provide a rational framework for understanding and explaining phenomena. It acts as a guide to indicate what type of data is needed and how to interpret phenomena by data analysis in social research (Creswell, 2009; Bryman, 2012). As Babbie (2013, p.69) mentions "*theory is systematic sets of interrelated statement intended to explain some aspects of social life*" and has been defined by Strauss and Corbin (1998, p.12) as, "*…theory that was derived from data systematically gathered and analysed through the research process*" and "*a statement of relationship between units observed or approximated in the empirical world.*" As such, theory is a basis for an argument, discussion and rationale, and is also helpful to explain social phenomena. Theory arises after observations have been accounted for, at which stage it is then called grounded theory or theory building (Handfield and Melnyk, 1998; De Vaus, 2001; Babbie, 2013). In this context, it is suggested that a theoretical underpinning of the thesis is needed before establishing the overall research strategy establishment.

In general, the research process can be based on two contrasting theoretical orientations:

deduction and induction. Essentially, deduction or deductive reasoning occurs when testing or verifying theory (Creswell, 2009; Gill and Johnson, 2010). The logical thinking within this approach therefore tends to move from general phenomena to specific events (Babbie, 2013). This requires the development of a logical structure which is used to guide the necessary data and data collection (De Vaus, 2001; Bryman, 2012). Conversely, Gill and Johnson (2010) suggest using inductive reasoning approach in social science because induction is used to derive a theory from observations. It begins by collecting data and information from the empirical world to develop the broad themes and a generalised model or theory regarding what phenomena have been observed (Creswell, 2009; Babbie, 2013). It is conducted to summarise the general concept or logical thinking from a number of abundant and typical cases. These generalisations and the resultant conceptualisation, it is suggested, are able to explain past and predict future phenomena. In summary, given the nature of this research and the employed methods, this research will be intrinsically inductive.

2.2.2 Awareness-Analysis-Action (AAA) Framework

In the context of increasing preparedness for future impacts of climate change, Luers and Moser (2006) and Tang *et al*. (2010) suggest that both the public and private sectors need to be aware of the possible risks and current impacts, and be concerned about how they will be personally and collectively affected by these risks and threats, and their responsibilities to respond to climate change. Therefore, the author considered it essential to develop a comprehensive framework based on these fundamental principles in order to climate change adaptation. The author's framework was informed by the initial guidance proposed by the United Kingdom Climate Impacts Programme (UKCIP, 2003), and the California Climate Change Centre (Luers and Moser, 2006). These early efforts had subdivided their adaptation frameworks into the three distinct components: awareness, analysis, action as shown in Figure 2.1.

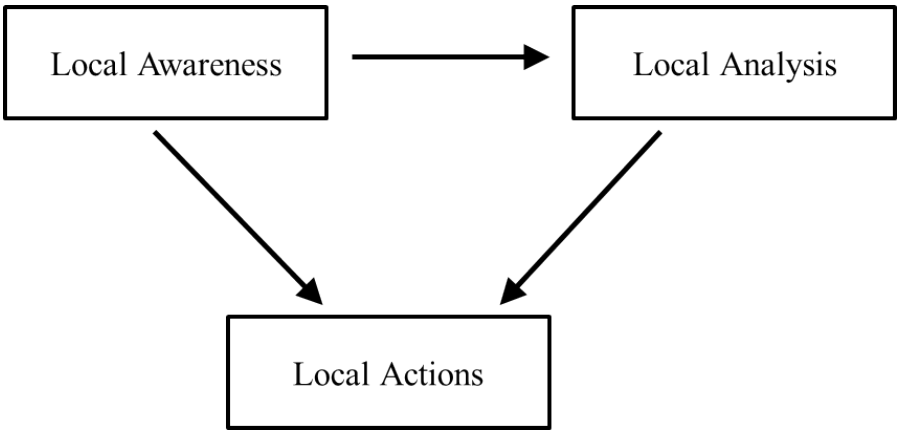


Figure 2.1: The Awareness-Analysis-Action (AAA) framework
Source: Tang *et al*., 2010

Given this framework had been widely applied to evaluate and establish comprehensive climate change adaptation systems across the world (see, for example: Tang *et al*., 2010; Moser and Luers, 2008; Baker *et al*., 2012; Tang *et al*., 2013), it was considered a useful model for this study. In particular, the author considered the framework provided an a useful integrated assessment of the impact, vulnerability and public awareness of climate change, as well as translating tangible information into concrete actions for tackling with climate change. As such, the framework has been widely used to measure and provide relevant scientific evidence and then use this to generate and improve the quality of proactive adaptation strategies and actions, such as those by Moser and Luers (2008), Tang *et al.*, 2010, and Tang *et al.*, 2013.

The functions of each component in the AAA framework can be described as follows:

Awareness: reveals the degree of understanding of climate change, public consensus of climatic drivers, consequences, and impacts. Awareness and concern are required to address local potential impacts.

Analysis: involves the available information and data to evaluate and explore the vulnerability, risks, hazards and costs from climate change.

Action: applies the relevant information to develop adaptation policies, strategies and actions to cope with identified impacts of climate change.

Whilst the conventional AAA model specified the broad framework for this study, the author considered it necessary to explore the literature further in order to define the specific scope and characteristics of each of the three dimensions. In relation to the

‘awareness’ dimension, the author was aware that previous research had highlighted the need for public awareness of climate change and associated uncertainty as well as better understanding of climate change impacts, alone with improved observation & scientific evidence. The critical factors which the author identified to be important to this dimension are shown in Table 2.1. As a result, the ‘awareness’ dimension in this study stresses the importance of public perception of climate change and hazard experience.

In Table 2.2, the author has compiled the critical factors most closely linked to the ‘analysis’ dimension, based on an extensive literature review. These factors relate to a range of differernt assessment processes and tools relevant to climate change including assessments of vulnerability, current and future hazard, risk, cost, and emission trends. This study focuses on the potential changes and non-climate factors of vulnerability to climate change may be the major task in the ‘analysis’ dimension. Finally, Table 2.3 summarises key literature related to the ‘action’ dimension, highlighting a wide range of types of actions associated with this. These include actions to reduce exposure & vulnerability, actions to increase resilience, transformation, action to effectively improve preparation, response, and recovery as well as those for sharing risks, and identifying appropriate approaches and priorities. Therefore, this research emphises that understanding public responses and actions, public perception of adaptation policies and actions, community engagement, and improving local adaptation framework should be a priority in the evaluation of the ‘action’ dimension.

In the context of this study, the AAA framework is considered as a Research Strategy Model because the AAA framework covers the critical foundations of climate change adaptation (Figure 2.2). Various themes related to the three components are discussed in subsequent sections in this chapter to develop a comprehensive Research Strategy Model (cross ref: Figure 2.6).

Table 2.1: Critical factors in ‘awareness’ dimension

	Awareness (UKCIP, 2003) ● Do you know what impacts climate change could have on your area?				
	Luers and Moser, 2006	**Moser and Luers, 2008**	**Tang *et al.*, 2010**	**Baker *et al.*, 2012**	**Tang *et al.*, 2013**
climate change			● concept ● effects & impacts		● extreme events ● climate change evidence
uncertainty	● uncertainty ranges around climate change impact projections to indicate scientific confidence ● distinction between more and less likely impacts ● scientific basis for uncertainty buffers	● uncertainty ranges around climate change impact projections to indicate scientific confidence ● distinction between more and less likely impacts ● scientific basis for uncertainty buffers			● uncertainty of climate change
resilience				● long term vision of how the community will adapt to climate impacts including the statement of quantifiable objectives and resource targets in regard to conserving resources under altered climates	● goal for building resilience
GHG emission			● concept, ● long-term goals, detailed targets		

Table 2.2: Critical factors in ‘analysis’ dimension

	Analysis (UKCIP, 2003) ● Can you identify and assess the risks from climate change to your services?				
	Luers and Moser, 2006	**Moser and Luers, 2008**	**Tang *et al.*, 2010**	**Baker *et al.*, 2012**	**Tang *et al.*, 2013**
***vulnerability**	● information about potential changes, and exploration of the implications of such changes	● information about potential changes, and exploration of the implications of such changes	● vulnerability assessment	● identification of non-climate determinants of vulnerability ● vulnerability assessment	● vulnerability assessment
***hazard**	● translation of projected sea-level rise, changes in coastal ocean, coastal storm frequency, and wave climate into shoreline retreat, beach erosion, and bluff retreat rates	● translation of projected sea-level rise, changes in coastal ocean, coastal storm frequency, and wave climate into shoreline retreat, beach erosion, and bluff retreat rates		● analysis of current and future conditions in regard to the consequences of climate change	● identification of hazard from climate change
***risk**	● remapping of flood zones under different sea-level rise projections ● more reliable forecasting of El Niño events, and any changes in the frequency or severity of such events and impacts on shoreline retreat rates	● remapping of flood zones under different sea-level rise projections ● more reliable forecasting of El Niño events, and any changes in the frequency or severity of such events and impacts on shoreline retreat rates		● risk assessment	● risk assessment
cost			● cost estimates for GHG emission reduction		● assessment of adaptation cost
emissions			● inventory ● base year emission ● emission trends forecast		
analysis tools			● using analysis tools		

Table 2.3: Critical factors in ‘action’ dimension

	Action (UKCIP, 2003) ● Does you emergency planning service take into account climate change? ● Are you addressing climate change in your local community strategy or community plan? ● Have you briefed your elected members on any key risks arising from climate variability and long-term climate change? ● Are developments with a lifetime of more than 20 years required to factor in climate change? ● Do you current policies, strategies and plans include provision for the impacts of climate change				
	Luers and Moser, 2006	**Moser and Luers, 2008**	**Tang *et al.*, 2010**	**Baker *et al.*, 2012**	**Tang *et al.*, 2013**
reduce exposure			● land use policies		● land use and development regulations, ● property acquisition programmes, ● defensive infrastructure and critical facilities policies, ● shoreline regulations and requirements
reduce vulnerability			● transportation, waste, resources management and energy policies		● building codes and design standards ● natural resource protection ● local incentive programmes ● public-private sector initiatives
increase resilience	● exchange of information among coastal states and communities about their responses to climate change-related impacts and risks ● better collaboration and exchange of relevant information among all involved agencies	● better collaboration and exchange of relevant information among all involved agencies ● exchange of information among coastal states and communities about their responses to climate change-related impacts and risks	● communication and collaboration policies		● public awareness, education. ● incorporation of risk management into economic development decision-making processes ● enhancement inter-organisational, cross-jurisdictional coordination ● establishment of environmental stewardship and sustainability platform

transformation	● inventory and integration of existing information into common formats ● accessibility of integrated databases at various spatial aggregation/resolutions and for different temporal resolutions ● adequate funding of ongoing monitoring of critical, management-relevant variables	● inventory and integration of existing information into common formats ● accessibility of integrated databases at various spatial aggregation/resolutions and for different temporal resolutions ● adequate funding of ongoing monitoring of critical, management-relevant variables	● implementation and monitoring strategies	● the direction of resource to achieve successful plan implementation and monitoring commitment	● identification of roles and responsibilities among sectors and stakeholders ● adaptive learning, continuous monitor, evaluate and update ● identification of potential financing sources ● advancing science data and analysis
prepare, respond, recover effectively				● principles to guide land use decisions to achieve goals, including spatial designs, policies and/or strategies for implementation	● promotion of early warning and communication ● emergency preparedness and response procedures for extreme events ● development of local all-hazard mitigation plans ● integration of climate change into coastal zone management plans
pool, transfer, and share risks			● financial tools		● mutual and reserve funds/incentive loans ● financial insurance ● tax credits ● development impact fees
options and priorities				● development, consideration, assessment and prioritization of alternative climate adaptation solutions	

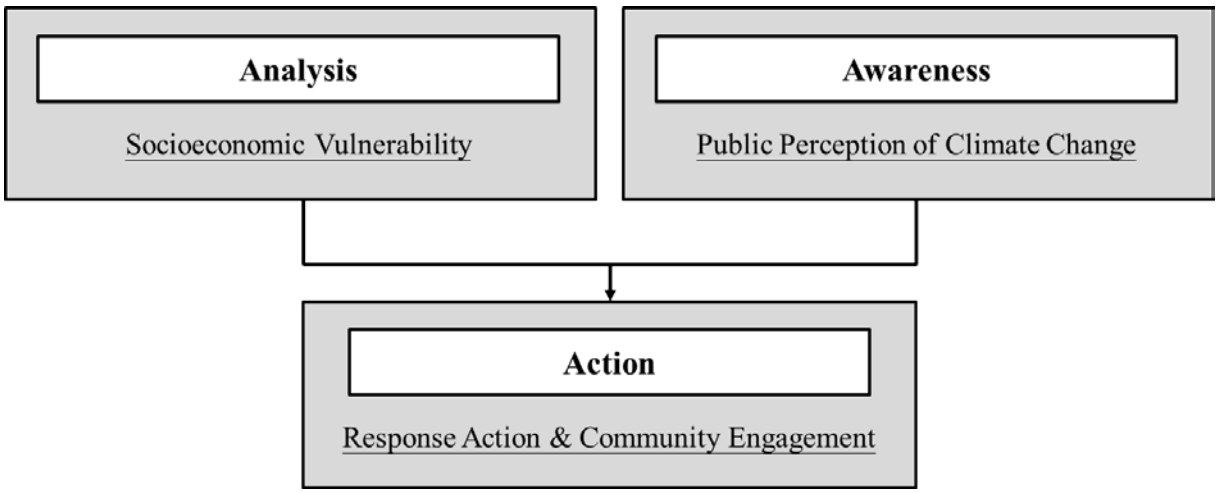


Figure 2.2: The key concepts of each components of Awareness-Analysis-Action (AAA) framework in this study

2.3 Adaptation

2.3.1 The Notions of Adaptation

Adaptation to climate change

Adaptation is based on analysis of existing observations of environmental variation as well as on previous knowledge relevant to measures for tackling future perturbations in climate (Ribot *et al.*, 2009). Therefore, adaptive capacity is a comprehensive and broad notion. In the context of this study, the definition provided by Tompkins and Eakin (2011; p3) may be most appropriate: "*climate change adaptations are the processes and actions that enable people to cope better with increasingly challenging weather and climatic conditions*." Previous studies (Klein and Tol, 1997; Huq and Klein, 2003; Smithers and Smit, 1997; Adger, 1999; Luers *et al.*, 2003; Tompkins and Adger, 2004) have identified four key components of adaptation which expand on this initial definition:

- enhancing the resistance of physical construction to external impacts;
- increasing the adaptive capacity and flexibility of vulnerable systems;
- reversing the trend of increased vulnerability, and;
- raising public understanding and preparation to external impacts.

Since adaptation, as a concept, emerged in the literature in the last decade, it has divided into capacities to cope with, adjust to, respond to, or recover from external impacts (see, for example: Gallopín, 2003; Adger, 2006; Carina and Keskitola, 2010). The former usually

applies to the short-term or to survival conditions whereas the later often applies to the long-term and to sustainable adjustment (Schneiderbauer and Ehrlich, 2004; Gallopín, 2006; Adger *et al*., 2004; Smit *et al*., 2000).

The damages and impacts of climatic events are highly related with human activities, and adaptation is considered to be a property of the human system which plays an important role and must be at the centre of climatic policy-making (Smithers and Smit, 1997; Pielke Jr., 2010; Scholz, 2010). Previous research (IPCC, 2007; Adger *et al*., 2007; Schneider and Aarukhan, 2001; Brooks, 2003; Pielke, 1998; Smit, 1993; Smith *et al*., 1996; Watson *et al*., 1996; Dessler and Parson, 2010) suggests that the key concept is the system adjustment in order to respond to climate change and current variability in a changing environment. It implies that three basic factors need to be established (Figure 2.3): "adapt to what?", "who needs to adapt?", and "how to adapt".

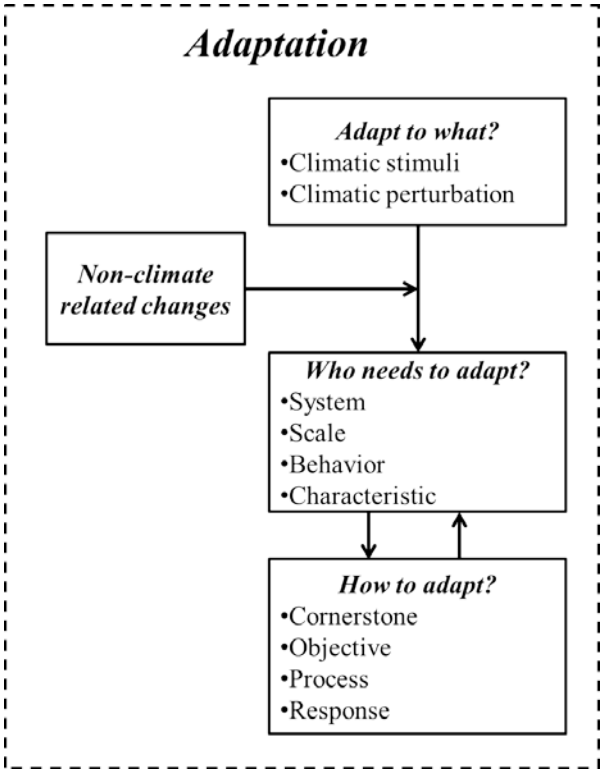


Figure 2.3: Key factors of adaptation to climate change

Source: adapted from Grafton, 2010; Smit *et al*., 2009

Adaptation and mitigation

Adaptation and mitigation are two essential approaches to address climate change identified by the United Nations Framework Convention on Climate Change (UNFCCC). Table 2.4

shows that several primary differences between the two approaches.

Table 2.4: Conceptual differences between adaptation and mitigation orientation

	Adaptation	**Mitigation**
Orientation	• Social and economic determinants of vulnerability	• Physical and biological science of impacts
Temporal Scale	• Short-term impact • Immediate benefits	• long-term phenomenon • Gradual benefits
Spatial Scale	• Local to global	• Global scale is effective
Comparable Benefit	• Difficult to express and compare with other adaptation options in a single metric	• Easy to compare with other mitigation options and expressed as CO_2 equivalent or cost-effectiveness.
Actor and Type	• Variety of sectoral interests and different levels (individual to national agencies)	• Limited sectoral actors and focus on greenhouse gas emission
Implementation	• Direct damage prevention	• Indirect damage prevention

Source: Sovacool and Brown, 2009; Klein *et al*., 2005; Verheyen, 2005, Adger, 2001; Grothmann and Patt, 2005; Webb *et al*., 2013; Baynham and Stevens, 2014

Although there are several differences between the mitigation and adaptation, Julia *et al*. (2009) emphasise that if policymakers concentrate only on one or the other this will be an insufficient response to climate change. This is because the impacts of climate change cannot be completely eliminated by mitigation actions alone, and so adaptation actions are indispensable to reduce vulnerability and increase resistance. Klein *et al*. (2007) suggest that the two-fold mitigation, adaptation division is too simplistic and, instead propose four categories which highlight the complex inter-relationships between adaptation and mitigation. They suggest the following categories: adaptation policies with functions of mitigation actions, mitigation actions containing consequences of adaptation policies, policies comprising synergy of adaptation and mitigation, and enforced process covering the results of adaptation and mitigation.

To date, the role of adaptation has become more important in climate change response policy due to the operational limitations in and insufficient efficacy of mitigation actions (Pielker, 1998). For this reason, adaptation has been considered as a valuable approach to climate change response by increasing numbers of policymakers and scientists in the last two decades (Grothmann and Patt, 2005; Schipper and Burton, 2009).

The adaptation of biological and human system

Initially, the notion of adaptation was used in biology and was defined as an evolutionary process or transformation of organisms in order to effectively respond to changing environmental conditions (Lawrence, 1995; Abercrombie *et al*., 1977). In this context it has been frequently referred to as genetic development or behavioral characteristics change to increase the survival and reproduction ability of organisms and ecosystems (Futuyama, 1979; Winterhalder, 1980; Kitano, 2002, Krimbas, 2004).

In human systems, adaptation has been considered as introducing and establishing new or improved measures to adjust individuals' and collective behaviours to cope with environmental change (O'Brien and Holland, 1992; Smit *et al.*, 2000). The responses of human systems are reactive and proactive, which can incorporate environmental observation and risk estimation to plan and manage adaptation (Smithers and Smit, 1997). Human adaptations are visible in the context of social, economic and institutional forces (Chiotti and Johnston, 1995), given that it is influenced by internal stresses such as economic resources, technology, information and skills, infrastructure, institutions and equity (Adger *et al*., 2005a; Keskitalo, 2008; Smit and Wandel, 2006; Füssel, 2007a). Therefore, adaptation should be established and based on the characteristics of human systems and the nature of environmental conditions.

2.3.2 The Characteristics of Adaptation

Based on an extensive literature search, Table 2.5 was devised to show the key characteristics of adaptation. These characteristics, include the governance framework in which adaptation is embedded, and include reference to the intent and, type of government, as well as the spatial scale, timeframe, and functions of adaptation actions and processes. Many authors, listed below the table, suggest that these properties are likely to influence the subsequent development and public acceptance of adaptation actions. The following sections discuss each of these characteristics in more detail.

Table 2.5: The various characteristics of adaptation to climate change

Characteristics	**Form**	
Intent	● Spontaneous ● Incidental	● Intentional
Type of governance	● Private	● Public
Spatial scale	● Local ● National	● Regional ● International
Timeframe	● Proactive ● Strategic	● Reactive ● Tactical
Function	● Technological	● Behavioural

Source: Waggoner, 1992; Smit, 1993; Carter *et al.*, 1994; Smit, 1994; Burton, 1994; Reilly *et al.*, 1994; Parry, 1986; Burton *et al.*, 1993; Smithers and Smit, 1997; Smit *et al.*, 2000; Wilbanks and Kates, 1999; Smit and Skinner, 2002; Huq *et al.*, 2003

Intent of adaptation

Adaptation is referred to as the result of appropriate and intentional responses or casual and incidental outcomes to climatic perturbations (Smithers and Smit, 1997), and, therefore, the intent of adaptation includes spontaneous, intentional, and incidental dimensions (Waggoner, 1992; Smit, 1993; Carter *et al*., 1994).

Spontaneous adaptation, which usually develops naturally (Carter *et al.*, 1994; Smit *et al*., 2000), is very rare compared with incidental adaptation in reality. Intentional adaptation is usually designed as a conscious and deliberate response, to compensate loss or alleviate suffering caused by external stresses (Carter *et al.*, 1994). It can be discriminated by the intent and timing of the initiatives or the involved human actors (Smit *et al*., 2000). It is often established and initiated before or during a hazard. Conversely, some policies and actions are developed or adopted for non-climatic events, and may accompany unintended or incidental results of influence mitigation and reduction (Waggoner, 1992; Smit, 1993; Carter *et al*., 1994; Wilbanks and Kates, 1999; Smither and Smit, 1997). These actions are usually initiated during or after negative events (Smit *et al*., 2000). Considering these different adaptation purposes, the author suggests that most adaptation action is intentional and incidental in Taiwan.

The type of governance in adaptation

Governance systems directly and indirectly influence the motivations for and implementation of adaptation actions (Smither and Smit, 1997). As shown in Table 2.5, governance involves private and public dimensions (Tobey, 1992). Adaptation measures can be implemented by an individual for private benefits or established by governments to address multiple sectors and issues (Adger *et al*., 2005).

Private adaptation, the ability of individuals and societies to adapt to environmental change, depends on the existing options and technological development of individuals/communities (Smither and Smit, 1997). In contrast, public adaptation includes both direct and indirect actions (Adger *et al*., 2005). Direct actions include proactive or reactive actions which can take place in short-term or long-term periods by government. Indirect actions include information interchange, public education, establishment of common consensus as well as, support for finance and incentives (Smither and Smit, 1997; Adger *et al*., 2005). Considering the above-mentioned, all levels of government and individuals have to engage in climate change adaptation.

Spatial scale of adaptation

As the APF emphasises, the adaptation framework should be based on the national level but should extend to local stakeholders (CEPD, 2012). Table 2.5 shows that adaptation involves a series of decisions established at local, regional, national and international scales (Adger *et al*., 2005; Smither and Smit, 1997; Smit, 1993). Therefore, adaptations range from localised to widespread, across a wide range of geographic contexts, and the literature suggests the relationship between each level should be close and cooperative.

Adaptations can occur at a broader spatial scale in response to regional conditions or in order to achieve national objectives which need international adaptation agreement. The most significant example is the United Nations Framework Convention on Climate Change (UNFCCC), the convention was developed by the United Nations Conference on Environment and Development (UNCED) in 1992, and many countries have established their National Adaptation Plans of Action (NAPAs) to facilitate coping with the impacts of climate change (Smithers and Smit, 1997; Kates, 2000; Kelly and Adger, 2000; Smit and Skinner, 2002; Ford and Smit, 2004). In general, international and national adaptation plans provide overall guidelines and knowledge, funds and technological assistance, but regional and local

adaptation plans establish and implement particular actions which are more attuned to the specific external stresses, social and economic conditions of local areas. National organisational frameworks have gradually considered the role at regional, local and community levels in the adaptation process (Adger *et al*., 2005). However, it was the author's perceived view at the outset that, while the national and local adaptation frameworks have developed in Taiwan, the community level in the adaptation process seemed insufficient.

Timeframe of adaptation

The speed and duration of climate change are particularly significant to adaptation. Previous study (Fankhauser *et al*., 1999; Smit *et al*., 2000; Smit and Wandel, 2006; Paavola and Adger, 2006; Smither and Smit, 1997) suggests that adaptation can be classified according to the timeframe, as shown in Table 2.5. Considering the timescale feature of perturbations may influence lead time and duration of adaptation, adaptations can be divided into proactive and reactive, according to initiative time relative to the timing of climatic events (Smither and Smit, 1997).

Considering the aspect of duration, previous studies (Parry, 1986; Burton *et al*., 1993;) highlight that some adaptation responses relate to climatic impacts in the short-term, while others are implemented in the long-term to modify and transform human systems. The short-term (daily or weekly) adjustment decisions deal with immediate and existing perturbations (tactical actions), whereas strategic actions are established to cope with enduring perturbations and long-term adaptations (Smither and Smit, 1997). Thus, adaptation also can be classified as tactical and strategic according to the duration of implementation (Fankhauser *et al*., 1999; Smit *et al*., 2000; Smit and Wandel, 2006). Therefore, the implementation of adaptation actions needs to consider the timescales to respond to immediate impacts or long-term influences.

The functions of Adaptation

The functions of adaptation, displayed in detail in Table 2.5, are multiple and include technological and behavioural adaptation (Smit and Wandel, 2006; Huq *et al*., 2003). Technological adaptation plays an important role, attempting to control or manage the impacts, and to protect the environment and humans (Smither and Smit, 1997). Many new technologies may be able to respond to potential climatic impacts, but not all are practical in different countries and communities (Klein, 2011). On the contrary, many climate change

adaptations do not use constructional technology, high-tech equipment and new infrastructure. Instead, adaptation is focused on so-called behavioural adaptation whereby new practices are designed as well as restructuring of institutional arrangements and transformation of human activities (Smither and Smit, 1997). So, behavioural adaptation is designed to modify public behaviour. The effectiveness of both types of adaptation highly depends on other factors such as finance, structure, legislation and regulation, institution and administration, education and information (Carter *et al*., 1994; Klein, 2011). As the functions of technological and behavioural adaptation are distinct, these may result in different public acceptance of these adaptation actions. Technological adaptation seems the main idea in Taiwanese adaptation framework.

2.3.3 Summary

The thesis considers that adaptation is a completely different notion to mitigation in the context of climate change. Adaptation can be considered as the resilience capacity of a system, including both a coping ability for surviving short-term impacts as well as a response capacity for sustainable adjustment in the long-term. In the context of climate change, adaptation should be a process according to interactions between response actions and climatic variability.

This section also highlights several distinct properties of adaptation, it may lead to a better understanding of adaptation development in Taiwan. Firstly, most known adaptation action is intentional and incidental depends upon their purposes in Taiwan adaptation framework, but the spontaneous adaptation actions are rare. It may be due to the public understanding of climate change and adaptation is insufficient. Secondly, considering the different roles of governance in adaptation, the climate change adaptation framework in Taiwan requires cross-sectoral integration within a multi-governance system (national, local, and private sectors), which may make adaptation framework more flexible and users are able to establish and implement climate change adaptation policies, measures and actions according to specific requirements and conditions. While the national and local adaptation frameworks have developed, community engagement and private organisations in the adaptation process seemed insufficient in the author's view at the start of the research period.

Thirdly, the literature suggests that the implementation of comprehensive adaptation policy framework should cover a range of different timescales to respond to immediate impacts or

long-term influences. Therefore, the priority of adaptation actions may be different in local circumstances in Taiwan. Fourthly, the functions of technological and behavioural adaptation are distinct. Technological adaptation is mainly a buffering measure for enhancing stability, but behavioural adaptation takes place to facilitate change or evolution to increase resilience and flexibility, and reduce vulnerability. The general public prefers technological adaptation rather than behavioural adaptation in Taiwan.

The study suggests that the timeframe and function of adaptation should be taken into account in formulating and implementing adaptation actions because it may influence public acceptance and support of these adaptation actions. Up to this point, however, it is a neglected area in Taiwan. Therefore, an investigation into the public perception of different adaptation actions with respect to efficacy and priority was deemed necessary in this study.

2.4 Vulnerability

2.4.1 The Concept of Vulnerability

The definition of vulnerability

Vulnerability is a frequently applied concept in risk, hazard and disaster-related research (Gilbert, 1995; Hewitt, 1995) and is of particular significance when dealing with the issue of climate change (Patt *et al*., 2009). Ribot *et al*. (2009) and GallopÍn (2006) suggest that vulnerability includes susceptibility to harm, and potential change or transformation of systems within encountered perturbations. In the context of this research, the definition proposed by Cutter (1996) is appropriate to further the theoretical and practical realisation of how and why places and people are vulnerable: *"vulnerability as pre-existing condition, vulnerability as tempered response, and vulnerability as hazard of place"*.

The first aspect focuses on the source of hazards, such as distribution of hazardous conditions, residents within disaster-prone areas, and the degree of damage related to particular hazard. This approach is generally employed by scientists and engineers to explore the characteristics of hazards, condition of exposure and bio-geographic vulnerability associated with natural hazard events (Nicholls *et al*., 1999). The second aspects relates to societal resistance and recovery capability to hazards. This emphasises that vulnerability is linked to individuals and the social resilience to hazards (Adger and Kelly, 1999; Cutter *et al*., 2000; Allen, 2003). It is used to present and highlight the socioeconomic vulnerability to hazards by social science

researchers. The third aspect is a combination of both previous elements, and therefore vulnerability is the various potential elements for loss (Cutter *et al*., 2003; Chambers, 2006; IPCC, 2007).

The elements of vulnerability

Previous studies (Cutter, 1996; Füssel, 2007b; Adger, 2006) suggest inconsistencies between the interpretation of vulnerability across disciplines (physical science, political, social science) and methodological practices. On top of this, there is also considerable variation in location (coastal area, low-lying land), exposure and type of external perturbations (flood, drought, extreme weather event). So, vulnerability is not only shaped by hazards external to the system, but also is linked to the internal susceptibility and resilience of a system (Turner II *et al*., 2003).

Over the last decade, IPCC (2001), Adger *et al.* (2002), Burton *et al.* (2002), McCarthy *et al.* (2001), Burton *et al*. (1993), and Cutter *et al.* (2003) provide the common underlying elements of vulnerability: exposure, susceptibility, and resilience. Although the use and interactions of these three elements are indistinct in some of the literature (for example in Brooks, 2003; Adger *et al*., 2004), these terms can be classified according to the time period or after the hazard event occurred: the susceptibility and exposure of a system existing prior to a particular hazard event, and the resilience (coping and response capacity) to absorb the influences and recover from the impacts (Figure 2.4).

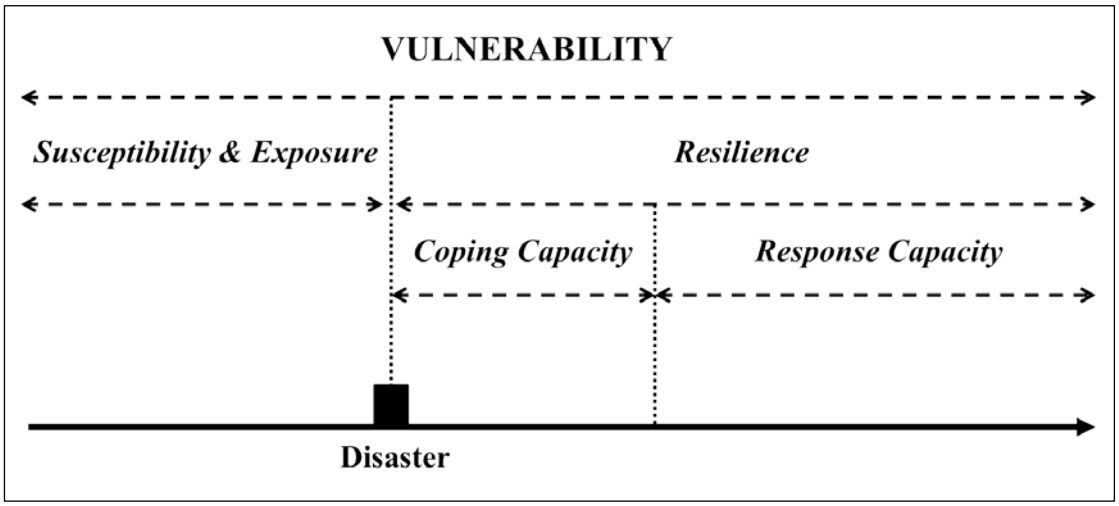


Figure 2.4: The key components of vulnerability

Source: adapted from Schneiderbauer and Ehrlich, 2004; Turner II *et al*., 2003; Gallopín, 2006; Sutherst *et al*., 2000; Schmidt-Thomé, 2005; Dovers and Handmer, 1992

The role of vulnerability in climate change adaptation

Although vulnerability is usually seen as a negative property or an adverse consequence, it sometimes can be viewed as a positive element to promote a beneficial transformation, such as institutional and social network improvement (Adger, 2006; Gallopín, 2006; Ribot *et al*., 2009). From a positive perspective too, vulnerability also plays an important role in verifying vulnerable areas and people, which helps to implement effectively adaptation actions (Patt *et al*., 2009). Therefore, it is not surprising that previous research (Brooks, 2003; Smit and Wandel, 2006; Gallopín, 2003; Turner II *et al*., 2003) suggests that the analysis of current and future vulnerability requires an overall understanding of adaptive factors, and that the role and operation of vulnerability varies with differing timeframes and needs, in order to moderate vulnerability via the appropriate adaptation strategies.

Whilst current vulnerability is generally considered as a baseline in climate change research, Ford and Smit (2004) and others suggest that there is a need to reduce it to an acceptable level in the context of available adaptive resources. In terms of the baseline (Brook, 2003; Adger *et al*., 2004), exploring the existing possible vulnerability and adaptive capacity is necessary to develop a baseline for preparing, responding and recovering from hazards. As future vulnerability is regarded as a potential risk, it is seen as a direct interaction between specific hazards and communities' susceptibility and resilience. Assessing future or potential vulnerability, therefore, involves the measurement of the likelihood of change in climatic attributes and socioeconomic conditions in order to estimate potential exposure, sensitivity and resilience to possible impacts (Ford and Smit, 2004).

Biophysical and social vulnerability

Vulnerability is a complicated concept, and previous studies (list below) suggest it is necessary to explicitly identify and define the concept of vulnerability in terms of science and social science perspectives. Table 2.6 shows that vulnerability includes internal socioeconomic and biophysical factors as well as external socioeconomic and biophysical factors, and also requires subsequent interaction between each component.

Table 2.6: Four categories of vulnerability factors

	Socioeconomic	**Biophysical**
Internal	• Household income • Social networks • Access to information	• Topography • Environmental conditions • Land cover
External	• National policies • International aid • Economic globalisation	• Severe storms • Earthquakes • Sea-level change

Source: Füssel, 2007b; Chambers, 1989; Ellis, 2000; Sanchez-Rodriguez, 2002; Pielke and Bravo de Guenni, 2003; Young, 2010; Gallopín, 2006; Kelly and Adger, 2006; Schröter, 2009

From the biophysical perspective, scientists emphasise the sensitivity of environmental and physical conditions to different hazards. Therefore, there is considerable examination of the direct sources of physical exposure and possible external perturbations in specific regions in the literature (see, for example: Blaikie *et al*., 1994; Füssel, 2007b; Ford and Smit, 2004). From the social perspective, vulnerability is generally considered as the capacity of human society to counteract, anticipate, cope with, and recover from the impacts of a natural hazard (Cutter and Emrich, 2006; Cutter *et al*., 2009; Holand *et al*., 2011). While social vulnerability plays a crucial role in the response and recovery phase (Solangaarachchi *et al*., 2012), it cannot directly lead to the hazard events and actual damages (Brooks, 2003). Therefore, social vulnerability scholars are interested in identifying and improving the inherent socioeconomic elements that influence coping and adaptive capacity (Dessai *et al*., 2004; Allen, 2003), especially those related to the social network and economic capital (Adger, 2003b; Kasperson and Kasperson, 2001; Kelly and Adger, 2000; Wisner *et al*., 2004; Adger and Kelly, 1999; Cross, 2001).

In the context of this thesis, biophysical vulnerability can be regarded as the combination of the likelihood of climatic hazard events occurrence and its' possible damages. Social vulnerability is considered as the inherent properties of human systems which could magnify or narrow the susceptibility and resilience to external hazards. Cutter (1996) and Turner II *et al*. (2003) highlight that the interaction between a particular hazard event and communities within different regions can create different degrees of negative consequences due to the

properties of social response which are distinctive in different communities.

2.4.2 Vulnerability Assessment

The notion of vulnerability assessment

It is know that the magnitude and type of vulnerability vary across regions, particularly in different social, economic and political conditions (Neuman, 1997; Birkmann, 2006; Patt *et al*., 2009; Adger and Vincent, 2005; Ribot *et al*., 2009). These causes and processes of shaping vulnerability are indispensable to understand and reduce the vulnerability (King and MacGregor, 2000; Barnett *et al*., 2008; Füssel and Klein, 2006). The related works reported in the literature suggest that the vulnerability-led approach can be used to determine the vulnerability of areas, systems and communities to existing or expected impacts, and to provide useful profiles to understand how to adapt to the existing threats (Lin, 2005; Cutter *et al*., 2000). Therefore, vulnerability assessment is required to understand the vulnerability of different communities exposed to hazard event in this study.

Figure 2.5 shows an holistic model designed to assist in the vulnerability assessment used in this thesis (Section 5.4.2). It includes four key aspects: ‘where is vulnerable?’, ‘vulnerable to what?’, ‘non-climate factor’ and ‘who is vulnerable?’

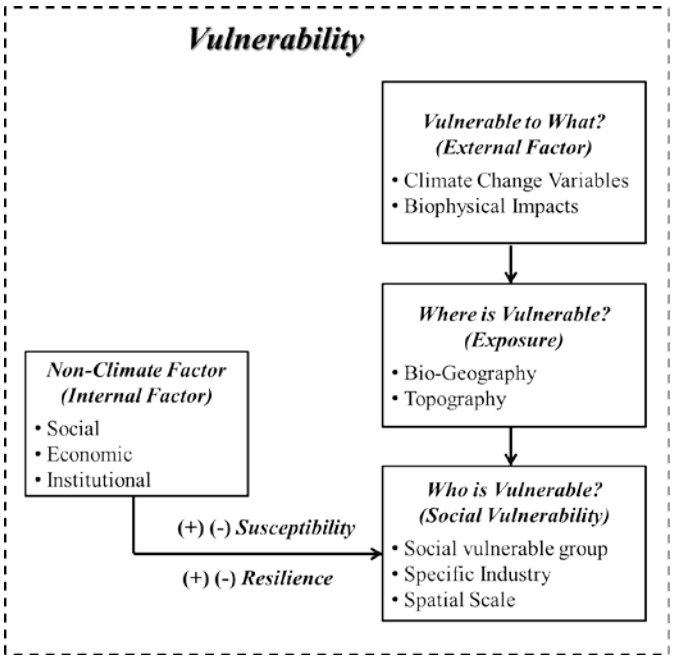


Figure 2.5: Key factors of vulnerability assessment

Source: Schrőter, 2009; Ribot *et al*., 2009; Adger *et al*., 2004; Turner II *et al*., 2003

The first stage, “where is vulnerable?” means that what environmental and geographic characteristics lead to population exposure to external pressures. Subsequently, it is necessary to identify external perturbations (vulnerable to what?) and internal factors (non-climate factor) in order to determine “who is vulnerable?” The internal factors are composed of economic status and demographic compositions (Dow, 1992; Adger and Kelly, 1999; Adger *et al.*, 2009), which able to expand or narrow potential impacts of climate change (Blaikie *et al*., 1994; Zahran *et al*., 2008). Therefore, these clearly have to be taken into account in any integrated vulnerability assessment structure.

The key components of vulnerability assessment

Risk exposure, susceptibility to impacts, and resilience capacity have been recognised as the distinctive elements of vulnerability (Section 2.4.1). These therefore have been used to develop the structure of vulnerability assessment employed in this study. Details of these are provided below.

Exposure

Exposure can be defined as, “*the nature and degree to which a system experiences environmental or socio-political stress*” (Adger, 2006; p: 270). As such it takes into account both physical, environmental aspects as well as the two aspects are fundamental for human welfare and safety (Crichton, 1999; Gasper, 2010). In the context of this definition, coastal areas, affected by dynamic and complex physical process, are recognised as being the most exposed areas to climate change, as exemplified by recent scientific predictions (Burton, 1997). Nicholls and Wong (2007) and Yasuhara *et al*. (2012) also stress the high levels of exposure of these areas associated with increasing risks associated with climate change over the next decades. Within recent research, Özyurt and Ergin (2010) and Adger *et al*. (2005b) have demonstrated that exposure of coastal areas is linked to external physical parameters, such as inundation, coastal erosion, flood, saltwater intrusion and, sea level rise.

Susceptibility

Susceptibility is defined (Smit and Pilifosova, 2001; p894) as the “*degree to which a system is open, liable, or sensitive to climate stimuli (similar to sensitivity, with some connotations toward damage*”. IPCC’s list of the sensitivities of human system to climate change (Wilbanks and Lankao, 2007) includes: physical infrastructure, social system, economic system, industries and settlements. In the context of this definition, previous studies suggest

(Klein *et al*., 2003; Dolan and Walker, 2004; McGranahan *et al*., 2007; Cutter, 2003; O'Brien and Leichenko, 2000; Olmos, 2001; Klein and Nicholls, 1999) that susceptible economic conditions, demographic structures, and infrastructure lead to human systems to unanticipated results of climate change and hazard events.

Resilience

Holling (1973; p.17) notes that "*resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb change of state variable, driving variables, and parameters, and still persist*". Timmerman (1981; p21) defines it as "*the measure of system's or part of a system's capacity to absorb and recover from the occurrence of a hazardous event*". According to these definitions, resilience is treated as a capacity of a system to respond to external perturbation. Social resilience includes reactive and proactive resilience (Dovers and Handmer, 1992; Carpenter *et al*., 2001). The former focuses on reinforcing the resistance to cope after external perturbations and the latter emphases the need to establish systems capable of adapting to future changing conditions. Previous studies (Tapsell *et al*., 2010; Cutter *et al*., 2003; Adger *et al*., 2004; Cutter *et al*., 2009; Klein *et al*., 2003) suggest that social resilience can be measured by the response capacity of social networks, economic structures and institutions to withstand and recover from external impacts.

The conceptual framework for vulnerability assessment

It is known that there are many different vulnerability assessment frameworks, and a previous study (summarised in Table 2.7) has presented numerous and diverse conceptual frameworks to explore the causal structure of vulnerability. Whilst these vary according to their discipline provenance (see, for example Chapin *et al*., 2000; Olmos, 2001), five approaches have been developed to conceptualise and measure the evolution of vulnerability.

Table 2.7: Common conceptual framework for vulnerability assessment

Approach	Vulnerability Factors				Denotation
	Internal Socioeconomic	Internal Biophysical	External socioeconomic	External Biophysical	
Risk-hazard	-	∨	-	-	Internal biophysical vulnerability
Political economy	∨	-	?	-	Cross-scale socioeconomic vulnerability
Pressure-and-release	∨	∨	-	-	Internal integrated vulnerability
Integrated (e.g. hazard of place)	∨	∨	∨	∨	Cross-scale integrated vulnerability
Resilience	∨	∨	?	?	Cross-scale integrated (?) vulnerability

Source: Original based on Füssel, 2007a; Kates, 1985; Coburn *et al*., 1994; Kasperson *et al*., 1995; Wisner *et al*., 2004; Luers, 2005; Janssen *et al*., 2006a; Cutter *et al*., 2000; Bohle *et al*., 1994; Turner II *et al*., 2003; Adger *et al*., 2001

These different approaches focus on distinct systems and particular factors, which can be employed for diverse purposes and within different frameworks. Obviously, these comprehensive approaches (pressure-and-release approach, integrated approach, and resilience approach) include the multi-layered and multi-dimensional capacity. This can be measured by the demographic, economic and institutional capabilities of those exposed to specific hazard events.

2.4.3 Summary

This section shows that various definitions of vulnerability now exist. The damage and impacts from hazard events are not only determined by the characteristics of the hazard but also the properties of the exposed social system. This implies that the degree of vulnerability of an affected population can be measured by consideration of a range of socioeconomic

variables (Brooks, 2003; Adger *et al*., 2004), a fact that underpins the vulnerability assessment (Section 3.4) throughout this thesis. Three common elements of vulnerability assessment have been recognised from the literature: 1. vulnerability from social and environmental perspectives; 2. place-based study; 3. identification of the vulnerable areas and communities. Therefore, the author considers that vulnerability is likely to be highly related to the specific characteristics and socioeconomic conditions of particular areas. This consideration has therefore informed the approach to socioeconomic vulnerability in this thesis.

Furthermore, clear and practical definitions of exposure, susceptibility, and resilience have been derived from the discussions in this chapter to inform the development of the vulnerability assessment undertaken in this thesis. In summary these are defined as follows. The term of "exposure", can be considered as the combination of known climatic hazards and geographic characteristics in a specific area where have affected population reside in (Section 3.3). Regarding to "susceptibility", it can be viewed as the interaction between inherent factors of human system and external stimuli form vulnerability. With regard to "resilience", it can be considered as the reactive and proactive capacity of society to retard or recover from the impacts of climate change (Section 3.4).

2.5 Stakeholder Participation in Climate Change Adaptation

2.5.1 Stakeholder Participation

Previous studies (Aggestam, 2014; Reed, 2008) suggest that stakeholder participation is essential to environment management, and Few *et al*. (2006) and Biesbroek *et al.* (2010) stress the need for participation of a broad range of stakeholders in decision-making and implementation. While many analysts and policymakers have developed frameworks for national climate change adaptation (Rayner and Malone, 1998), the effectiveness and practicability of national policies and measures to respond to the long-term and different local risks is still problematic (Few *et al*., 2007a). Previous studies (Stirling, 2008; Carina and Keskitalo, 2004; Bärlund and Carter, 2002) suggest that the robustness and effectiveness of such adaptation policies can be strengthened if the all stakeholders' concerns are included when these decisions and policies are being made, especially in the local context (Füssel, 2007b; Gezelius and Refsgaard, 2007; Patel *et al*., 2007). In this context, Bormann *et al*. (2012) suggest that establishing a stakeholder forum for collaborative adaptation planning can

improve cooperation and cites good examples of such an approach including the Green Ribbon Task Force; the Public Task Force (working groups); and Community Workshops in the United States. However, elsewhere, many National Adaptation Strategies (including for example those in Denmark, Finland, UK) lack concrete action for participation (Biesbroek *et al.*, 2010).

Stakeholders

In the context of climate change adaptation, stakeholders are defined as "*individuals or groups who have current and past experience of coping with, and adapting to, climate variability and extremes*" (Conde *et al*., 2004; p51). They include policymakers, scientists, administrators, communities, and economic managers at risk (Conde *et al*., 2004). The literature suggests that the involvement of stakeholders is required to help inform critical short-term response decisions (Connelly and Richardson, 2009; Niang-Diop and Bosch, 2004; Shackley and Deanwood, 2002) as well as longer-term scenarios analysis (Larsen and Gunnarsson-Östling, 2009) for climate change adaptation.

The level of participation

Nicholls (2002a), Wilsdon and Willis (2004) highlight that the policymakers can obtain and incorporate a more in-depth understanding and experience from participants through stakeholder participation in policy development for climate change adaptation as this enables them to develop more advanced and innovative actions. However, the levels and functions of stakeholder participation vary, so that previous studies (Tàbara *et al*., 2010; Larsen and Gunnarsson-Östling, 2009) suggest that the effectiveness of stakeholder participation can be affected by social learning as well as the contributions of the different levels of stakeholder.

An appropriate and clear participation level is necessary for stakeholder participation in climate change adaptation planning. Figure 2.6 displays the different levels and benefits of participation and illustrates how stakeholders may participate, how stakeholder information and experience is used and how policy is influenced by this, informed from the literature (notably from: Pretty, 1995; Conde *et al*., 2004; Biesbroek *et al.*, 2010). Therefore, it is suggested that stakeholder participation plays an important role in bridging top-down and bottom-up approaches to adaptation (De Bruin *et al*., 2009).

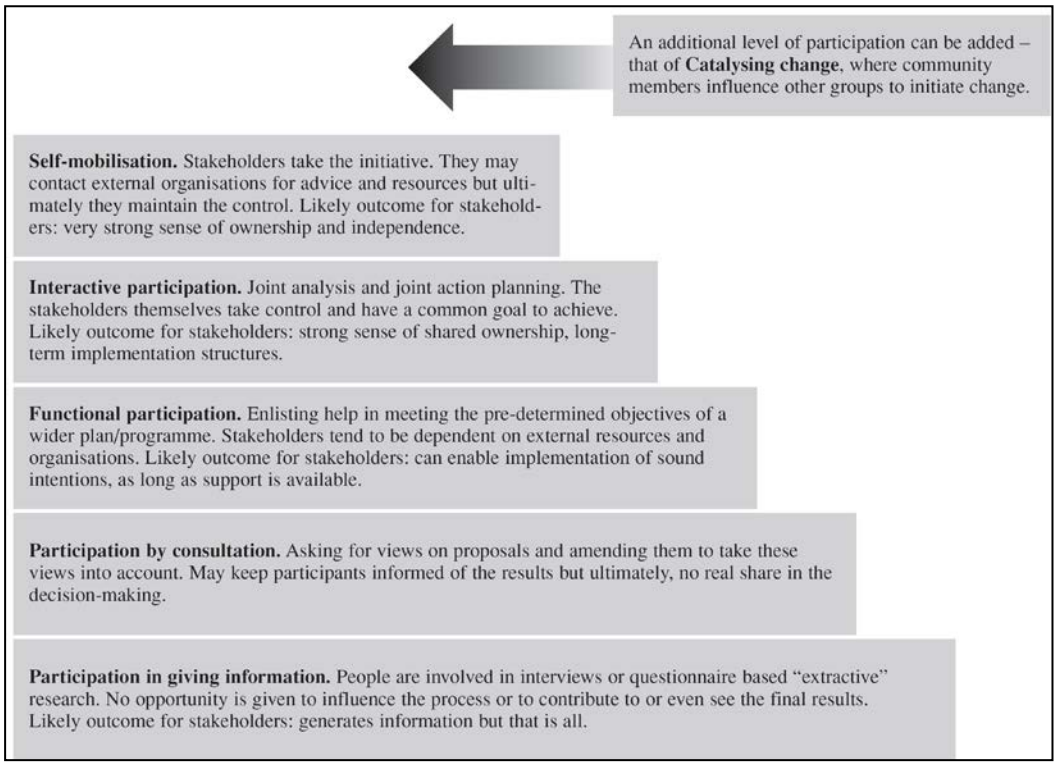


Figure 2.6: The multi-levels of stakeholder participation

Source: Conde *et al*., 2004

2.5.2 Top-down and Bottom-up Perspectives in Adaptation Governance

The pros and cons of top-down and bottom-up perspectives

A top-down perspective involves the formulation of policy from a high level, strategic viewpoint such as from a national or international body. As such it demands clear objectives and often involves statutory planning and national policymaking. Such an approach is designed to inform practical actions at lower levels including the micro-(local) scale. It also generally involves a measuring, reporting and verification mechanism. For a fairly comprehensive overview of the top-down approach the reader should refer to Urwin and Jordan (2008), Hare *et al*. (2010) and Burton *et al*. (2002), for example. Significant top-down agreements on climate change are the IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations (Carter *et al*., 1994) and the Kyoto Protocol (Leal-Arcas, 2011; Sovacool and Brown, 2009). Mataki *et al.* (2008) assert that the top-down approach places the responsibilities on the national government and agencies to develop, implement, promote and support adaptation policy. However, the top-down approach exceedingly focuses on statutory mechanisms and this focus at a high level can instill dissatisfaction and distrust at

local levels which is frequently associated with limited local adaptation effort and concern (Van Aalst *et al*., 2008; Urwin and Jordan, 2008). Others suggest it can cause insufficient public awareness and local engagement in the policy decision-making process (Kasemir *et al.*, 2003; Teka and Vogt, 2010).

In contrast, the bottom-up perspective focuses on the lowest feasible level of governance and the participants, instead of high-level decision-makers, design and implement climate change policies without a formal higher level agreement (Rayner, 2010; Bormann *et al*., 2012). Van Aalst *et al*. (2008), Mataki *et al.* (2008), and Elmore (1979) suggest that the bottom-up process implies two key elements: local stakeholders need to be involved in the process; the process sets adaptation policies and actions according to local experiences and information. Therefore, it is suggested that the bottom-up perspective can be feasible, effective, and practical in both local and regional level settings (Leal-Arcas, 2011; Shackley and Deanwood, 2002). As such, it also has been explicitly expressed in the UNEP Guidelines (Feenstra *et al*., 1998) and applied in the Adaptation Policy Frameworks for Climate Change (Spanger-Siegfried and Dougherty, 2004) at a global level. However, implementation of climate adaptation through local planning has a short history, Measham *et al*. (2011), Sovacool *et al*. (2015), and Amundsen *et al*. (2010) have noted that local adaptation is subject to recognised constraints and challenges, such as budgetary constraints, institutional capacity, lack of data and local expertise, for example.

The coordination of top-down and bottom-up perspectives in adaptation

Previous studies (Amundsen *et al*., 2010; Mataki *et al.*, 2008; Hill and Hupe, 2002; Urwin and Jordan, 2008; Adger *et al.*, 2009; Biesbroek *et al.*, 2010) propose that climate change adaptation requires the cooperation of local and national governments and authorities to design adaptation actions, and facilitate the development of essential motivation for local governments and communities to follow political guides and implement these actions. Urwin and Jordan (2008) suggest that local governments can organise and implement their own actions and plans based on local expertise and requirements, while national governments can prioritise the objectives of policies and provide the necessary assistance. This implies that responses at all levels of governance are required for adaptation development. Therefore, Shackley and Deanwood (2002) suggest that an effective integration of top-down and bottom-up decision making is more important than concentrating on decision making powers at any scale. Stakeholder participation can be used to embrace the top-down and bottom-up

perspectives in the process of policy development in macro, meso and micro scales (Young, 2002).

In the context of this thesis, Urwin and Jordan (2008), Sovacool and Brown (2009) and Hare *et al*. (2010) suggest that the terms top-down and bottom-up perspectives can provide for two-way communication and information transfer in climate change adaptation. The two perspectives have been used to engage with different communities in discussions and planning for collaborative adaptation, and to bridge the gap between public, experts and scientists debating on the issues of climate change and adaptation (Sheppard, 2008; Biermann, 2007; Shaw *et al*., 2009; Sabatier, 1986; Hill and Hupe, 2002; Alexander *et al*., 2012). Therefore, successful adaptation requires coordination between different levels of governance and stakeholders (Urwin and Jordan, 2008; Amundsen *et al*., 2010; Sheppard *et al*., 2011; Bulkeley and Betsill, 2005; Cash *et al*., 2006; Pulwarty, 2003; Steel *et al*., 2004; Rowe and Frewer, 2005), and the two perspectives have been used as the main concept to develop the research approach with respect to improve climate change adaptation.

2.5.3 Community Engagement

Research over the last two decades suggests that community engagement in adaptation planning can improve policy intervention and efficiency (Cohen, 1997; Janssen *et al*., 2006b; Huntjens *et al*., 2010; Bormann *et al*., 2012; Conde *et al*., 2004; Amajirionwu *et al*., 2008; Sheppard *et al*., 2011) as well as in the development of practical applications (Alexander *et al*., 2012). Failing *et al*. (2004), Van der Windt *et al*. (2007), Schusler *et al*. (2003), and Goven *et al*. (2012) highlight that the winning combination of expert knowledge and public experience provided by both approaches as well as the awareness raising and social learning are the key contributions of community engagement in climate change adaptation.

The definition of community

The term ‘community’ has many meanings but in the context of this thesis, the definition provided by Koliba and Gajda (2009; p101) may be most appropriate: “*a group of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis.*” This definition not only explains the common interests and concern of issues but also illustrates the territorial dimensions (Quarantelli and Dynes, 1976). In the context of this definition, the ‘area’ generally always relates to simple administrative levels or geographic units, and can include

streets, towns, cities and regions (Bulmer, 1987; Gusfield, 1975). Therefore, this study assumes that the term ‘community’ needs to encompass people, areas, and common issues. It has also been taken to mean groups of people with diverse backgrounds and perspectives.

The definition of engagement

Lorenzoni *et al*. (2007) define the term “engagement” in the climate change context. They contend that it involves a personal state of ‘connection’ with climate change, rather than the simple process of public participation in policy making, which others have suggested. So, this suggests that people have to know about climate change, to care about it, and to be motivated and able to take action in order to be engaged with the issue of climate change. Therefore, Lorenzoni *et al*. (2007), Whitmarsh and O’Neill, (2011) suggest that community engagement implicitly comprises cognitive, affective and behavioural aspects.

Lorenzoni *et al*. (2007), Sutton and Tobin (2011) further expand the definition and clarify the concept and relationships between the three dimensions. The cognitive dimension includes public understanding, observation, and knowledge about climate change, its causation, impacts, and potential actions (Bord *et al*., 2000; Capstick *et al*., 2015a; Capstick *et al*., 2013; Spence *et al*., 2011; Taylor *et al*., 2014b; Lorenzoni and Hulme, 2009; Weber, 2010; Macey and Schneider, 2008; Gifford, 2011). Many recent studies also suggest that adequate understanding and knowledge may affect public values, effectiveness of policies, and public willingness to adopt actions (Shackley and Deanwood, 2002; Lebel, 2013). The affective engagement encompasses the levels of communities’ concern about climate change and associated negative affects (Sutton and Tobin, 2011; Whitmarsh, 2008; Weber, 2010; Taylor *et al*., 2014b), affective responses (Loewenstein *et al*., 2001; Weber, 2006), trustworthy information sources (Lowe *et al*., 2006; Gifford, 2011), and uncertainty (Few *et al*., 2007b; Norgaard, 2006; Poortigna *et al*., 2011). Bord *et al*. (2000) suggest that the negative feelings and judgement of the results of climate change will increase public willingness or desire to take actions. Behavioural engagement is directly observable. It is defined as investment of personal resources (e.g. time and money) to undertake action (Koletsou and Mancy, 2012; Sutton and Tobin, 2011; Höppner and Whitmarsh, 2011). Previous studies suggest that the level of behavioural engagement will be restricted by many different personal factors, such as inequity (Aquino *et al*., 1992; Howgate and Kenyou, 2009), cost and economy (Gifford, 2011; Keller *et al*., 2004), powerlessness (Lorenzoni *et al*., 2007; Butler and Pidgeon, 2011; Dessai and Sims, 2010), and habits (Maio *et al*., 2007; Eriksson *et al*., 2008).

In the context of this thesis, this point is very important because it determines the potential cognitive, affective and behavioural factors in community engagement in climate change adaptation. This has informed the research approach to investigating community engagement in Taiwan in this thesis, particularly within Section 7.3.

The role of community engagement in climate change adaptation

Though community engagement in decision-making and actions is time consuming and expensive (Larson *et al*., 2010), previous studies (Heberlein, 1976; Wiseman *et al*., 2010; Cuthill, 2003; Besley, 2010; McKinney and Harmon, 2007; Upham *et al*., 2009) summarise several reasons for working with communities specifically on the climate change adaptation:

- maximising the resilience and adaptive capacity of local communities;
- creating essential transformations and innovation in social, environmental and economic institutions and relationships;
- improving effective communication and increasing the trust, transparency and credibility of the decision-making processes;
- providing technical competence and the essential changes in the behaviour of individuals, households and communities;
- ensuring effective local distribution and governance systems as key elements for the development of innovative and effective climate change mitigation and adaptation strategies.

In the context of adaptation implementation, recent findings (Adger, 2003b; Lorenzoni *et al*., 2007; Wiseman et al., 2010; Sheppard *et al*., 2011; Whitmarsh *et al*., 2011; O'Neill *et al*., 2013; Höppner and Whitmarsh, 2011; Lorenzoni and Pidgeon, 2006) highlight the specific importance of community engagement to successfully implement climate change adaptation policies, because:

- there has to be a degree of acceptance by the affected people to actions;
- the practice of risk communication becomes more difficult if adaptation policies and citizen frames of reference differ;
- communities could misunderstand, distrust, disregard and disagree with climate change adaptation implementation without effective community engagement.

2.5.4 Public Perception

The importance of public perception in adaptation

Previous study (Arnell, 2010; Berrang-Ford *et al*., 2011; Sheppard *et al*., 2011) emphasises that implementation of adaptation policies needs to engage with multiple groups in a society. However, aggregating the different stakeholders in such a participation and consultation process is a significant challenge (Tompkins *et al*., 2008; Kasemir *et al*., 2000). In particular, it is difficult to involve all stakeholders especially where the spatial scale of the area in question is widespread (Carina and Keskitalo, 2004). At the micro-scale, however, there is a wealth of relevant research, which suggests that tailored adaptation actions can be identified and developed at this level. Reference to studies by Carina and Keskitalo, (2004), White *et al*. (2010), Spence *et al*. (2011), Næss *et al*. (2005), Shackley and Deanwood (2002), Cohen *et al*. (2006) and others is relevant here.

Boswell *et al. (*2012), Few *et al*. (2006), Alexander *et al.* (2010), and Bormann *et al*. (2012), amongst others suggest that public participation has become standard practice in the preparation of climate adaptation plans. Previous studies (Spence *et al.*, 2002; Patt and Schröter, 2008; Dobson, 2003; Horton, 2006; Bormann *et al*., 2012; Krysanova *et al*., 2010; Larsen and Gunnarsson-Östling, 2009; Burton and Mustelin, 2013; Moser and Dilling, 2007) suggest that public plays an important role in stakeholder participation for the formation and implementation of adaptation policies. More specifically, Adger *et al*. (2005a), Allen (2003), Grothmann and Patt (2005), Tomkin and Eakin (2011), Lorenzoni *et al*. (2007), and Julia *et al*. (2009) stress that public perception of climate change risk is essential to acquire extractive information and experiences for successful local adaptation. Moreover, public acceptance of designed adaptation policies in response to climate change is critical, as noted by Alexander *et al*. (2010) and Moglia *et al*. (2011) for example.

A number of studies (Tàbara *et al*., 2010; Conde *et al*., 2004; Rayner *et al*., 2005; Moser and Luers, 2008; Morgan *et al*., 2002) have explained the ways in which public perception may influence successful adaptation to climate change. These, they detail as follows:

- **Perceptions, frames and awareness**: *these all influence and shape the overall adaptation process.* Variations in these occur within both the policy making community as well as within local stakeholders. Therefore, some investigations are necessary before making any adaptation policy, such as whether people perceive the need to adapt, any opportunities and

barriers to improve awareness and, whether different perceptions influence on the adaptation actions and public willingness to undertake actions.

- **Incentives, sanctions and motives**: *tailored motives and incentives are needed to embrace the different interests and concerns of the public.* This recommendation arises out of the recognition that people may still lack motivation to take adaptation actions even when they acknowledge climate change as an issue. As such, it is crucial to understand not only whether or not the public is specifically motivated to adapt, but also to determine what kind of incentives and sanctions are likely to be supported by general public.
- **Adaptation options and resources**: *these need to take account of public perception.* Without a comprehensive understanding of public perception of adaptation options and available resources may constraint the public support in climate change adaptation. In order to provide feasible options and resources for public adaptation, public perception can help policymakers to understand whether adaptation options are possible, potential barriers of public participation, what new technologies may be implemented, and what networks can be promoted.

Factors influencing public perception

However, Cohen, (1997) and Veraart *et al*. (2010) suggest public perception is often based on vague suppositions, because the public tends to trust personal knowledge and experience more than scientific evidence. It has been argued, by a number of studies (McCright, 2010; Upham *et al*., 2009; Bickerstaff, 2004; Blake, 2001; Kollmuss and Agyeman, 2002; Reser *et al*., 2014; Jones *et al*., 2012; Upham *et al*., 2009; Teka and Voge, 2010; Aitken *et al*., 2011; Brody *et al*., 2008; Crona *et al*., 2009), that public perceptions are highly subjective to a wide variety of elements to interpret and understand environmental information, which includes physical surroundings, personal experiences, knowledge and feelings, social context, institutional trust, and socioeconomic status.

Particularly, some key factors, such as experience, concern, understanding, are likely to produce more confident attitudes and consistent behavior for improving adaptation, to make climate change more tangible to communities, to encourage people to look for further information and enhance their understanding and response, to develop tailored policies and actions for specific communities (Dwyer *et al*., 2004; Tompkins *et al*., 2008; Grothmann and Patt, 2005; Fazio and Zanna, 1981; Fortner *et al*., 2000; Whitmarsh, 2008; Spence *et al*., 2011;

Nursey-Bray *et al*., 2014). Adger (1999), Teka and Voge (2010), Slovic (2000), Bord *et al*. (2000), Patt and Schröter (2008), and Haller and Hadler (2008) suggest that public, as collections of individuals, also display dissimilarities in their perception, and therefore attitudes towards adaptation and their behaviour (i.e. response). Public perception, though still somewhat inconsistent or unclear, may be able to provide insight into public behaviour, values, and concerns (Dwyer *et al*., 2004). As a result, it is important not only to understand the factors influencing individual perception but also the effect of these more widely on public attitudes and behaviour in response to climate change.

In the context of this study, public perception of climate change is an integral part of the research model. As this review has shown, public perception, understanding, concern, hazard experience has been used to develop the public questionnaire to evaluation the public perception of climate change (Section 6.2; Section 6.3) and adaptation actions (Section 7.2) in Taiwan.

2.6 Summary – Research Strategy Model

This chapter commences by identifying and explaining the underlying theoretical foundations which have shaped the development of Research Strategy Model used in this study. A number of working definitions of key terms and practices relevant to the thesis have been highlighted. Firstly, adaptation and vulnerability have been recognised as the key components for this climate change research. The key term of ‘adaptation’ has been detailed in Section 2.3 and in Section 2.4 exposure, susceptibility, and resilience have been identified as key factors for vulnerability assessment. The exposure factor was used to help select the case study and the susceptibility and resilience factors have been then used in inform the practical vulnerability assessment framework used in this study.

Secondly, the literature review has also revealed that the importance of different stakeholders in climate change adaptation (Section 2.5.1). Given that recent studies have focused on place-based and bottom-up perspectives, public perception of climate change and responses (Section 2.5.4), and community engagement in adaptation (Section 2.5.3) are the key theoretical foundations in this research. As the literature suggested that a combination of both top-down and bottom-up perspectives can contribute to effective climate change adaptation (Section 2.5.2), the experts’ perspective on existing Taiwanese adaptation frameworks became an indispensable part of Research Strategy Model.

In light of these discussions, the Research Strategy Model (RSM) is based on the AAA framework (cross ref: Figure 2.1) which was detailed in Section 2.2. The AAA framework was expanded with some modifications for this thesis and, has been used to encompass all of the key themes arising from the literature review. The thesis defines the "AAA framework" as encompassing 'analysis of vulnerability', 'awareness of climate change', and 'action for adaptation' (Figure 2.7). The three key components of this framework (cross ref: Figure 3.1) can be summarised as follows:

- **Analysis**: this focuses on socioeconomic vulnerability assessment to understand the susceptible and resilient capacity of local communities and to explore their potential vulnerable factors to climate change in disaster-prone areas.
- **Awareness**: this emphasises public awareness of climate change, and hazard experiences and personality profiles which influence public perception of climate change.
- **Action**: this focuses on the bottom-up perspective related to response actions to climate change, community engagement in local adaptation, and expert view on local adaptation framework.

The author considers that these fundamental concepts of the three components may form "a comprehensive evaluation framework, to evaluate and develop initiative local adaptation framework for Taiwan." These underlying theoretical foundations have shaped the development of the research methodology for data generation, Chapter 3 will introduce the research instruments associated with each component of AAA framework.

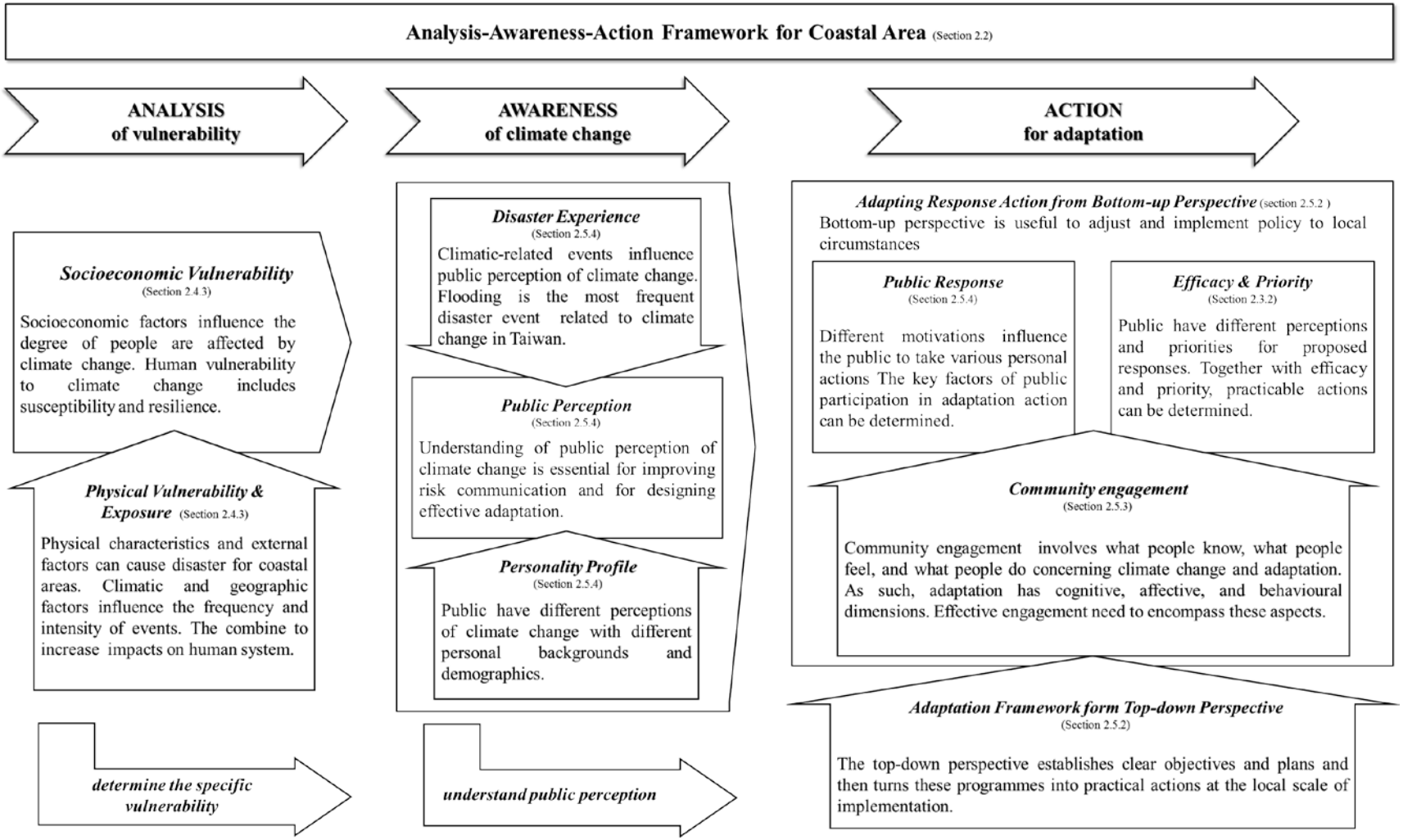


Figure 2.7: The outline of Research Strategy Model (modified AAA framework)

Chapter Three Methodology

3.1 Introduction

This chapter presents detailed information of the Research Strategy Model (RSM) and proposes the methodology to address the research aims and objectives. In order to obtain the required data, three different research instruments were employed to collect qualitative and quantitative data. These were indicator system, questionnaire, and focus group. Section 3.2 outlines the RSM and highlights the research instruments used for data generation. Section 3.3 presents the design of the multiple-case study approach and provides a summary of the key characteristics of the selected case studies; this includes a range of figures generated by Geographic Information System (GIS). Section 3.4, 3.5, and 3.6 then provide detailed discussions of the research instruments employed in the case studies. These sections summarise the rationale, development, and application of research approaches. Finally, the chapter concludes by considering the limitations of the methods used in this study.

3.2 Research Aims and Data Requirements in RSM

3.2.1 Research aims in RSM

As noted in Section 2.6, the RSM was developed to provide valuable insights for evaluating development of climate change adaptation. The RSM recognised several key factors of the three components that correspond with the research objectives (Figure 3.1).

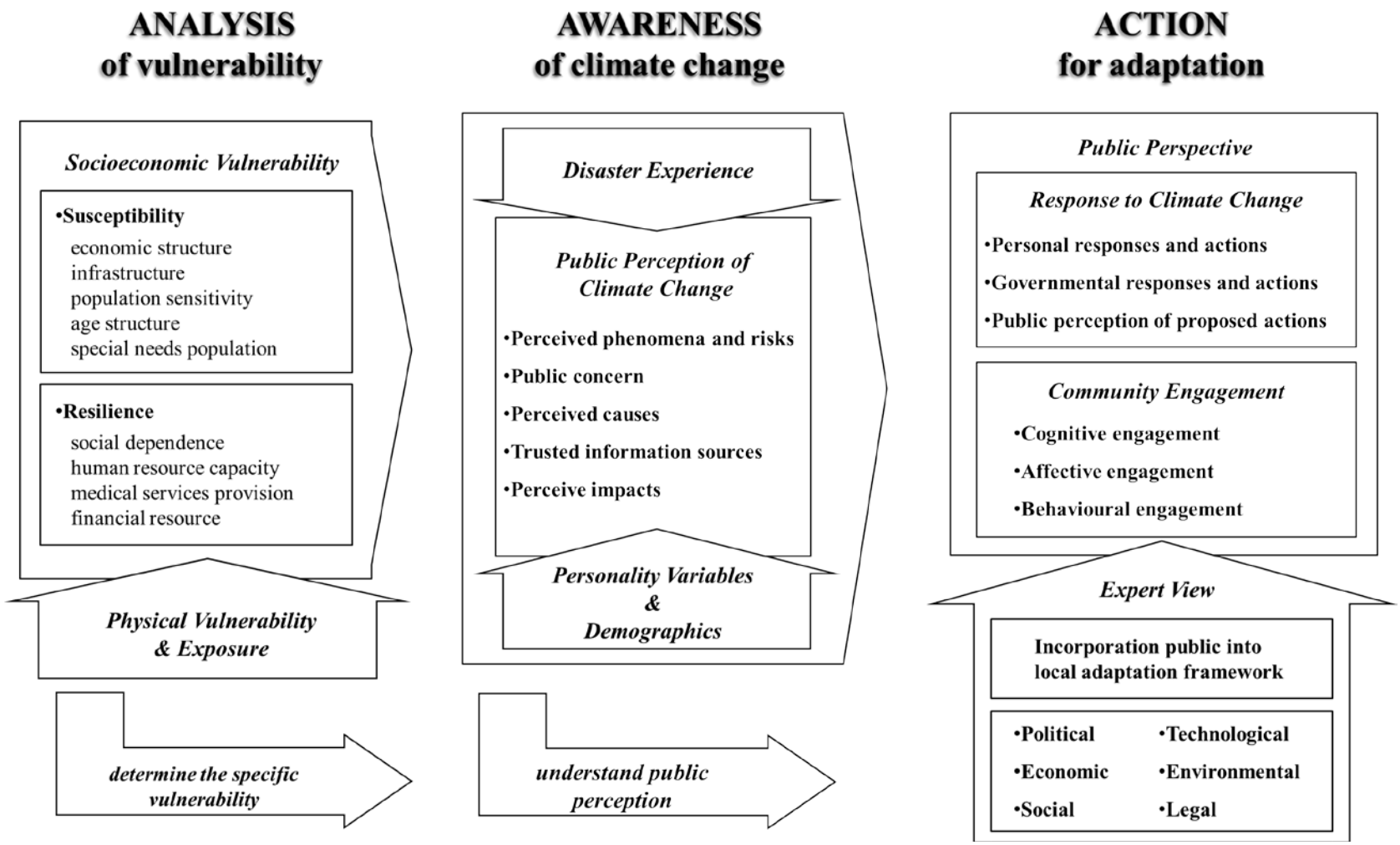


Figure 3.1: The components of Research Strategy Model (modified AAA framework)

The detailed relationship of each with the thesis research objectives can be explained as follows:

To achieve the first research objective: "*develop and undertake an analysis of community vulnerability to climate change with respect to socioeconomic factors*." in the 'analysis' dimension, socioeconomic vulnerability is considered as a condition of the community, as noted in Section 2.4.2. In the context of adaptation planning, this study builds on the discussion in this previous section and employs the approach advocated by Adger and Vincent (2005), Füssel and Klein (2006), Cutter *et al.* (2009), and Moser and Luers (2008). This suggests that the result of socioeconomic vulnerability assessment may contribute to the determination of communities' susceptibility and resilience, and the identification of particularly vulnerable communities to existing and future impacts of climate change.

To achieve the second research objective: "*evaluate and conceptualise public awareness of climate change*." Following on from the discussion in Section 2.5.4, it is considered that the 'awareness' dimension needs to investigate the role of public perception, understanding, and concern for climate change and adaptation. This study has also been designed in the context of statements within the literature, notably from Nicholson-Cole and Whitmarsh (2008), Kasemir *et al*. (2003) and Dietz and Stern (2008) that suggest that incorporating public awareness and concern with science into climate change assessment and decision making processes will improve the quality, legitimacy and capacity of climate change adaptation action.

To accomplish the third research objective: "*identify factors influencing public participation and community engagement in local adaptation*" and the fourth research objective: "*derive recommendations for local adaptation framework improvement*." The 'action' dimension needs to bring together top-down and bottom-up perspectives on climate change adaptation, as noted in Section 2.5.2. In this context, the views previously noted in Section 2.5.3 and 2.5.4 related to community engagement and public responses, respectively, are also important. Also, as noted in the previous chapter (Section 2.5.2), some known and unknown constraints may influence the implementation of local adaptation frameworks and actions. As such, this study follows the suggestion from Young (2002), Van der Windt *et al*. (2007), Schusler *et al*. (2003), and Goven *et al*. (2012) that different stakeholder participation can embrace different

perspectives in order to improve the local adaptation frameworks and actions.

3.2.2 Data Generation and Method

The three components of AAA framework employed both qualitative and quantitative data collection techniques in order to look for practical ways to collect and analyse qualified data. The detailed data requirements were identified as follows:

- **Analysis:** demographic structures, population census, infrastructures and economic conditions.
- **Awareness:** personal background, flood experiences, public perception of the issues of climate change
- **Action:** public perception of response actions, community engagement in adaptation, and local climate change adaptation framework concerning political, economic, social, technological, legal, and environmental (PESTLE) aspects from the view of experts and planners who are responsible for the adaptation framework.

In order to collect and obtain above the data, this research employed multiple instruments in different sections. Four different instruments were used: an indicator system, a questionnaire survey, an expert workshop and a follow-up questionnaire. These build on similar approaches used in previous research.

Firstly, indicator systems have been widely used to reveal phenomena, quantify socioeconomic features and communicate related information in the context of natural hazards (Wongbusarakum and Loper, 2011; King and MacGregor, 2000; Malone and La Rovere, 2004, Cutter *et al*., 2003; Adger *et al*., 2004). These were therefore considered relevant to the first stage of this study. Secondly, Oppenheim (2001) and May (2001) suggest that a questionnaire survey is an accepted, measurable and low-cost research method for data collection of general public perspectives. Given that the resources at hand for this study were limited, including both budget and time, a questionnaire survey was employed to investigate public perception of climate change, public participation in response, and community engagement in local adaptation. These were considered relevant to the second and third stages of this research. A focus group workshop is also a common way of data collection in social research as well as communicating with and obtaining in-depth information from participants (Bryman, 2012; Kumar, 2014), and a follow-up survey was conducted to understand the potential problems in local

adaptation framework. The details of each method are provided in Sections 3.4-3.6. The accomplishment of these is a prerequisite for the construction and implementation of the RSM.

3.3 Case Study Selection (Exposure)

This section addresses the process of case study selection for the purpose of data generation. A multi-case (embedded) study design was employed to develop selection criteria for selecting qualified cases. These cases have been selected according to their degree of exposure to the impacts of climate change. The visual information is an output from using Geographic Information System (GIS: Mapinfo 6.0). The following subsections are used to interpret the motivation, principles and justification of the methods in this study.

3.3.1 Case Study Approach

Introduction & overarching rationale

The case study approach is a satisfying way and broader research perspective to increase existing experience and improve understanding of particular circumstances (Coombes, 2001; Stake, 2000; Wolcott, 2001). The case study approach was defined by Yin (2009, p.18) as: "*an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident.*" Compared with survey research and experimental methods, this approach is able to employ a range of investigation instruments and analysis techniques to expand the research perspective, and is easier to access representative cases and focus in a detailed analysis, as well as saving time and money (Table 3.1).

Table 3.1: Advantages and limitations of the case study method

Advantages	Limitations
● access to certain cases ● sheds in-depth information ● time-saving and lower cost ● disproves or qualifies a general statement ● highlights new insights or ideas ● rich, detailed, individual analysis	● Limited scope ● Lacks control over important variables ● Can be prone to bias ● Cases may not be representative and findings cannot be generalised

Source: adopted from Coombes, 2001; Donmoyer, 2000; De Vaus, 2001; Yin, 2009; Mabry, 2009; Wolcoot, 2001

The term 'case' is seen as a bounded system or object that a researcher is interested in (Stake, 2000; Bryman, 2012), which can be used as a unit of data analysis and collection (Hammersely and Gomm, 2000). Case study research can include both single-case design and multiple-case design with holistic and embedded analysis units (Yin, 2009; Bryman, 2012). Whilst Chaskin (2001) and Yin (2009) suggest that a case study design should embrace at least two cases, Eisenhardt (1989), Eisenhardt and Graebner (2007) suggest the optimum number of cases for theory development lies between 4 and 10. The integrated evidence base is more substantial and can strengthen the justification of research results and findings, and the different results from contrasting cases may help researchers understand particular phenomena better (Yin 2009; De Vaus, 2001; Schofield, 2000).

Within multiple case study research, Yin (2009) suggests that the explicit interpretation and distinction of the representative case is essential to avoid inaccuracy and bias. In order to access these, a significant research foundation is required to recognise and select strategically the typical cases (Mabry, 2009). Yin (2009), Denscombe (2007), and Bryman (2012) suggest that a concrete boundary (spatial and temporal) and an abstract topic (phenomenon and relationship) can be selection criterion to guide the selection of case studies. Consequently, the author considers that the case study approach is useful to explore information in detail, examine general statements and highlight new insights or ideas and is therefore appropriate for this study. In this research, the defined selection strategy, principles, and characteristics are critical in order to select the representative cases.

3.3.2 Geographic Information System

Introduction & overarching rationale

In last decade, a GIS-based approach has been widely adopted to visualise regional climate changes and vulnerability assessment (Bai *et al*., 2013; Liu *et al*., 2011; Thumerer *et al*., 2000). Compared with hand-drawn maps, Table 3.2 shows that GIS is a powerful way of collecting, storing, integrating, analysing, transforming and displaying spatial data and can translate such information into formats suitable for a variety of purposes (Table 3.2). The spatial information generated from GIS can be displayed and summarised in clear and logical tabular and graphical formats as well as maps (Demers, 2005), and such graphics and maps can be generated at a range of scales (Lund and Sinton, 2007). Furthermore, GIS is time-saving and a cheap way of producing both thematic maps and topographic maps, and can combine these to display particular phenomena in specific regions (Chang, 2008; Heywood *et al*., 2011).

Table 3.2: The advantages of GIS compared with manual maps

	GIS	Manual map
Data Storage	● digital data base ● easy to save	● paper maps for each dataset ● easy to lose
Overlay	● easy ● high efficiency	● time-consuming ● low efficiency
Spatial analysis	● easy ● use computer to measure, compare and describe ● allow to aggregation and reclassification for further analysis	● complicated ● ruler, planimeter, compass are used by human analyst ● only simple analysis because restricted
Display	● cheap ● high efficiency	● expensive ● time-consuming

Source: adopted from Longley *et al*., 2001; DeMers, 2005; Burrough and McDonnell, 1998; Chang, 2008; Bartlett, 1994

GIS has been extensively applied in multidisciplinary research to integrate huge databases and provide advanced mapping and spatial analysis (Bartlett, 1994; Chang, 2008; Heywood *et al*., 2011). In this tradition, the author has employed GIS to display

various representative cases in order to demonstrate that these cases have satisfied for the selection principles in this study.

3.3.3 Application of Case Study Selection

Flynn *et al*. (1990) suggest that the design of a case study is relevant to theory building and theory verification. For this research, Figure 3.2 shows that the multiple-case study was adopted and the representative cases were chosen by strategic selection to reduce bias and generalise findings. Considering the limited time and budget, this study selects four cases from two counties in order to generate substantial findings and explore specific results from different cases for theory verification.

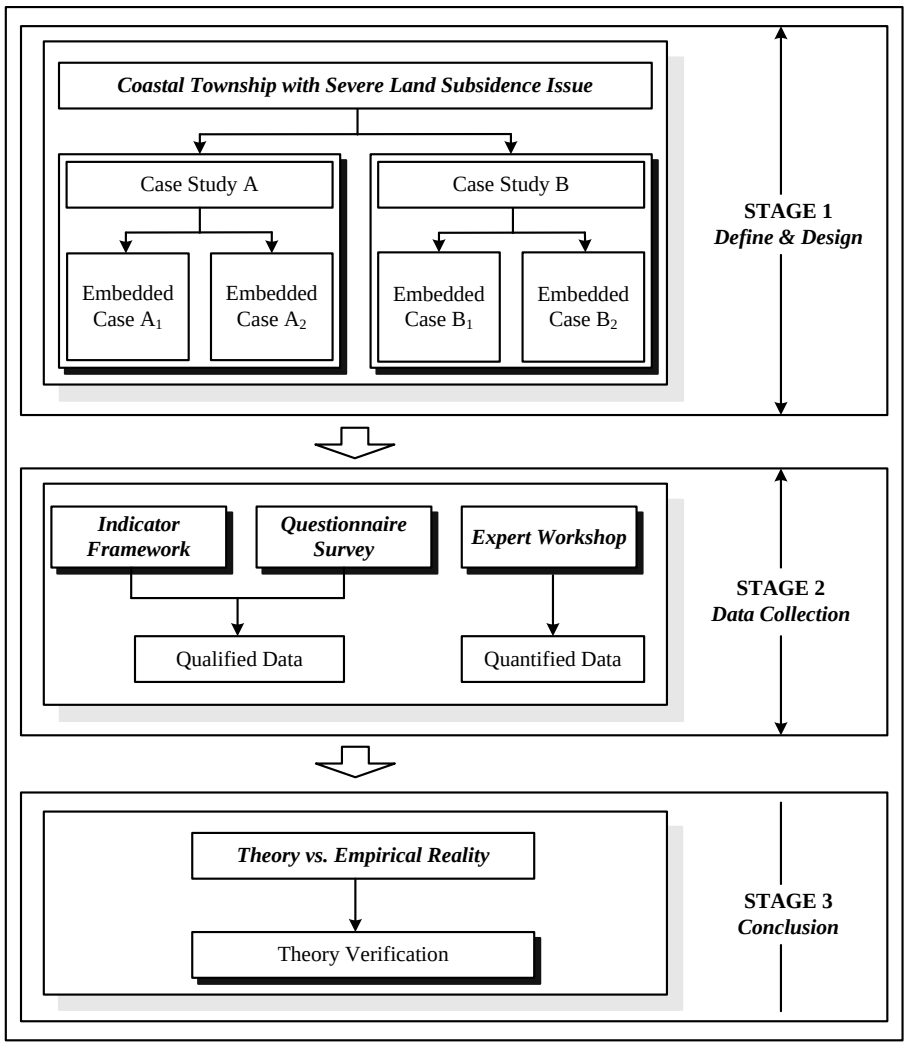


Figure 3.2: Process of multiple-case study approach

In the context of the literature on case study research, as noted above (Section 3.3.1), deliberative and reasonable selection principles are essential in order to access typical cases, assimilate in-depth information, and conduct detailed analysis. Moreover, GIS

has been employed to demonstrate and overlay these specific criteria which relate to particular geographic characteristics. The process of case selection includes four fundamental steps: purpose, scale, data input, and display. Figure 3.3 shows the selection process employed in the development of the GIS.

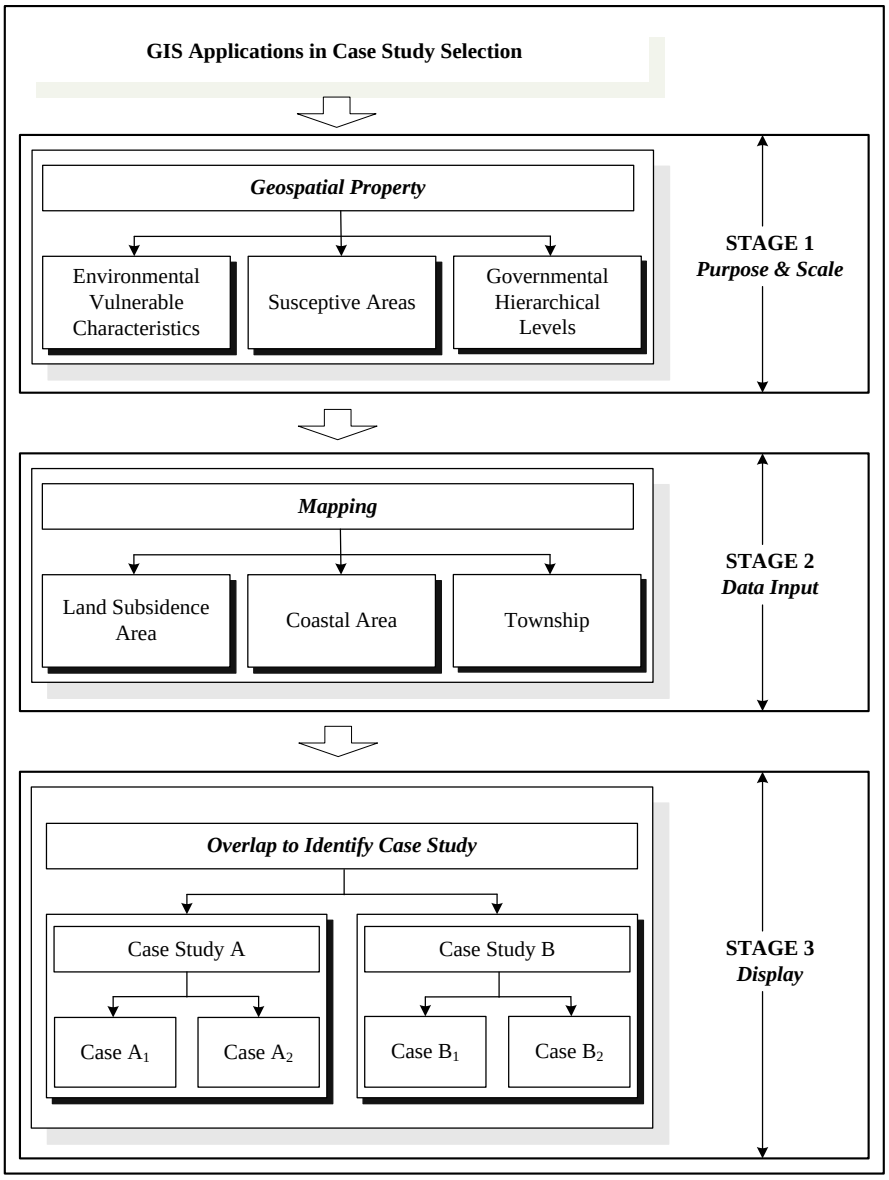


Figure 3.3: GIS application in case study selection

In Stage 1, the purpose and scale of selection criterion were determined. In the context of climate change, the criteria relate to naturally vulnerable areas with high exposure to and existing susceptive areas to climate change but there has also had to be consideration of administrative and practical aspects as well. Therefore, this study summarises three geospatial properties as selection criteria: environmentally vulnerable characteristic, susceptive area, governmental hierarchical levels.

- *Environmentally vulnerable characteristics*: anthropogenic land subsidence is the most severe geographic problem along coastal areas of Taiwan (Section 4.2.1), and these land subsidence areas are susceptible to the impacts of climate change. Consequently, land subsidence is seen as an important geographic feature to help inform the selection of the case study sites.
- *Susceptible areas*: coastal areas are the most sensitive areas to the impacts of climate change in Taiwan due to their particular socioeconomic backgrounds, natural geographic factors and other coastally-specific hazards (Section 4.2.2; Section 4.2.3). Therefore, coastal areas selected as study areas.
- *Governmental hierarchical levels*: the Water Resources Agency (WRA) uses townships as a unit to identify land subsidence areas in Taiwan. Therefore, the township level is employed as the administrative unit for the selected cases. This means that coastal townships with land subsidence are the top priority cases in this study.

In Stage 2, the spatial datasets of these geographic features were collated. Data from the WRA land subsidence dataset (WRA, 2006a) was used and then Mapinfo 6.0 was employed to visualize land subsidence at township level (cross refer to 4.2.1).

In Stage 3, a multiple-case (embedded) design was employed to help identify the two cases in two counties for subsequent analysis (Figure 3.2). It also enabled the identification of the four coastal townships which have been selected as the case study. As a result of this process, the four townships of: Mailiao and Kouhu Township in Yunlin County; Linbian and Jiadong Township in Pingtung County were selected. These were chosen because they are located within severe land subsidence areas, as well as being within coastal and estuary areas, and also within the same administrative structure (Table 3.3). The overlays are useful maps, displaying the natural exposure (severe land subsidence) of these cases (Figure 3.4 & 3.5). The first group in Table 3.3 (case study A: Yunlin County) with two comparable cases (case study A_1 & $A_{2:}$ Mailiao & Kouhu Township) have differential socioeconomic profile. In the second group (case study B: Pingtung County), the two cases (case study B_1 & B_2: Linbian & Jiadong Township) possess similar socioeconomic backgrounds. These socioeconomic characteristics can be used to examine and understand the influence of the economic activities and demographic structures on their susceptibility and resilience to climate change.

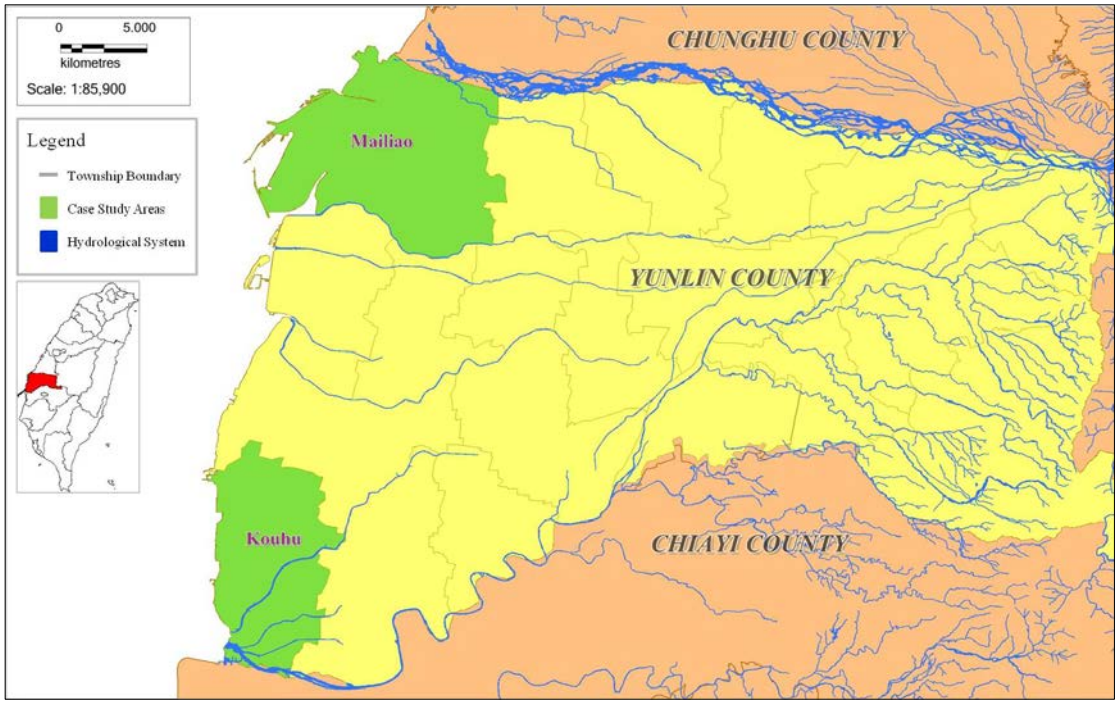


Figure 3.4: Severe land subsidence townships in Yunlin County

Source: Original

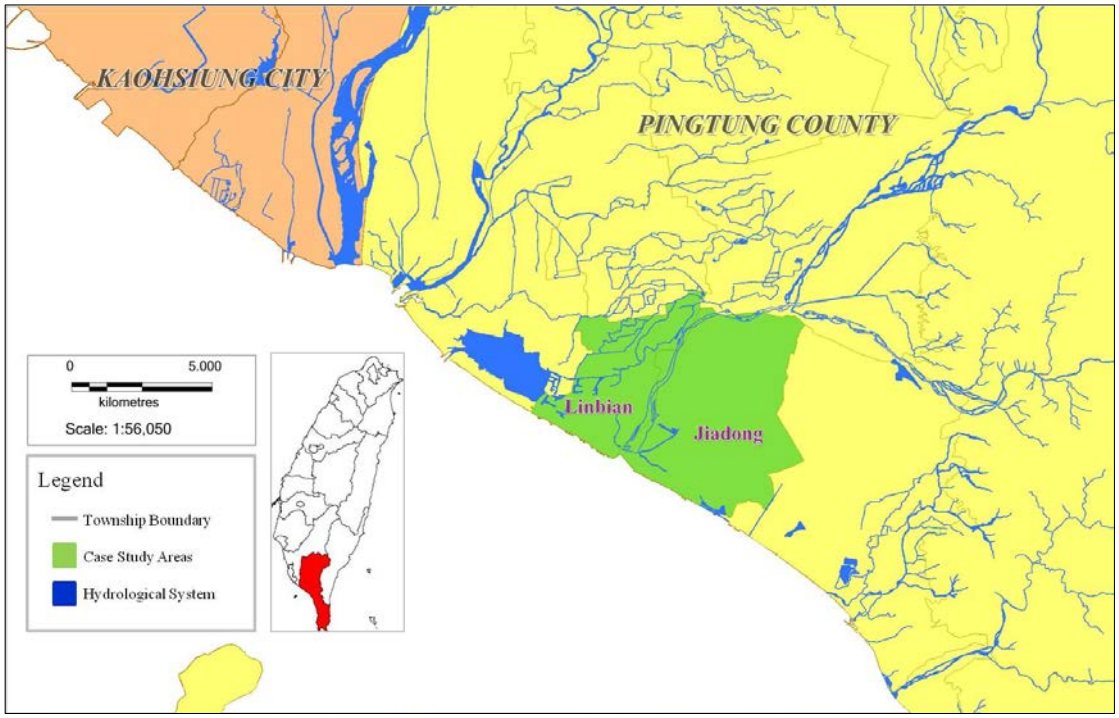


Figure 3.5: Severe land subsidence townships in Pingtung County

Source: Original

Table 3.3: The general characteristics of case studies

	Case Study A (Yunlin)		**Case Study B (Pingtung)**	
	Case Study A_1 (Mailiao)	**Case Study A_2 (Kouhu)**	**Case Study B_1 (Linbian)**	**Case Study B_2 (Jiadong)**
Vulnerable environmental characteristics	● Severe land subsidence	● Severe land subsidence	● Severe land subsidence	● Severe land subsidence
Susceptive areas	● Coastal area ● Estuarine area	● Coastal area ● Estuarine area	● Coastal area ● Estuarine area	● Coastal area ● Estuarine area
Governmental hierarchical levels	● Township level ● Yunlin County	● Township level ● Yunlin government	● Township level ● Pingtung County	● Township level ● Pingtung County
Addition condition	● Differential socioeconomic background		● Similar socioeconomic background ● Disastrous flood experience in 2009	

3.4 Socioeconomic Vulnerability Assessment (Susceptibility & Resilience)

This section presents the approach applied within the vulnerability assessment. This includes the development of representative indicators in order to understand the coastal communities' vulnerability to climate change, and to highlight the specific susceptibility and resilience under the threat of climate change. The following subsections reveal the motive and application that justify the research method used in this study.

3.4.1 Socioeconomic Vulnerability Indicator Framework (SVIF)

Rationale

Understanding vulnerability is key for targeting, formulating and evaluating adaptation policies (Downing *et al*., 2005a). As noted in the previous chapter (Section 2.4.2), the practice of vulnerability assessment involves taking into account the specific contextual conditions influencing the exposure of a region to climate change, as well as the communities' susceptibility and resilience . It can help alter the status of human and environment system before climatic and other hazard events occur, as well as offering insights into better ways to respond to and recover from changes (O'Brien *et al*., 2007).

Indicators

Previous studies (Kubal *et al*., 2009; Vincent, 2004; Wisner *et al*., 2004; Mustafa *et al*., 2010) suggest that indicators have been widely used as an instrument of communication and measurement. Various authors suggest that a proxy (or indicator) can identify the characteristics of a vulnerable community, simplify a complex reality into discrete single measures and directly measure or observe it (Adger *et al*., 2004; Wongbusarakum and Loper, 2011; Vincent, 2004; Moss *et al*., 2001; EEA, 2004; Wong, 2006; Gallopín, 1997). Therefore, Cutter *et al*. (2008: p7) define indicators as "*quantitative measures intended to represent a characteristic or a parameter of a system of interest using a single value.*" A set of indicators can provide an overall profile (Downing *et al*., 2006), for example, coastal conservation managers and researchers have used indicator systems to help better understand the vulnerability and adaptive capacity of communities to the impacts of changing climate (Wongbusarakum and Loper, 2011).

The United Nations (2005; p7) suggests the "*develop systems of indicators of disaster risk and vulnerability at national and sub-national scales that will enable decision-makers to assess the impact of disasters on social, economic and environmental conditions and disseminate the results to decision makers, the public and*

populations at risk." It is widely recognised that the nature of vulnerability is multiple and cannot be presented by a single factor (Roncoli, 2006; Wongbusarakum and Loper, 2011; King and MacGregor, 2000). Furthermore, the vulnerability levels of communities to climate change vary considerably, with several internal factors influencing a community's susceptibility, resistance and recovery to external impacts (Jodha, 1996; Wu *et al*, 2002; Adger and Kelly, 1999). As a result, various academics, for example Cutter *et al*. (2003), have developed a Social Vulnerability Index (SoVI) to help measure such diversity, which relates to the economic and demographic background of communities. Adger *et al*. (2004) and Pielke (2010) highlight the quantitative measurement of vulnerability provided by such indicators which enable the prediction of future possible trends in vulnerability.

Relevant research about socioeconomic vulnerability to climate change has gradually tended to focus on local scales or specific case studies in recent years (Wilkie *et al*., 1999; Cutter *et al*., 2003; O'Brien *et al*., 2004; Schröter *et al*., 2005; Eriksen and Kelly, 2007; Wong, 2006). Hinkel (2011) and Tapsell *et al*. (2010), amongst others, suggest that a vulnerability indicator system is appropriate for local levels when the indicator system can be narrowly defined, and semi-quantitative evaluation can be employed (Petschel-Held *et al*., 1999; Rotmans and van Asselt, 2001; Benestad, 2001; Hanssen-Bauer and Førland, 2000). Consequently, indicators are employed in this study to define vulnerability variables for coastal communities.

3.4.2 Development of Indicator Framework

An explicit framework for indicator development is a prerequisite to ensure the indicator system corresponds with the theoretical framework and research objectives. Eriksen and Kelly (2007) suggest that a process-based approach can be adopted. This focuses on three elements of vulnerability indicator analysis: the robustness of the indicator, the transparency of the conceptual framework, and verification of vulnerability. Figure 3.6 depicts the underlying phases of indicator system development used to inform the approach taken in this thesis within a process diagram. The figure is based on a range of different academic literature sources, as indicated.

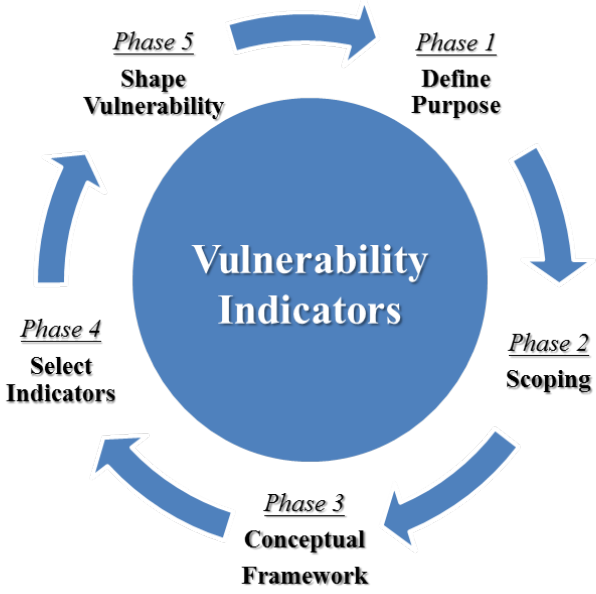


Figure 3.6: A generic procedure of vulnerability indicator framework

Source: Adopt from Maclaren, 1996; Adger *et al.*, 2004; Eriksen and Kelly, 2007; Birkmann, 2006; Schröter *et al.*, 2005; Tapsell *et al.*, 2010; Hinkel, 2011; Polsky *et al.*, 2007.

In the context of this process, firstly, the author suggests that the development of any indicator system needs to be based on the clear definition of relevant goals (Phase 1) in order to determine the appropriate conceptual framework of vulnerability assessment (cross ref: Table 2.8). In Phase 2, the scoping stage, there is a need to consider the most appropriate spatial scale for the assessment. In this context, Birkmann (2007) and Adger *et al*. (2004) suggest that global index programmes should be downscaled to the national, community and individual levels in order to obtain more detailed and meaningful information. However, data at individual level is insufficient or unavailable to assess the vulnerability (Birkmann, 2006) and the investigation of first-hand data of individuals or households is costly and time-consuming (Tapsell *et al*., 2002). Therefore, this also influences the choice of indicators and the degree of detail required as social and economic vulnerabilities vary across various spatial scales.

In the third phase, a coherent conceptual framework is required to embrace appropriate factors and variables, and these variables are closely related with assumption. A systematic process also influences the selection of indicators (Vincent, 2004; Adger and Kelly, 1999). In the following phase, Phase Four, possible representative and practical indicators need to be selected based on relevant literature and scientific knowledge

rather than the crude aggregation of indicators (Leichenko and O'Brien, 2009; Hinkel, 2011). Based on the criteria for indicators evaluation (Flowers *et al*., 2005; Gallpoín, 1997; Tapsell *et al*., 2010; Charles *et al*., 2002; Dahl, 2000), this study proposes that construction of indicators must be clear, transparent and understandable. Finally, vulnerability verification occurs in the last phase. This step assesses vulnerability, and identifies the vulnerable communities in different areas. The result of vulnerability indicator can reflect the particular vulnerability of communities and the representation of the process.

3.4.3 Application of the SVIF

Figure 3.7 shows the detailed description of the process and steps of the SVIF as applied in this research. The following text explains the key phases of this process in more detail, as applied to the Taiwanese case studies.

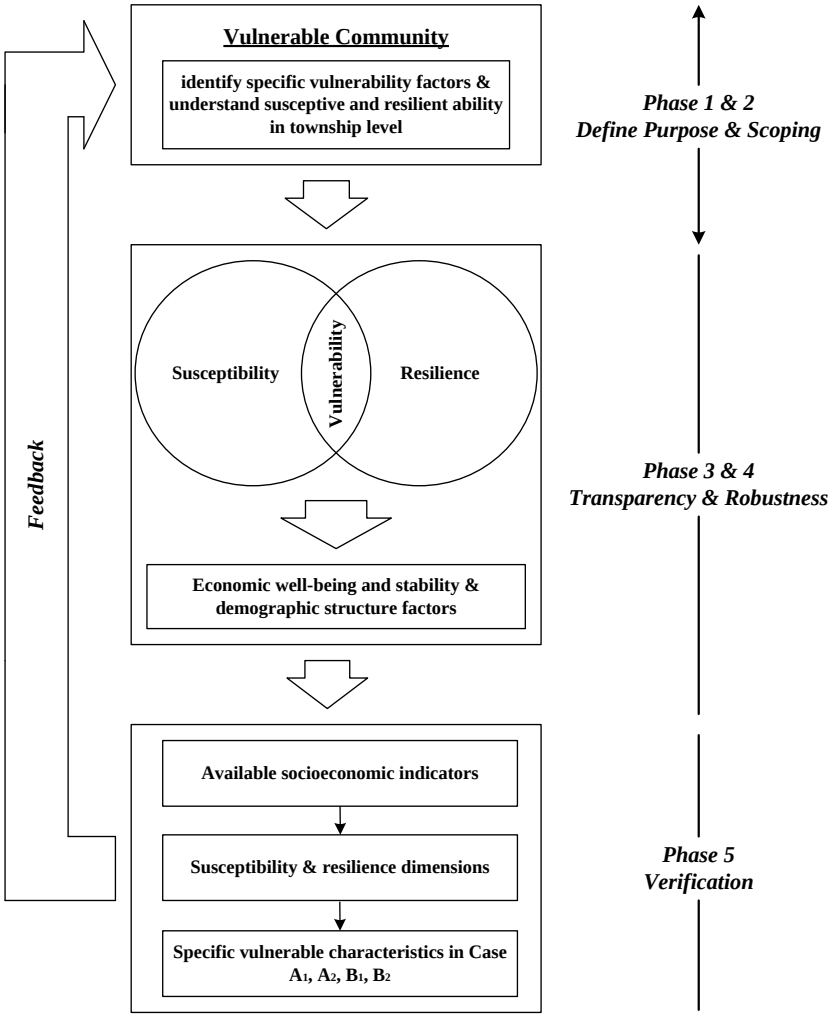


Figure 3.7: The development of the SVIF

Phase 1: Define the Purpose

The specific purpose of this vulnerability assessment was to identify and demonstrate the specific vulnerability factors of different communities with respect to socioeconomic characteristics to climate change. It was envisaged that the results from this would enable a better understanding of the potential susceptibility and resilience of communities to potential climatic hazards along the south west coast of Taiwan, and would provide useful information for stakeholders to develop appropriate adaptation actions. This, it was suggested, would inform the discussions within Chapter 7.

Phase 2: Scoping

This study conducted a socioeconomic vulnerability assessment at township level in 2014 as this was deemed the most appropriate given the availability of census data from local government at this level and the need to capture details regarding each township's respective socioeconomic context in detail.

Phase 3: Conceptual Framework (Transparency)

The key role of the conceptual framework for this study was to develop a socioeconomic vulnerability measurement in order to explore the factors which shape vulnerability. It focuses on the essentials and drivers of socioeconomic vulnerability which are closely related to the resilience and sensitivity of communities to the impact of climate change. The framework covers two main areas: susceptibility and resilience, as noted in Section 2.4.2. The two elements can be used to underline the double structure of vulnerability (Van Dillen, 2004). These two dimensions were used to establish the indicator group which focuses on the socioeconomic and demographic variables that able to influence the sensitivity and resilience of communities.

Phase 4: Indicator Selection (Robustness)

Representative indicators were selected based on the components of the conceptual framework: susceptibility and resilience. In this study, the deductive approach was employed to select practical indicators by identifying relationships between these two components. Potential indicators were selected based on the literature related to vulnerability assessment (Section 2.4.2), these indicators are described as follows:

Economic well-being and infrastructure: The relationship between economic status and vulnerability shows that a strong economic condition can increase recovery and resilience as well as decreasing susceptibility to impacts of climate change (Cannon,

1994; Moss *et al*., 2001). Moreover, economic vulnerability also influences people with good access to resources to maintain livelihoods or to expand their coping ability (Vincent, 2004). In practice elsewhere, communities' vulnerability to climate change relates highly to the economic status and industrial development of an area and the availability of infrastructure, such as housing/transportation, medical service and physical infrastructures. These variables may influence communities' sensitivity and coping ability to climate change. In the context of such observations therefore, this study chose the following the themes and indicators of economic well-being and stability: economic status, housing/transportation, industrial development, and physical infrastructure (Table 3.4).

Table 3.4: Summary table of indicators related to economic well-being & stability and vulnerability

Theme	**Indicator (reference)**	**Description**	**Effect on Vulnerability** (if high value)
Economic Status	Income (A;B;C;D;K;L;M;O;P;T;V;W)	People below the income poverty line are sensitive	Vulnerability ↓
	Poor household (D;G;H;L;M;T;V;W;X)	People who need social services for survival, their resilience is lower	Vulnerability ↑
	Insurance (Q;V)	Life or health insurance is helpful for recovery	Vulnerability ↓
	Unemployment (A;C;D;L;M;N;O;S)	Unemployed workers are slower recover	Vulnerability ↑
Housing/ Transportation	Housing unit (E;I;M;O)	More houses means that more people live in the area that is likely to be affected by hazards	Vulnerability ↑
	Housing tenure (A;C;D;G;H;N;O)	Renters lack sufficient shelter options when lodging is uninhabitable or costly	Vulnerability ↑

	Available vehicle (K;M;N;U)	These facilities can help people move to safe places when they are affected by hazards	Vulnerability ↓
	Mobile home (A;E;M;O)		Vulnerability ↓
	Crowding (A;M;N;O)	More people per unit space at household level means less resilience to hazards	Vulnerability ↑
	Residential property (C;E;G;O;V)	Expensive houses on the lowland or coast are costly to replace.	Vulnerability ↑
Industrial Development	Employment in primary industry (A;C;D;F;G;J;T;U)	The employment, value and area of primary industry indicates the state of economic health of community	Vulnerability ↑
	Value of primary industry (C;F;J;P;T)		Vulnerability ↑
	Area of primary industry (G;R;P;T;U)		Vulnerability ↑
Physical Infrastructure	Public facility (C;G)	Sufficient public facilities or requirements will decrease the susceptibility of community to hazards	Vulnerability ↓
	Medical service (C;D;F;G;J;W)	Sufficient medical service is helpful for short-term recovery	Vulnerability ↓
	Access to water supply (B;C;F;G;J;O;P;U)	Insufficient clean water may increase susceptibility to hazard	Vulnerability ↑

Source: Tapsell *et al*., 2010[A]; Moss *et al*., 2001[B]; Cutter *et al*., 2003[C]; Cutter *et al*., 2009[D]; Cutter *et al*., 2000[E]; Adger *et al*., 2004[F]; Heinz Center for Science, Economics,

and the Environment, 2000[G]; Morrow, 1999[H]; Kubal *et al*., 2009[I]; Brooks *et al*., 2005[J]; Rygel *et al*., 2006[K]; Vincent, 2004[L]; Flanagan *et al*., 2011[M]; Tapsell, 2002[N]; Tubi *et al*., 2012[O]; Wu *et al*., 2008[P]; Hewitt, 2000[Q]; Webb *et al*., 2000[R]; Mileti, 1999[S]; Kuo, 2010[T]; Li and Chen, 2010[U]; Lee *et al*., 2009[V]; Chen *et al*., 2011a[W]; Siagian *et al*., 2014[X]

Demographic structure: The population structure of a community can influence both a community's susceptibility and resilience, particularly to adapt to new conditions (Moss *et al*., 2001; Vincent, 2004). Klein (2002) suggests that a community is more sensitive to impacts due to its insufficient adaptive capacity. In practice elsewhere, communities' vulnerability to climate change relates highly to the population structure and distribution, insufficient socioeconomic support and physical limitation. This occurs because these variables may influence social services networks and the ability of communities to obtain to relevant information and resources. In this current research study, Table 3.5 summarises the variables which have been chosen to represent the demographic structure of the communities, based on these observations. These include the population structure, access to resources, and physical limitations.

Table 3.5: Summary table of indicators related to demographic structure and vulnerability

Theme	**Indicator** (reference)	**Description**	**Effect on Vulnerability** (if high value)
Population structure	Population growth (C;D;G;J;R;S;W)	Social services network cannot adjust to the rapid growth of population which increases susceptibility	Vulnerability ↑
	Population density (A;B;C;F;Q;V;W)	High density is associate with increased risk	Vulnerability ↑
	Dependency ratio (B;C;D;F;L;Q;S;V)	High dependent population will reduce resilience to hazards	Vulnerability ↑
	Young (A;C;D;E;H;I;K;L M;O;S)	Young people who are poor or physically weak and unable to respond to hazards	Vulnerability ↑

	Elder (A;C;D;E;H;I;K;LM;N;O;S;U;W)	Elderly people who are poor or physically weak and unable to respond to hazards	Vulnerability ↑
	Lone Parents (A;C;D;G;H;K;MN)	Single-parent households are likely to live in poverty and have limited ability to recover.	Vulnerability ↑
	Family Composition (A;C;D;G;H;M;O)	Large numbers of dependents within a family that affect the resilience and recovery.	Vulnerability ↑
	Race / Ethnicity (C;D;M;O)	Social and economic marginalisation of racial and ethnic populations which are more vulnerable to hazard	Vulnerability ↑
	Aging (U;V;W)	Aged society lacks self-protection ability and are more vulnerable	Vulnerability ↑
Access to resources	Literacy (B;F;J;P;Q)	High literacy improves the understanding of warning information	Vulnerability ↓
	Educational Level (A;C;G;M;O;W)	High education improves the ability to access information and resources	Vulnerability ↓
	Population in the workforce (B)	Social and economic resources available for adaptation	Vulnerability ↓
Physical limitation	Gender (A;C;D;E;H;K;O;U)	Women have a more difficult time during recovery than men	Vulnerability ↑
	Disability (A;F;H;J;K;P;U;V)	People in poor health are less prepared to be able to cope with the impacts	Vulnerability ↑

	Mortality rate (R)		Vulnerability ↑
	Infant mortality (R)	These indicators show that people who are unable to access health services or with insufficient nutrition, have lower resilience and their recovery ability is poor	Vulnerability ↑
	Maternal mortality (F;J)		Vulnerability ↑
	Birth rate (B;C;F;G;O;S;T)		Vulnerability ↓
	Life expectancy (B;F;J;L;T)		Vulnerability ↓
	Special needs populations (C;D;H;V)	Special needs population (transient and homeless) lack ability to adapt and are mostly ignored during recovery	Vulnerability ↑

Source: Tapsell, 2010[A]; Moss *et al*., 2001[B]; Cutter *et al*., 2003[C]; Cutter *et al*., 2009[D]; Cutter, *et al*., 2000[E]; Adger *et al*., 2004[F]; Heinz Center for Science, Economic, and the Environment, 2000[G]; Morrow, 1999[H]; Kubal *et al*., 2009[I]; Brooks *et al*., 2005[J]; Rygel *et al*., 2006[K]; Vincent, 2004[L]; Flanagan *et al*., 2011[M]; Tapsell, 2002[N]; Boruff *et al*., 2005[O]; Tubi *et al*., 2012[P]; Malone and La Rovere, 2004[Q]; Wu *et al*., 2008[R]; Kuo, 2010[S]; Li and Chen, 2010[T]; Lee *et al*., 2009[U]; Chen *et al*., 2011b[V]; Siagian *et al*.,2014[W]

Phase 5: Shape Vulnerability (Verification)

As noted above (Section 3.4.2), the purpose of the last phase is to measure and verify vulnerability. In this study, secondary data were collected from the local government census and from existing economic reports. The data on the socioeconomic characteristics, from 2014 onwards, for the four cases, were collected from the Budget, Accounting and Statistics Department, Yunlin County Government (2014) and Pingtung County Government (2014), given the time constraints of this study which did not permit expensive and time-consuming interviews or focus group approaches to collect more customised data.

Vincent (2004) and Siagian *et al*. (2004) suggest that standardisation is an important step in order to ensure the crude percentages or original values of indicators are comparable. All indicators have been standardised so that the standardised scores can be used to represent the distance between the raw score and the population mean in units of

the standard deviation. Therefore, the *z* score corresponds to the probability of a standard normal distribution, and these variables are fitted to the normative scale of what is deemed high or low (Vincent, 2004; Li, 2014). Finally, Windows Office Excel 2007 was employed to normalise indicators and through displaying the specific vulnerabilities for the different cases.

3.5 Questionnaire Survey

This section presents the second research instrument used for data generation in this study (Figure 3.1), the questionnaire survey. This was employed to gather individual experiences, public awareness of climate change and adaptation actions, and community engagement with local adaptation actions. This thesis adopted a semi-open questionnaire format, considered convenient for both respondents and data analysis. The following subsections describe the rationale, questionnaire design, and application adopted in this study.

3.5.1 Introduction and Rationale

While many methods can be used to collect required data in social research, such studies deem the questionnaire to be an effective and practical instrument (De Leeuw, 2008; Oppenheim, 2001; Bryman, 2012). Questionnaire surveys have been widely used to explore public awareness and perception in climate change studies across the globe (Sutton and Tobin, 2011; Capstick *et al*., 2013; Spence *et al*., 2011; Lorenzoni and Pidgeon, 2006). There are many advantages of questionnaires in this type of study: they enable the collection of large amounts of information in a cheap and relatively efficient manner, convenient way to answer for respondents, easy to measure and quantify the attitudes and awareness. In general, there are four types of questionnaire surveys that can be used to generate data: face to face, telephone, postal, and the internet. However, the different delivery methods of questionnaire can influence response rate, accuracy, cost, speed, sample size and length of the questionnaire (Gorard, 2003), and therefore researchers need to consider the advantages and disadvantages of each (Table 3.6).

Table 3.6: The advantages and disadvantages of various data collection methods

	Advantage	Disadvantage
Face to Face	● Clearly structured, flexible and adaptable ● Personal interaction ● Respondents can be observed ● Control the survey environment ● High response rate ● High confidence	● Interviewer bias ● High cost ● Geographical limitations ● Time pressure to respondent ● Limited sample size ● Convenience sampling
Telephone	● Random sampling ● Geographical coverage ● Personal interaction ● Low cost ● Timeliness and completion speed ● Personal interaction	● Interviewer bias ● Low response rate ● Inability to use visual help ● Refusal of many people ● Non-representative samples ● Lack of respondent trust ● Need to be brief
Postal	● Use a large sample ● Geographic coverage ● No interviewer bias ● Less respondent time pressure ● Various questions may be asked ● Low cost	● Time needed to receive all responses ● High non-response rate ● Unclear instructions ● The tendency for some item non-responses ● Answers are left blank
Online	● Visual, interactive, flexibility ● High speed ● Convenience ● Ease of data entry and analysis ● Low cost ● Ease of follow-up ● Controlled sampling ● Large sample easy to obtain ● Don't require interviewers	● Perception as junk mail ● Skewed attributes of internet population ● Limited computer literacy ● Technological variations ● Unclear answering instructions ● Impersonal ● Privacy issues ● Low response rate

Source: Frey and Oishi, 1995; Evans and Mathur, 2005; Szolnoki and Hoffmann, 2013; Gorard, 2003; Bryman, 2012; Oppenheim, 2001

Given that the author considered that the issue of climate change was likely to be quite obscure to the general public in Taiwan, a face-to-face questionnaire was conducted with local communities in the four coastal townships to probe deeply on the information about public awareness, and increase the response rate and quality of data in spite of the fact that this method was more costly and time-consuming than other methods, such as

internet and telephone. A face-to-face survey has been a common method of data collection since the 1940s (Szolnoki and Hoffmann, 2013), Gorard (2003) and Oppenheim (2001) suggest that this interview approach provides a means of optimal communication to motivate all sections of society (including the poorly educated populous with low levels of literacy) to complete the survey. A key advantage of this approach is the higher response rate than other methods which results from its broad coverage and dedicated focus on the intended population. Further concerns about other methods reinforced the choice of this survey instrument. For example, Wu (2010) recently has noted that the prevalence of fraud in Taiwan had led most Taiwanese to be distrustful of and therefore unwilling to engage with telephone interviews and postal questionnaires in recent years. As a result, the author considered that the face-to-face questionnaire survey might be better at effectively engaging with the wider public and stakeholders in order to obtain respondents' trust and confidence.

3.5.2 Application of Face to Face Questionnaire Survey

Survey content and structure

A good structure to a questionnaire is essential to ensure the logical flow of information and thought. To facilitate questionnaire completion, a pre-prepared explanation of the purpose and context of the questionnaire is recommended to help convince respondents to participate in the survey as well as to help avoid misunderstandings and increase accuracy of results. In this context of the survey, the questionnaire included sections specifically relating to personal backgrounds, flood experiences, perceptions of and responses to climate change, and the factors relating to community engagement. Within each theme practical and explicit questions were devised. In detail, the contents of these questions emerged from extensive review of the literature (Section 2.3, Section 2.5) as well as an understanding of previous hazard experiences in Taiwan (Section 4.2.3). This study adopted a semi-open question format with yes/no questions, single and multiple choice questions, and five-point bipolar scale. This enabled respondents to answer these questions quickly and accurately, to provide additional information or answers, to restrict the survey time to within 20 to 25 minutes in order to reduce collection time for the survey administrator (the author), to reduce participant fatigue and also enable participants still to have enough time to complete the survey.

Before embarking on the full survey, many suggest a pilot should be conducted to

ensure the survey is clear and is working as intended (Oppenheim, 2001). As a result, the questionnaire for this study was piloted with Ph. D researchers and colleagues (N=16) in Cardiff University (including physical scientists, policy makers and social scientists, including environmental psychologists), in order to check the usability, specificity and robustness of questions and the overall questionnaire design. Whilst this pilot might not have been as robust as one conducted in situ, in Taiwan, it was considered a useful exercise as it did enable refinement of the questionnaire. Some superfluous words, jargon, and ambiguities in meaning of question were identified but no major issues were noted. The final questionnaire was produced. It comprised 12 pages of quantitative questions and under 11 sections (Appendix A). A brief summary of the questionnaire is provided below.

1. **Introduction and Consent:** A welcome page contains a clear description of the aims of study, the usage and storage of data, and author contact details.

Part A. Personal background and general perception

2. **Demographic questions (Q1-7):** as previous research (McCright, 2010; Capstick *et al*., 2013; Whitmarsh, 2011; Lorenzoni *et al*., 2007; Upham *et al*., 2009) suggest a connection between risk perception and demographic factors. It consisted of seven questions on age, gender, residential area, length of residence, educational level, occupation, and annual income.

Part B. Flood experience

3. **Flood experience (Q8-9):** as Few (2003) suggests flood can include various forms and several experiences, this study, defined the term “flood experience” as property loss, physical injury, and effect upon surroundings. This section was designed to explore the respondents’ flood experience and losses. It includes a yes/no question (with an additional ‘not sure’ option) and a single-multiple choice question.

4. **Causes of flood (Q10):** this question was designed to explore coastal communities’ opinion on the possible causes of flood. It includes natural elements, anthropogenic factors, and climate change. This question asked respondents to tick up to 3 of 13 relevant causes of flood (with a “none”, “I don’t know” and “other” options) in their home districts.

5. **The trends of future flood (Q11)**: although scientific communities unanimously agree that there will be more flood along coastal areas (Thumerer *et al*., 2000; Klein and Nicholls. 1999; Dolan and Walker, 2004), it is interesting to explore whether the general public agree with this opinion. So, this section was designed to investigate respondents' opinion about future trends of flood by 2025, 2050, and 2100, on a 5-point response scale ranging from much more, slightly more, same, slightly less and much less (with a 'not sure' option).

6. **The influence of flood experiences on public perception (Q12):** previous studies (Grothmann and Reusswig, 2006; Whitmarsh, 2008; Trope and Liberman, 2010; Weinstein *et al*., 2000; Reser *et al*., 2014; Cruikshank, 2001) suggest that hazard experience may influence or shape public perception and actions. This section was designed, therefore to explore whether flood experience influences public perception of climate change. It consisted of 10 statements and included responses on a five-point agree/disagree (with a "don't know" option) bipolar scale.

Part C. Public perception:

7. **Concerns (Q13-14):** two questions were designed to investigate the issues and levels of public concern. Question 13 asked respondents to tick up to 3 of 11 issues (with a "none", a "no comment" and an "other" option). Question 14 consisted of a single-choice question with 5 response options: very concerned, fairly concerned, neutral, not very concerned, not at all concerned.

8. **Causes (Q15):** previous research (Lorenzoni and Pidgeon, 2006; Lorenzoni *et al*., 2006; Whitmarsh *et al*., 2011; Sutton and Tobin, 2011; Wang and Li, 2012; Yu *et al*., 2013; Pelham, 2009) suggested that the public have gradually accepted the idea of anthropogenic climate change. Consequently, this question was designed to investigate public perception of the causes of climate change. It consists of a single-choice question with 8 response options (with a "climate is not changing", a "I don't know", and an "other" option)

9. **Trust in information sources (Q16):** it is generally known that trustworthy information sources may influence public understanding of climate change (Upham *et al*., 2009; Weber and Stem, 2011). As a consequence, this question was designed to investigate which information sources on climate change

Taiwanese respondents trusted most. It asked respondents to tick up to 5 of 13 most trusted information sources in order to know the effective communication tool with general public.

10. **The impacts (Q17-19):** Srang-iam (2013) highlights that the risks of climate change can be determined through direct observation and repeated experience of weather phenomena and climatic hazards. As a consequence, Questions 17-19 focus on public perceptions of impacts and relevant phenomena. First, a single-choice question asked participators when they would expect to see the impacts of climate change. The second question asked participants to choose the climatic phenomena (with an 'other' option) that they have observed, they have been affected by, and which ones are of most concern to them. A multiple-choice question asks respondents to tick up to 5 of 18 negative effects of climate change that would be of personal concern, or to tick the "none" option if they are of no concern. The results would determine the priority threats and impacts from local communities' experiences

11. **Individual and governmental actions (Q20-24):** These questions were designed to investigate views regarding personal and governmental responses to climate change. They consisted of two types of questions. A single-choice question with 6 response options focuses on the time to take actions, and four multiple-choice questions were designed to understand individual actions and its' motivations, implemented governmental actions, and critical institutional arrangement for general public. It was intended that these results would help identify mechanisms to motivate communities and provide incentives for public participation, which would be further discussed in Chapter 7, under 'Actions'.

12. **Effectiveness (Q25):** Burton *et al*. (2004) and Kuo (2008) propose that public opinion also can help to identify suitable and applicable adaptation actions, and assist policymakers in forming and implementing adaptation policies. This question consisted of 15 options (with a "no action can tackle with the climate change" option) were measured on a five-point (strongly agree, tend to agree, neutral, tend to disagree, strongly disagree, and a "don't know" option) bipolar scale. It was hoped that the results should reflect the different values and efficacy of these actions from the public perspective as well as identifying their specific requirements and preferences for different adaptation actions.

13. **Priority (Q26):** different actions should be developed and implemented within different timescales in order to both respond to immediate risks from extreme weather events as well as to longer-term influences of climate change (Lebel, 2013). This question was designed to investigate the public's priorities for response actions under such time scales, to inform Chapter 7, Section 7.2.3. The question asks respondents to tick their priority (short-term, medium-term, long-term) for each action and an additional "ineffective action" and "don't know" options were provided as alternative. It was envisaged that the results would reflect the priority of response actions from the public perspective and might be able to indicate if some adaptation actions needed longer-term planning.

Part D. Cognitive engagement

14. **Perception, understanding, and attitude (Q27):** this question used a agree/disagree format. Respondents were asked to select strongly agree, tend to agree, neutral, tend to disagree, and strongly disagree (with an additional "don't know") in relation to fifteen statements about their knowledge, understanding and learning of climate change. It was divided into three groups: perception (question **a-e**), understanding (question **f-j**), and attitude (question **k-n**). The results may be able to verify and illustrate the influence of public cognition on community engagement in local climate change adaptation.

Part E. Affective engagement

15. **Concern, feeling, uncertainty/skepticism, and trust (Q28):** this question asks for responses in relation to 13 statements about concern, feeling, skepticism, and trust on climate change related issues. The choices provided were 'strongly agree', 'tend to agree', 'neutral', 'tend to disagree', 'strongly disagree', and 'don't know'. It includes four groups: concern (question **a-d**), feeling (question **e-g**), uncertainty/skepticism (question **h-k**), and trust (question **l-n**). The results were used to explain how public concerns, feelings, skepticism and trust influence the community engagement in climate change adaptation, thus informing future adaptation measures.

Part F. Behavioural engagement

16. **Barrier (Q29):** the question employs the same agree/disagree format as Section 14 and 15 above. It consisted of 13 statements about the possible constraints and barriers (question **a**-**n**) on personal behaviour and willingness to engage in the issues of climate change, such as inequity, cost and economic development, powerlessness, and habit. The results were used to demonstrate the various barriers which may influence public willingness to engage with climate change adaptation actions and informing future adaptation strategies.
17. **Appreciation:** a brief statement to thank participants for their time and contributions.

Questionnaire translation

In order to save time, to gain feedback from my supervisor and to carry out a pilot study in Cardiff University, the questionnaire was written in English first. Therefore, once completed and piloted, a translation of the questionnaire was required from English to Traditional Chinese, so that participants were able to understand it. This preliminary translation was done by the author of this study. In the process of translation, the author had to consider various institutional and cultural differences between the UK and Taiwan. As a result the term “district” was replaced by “township”, and “£” was replaced by “NT$” (The Taiwanese currency, exchange rate = 1:50). Furthermore, it was always necessary to ensure that the translation reflected the intended meaning in the original questionnaire. This was done by employing three external evaluators who checked that the meaning, substance and clarity of the preliminary translated questionnaire and the original questionnaire were the same. All three evaluators were bilingual and interested in relevant issues (coastal management, climate change adaptation). Each was given the translated and original questionnaire to review and comment on. Their comments and suggestions resulted in redrafting of a few incongruous translations. This process was continued until all the meanings of translated document were consistent with the original.

Sampling and distribution

The literature suggests that the principle of sampling describes the search for a small group of people who can represent an extensive population, with every member of these people having a statistically equal chance to be selected (Bryman, 2012; Oppenheim, 2001). An efficient sampling plan should contact the potential respondents for the survey and provide useful and available information. In this study, convenience

sampling was employed because it was simple and allowed the researcher easy access to respondents (Bryman, 2012; Harris and Jarvis, 2011). The survey was conducted using the self-completion method except for the elderly and people with low illiteracy.

Although there were practical limitations in terms of time constraints and costs, coupled with the complexity and length of the questionnaire, 1,600 residents were randomly selected from streets, local organisations, schools, and institutions. Out of these a total of 917 residents from the four cases areas voluntarily participated in the study giving a high overall survey response rate of 57.31 %. Out of these a total of 516 questionnaires were available for data, giving an overall valid response rate of 56.27%. 401 invalid questionnaires were missing response, incomplete, invalid responding. The invalid questionnaires were removed from the dataset because:

- Reproduction: respondents were identified to have filled the questionnaire twice. Their second responses were deleted.
- Missed response: respondents had missed answering a few questions.
- Same response: respondents filled their questionnaire with the same response for the whole row of questions.

The high response rate and valid rate may be because the face-to-face questionnaires allowed the participants to be spontaneous in answering questions and the interview was able to explain complicated and unfamiliar issues and questions to participants. It proved advantageous to significantly improve the valid response rate and the quality of data, to make contact with potential respondents such elderly group and the illiteracy.

Timing of survey

The questionnaire survey was conducted over two months (1st April to 6th June in 2014) in the four cases. Linbian Township was surveyed from 1st April to 20th April and Jiadong Township was surveyed between 21st April and 9th May. Mailiao Township was surveyed from 12nd May to 25th May and Kouhu was surveyed between 26th May and 6th June. These townships were surveyed from 10am to 8pm in order to obtain wide representation of respondents.

Field methods

In order to increase the response rate, respondents' trust, and valid response rate, the interviewer briefly introduced the purpose of the survey and how to answer the questionnaire, to interviewees. The interviewer also needed to initially check the

responses and identify any missing responses. It was observed that the last page, Q25 and, Q26 were frequently unanswered. This may be because some participants overlooked these questions and forgot to answer them. It was decided to conduct the face-to-face questionnaires in a slightly different manner for the elderly and the illiterate groups. For these, the interview process for the two groups was carried out by reading out to the respondent and the responses were written down by interviewers. It enabled the illiterate and elderly people to participate in this survey. However, it is contended that this did not influence the results.

Data analysis

The original survey data was checked before statistical analysis was carried out. All the questionnaire data was analysed using SPSS (Statistical Package for the Social Sciences version 12), and Windows Office Excel 2007 was used to summarise and present these results. Nominal and ordinal data were analysed by nonparametric methods, including:

- Chi-square test for goodness of fit: this was used to determine whether the sample data were consistent with a hypothesized distribution.
- Mann-Whitney test: Given that the data were not normally distributed, this nonparametric test was used as an alternative to the independent sample t-test. It was used to determine if there were any statistically significant differences between two independent groups. This was used to determine if there were any significant differences between data such as personal background and level of concern about climate change.
- Kruskal-Wallis test: Another nonparametric alternative to the one-way ANOVA. It was used to determine if there are statistically significant differences between more than two independent groups.
- Dunn test: A non-parametric multiple comparisons procedure based on rank sums, was used to demonstrate multiple pairwise comparisons after a Kruskal-Wallis test.
- Chi-square test for independence: This test was used to determine if there was a significant relationship between two nominal (categorical) variables. It was used to determine whether there is a significant association between the two variables

3.6 Focus Groups

Focus groups were used to further collect qualitative data and review critical issues in

the local adaptation frameworks and community engagement with adaptation from experts' perspectives. Informed from the results of the questionnaire survey and evaluation of the national and local governments' climate change adaptation websites, a workshop was designed to enable consensus between participants with different perspectives (scholars, government officials) on the community engagement and the critical factors that needed to be overcome in existing local adaptation frameworks. A PESTLE analysis provided the framework for the approach. Subsequently, a follow-up questionnaire was conducted with the officers responsible for local adaptation planning in the two counties. This was essential given the limited attendance of county level officials in the workshop and it enabled the determination of the actual problems in the local adaptation frameworks and the possible recommendations for improvements in local adaptation.

3.6.1 Introduction and Rationale

Participant observation and individual interviews are the two main techniques to collect qualitative data. Using focus groups is a collectivistic research method which focuses on participants' attitudes, experiences, and knowledge (Madriz, 2000). Focus groups or group interviews can create lines of communication for listening to people and learning from them, and encourage participation in design, brainstorming and boarding of concepts based on their experiences or perspectives (May, 2011; Morgan, 1998, Morgan and Krueger, 1998). Interactive discussions between different participants can produce more information than the same number of individual interviewees. Morgan and Krueger (1998) suggest that government agencies, nonprofit organisations, academic researchers, and public relations experts are valuable participants of such groups. Therefore, this is a technique which not only promotes and motivates group discussion amongst participants (Kumar, 2014; Bryman, 2012) but also supplies rich information and can explore unforeseen ideas within a short-period (Sim, 2002).

The focus group method clearly includes several participants, with an emphasis on a tightly defined topic. It also promotes interaction within the group to provide a joint construction of meaning (Bryman, 2012; Bloor *et al*., 2001). Previous studies (Morgan and Krueger, 1998; Vaughn *et al*., 1996; Puchta and Potter, 2004) suggest that the preparation and implementation of group sessions consists of four basic steps:

- **Planning**: deciding what the researcher needs to know and hear from the

participants;

- **Recruiting**: determining how many people are enough and who are the right people to produce a decent discussion;
- **Moderating**: creating an environment and conversation process among the participants around the topic;
- **Analysing and reporting**: summarising the information that has been learned and known from the participants' discussions.

3.6.2 Application of Workshop and Follow-up Questionnaire for Focus Group

Group composition

Within focus groups, the choice of participants has an intense influence on the quality of discussion and results, and therefore considerable effort needs to go into determining participation composition. This needs to consider two aspects: homogeneity among participants and the level of acquaintance among participants (Hennink *et al*., 2011; Ritchie and Lewis, 2003). Kumar (2014) and Bloor *et al*. (2001) suggest that the participants should be recruited from people who are best able to discuss what you want to probe. However, it is suggested that the group should be neither too large nor too small considering the extent and quality of the discussion (Kumar, 2014; May, 2011). It is possible that a few participants may be silent or only provide limited information in a larger group. With a smaller group of participants there may be more ready interaction between individuals (Alasuutari *et al*., 2008; Brannen *et al*., 2002). Therefore, previous studies (Hennink *et al*., 2011; Babbie, 2013; Bryman, 2012; Alasuutari *et al*., 2008) suggest that the numbers of selected participants should between 6 to 12 people and not less than four.

Considering climate change adaptation covers a diverse range of issues and multi governance, the workshop for this research invited representatives from a range of bodies, including central government, local governments, research centers, and academic institutions. These included representatives interested in or responsible for implementation of measures relating climate change adaptation. Considering it is more difficult for a Ph. D student to successfully convene an expert workshop in Taiwan than in the UK, the author requested Professor Wen-Hong Liu who has relevant experience and resources to facilitate the workshop. Professor Liu assisted in encouraging participants to attend the event in the name of academic research. 6 out of 12 invited

participants attended this expert workshop, a number in alignment with the advice from the literature, noted above. Unfortunately, the heavy workloads and time constraints of other invitees were given as the main reasons for a lack of attendance.

Structure of the discussion question

Before the beginning of the discussions, a list of themes and relevant questions was provided to all the participants. This provided a guide and made sure the discussion were conducted around the topic. The discussion guide is seen as a checklist and not only can it be used to assist the moderator to introduce the topic, open the discussion, and focus on key topics, but also can ensure all of themes and questions are discussed. The structure of the discussion guide in this workshop was composed of four parts:

- **Introduction**: this provided information about the purpose of the workshop, ethical issues and explained how the discussion would be conducted. It also showed a general statement to participants so that they know what topic will be discussed.
- **Trends in flooding**: this statement focused on experts' views about future trends of flooding. It was intended that these comments could be compared with the results from the public questionnaire.
- **State quo of community engagement**: this section highlighted the potential opportunities and barriers for community engagement in the formulation process of local adaptation actions, and the possible effects on local adaptation actions without community engagement.
- **Critical issues of for local planning in adapting to climate change**: this section began with broad and then narrowed to specific questions. This study employed a PESTLE approach which is already accepted by industry as a comprehensive method of assessing the state of particular industries or markets (Zalengera *et al.*, 2014; Kolios and Read, 2013; Basu, 2004). Unlike the SWOT analysis which identify issues in four categories of strengths, weaknesses, opportunities and threats, a PESTLE is used to identify political (P), economic (E), social (S), technological (T), legal (L), and environmental (E). It focused on issues which policy makers should address in the local adaptation framework. The broad opening questions were employed to open the group discussion and invite participants to discuss the specific topic. The specific questions focused on the

essential issues to the research topic that generated discussion and richness of information.

The detailed topics and questions of the expert workshop are shown in Appendix B.

Workshop format and exercises

In this study, the workshop was conducted as a round table discussion, on 25th October 2014. It comprised a moderator (the researcher), a note-taker (a research assistant from National Kaohsiung Marine University), and six expert participants. The moderator plays a key role in the process of group discussions (Wilkinson and Kitzinger, 1996; Alasuutari *et al*., 2008; Hennink, 2007; Hennink *et al*., 2011), he was neutral and responsible for the conduct of the group and managed the group discussion, ensuring all topics are covered and all participants have a chance to share their opinions. The note-taker recorded the discussions in detail, including key points, participants' responses and narratives. In order to take notes and remind the moderator to control the discussion time in each section, the note-taker did not participate in the discussion. In addition, a recording device was used to record the full discussions in this meeting.

Before the discussion began, the moderator introduced the purpose and ethical issues to create a comfortable environment for participants. The moderator guided the discussion around the research issues and encouraged the participants to share their opinions. The participants were asked to consider individually and provide their opinions according to their own experience and knowledge. The aim was to see what they thought were the significant issues interfering with the local adaptation and community engagement in Taiwan. A set of elaborate questions were available, and the moderator was able to follow up participants' responses, asking further specific questions. It also helped participants to start thinking about deeper issues. This strategy seemed to promote effective and active group discussion. In particular, where there were differences of opinion between participants, this approach helped spark a greater discussion and understanding of the critical issues. This allowed critical factors to be identified and solutions to be suggested, enabling the workshop to identify possible future directions for adaptation planning.

Consequently, significant data on different topics were generated by the participants voicing mutually agreeable opinions. The detail records and results of the group discussion were collected and typed out from the notes. The results of the analysis of

this data were used to strength the results of the public questionnaire and develop the follow-up questionnaire. This is reported in Chapter Six and Seven.

Follow-up survey

In order to explore the findings further a follow-up questionnaire survey was undertaken. This explored explicit and realistic information about governmental actions and institutional arrangements, the actual circumstances of community engagement related to local adaptation actions, and the key issues of and possible solutions to local adaptation. In particular, the survey collected the views of the key executives in Yunlin and Pingtung County, supplementing the results of both the questionnaire and expert workshop. It was important to gain the opinions of these executives because their direct experience and views can be used to identify the existing challenges in developing and implementing local adaptation frameworks and actions. A self-administered and semi-open follow-up questionnaire was developed using specific questions. This short follow-up questionnaire is shown in Appendix C and summarised below.

1. **Introduction**: a brief introduction and welcome page which contained the research aim and detail information of interview process, and a brief paragraph to thank participants for their time.
2. **Personal background**: this section asked interviewees to provide personal background, which includes: name, organisation, position, working experience, education degree, and specialty.
3. **Governmental actions**: the previous public survey (Figure 7.6) had shown that the public are not well aware of existing local adaptation actions, and therefore this section was designed to investigate the status quo of three main kinds of adaptation actions, public engagement associated with these actions, and why the public is unaware of these.
4. **Institutional arrangements**: the public survey (Figure 7.7) had shown that specific institutional arrangements are necessary to increase the community engagement in local adaptation actions. Therefore, this section was designed to understand these, including related problems, further plans, and suggestions associated with community engagement with local adaptation actions.
5. **The potential problems in local adaptation framework:** As noted above, the expert workshop had previously provided the professional opinions and suggestions

about the local adaptation framework based on the PESTLE framework. This section was designed to explore whether or not the executives of the local adaptation framework supported the experts' ideas. This section also enabled them to make further comments according to their experiences. In the context of the design of this follow-study, the summarised topics from the expert workshop were:

- Political perspective: interdepartmental coordination; clear roles and responsibilities among sector of local government.
- Economic perspective: sufficient financial support and budget; available financial sources.
- Social perspective: increasing public awareness; better communication with public.
- Technological perspective: reliable database and using scientific data efficiently; effective defensive infrastructure, facilities, preventive action and emergency preparedness.
- Legal perspective: specific laws and administration; integrating the idea of adaptation into management plans and projects.
- Environmental perspective: hazard prevention and environmental protection; artificial infrastructure involve protection and be environmental friendly.

The executives of the local adaptation framework in the two counties were selected as the subjects of this follow-up questionnaire in order to reveal and understand the practical experiences and suggestions. Furthermore, considering the respondents' willingness to comply with the request and the time and space constraints of the author, the author requested Professor Wen-Hong Liu to conduct this follow-up questionnaire and to act as the interviewer. Furthermore, as Professor Liu has a good relationship with the local government officials, they would be more willing to share their information and experience with him. Without this, it was agreed that it would have been impossible for the researcher (as a Ph. D student) to be able to access these officials. Therefore, this whole approach necessitated the author to provide all the appropriate information to Professor Liu and to discuss the rationale and approach to be used in considerable detail, via Skype. This included a list of potential representatives; detail results and interpretations of public questionnaire and expert workshop; follow-up questionnaire. The researcher also had to explain all the aims, structure, and expected results to

substitute interviewer, in order to ensure the integrity of the survey with respect to topics and objectives.

Finally, 3 representatives from Yunlin County and 5 representatives from Pingtung County, all with responsibility for local adaptation took part in the follow-up survey. The follow-up survey of the local executives was conducted within a period of around one month: 05/05/2016 in Pingtung County and 01/06/2016 in Yunlin County. The results of the follow-up questionnaire show the level of agree/disagree of expert's opinions and suggestions, and substantive comments about the PESTLE challenges in local adaptation frameworks. Furthermore, it was intended that any explicit comments and suggestions from this follow-up could be used to compare with the results of the public questionnaire and expert workshop, to highlight the current problems in the local adaptation framework, and to provide recommendations for improving the local adaptation framework and community engagement.

3.7 Methodological Limitations

Multiple research methods have been used within the four case studies in this study. Each method has its distinctive limitations as illustrated in following sections.

3.7.1 Limitations of the SVIF

Limited availability of data

The gathering of accurate, available and feasible data is the major limitation of any socioeconomic vulnerability indicator system (Birkmann, 2006; Cutter *et al*., 2008; Flowers *et al*., 2005; Flanagan *et al*., 2011; Eriksen and Kelly, 2007). Whilst this study used the national census data because this national dataset was reliable and accessible, there remain some questions as to whether it was sufficient and accurate enough for the local assessment of vulnerability. This is discussed in more detail in Section 5.4.3, following the results of the vulnerability assessment.

Lack of dynamic snapshot

Socioeconomic vulnerability is a complicated and dynamic process. Whilst an indicator framework is able to provide a theoretical underpinning and snapshot of socioeconomic characteristics of communities (Vincent, 2004), any vulnerability assessment framework is limited in exhaustively representing the relationships and interactive process between indicators. The author would concur with the opinion of previous studies (Cutter *et al*.,

2008; Adger *et al*., 2004; Malone and Engle, 2011), which suggest that there is no comprehensive indicator framework that can involve or represent all the factors to determine the interaction between these key variables.

3.7.2 Limitations of Face to Face Interview Questionnaire Survey

Time-consuming

On average, more than two weeks were spent in each cases study area, on the survey of 200 respondents. This proved that face to face interview are more time-consuming than other data collection methods, such as telephone and email survey. It took about 25 minutes for each respondent to complete the questionnaire. Moreover, the demographic characteristics of interviewees had a significant relation on questionnaire completion time. For example: the elderly group (more than 40 minutes) took more time than the young group (less than 20 minutes). Highly educated respondents, however, spent considerably less time on the survey than those from low education group. In contrast respondents representing primary industries (farming/fishing/husbandry) took more time than other occupations. These slow completion times were caused by: the issue of climate change being unfamiliar, some difficult and complicated questions (Q18, Q25, and Q26), the small character size of questionnaire, and a general lack of understanding of some questions. Therefore, the interviewer needed to spend more time to explain or read aloud these questions for some specific groups of respondent to obtain more accurate responses.

Low response willingness of general public

Although the interviewers had briefly explained to the potential respondents about the purpose of the questionnaire, in order to increase the response willingness, the willingness of general public was generally low. The potential interviewees were frequently busy or they considered it would take too much time to complete. According to the interviewers' observations, the response willingness of the high education group was higher than of the low education group, those surveyed between 15:00 to 20:00 showed a higher willingness than these in the period of 10:00 to 14:00, women were of higher willingness than men, middle-aged people demonstrated a higher willingness than the elderly people, and those from tertiary industry (education, services, official) proved more willing to respond than those from primary (farming, fishing) and secondary (industry, technical) industries. The response willingness in these local

institutions and schools was higher than from the random samples on the road.

Interviewer's bias

An interviewer without good training may influence responses causing misinterpretation of questions (Bryman, 2012; Kumar, 2014) and bias, causing significant implications for survey validity (Bowling, 2005). Therefore, it was necessary to take precautions to avoid interviewer's preconceptions influencing interviewee's responses. The semi-structured questionnaire and self-administration were used to reduce the miscommunication and misunderstanding between interviewer and interviewee (Denscombe, 2007). Secondly, all of the interviewers had to fulfill a questionnaire before the survey was conducted with interviewees in order to understand the content and how to answer it. Finally, interviewers needed to point out that there were no right and wrong answers to questions and professional knowledge was not necessary before the beginning of the survey. This approach helped ensure that interviewers appeared neutral during the survey.

3.7.3 Limitations of the Focus Group

The difficulty in organizing a focus group meeting

Organising a focus groups workshop is not an easy task. To get the agreement of many experts to participate, and to persuade them all to turn up in one place at the same time requires some persuasion and effort. Although the author provided a transportation allowance in order to induce participation, half of the expected participants still did not turn up. Heavy workloads and other commitments were the primary reasons given for their absence, as noted above.

The data are difficult to transcribe and analyse

Recordings are generally much more time-consuming to transcribe than individual interviews (Bloor *et al*., 2001). As there are voice variations and also as a huge amount of data is quickly produced, it is very difficult to record all what is said in detail. This may affect the subsequent transcription and data analysis. Therefore, a recording device was used in group discussions to record the whole communication after having obtained the participants' agreement. Consequently, the thematic interests which arose in the discussions were more completely and reliably recorded.

3.8 Summary

This chapter has presented the methodology of the thesis based on its own specific theoretical perspective. It has outlined the approaches which were employed to find answers to the research questions. As such, the methodology was determined from the research questions and also planned with reference to the AAA framework. A Research Strategy Model that detailed the construction of theory and the data collection using three separate methods was presented. The Research Strategy Model in this study was structured in such a way as to identify: socioeconomic vulnerability characteristics (socioeconomic vulnerability); public awareness of climate change (bottom-up perspective); public response and community engagement (bottom-up perspective), and critical issues in the local adaptation framework and community engagement (top-down perspective)

The GIS employed in this thesis was used to assist the selection of the representative cases only based on visible and trustworthy evidence according to specific characteristics. Reasons for this were that visible maps are more convincing than simple text description. Eventually, a multiple-case design was employed and four townships were selected as the case studies for summarising and comparing the findings. Three investigative instruments were employed in order to collect necessary information from these case study areas. The chapter also outlines the approaches used for the questionnaire surveys and indicator system as well as the processes which were developed and applied to collect and analysis quantitative data. Finally, the chapter has outlined the expert workshop and a follow-up survey which were used to gather qualitative data.

Lastly, this research has embodied the logic and rationality that has driven the Research Strategy Model and linked the research aim, the empirical data and the study's theory modification and reconstruction. The resulting data from the indicator system, public questionnaire, and focus group were analysed and are displayed in the following chapters.

Chapter Four: Coastal Vulnerability and the Adaptation Framework in Taiwan

4.1 Introduction

This chapter provides an overview of the vulnerability of Taiwan's coastal areas, it includes exposure of geographical features (Section 4.2.1), socioeconomic sensitivity (Section 4.2.2), and existing impacts of climate change (4.2.3). Section 4.3 then introduces Taiwan's national adaptation framework and the local adaptation frameworks for the two case study areas. Finally, a brief summary presents findings, organised according to the three constituent elements of the AAA framework in Section 4.4.

4.2 Vulnerability of Coastal Areas in Taiwan

Taiwan is an island country, located on the Pacific Ring of Fire and within the tropical cyclone active area of the Western Pacific where earthquakes and storms are frequent (Hsu *et al*., 2002; Chiau, 2011). Therefore, numerous domestic and international researchers suggest that Taiwan is highly vulnerable to natural hazards and is one of the high-risk regions in the world, because of its particular location and specific landforms (Tasi, 2000; World Bank, 2010; Chiu and Yu, 2006; Teng *et al*., 2006). Arnold *et al.* (2005) and Dilley *et al.* (2005) highlight that more than 70% of Taiwan and its population are exposed to tropical storms, droughts, earthquakes and about 99% of its land and population are exposed to tropical storms and earthquakes. From the topographic perspective, 37% of the land is coastal area with elevations under 100m in Taiwan (Teng *et al*., 2006). Therefore, human settlement has long been drawn to coastal areas, especially the western coastal plains which provide considerable trading opportunities and resources for industry, commerce, agriculture, and aquaculture. In recent years, weather-related events and impacts have posed considerable uncertainty and threats to coastal areas and communities in Taiwan.

Coastal features are diverse in Taiwan, including rocky coasts, sandy beaches, and coral reefs. Moreover, there are various types of wetlands on the western coast, including estuaries, intertidal areas, lagoons, mangroves and, marshes. These play an important role in preserving and controlling water sources and resisting storm surge to prevent flood in coastal areas (Hsieh *et al.*, 2011a; Chiau, 2011). However, reclamation projects, embankment construction, and a large number of wave energy dissipation structures have caused a gradual loss of natural coast, especially in the west. Table 4.1 shows that more than 50% of the natural coastline has been transferred into an artificial shoreline

(MOI, 2007). These transitions have generated significant impacts on coastal wildlife habitats, natural environments, and coastal communities.

Table 4.1: The proportion of natural and artificial coastline in Taiwan

Western Coastal Region					
City name	**Coastline (m)**	**Natural Coastline**		**Artificial Coastline**	
		Length (m)	Proportion (%)	Length (m)	Proportion (%)
New Taipei City	148,024	58,636	39.6	89,388	60.4
Taoyuan	46,174	21,902	47.4	24,271	52.6
Hsinchu	37,420	2,996	8	34,424	92
Miaoli	52,075	13,996	26.9	38,079	73.1
Taichung	49,024	4,388	9.0	44,636	91.1
Changhua	76,951	4,016	5.2	72,935	94.8
Yunlin	68,029	3,698	5.4	64,331	94.6
Chiayi	43,081	2,251	5.2	40,830	94.8
Tainan	70,787	25,222	35.63	45,565	64.37
Kaohsiung	83,133	13,681	16.45	69,451	83.55
Pingtung	173,813	129,412	74.5	44,401	25.6
Subtotal	848,510	280,198	33.03	568,311	66.97
Eastern Coastal Region					
City name	**Coastline (m)**	**Natural Coastline**		**Artificial Coastline**	
		Length (m)	Proportion (%)	Length (m)	Proportion (%)
Taitung	246,642	171,162	69.4	75,479	30.6
Hualien	120,273	79,712	66.3	40,560	33.7
Yilan	114,370	69,343	60.6	45,027	39.4
Keelung	19,188	2,962	15.4	16,227	84.6
Subtotal	500,473	323,179	64.57	177,293	35.43
Total	1,998,433	1,123,541	56.2	874,893	43.8

Source: (MOI, 2007)

Results from the global assessment of coastal vulnerability index (CVI) indicate that coastal areas of Taiwan are highly vulnerable (Singh *et al*., 2006). Moreover, Hsu (2011)

and Chien *et al*. (2010) refer previous study (Doukakis, 2005; Hong *et al*., 2006; Kumar and Tholkappian, 2006; Singh *et al*., 2006) to evaluate vulnerability and suggest that western coastal areas are the most vulnerable in Taiwan. Consequently, these coastal areas seem the most susceptive and vulnerable regions to existing climatic events and potential threats from climate change. This study categorised the three vulnerable factors of coastal areas as follows (Figure 4.1):

- Exposure of geographical features to external threats;
- Sensitivity of socioeconomic conditions;
- Impacts of climate change.

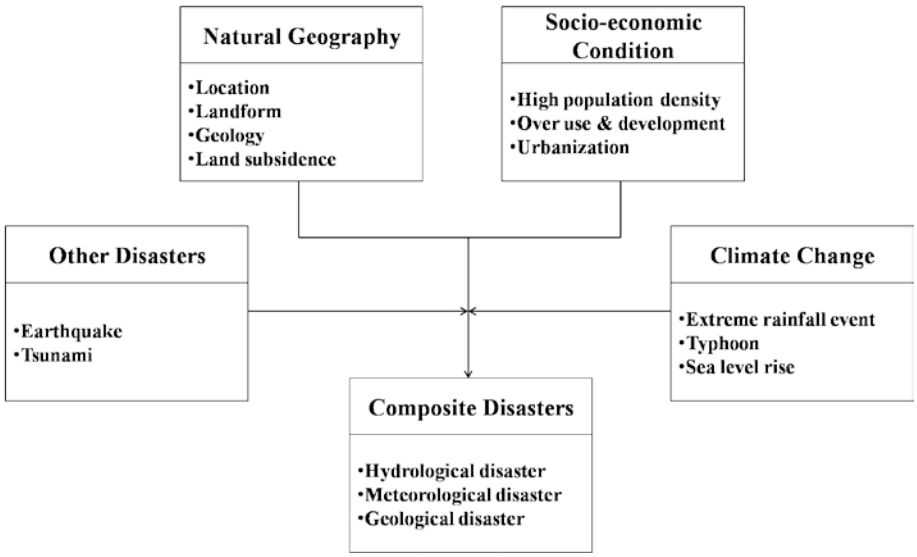


Figure 4.1: Vulnerability factors of coastal areas in Taiwan

4.2.1 Exposure of Geographical Features to External Threats

Land subsidence is a severe anthropogenic environmental hazard that has led to permanent damage of the land surface in the western coastal areas of Taiwan since the 1970s. The causes of land subsidence are multiple and complex. Dissolution of limestone aquifers, volcanic eruptions, and earthquakes were regarded as the natural phenomena for land subsidence. However, anthropogenic activities are the primary cause of land subsidence in the western coastal areas (WRA, 2003; Chen *et al.*, 2010; Tung and Hu, 2012; Hsu, 1998), because groundwater which has been abundantly used as a substitute for surface water has led to excessive pumping of water from underground reservoirs for economic development activities (e.g. heavy industries, agriculture and aquaculture). Land subsidence frequently leads to flood and inundation

of coastal low-lying areas in the typhoon and rainy seasons. It also results in significant damage and impacts on the coastal environment and community (Hsieh *et al.*, 2011b; Wang *et al.*, 2011; Hung *et al.*, 2011). Specifically, the climate change related events such as sea level rising and extreme rainfall combined with land subsidence further aggravates flooding in Taiwan (Ching-Nuo *et al.*, 2014). So far, the total land subsidence area is nearly 900km^2 in 10 counties. It includes Yilan, Taipei, Taoyuan, Miaoli, Changhua, Yunlin, Chiayi, Tainan, Kaohsiung and Pingtung (Figure 4.2). This reveals that the land subsidence areas are largely centred on western coast except for Yilan County. Furthermore, Changhua County (Figure 4.3), Yunlin County (Figure 4.4), Chiayi County (Figure 4.5), Tainan City (Figure 4.6), and Pingtung County (Figure 4.7) with 24 townships are identified as severe land subsidence areas (WRA, 2006a). Table 4.2 shows the current situation related to land subsidence. It highlights the continuous subsidence areas (Figure 4.8) and the maximum subsidence rates (Figure 4.9). The most serious is Yunlin County, and the area of highest accumulative subsidence is Pingtung County, where the problem is more acute than in the other counties (Figure 4.10). Therefore, Yunlin and Pingtung County are considered as the appropriate case study areas for this thesis.

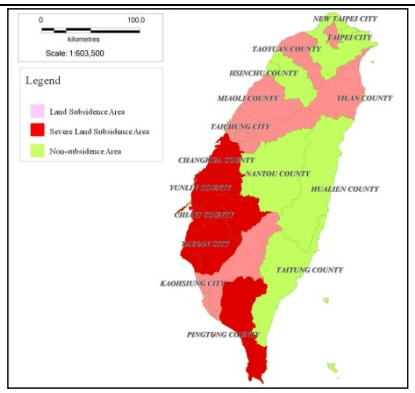


Figure 4.2: Land subsidence counties in Taiwan

Source: WRA, 2006

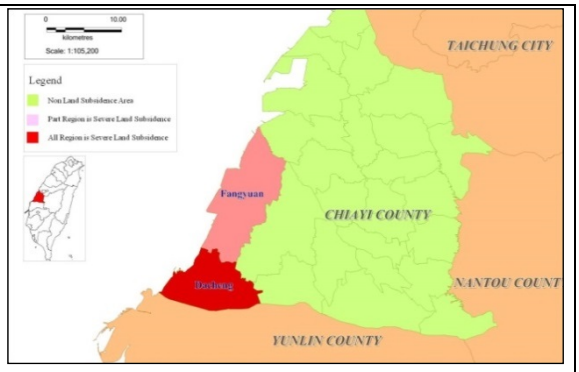


Figure 4.3: Land subsidence townships in Changhua County

Source: WRA, 2006

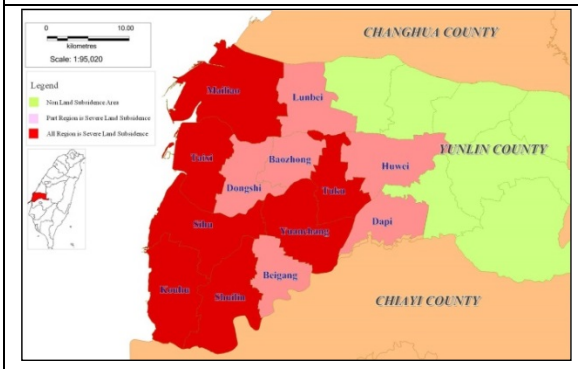


Figure 4.4: Land subsidence townships in Yunlin County

Source: WRA, 2006

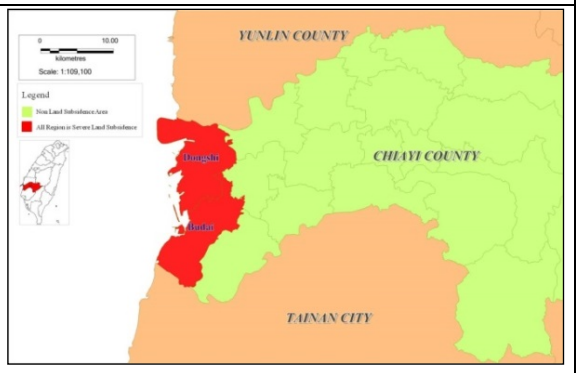


Figure 4.5: Land subsidence townships in Chiayi County

Source: WRA, 2006

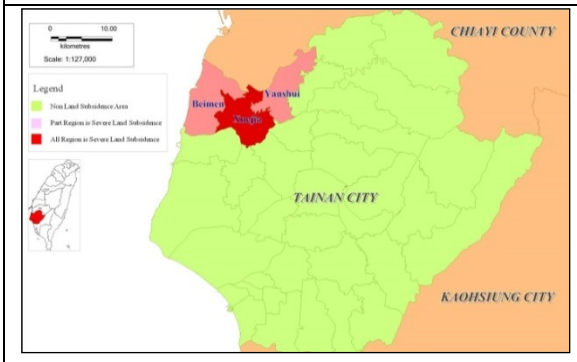


Figure 4.6: Land subsidence townships in Tainan City

Source: WRA, 2006

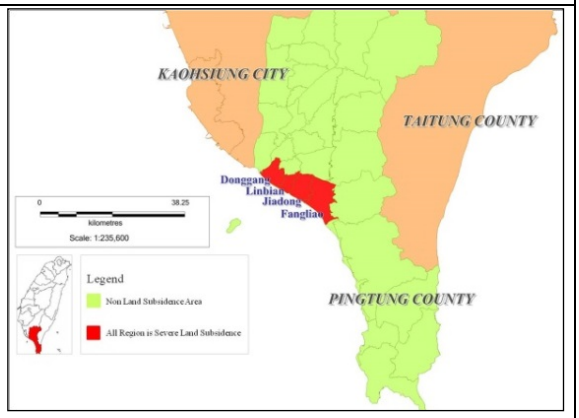


Figure 4.7: Land subsidence townships in Pingtung County

Source: WRA, 2006

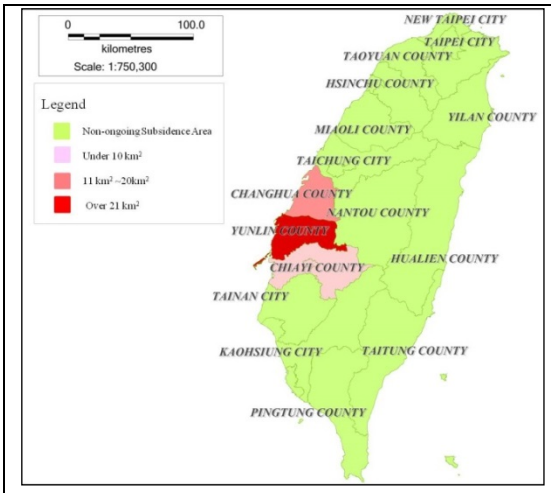


Figure 4.8: Continuous land subsidence areas in Taiwan

Source: WRA, 2003

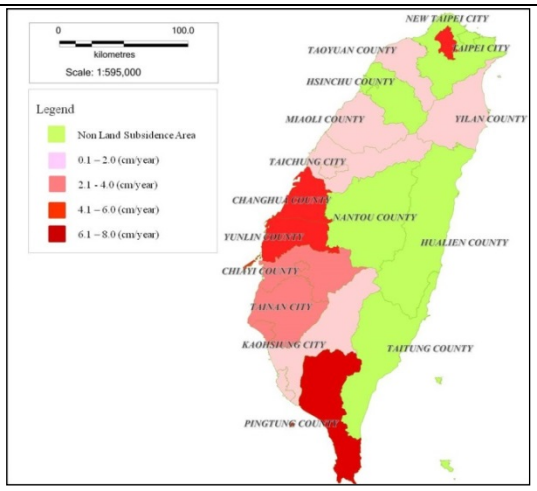


Figure 4.9: Land subsidence rates in Taiwan

Source: WRA, 2003

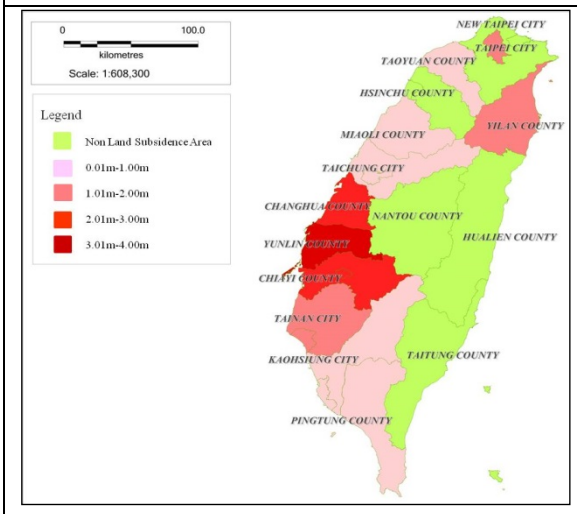


Figure 4.10: Accumulated land subsidence depths in Taiwan

Source: WRA, 2003

Table 4.2: Overview of current land subsidence in Taiwan

County	Period	Continuous subsidence area (km^2)	Maximum of accumulative subsidence depth (meter)	Maximum subsidence rate (cm/year)
Taipei City	1950 - 2012	0	2.11	2.4
Yilan County	1984 - 2012	0	0.47	2.8
Taoyuan County	1997 - 2010	0	0.12	0.2
Miaoli County	2006 - 2012	0	0.02	0.4
Taichung City	2006 - 2012	0	0.02	0.4
Changhua County	1985 - 2012	19.9	2.5	5.4
Yunlin County	1975 - 2012	261	2.47	7.4
Chiayi County	1988 - 2012	5.57	1.50	4.2
Tainan City	1988 - 2011	0	1.02	2.4
Kaohsiung City	1987 - 2011	0	0.25	1.8
Pingtung County	1972 - 2012	0	3.40	1.9

Source: WRA, 2003

4.2.2 Sensitivity Associated with Socioeconomic Characteristics

As noted above, Taiwan's coastal areas have been gradually developed and transformed into industrial, residential, agricultural, and fish farming areas. This also has led to overuse and improper utilisation of these coastal areas (Chen *et al*., 2007; Hsieh *et al*., 2011b).The trend is anticipated to continue increasing pressure on coastal areas and changing natural landforms and environments, especially along the southernwest coast

of Taiwan (Kuo, 2010; Chiau and Kuo, 2006; Ko and Chang, 2012). Take aquaculture fishery as an example. It is one of major economic activity in coastal areas. There are 46 fish farming areas distributed on the coastal areas of over 8 counties (Table 4.3). The two case study areas, Yunlin and Pingtung County, are both main aquaculture production areas (Aquaculture Development Association, 2012).

Table 4.3: Fish farming areas in Taiwan

County	**Fish Farming Area**	**Total Area (hectare)**
Yilan County	Xiapu Area, Dawen Area, Zhuan Area, Zhuangwei Area, Changxing Area, Chaoyang Area, Xinshui Area	1,467 ha
Hualien County	Shoufeng Area, Sanmin Area	736 ha
Changhua, County	Wangkung Area, Yongxing Area, Hanbao Area	1,126 ha
Yunlin County	Xihuhou Area, Shuijing Area, Xingangbai Area, Xingangnan Area, Xialunbei Area, Jinghan Area, Taizi Area, Kantzuliao Area,	2,334 ha
Chiayi County	Haomei Area, Sixindian Area, Donghaomei Area, Ganzilian Area, Wengang Area, Xindian Area, Guzilu Area, Beihua Area,	1,680 ha
Tainan County	Haibu Area, Guoan Area, Baoan Area, Shuangchun Area, Nansing Area, Rokkan Area,	2,616 ha
Kaohsiung County	Yongan Area, Yonghua Area, Xingang Area, Mituo Area	1,337 ha
Pingtung County	Xiaputau Area, Dazhuang Area, Peishihlaos Area, Fanzailun Area, Wenfeng Area, Yanpu Area, Donghai Area	1,683 ha

Source: Aquaculture Development Association, 2012

In addition, coastal areas are important residential areas, the population of coastal towns is around 4.6 million comprising 19.76% of the total population of Taiwan (MOI, 2014). Figure 4.11 illustrates that the western coast is main residential area and the population density is dramatically higher than other areas.

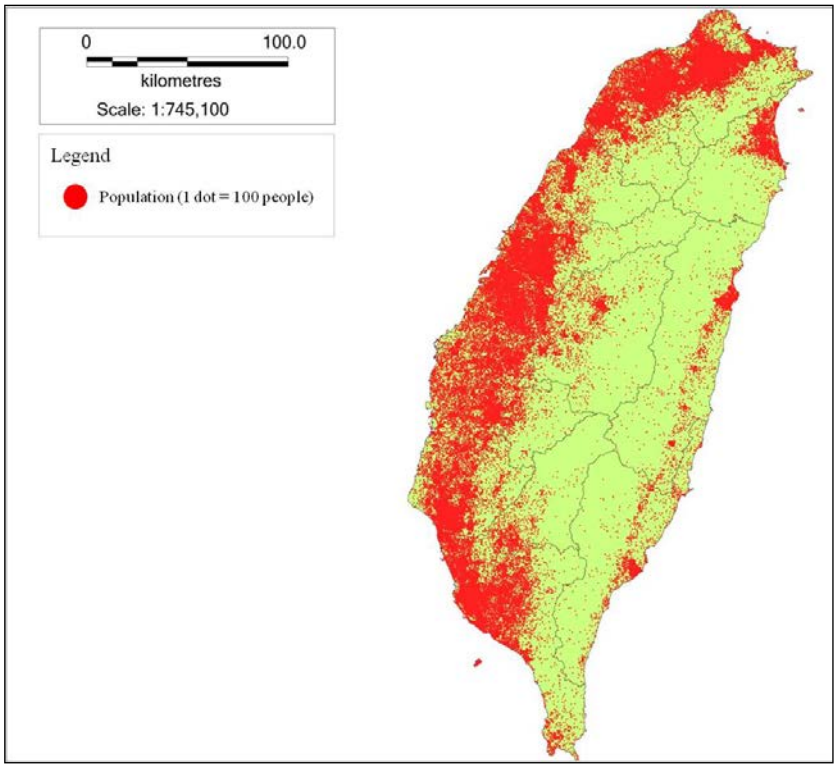


Figure 4.11 : High Population density in west coast of Taiwan
Source: MOI, 2014

It should be noted that the demographic structure is different in the two case study counties. The population in Yunlin County is concentrated in the central areas and the population is decreasing and aging in the coastal communities (Yunlin County Government, 2013). However, the Pingtung County has two distinct communities: the coastal communities and the aboriginal communities in mountain areas (Pingtung County Government, 2015). It seems that the topography and surrounding may influence settlement and urban development significantly. In the context of this thesis, it is suggested that the selected cases of Yunlin and Pingtung counties provide excellent study sample for socioeconomic vulnerability, public awareness of climate change, and flood experiences.

4.2.3 The Threats from Climate Change

According to global long-term statistical analysis of natural hazards (hydro-

meteorological, geological and biological), hydro-meteorological events have increased by 78% over the last 10 years and have resulted in major hazards globally (ISDR, 2005). In the period of 1994-2004, many Asian coastal communities were devastated by flood (Roger and Matthies, 2006); 2 million were affected and about a 60 thousand people died (McGranahan *et al*., 2009). The risk of flooding has increased and caused various environmental impacts on coastal areas, and subsequently posed great threat to life, property, and physical and spiritual injury on the population along river banks and coastal areas (Nicholls, 2002; Klein *et al*., 2003; Ho *et al*., 2008; Wang, 2010; Ahern and Kovats, 2013; Parker *et al*., 2007; Tapsell *et al*., 2002). In Taiwan, Chen *et al*. (2007) and Hsu *et al*. (2011) have demonstrated that climatic change and extreme weather events, such as high frequency of typhoons, increased rainfall intensity, changes in rainfall patterns and sea level rise, have increased. In turn, Lu (2010) suggests these have caused significant affects on the natural environment, ecosystems and socioeconomic development.

Extreme rainfall events

A range of recent studies have shown rainfall intensity and frequency to be increasing in Taiwan. Liu *et al*. (2009), in comparing the annual precipitation of warm and cold years, has revealed that global warming has contributed to the frequency, duration and intensity of precipitation in Taiwan. However, other previous studies (Wang, 2006; Hsu and Chen, 2002; Shiu *et al*., 2009) have shown no dramatic fluctuation in annual rainfall and have indicated that annual rainfall hours are reducing.

Extreme rainfall is highly associated with typhoons in Taiwan, and therefore many meteorological studies focus on the intensity and frequency of typhoons (Webster *et al*., 2005; Zhong and Zhang, 2006; Nott, 2007; Krishan, 2009; Schmidt *et al*., 2009). Webster *et al*. (2005) indicated that the numbers and intensity of typhoons have gradually increased in many ocean areas over the last 30 years (Table 4.4). Likewise, the number of landing typhoons has increased consecutively by 0.3 every decade since 1980 compared with 0.1/decade of the pre-1960 in Taiwan (CWB, 2009; Li and Gu, 2008), and Tu *et al.* (2009) also point out that the number has increased over time, with the annual average increasing from 3.3 (1970-1999) to 5.7 (after 2000).

Table 4.4: The numbers and proportion of typhoons in each ocean region between the period of 1975-1989 and 1990-2004

Ocean Area	1975-1989		1990-2004	
	Number	Percentage	Number	Percentage
Eastern Pacific	36	25%	49	35%
Western Pacific	85	25%	116	41%
North Atlantic	16	20%	25	25%
Southwest Pacific	10	12%	22	28%
North Indian Ocean	1	8%	7	25%
South Indian Ocean	23	18%	50	34%

Source: Webster *et al.*, 2005

The main negative consequence of typhoons relevant to this thesis is extreme rainfall (and subsequent flood), rather than strong winds (Chen *et al.*, 2010b). For example, Typhoon Morakot was a moderate typhoon in 2009, but it brought an accumulated rainfall of 2,777 mm (Ge *et al.*, 2010), and the maximum daily rainfall of 1634.5 mm which is very close to the world record (1870 mm). Figure 4.12 shows that the average frequency of extreme rainfall typhoons was about once every 3-4 years during 1979-1999, and it had increased after 2000. Therefore, recent investigations of invasive typhoons emphasise the trends of rainfall intensity in Taiwan (Hsu *et al.*, 2011).

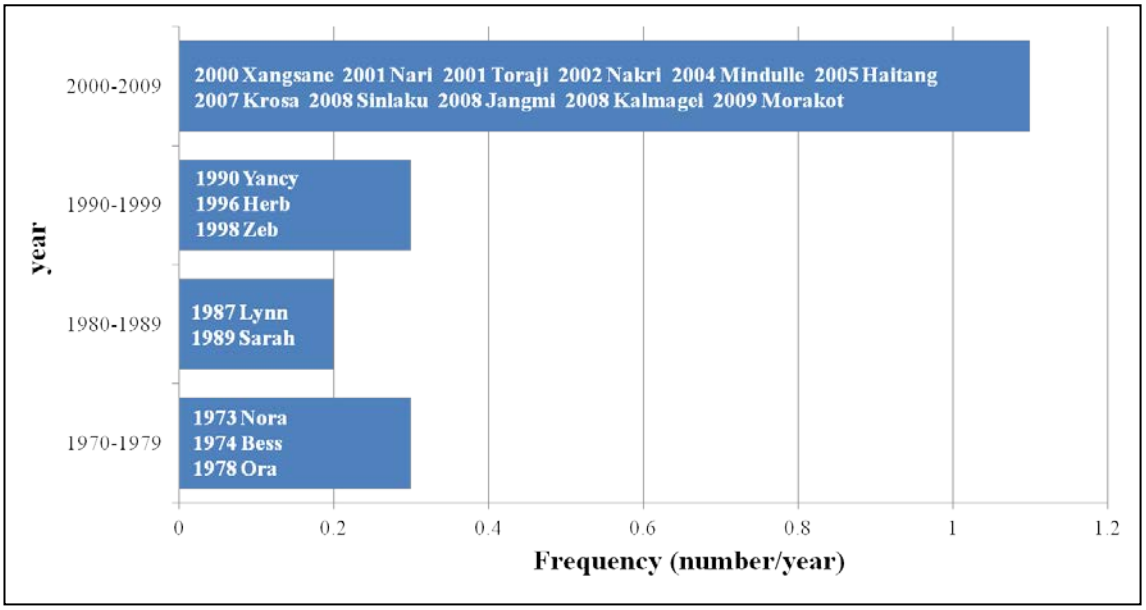


Figure 4.12: The frequency of extreme rainfall typhoons in Taiwan, from 1970 to 2009
Source: Chou and Chen, 2009; Liou and Hsiao, 2009

Flooding

The risk of flooding has increased and has caused various impacts on the coastal areas of Taiwan. The most susceptible areas to flood risk are Changhua, Yunlin, Chiayi, Tainan, Kaohsiung, Pingtung and Yilan counties, and most of these areas are clustered on the southwest coast (Lu *et al.*, 2009). WRA (2006b) and Chen *et al*. (2010b) both acknowledge that these areas are flood-prone areas because they are low-lying and river influx regions. According to statistical data (Executive Yuan, 2011), there were flood incidents at an annual average of 7.4 times between 2000 and 2009 (Table 4.5), and it show an apparent increasing trend of flood events compare to the preceding period of 1950-2000 (4.03).

Table 4.5: Statistical results of damages from flooding in Taiwan, period of 2000 to 2009

Year	Cases	Casualties (person)			Collapsed Houses (house)	
		Death	Missing	Wounded	Entirely Collapsed	Partly Collapsed
2000	8	84	33	184	434	1725
2001	8	225	129	585	646	1978
2002	3	5	1	12	0	0
2003	7	6	1	5	0	0
2004	11	58	34	524	376	154
2005	6	41	8	152	27	143
2006	7	7	4	8	43	32
2007	8	18	3	149	54	85
2008	12	42	14	105	66	17
2009	4	644	60	1557	99	250
Total	74	1130	287	3281	1745	4384

Source: Executive Yuan, 2011

Teng *et al.* (2006) indicate that these flood events had damaged approximately 3,000 buildings and brought £310 million of annual economic losses. Previous studies (Hsu *et al.*, 2011; Teng *et al.*, 2006) highlight the following as the key causes for the frequent flood events in the southwest coast of Taiwan:

- **Inequality of Rainfall Distribution:** Hsu *et al.* (2011) and Teng *et al.* (2006)

indicate that the extremely uneven distribution of rainfall durations is the key problem. It has a significant spatial and temporal variation in Taiwan. Wang *et al.* (1994) and EPA (2010) both noticed that the light and no-rain days are decreasing but short and heavy bursts are increasing. Therefore, flood events are more frequent, especially in the rainy seasons, accompanied by extreme rainfall.

- **Particular Geographical Characteristic:** The short and steep rivers and the huge deposition of sediments in streams and channels decreases channel capacity and flood-carrying capacity, thus greatly aggravating the intensity and frequency of flood (Hsu *et al.*, 2011; Teng *et al.*, 2006).

Sea-level rise

All scientific evidence shows that the rate of sea level rise surrounding Taiwan is higher than the global average and it poses a grave threat to the coastal areas. The Fourth Assessment Report of the IPCC (2007) indicates that the mean global sea-level has increased by 3.1 cm from 1993 to 2003 and experts' estimate that the level will increase by 18-59 cm by 2100 (Nicholls *et al.*, 2007). Many assessments and forecasts have predicted that global sea level will be 1.4 meters higher in 2100 compared to 1990 (Horton *et al.*, 2008; Rahmostorf, 2007). Nicholls and Cazenave (2010) indicate that most coastal countries in South, Southeast, and East Asia are highly vulnerable to climate-induced sea level rise. Taiwan is clearly one of these countries (Figure 4.13).

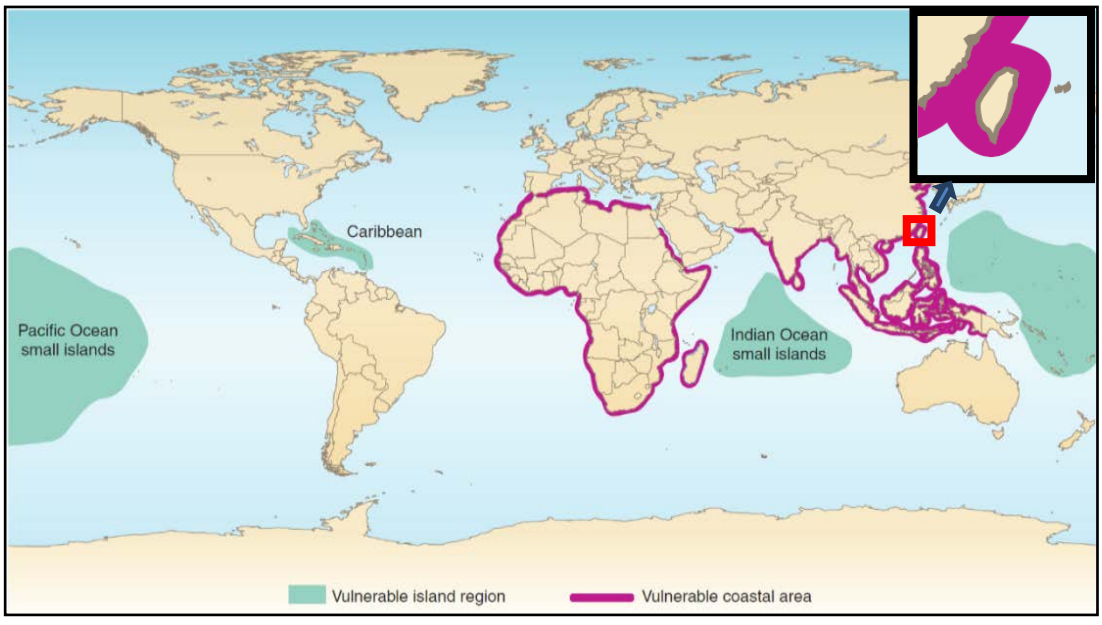


Figure 4.13: Regions vulnerable to coastal flooding caused by climate-induced sea-level rise

Source: Nicholls and Cazenave, 2010

The EPA (2010) suggests that the sea level change trends in Taiwan are related to decadal oscillation, with an average annual rising rate of 0.24 cm from 1961 to 2003. This indicates a trend approximately 1.4 times the global average. In the period 1993 to 2003, the average annual rate of increase was shown to be 0.57 cm and 0.53 cm from the tidal records of tidal stations around Taiwan and analytical results of satellite altimetry, respectively (Tseng *et al.*, 2010). The EPA (2010) study has explicitly suggested that if sea level rises by 0.5 meter, almost 105 km^2 land will be lost; if sea level rises 1 meter, about 272 km^2 land will be lost. The major susceptible areas to sea level rise are Yilan, Changhua, Yunlin, Chiayi, Tainan, Kaohsiung, and Pingtung County, these counties are also the major land subsidence areas, and therefore sea level rise may exacerbate and accelerate the impacts and damages to coastal communities.

4.3 Adaptation Policy Framework in Taiwan

Given the above impacts associated with climate change, the development of a national adaptation framework is vital for the effective response to climate change in Taiwan. In this context, the Executive Yuan proposed a "National Climate Change Adaptation Policy Framework" (CEPD, 2012) which is based on the APF proposed by the UNDP (Burton *et al.*, 2004). This serves as the main reference for future adaptation work in different sectors in Taiwan. The author interprets that the Taiwanese national framework supports the idea of cooperative implementation and also demonstrates a top-down process. This section of the thesis comprises two sub-sections. Section 4.3.1 introduces the Taiwanese adaptation framework and associated organisations and agencies at national and local levels. Section 4.3.2 provides an overview of the implementation of the national adaptation strategy, highlighting relevant actions and specific local adaptation actions relevant to the two case studies.

4.3.1 Cooperative Organisations and Agencies

Considering that climate change adaptation needs a comprehensive framework and interdisciplinary and inter-department coordination, the Executive Yuan has rapidly expanded the functions of the National Council for Sustainable Development (NCSD). There is a range of working groups and task forces which help to develop mitigation and adaptation policies. The NCSD includes the Energy Conservation, Carbon Reduction and Climate Change Working Group, and cooperates with the Environmental

Protection Administration (EPA) and the Council for Economic Planning and Development (CEPD). In order to strengthen the adaptive capacity, minimise vulnerability, and establish an integrated network and implementation basis for policy structure and plan promotion, CEPD formed a multidisciplinary consultation team and further established a “Task Force for Formulating and Promoting the Climate change Adaptation Policy Framework and Action Plan” in 2010. This Task Force is composed of related agencies, experts, scholars, representatives of NGOs and industries which monitor and coordinate the progress of the Adaptation Policy Framework and Action Plan.

There is a well-defined structure for the organisation of the adaptation framework which reflects the different issues. Figure 4.14 shows that eight sectors (disasters, infrastructure, water resources, land use, coastal areas, energy supply and industry, agricultural production, health) have been assigned to the specific Task Force. Whilst a specific ministry or council is assigned lead for each sector, these bodies are supported by a range of co-organisers, other ministries and councils with experience and responsibilities relevant to the sector. Clearly, there are many overlaps in membership between the different Task Force panels, which, presumably has been designed to facilitate joined-up thinking and practice in adaptation. For example, the Ministry of the Interior, the host organisation for the ‘Coastal Zone’ is also represented in other sectoral Task Force panels (disaster, infrastructure, land use, agricultural production and biodiversity), because the MOI covers a broad range of responsibilities include population, land, construction, military service administration, national emergency services, local administration systems, law enforcement and social welfare. Such cooperative working arrangements may ensure that adaptation actions are embedded cross-sectorally and implemented jointly.

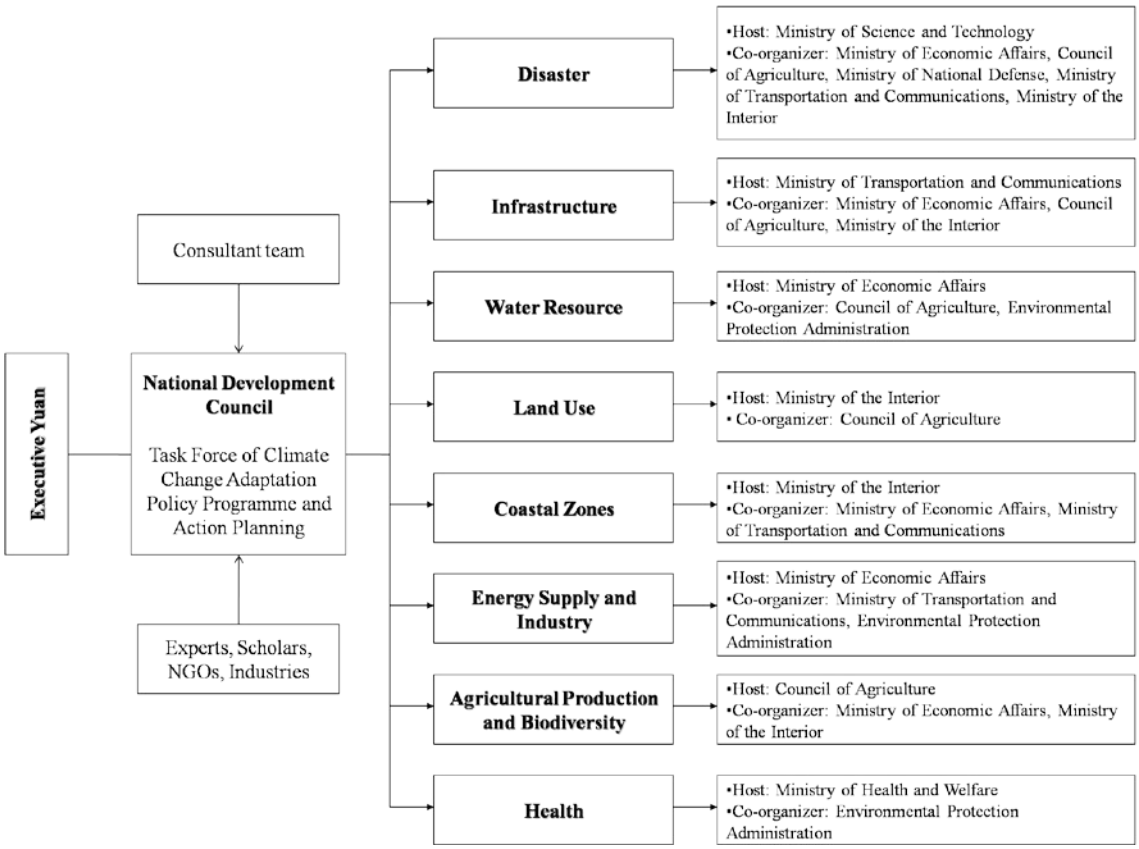


Figure 4.14: The organisations and agencies of the national adaptation strategy framework in Taiwan

Source: CEPD, 2012

To facilitate the development of the local adaptation strategy and associated actions at county level, a guide has been produced at the national level by the CEPD (2012). The Guidance for Local Adaptation Planning to Climate Change provides a reference frame and standard operating procedure for local governments to facilitate interdisciplinary and interdepartmental integration. Particularly, the guide emphasises the need for local actions to be developed in the context of the local situation, in other words, taking into account the diversity of local geospatial features and socioeconomic characteristics. Furthermore, the cooperative framework (Figure 4.15) specifies that Central Government should provide special subsidies to support local governments develop and undertake appropriate adaptation planning and implementation measures.

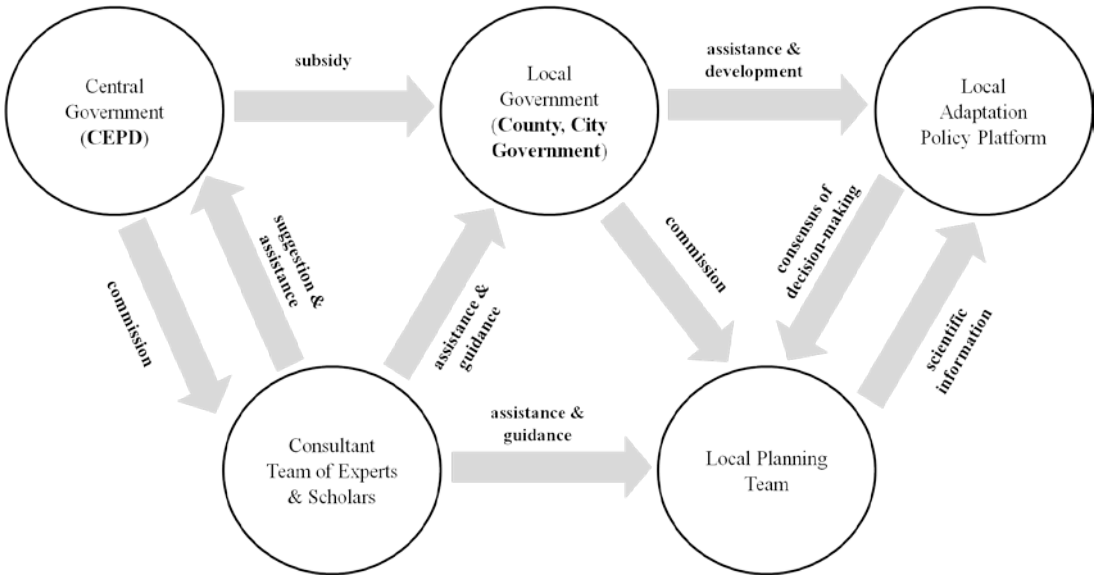


Figure 4.15: The cooperation framework of Taiwanese climate change adaptation
Source: CEPD, 2012

CEPD (2012) suggests that the local climate change adaptation platform should include:

1. Establishing an integration working group: this should be developed to promote the planning of local climate change adaptation actions, to communicate and cooperate with the central government and professional institutions, and to strengthen the inter-departmental coordination.
2. Developing internal individual teams for different issues: these teams can be formed with officers from different departments with different sectoral responsibilities and professional skills, enabling collaborative adaptation actions.
3. Cooperating with professional institutions: in order to enforce the comprehensive climate change adaptation strategies and actions, local government should cooperate with professional institutions, such as planning consultants, scholars, and experts who are experienced and professional in climate change adaptation planning.

In the context of the latter, the recruitment of a range of experts, scholars, and consultant teams in this framework is required, and these 'experts' will only provide technical support, appropriate inputs, suggestions and assistance. The local climate change adaptation policy platform can effectively produce local specific adaptation actions when these participators reach a consensus on such measures. There appears to be a focus on expert input and limited public engagement, a feature that will be explored later in this thesis.

With respect to the two research case studies, Yunlin County and Pingtung County, both have developed individual climate change adaptation policy platforms according to this national cooperation framework, as shown in Figure 4.16 and 4.17.

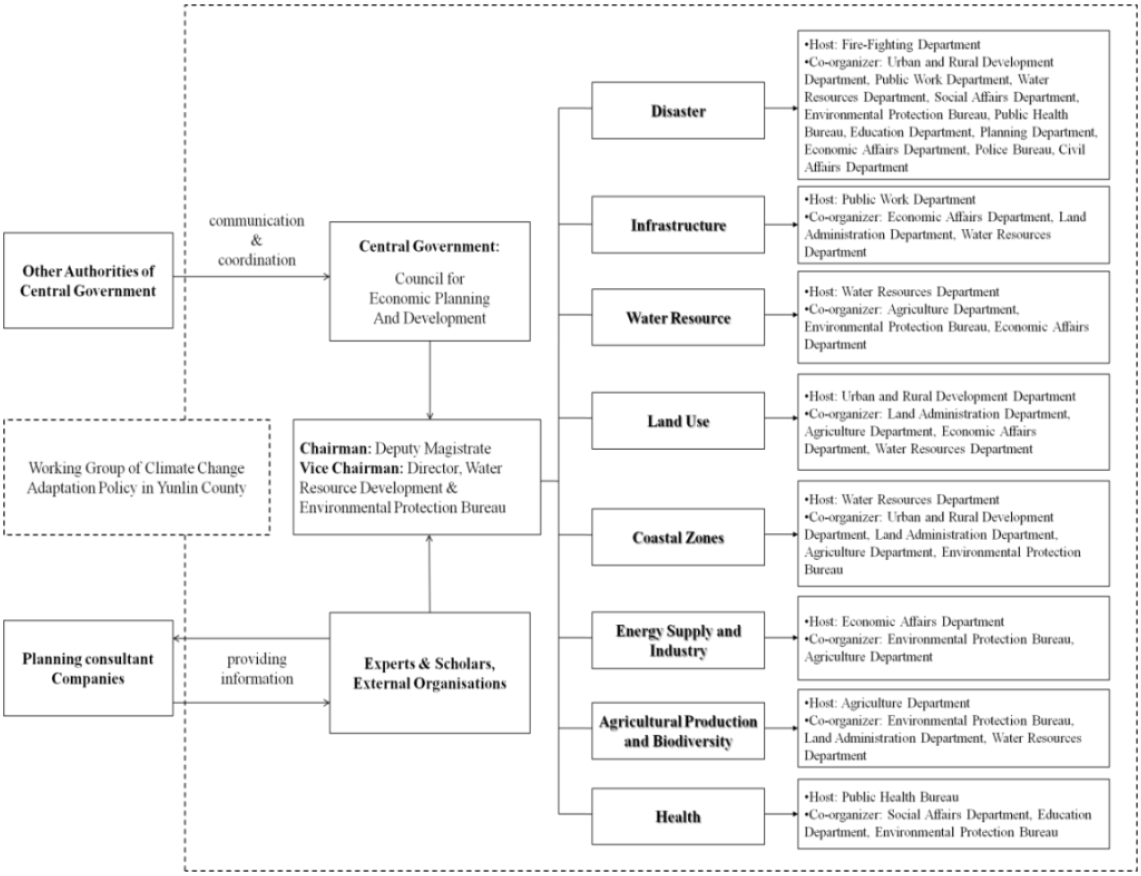


Figure 4.16: The climate change adaptation policy platform and organisations in Yunlin County

Source: Huang, 2014

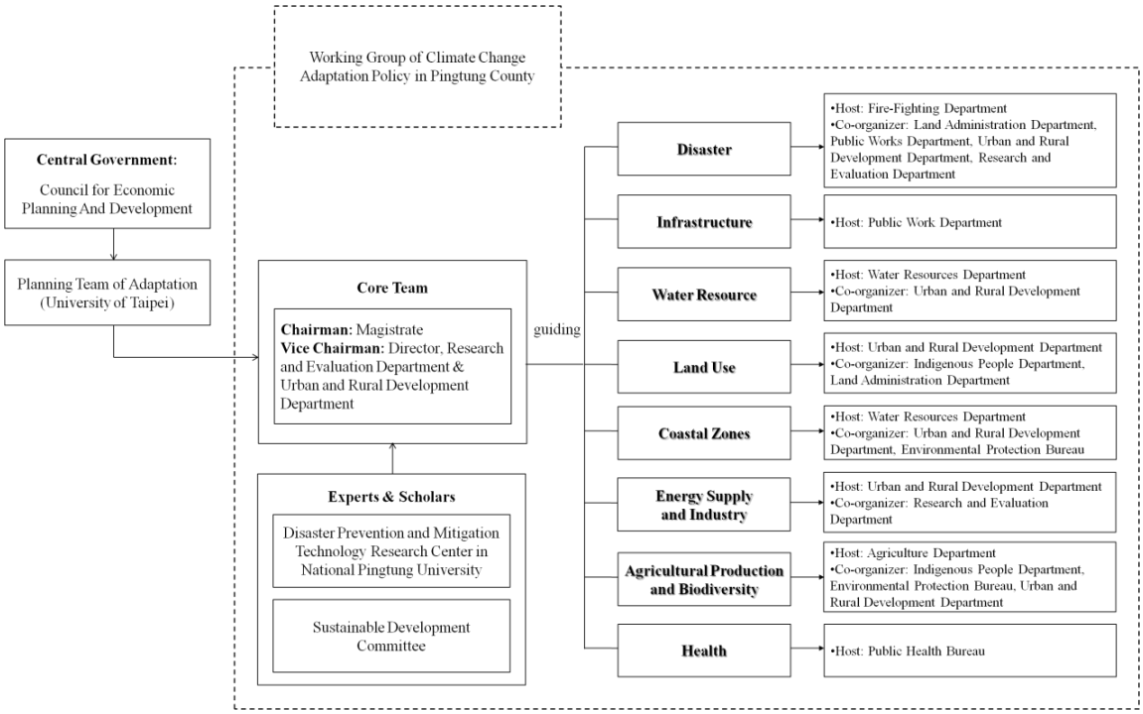


Figure 4.17: The climate change adaptation policy platform and organisations in Pingtung County

Source: Huang, 2012

Basically, the organisational structure of the policy platforms is similar, with both including relevant departments from central and local government, as well as experts and scholars, and consultant teams. More specifically, both working groups include a core team as well as individual task force teams, representing different issues. The core team is responsible for interdepartmental cooperation, coordination and discussion. The actions and responsibilities of individual task force teams depend on the direct connection between the nature of adaptation action and the responsible affairs of individual departments in the eight sectors. Therefore, the task force team includes the host department and other co-organisers. It implies that inter-department cooperation may be a signification factor in implementing the proposed adaptation strategies and actions. More importantly, the framework highlights the importance of internal interdepartmental cooperation and external professional support for developing the local adaptation strategies and actions.

4.3.2 Adaptation Strategies and Relevant Actions

In order to implement the adaptation policies in a more effective way, clear aims and objectives of adaptation strategies for each sector are very important to determine the

host departments and co-organisers. Figure 4.18 shows the implementation structure of the national adaptation strategy.

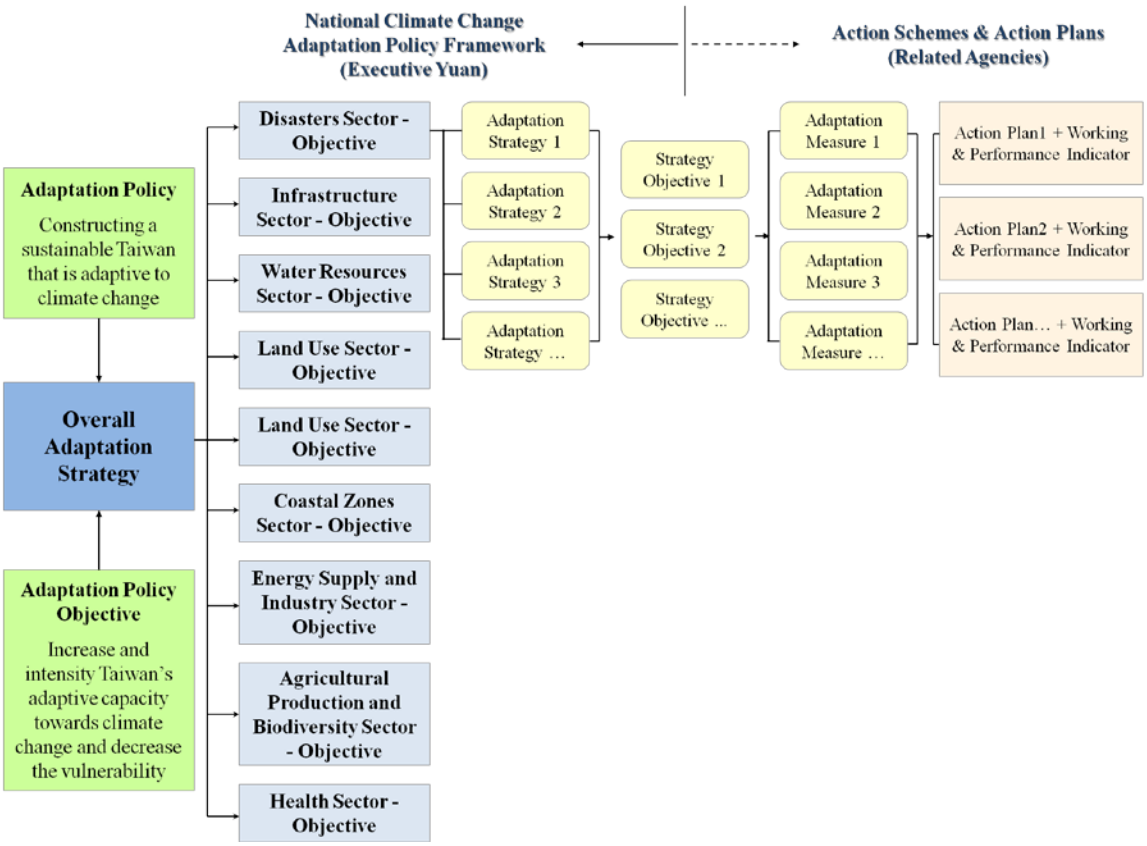


Figure 4.18: Implementation structure of national adaptation strategies
Source: CEPD, 2012.

The overall adaptation strategy is supported by several underlying 'sectoral' objectives (blue column), which includes the individual sectoral adaptation strategies, as well as the objectives and measure for each sector (yellow column). The top priorities for all sectors are:

1. Implementation in territorial planning and management;
2. Enhancing hazard prevention and avoidance capacities in environmental, social and economic systems;
3. Carrying out comprehensive river-basin governance;
4. Prioritising high-risk regions for climate change;
5. Enhancing prevention and protection capacities for adaptation in urban areas.

Finally, each plan has to set up specific working and performance indicators in order to evaluate and review the results and performance in the stage of follow-up strategy planning (red column).

Considering the multiple influences of climate change and different vulnerability levels and factors, the adaptation strategies and actions need to be specific to different local contexts. Furthermore, CEPD (2012) suggests that the proposed adaptation actions should correspond with existing national and local programmes and policies. Therefore, the design and objectives of local adaptation strategies and actions in the two cases are slightly different. The detail adaptation strategies and actions in Yunlin are showed in Appendix D and the overall adaptation strategies and actions in Pingtung are shown in Appendix E. In addition, the proposed adaptation actions for the coastal zone in the two cases, which are also concerning the issues in the sector of disaster, land use, water resource, and agricultural production and biodiversity, are shown in Table 4.6.

Table 4.6: The proposed adaptation actions related to different issues

	Yunlin County	**Pingtung County**
Coastal zones	disaster, land use, water resource, agricultural production and biodiversity	disaster, land use, water resource, agricultural production and biodiversity
Disaster	coastal zones, land use, water resource	coastal zones
Land use	disaster, coastal zones, energy supply and industry	coastal zones, energy supply and industry, agricultural production and biodiversity
Water resource	disaster, agricultural production and biodiversity, coastal zones	coastal zones, land use, agricultural production and biodiversity
Agricultural production and biodiversity	coastal zones, water resource	land use, agricultural production and biodiversity
Energy supply and industry	land use, water resource	water resource, land use, coastal zones

Regarding community engagement with local adaptation, the thesis used three principles to identify and classify the nature of public engagement in these adaptation actions, as follows:

Explicit engagement actions: These proposed adaptation actions require a definite cooperation and collaboration with individuals or local communities for successful implementation of these actions or to change public behaviour.

Implicit engagement actions: These proposed adaptation actions have the potential to increase public awareness and understanding of climate change with passive public participation in these adaptation actions.

Without engagement: There is no need for public engagement for these proposed adaptation actions as these actions can be effectively undertaken to protect general public or increase their adaptive capacity to climate change.

Most actions in Yunline County (Figure 4.19) and Pingtung County (Figure 4.20) are classified as being ones with implicit public engagement or ones which do not require any public engagement, a limited number of proposed actions need explicit community engagement.

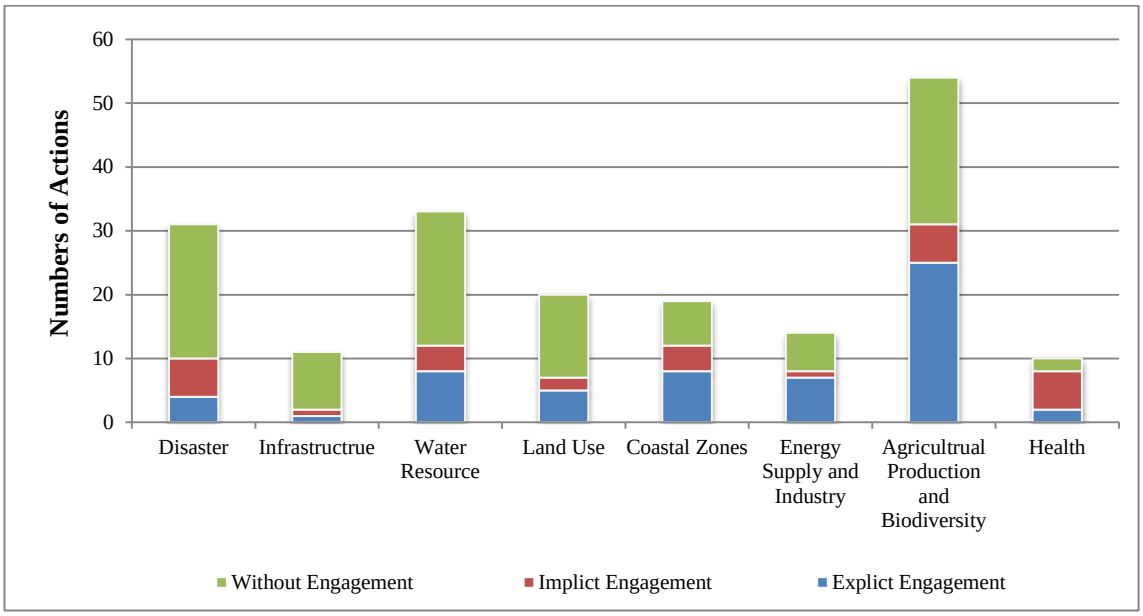


Figure 4.19: The public engagement in the proposed adaptation actions in Yunlin County

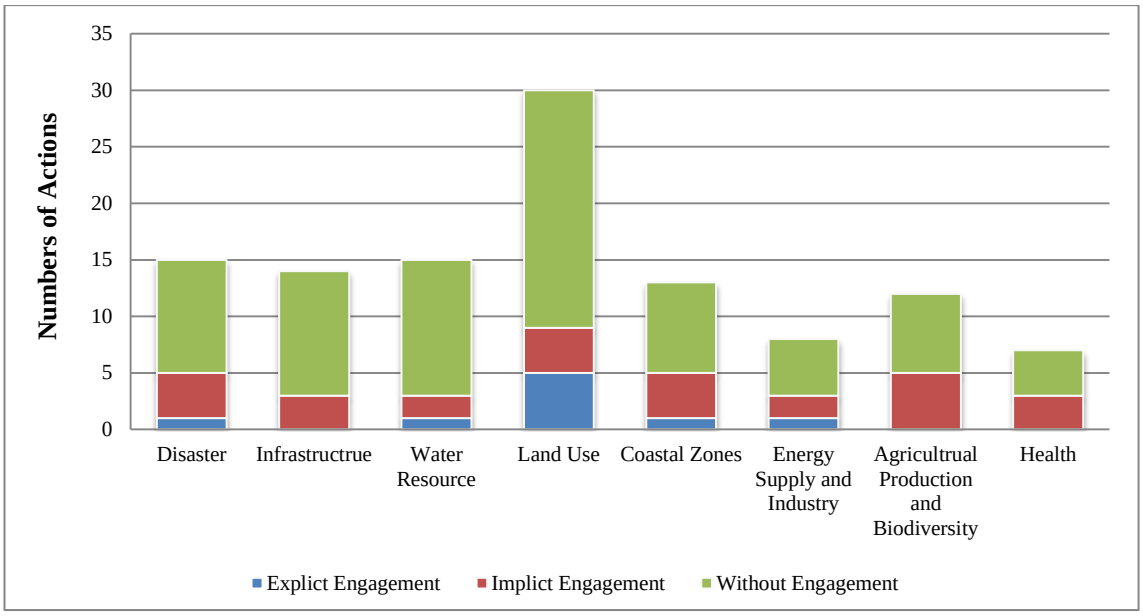


Figure 4.20: The public engagement in the proposed adaptation actions in Pingtung County

Consequently, several implications of local adaptation strategies and actions can be drawn from this section. Firstly, coastal adaptation is particularly complicated, covering multiple issues, compare with other sectors in both two case counties. Given that coastal adaptation actions involve more complex issues, the author assumes that the successful implementation and enforcement of relevant adaptation actions is likely to need inter-departmental cooperation and support. Secondly, with a lack of performance surveys of individual adaptation actions in the two local adaptation frameworks, it may be difficult to realise whether the anticipated performance has been reached in order to adjust or modify the inappropriate actions. Lastly, the local adaptation strategies put emphasis on increasing public awareness and protective capacity, rather than on community engagement in adaptation actions. Therefore, the local adaptation strategies to climate change in the two cases are still based on a top-down perspective.

4.4 Summary

This chapter has reviewed the current coastal vulnerability, the threats from climate change, and the adaptation framework to climate change in Taiwan. Given the findings in Section 4.2, it surmised that coastal communities could be extremely vulnerable to climate change on southwest coast of Taiwan, and therefore they are appropriate subjects for this study. By applying the AAA framework, this research assesses socioeconomic vulnerability of coastal community to climate change (Chapter Five),

investigates the public awareness of climate change and flood experience (Chapter Six), in order to further identify the specific internal vulnerability of coastal communities and how do coastal communities become aware to climate change.

Section 4.3 presented the national and local adaptation frameworks that have been developed to respond to known and potential impacts of climate change relating specifically to: hazard, infrastructure, water resource, land use, coastal zones, energy supply and industry, agricultural production and biodiversity, and health. For evolution of Taiwanese adaptation frameworks and these proposed local adaptation actions, there is limited process of community engagement and the bottom-up perspective in the two cases. Moreover, developing adaptation framework and action is a complicated process and innovative thinking, which embraces several issues such as, inter-department coordination, stakeholder participation, human society protection, and environmental conservation. Therefore, this study evaluates the public participation in responses and local adaptation, and explores the relevant challenges and opportunities of Taiwanese adaptation framework in terms of political, economic, social, technological, legal, and environmental aspects in Chapter 7.

Chapter Five The 'Analysis' Component of the AAA Framework

5.1 Introduction

This chapter demonstrates the development of a Socioeconomic Vulnerability Indicator Framework (SVIF) for evaluating and demonstrating specific vulnerability. The SVIF is used to explore a better understanding of the particular susceptive and resilient characteristics of different communities in order demonstrate how impacts may be influenced by socioeconomic profiles (Figure 5.1). Moreover, the results will be used to substantively define the orientation and priority of adaptation options to different communities. The chapter is divided into several sections. Section 5.2 introduces the development of SVIF in this study. Section 5.3 presents the analysis and results of the vulnerability analysis. Section 5.4 then discusses these findings in relation to the thesis objectives, considers the implication of SVIF, and then details the limitations of the research process.

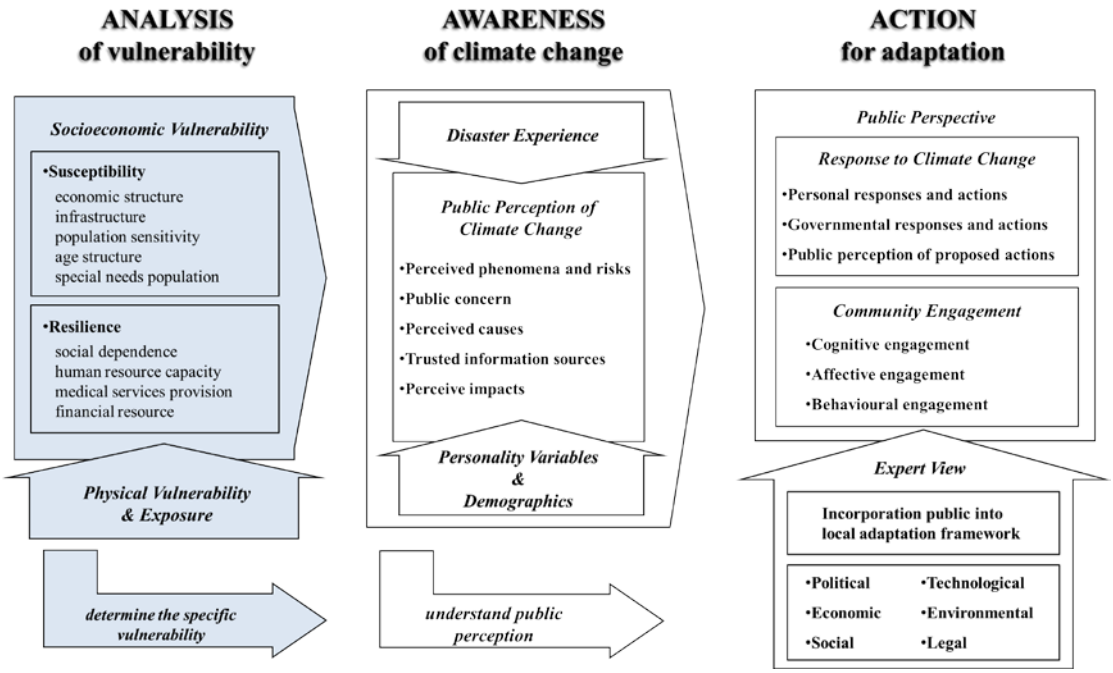


Figure 5.1: Analysis of vulnerability in AAA framework (cross ref: Figure 3.1)

5.2 Establishment of SVIF

5.2.1 Conceptual Framework

Vulnerability is a useful integrative concept for the evaluation of the potential effects of climate change, but it is complex and cannot be directly measured or observed. Therefore, the development of a conceptual framework is an important step of any

vulnerability assessment programme. In the light of research (for example: Klein *et al*., 2003; Timmerman, 1981; Tapsell *et al*., 2010; Cutter *et al*., 2003; Adger *et al*., 2004; Cutter *et al*., 2009; Dolan and Walker, 2004; Klein and Nicholls, 1999; Cutter, 2003; Schneider *et al*., 1998), this study has constructed a two dimensional framework for calculating the susceptibility and resilience of present circumstances to climate change.

5.2.2 Indicator Selection

A group of proposed indicators was selected from the literature. Indicators were related to socioeconomic vulnerability, specifically relating to the communities' demographic, social, infrastructure and economic conditions. While the use of vulnerability indicators is a well recognised and repuFigure approach, grounded in numerous empirical studies (Adger *et al*., 2004; Vincent, 2004; Cutter *et al*., 2003; Eriksen and Kelly, 2007; Siagian *et al*., 2014), many different approaches have been taken. Different indicators have been applied or developed for different cases as a result of each study's contrasting cultural context, hazard events, spatial level, assessment approaches and aims. Therefore, it was realised that a specific suite of tailored indicators would be required for this study, to reflect the particular features of the Taiwanese situation.

To inform the selection of indicators for this study, a broad overview of existing practice was undertaken. The thesis has employed a commonly accepted set of principles to help select the appropriate indicators. These principles, drawn from previous studies (see for example: Füssel, 2010; Birkmann, 2006; Dwyer *et al*., 2004; Vandermeulen, 1998; Moss *et al*., 2001; King and MacGregor, 2000; Li, 2014; Gallopin, 1997), are representativeness, acceptability, and accessibility (Table 5.1). These are explained below:

- Representativeness: indicator selection needs to consider comprehensively all the components and variables which demonstrate the underlying phenomenon and which are also relevant, significant, and suitably sensitive. Additionally, these selected indicators need to be reproducible in similar situations.
- Acceptability: indicators should be interpretable and understandable for the general public and lay people. Results must be consistent with scientific credibility and public understanding. Therefore, these indicators were selected according to the 'straightaway' meaning and not too complicated or professional.

- Accessibility: indicators should be measurable, based on available data and appropriate scope. Moreover, these indicators need to be replaceable by alternative proxies if the data is insufficient and inaccessible or with an inconsistent scale.

These three principles were employed to identify the appropriate indicators from a group of proposed indicators based on literature related to vulnerability assessment (see: Table 3.4 & Table 3.5). Regarding the principle of representativeness, the indicators for 'housing unit', 'mobile home', and 'birth rate' were considered inappropriate for the social status and cultural context in Taiwan because these indicators may be unable to reflect the real situation. While a number of studies (Cutter *et al*., 2000; Kubal *et al*., 2009; Flanagan *et al*., 2011; Tubi *et al*., 2012) suggest that the indicator of the "housing unit" has been used to estimate the crowdedness, the indicator is highly irrelevant and unrepresentative, given the existing crowdedness in Taiwanese context. The major reason for this criterion's inappropriateness is that there has been a migration of young workforce from the rural areas to the city which led to a large number of vacant houses in rural areas (Hung and Yin, 2008; Yang and Chen, 2002). Instead, the author suggests that the indicator of 'housing unit' should be more representative to reveal the crowded population.

'Birth rate' has been employed in previous studies (for example, Moss *et al*., 2001; Cutter *et al*., 2003; Adger *et al*., 2004; Boruff *et al*., 2005) to express the level of medical service provision and resilience to hazards. However, in the context of Taiwan, there is no direct connection between the birth rate, physical limitation, and medical service provision because Taiwan has become the lowest-fertility country in the Northeast Asian region, according to Luoh (2007) and Kohler *et al*. (2002). Currently, the birth rate in Taiwan is low as a result of a range of social and economic factors, such as changing fertility values, increasing costs of raising children, broad use of contraceptive measures, and increasing employment opportunities for women (Yue and Lan, 2003; Huang and Yue, 2002). Therefore, the author suggests that 'infant mortality' might be a more appropriate indicator. Lastly, the author would argue that using 'mobile homes' as an indicator is irrelevant in the Taiwanese context. The main reason is that these are virtually non-existent along the Taiwanese coast. There is no substantial evidence to show that they are have been used safe refuges in Taiwan either, as suggested in the literature for elsewhere (Tapsell *et al*., 2010; Cutter *et al*., 2000;

Flanagan *et al.*, 2011; Tubi *et al.*, 2012). Therefore, for this study, the representativeness and acceptability of the indicator of 'mobile home' are doubtful.

Regarding the principle of accessibility, this is the most significant limitation in selecting indicators for this study. There is a distinct lack of available data at the 'township' level for some indicators. Indeed, Table 5.1 shows that 13 of the proposed indicators are impracticable as a result of this. These include 'insurance, the number of mobile homes and housing units, income, unemployment, housing tenure, available vehicles, the number of residential properties, the value of primary industry, educational levels, infant mortality, and life expectancy'. While there are some indicators where data is inaccessable and therefore missing, the author considers that the remaining indicators are still be able to reflect a complex reality even though this may not be a full, comprehensive assessment. Nonetheless, it is considered that this selection will inform policymakers and researchers of which data is insufficient or incomplete through the process of developing the indicator framework. In this context, further research might usefully extend the present use of indicator framework to ensure the most robust and durable results.

Finally, reliable data sources are required in this study in order to understand the specific socioeconomic characteristics of the four townships as realistically as possible. All the available proxies for each indicator are displayed in Table 5.1. 22 practical proxies have been selected from the literature. Given the importance of the strength of the financial status, one previously neglected indicator employed in this study was used to expand on the SVIF (Table 5.1). This additional indicator is the financial state of relevant local governments. It is suggested that this provides an indication of the recovery and response capacity of governments (Adger *et al.*, 2004; Yau *et al.*, 2010). Therefore, this study employs the health of the financial status to estimate the resilient capacity of local governments, which includes the receipts from subsidies and assistance, self-financing resources, and receipts from taxes. The detailed interpretation is shown in the next section.

Table 5.1: Proposed indicators, selection principles, and representative proxies in the SVIF

Themes	Proposed indicator	Representativeness	Acceptability	Accessibility of Data		Available Data
				Township	County	
Economic Status	Income	ˇ	ˇ	ND	ˇ	Low-income population
	Poor household	ˇ	ˇ	ˇ	ˇ	
	Insurance	ˇ	ˇ	ND	ND	
	Unemployment	ˇ	ˇ	ND	ˇ	
Housing/ Transportation	Housing unit	NAP	ˇ	ND	ˇ	
	Housing tenure	ˇ	ˇ	ND	ˇ	
	Available vehicle	ˇ	ˇ	ND	ˇ	
	Mobile home	NAP	NA	ND	ND	
	Residential property	ˇ	ˇ	ND	ˇ	
Industrial Development	Employment in primary industry	ˇ	ˇ	ˇ	ˇ	Primary industry employee
	Value of primary industry	ˇ	ˇ	ND	ˇ	
	Area of primary industry	ˇ	ˇ	ˇ	ˇ	Primary industry area

Physical Infrastructure	Public facility	ˇ	ˇ	ˇ	ˇ	Relative height of seawall
	Medical service	ˇ	ˇ	ˇ	ˇ	Population served per bed in hospitals and clinics Population served per hospital and clinic Population served per medical personnel
	Access to water supply	ˇ	ˇ	ˇ	ˇ	Availability of domestic water supply
Population Structure	Population growth	ˇ	ˇ	ˇ	ˇ	Population growth
	Population density	ˇ	ˇ	ˇ	ˇ	Population density
	Dependency ratio	ˇ	ˇ	ˇ	ˇ	Dependency ratio
	Young	ˇ	ˇ	ˇ	ˇ	Young population
	Elder	ˇ	ˇ	ˇ	ˇ	Elderly population
	Lone Parents	ˇ	ˇ	ˇ	ˇ	Lone parents rate
	Family Composition	ˇ	ˇ	ˇ	ˇ	Household size
	Race / Ethnicity	ˇ	ˇ	ˇ	ˇ	Aboriginal population
	Aging	ˇ	ˇ	ˇ	ˇ	Ageing index
Access to Resources	Literacy	ˇ	ˇ	ˇ	ˇ	Illiteracy
	Educational Level	ˇ	ˇ	ND	ˇ	
	Population in the workforce	ˇ	ˇ	ˇ	ˇ	Labour force

Frail and Physical Limitation	Gender	ˇ	ˇ	ˇ	ˇ	Gender ratio
	Disability	ˇ	ˇ	ˇ	ˇ	Disabled population
	Mortality rate	ˇ	ˇ	ˇ	ˇ	Death rate
	Infant mortality	ˇ	ˇ	ND	ˇ	
	Maternal mortality	ˇ	ˇ	ND	ˇ	
	Birth rate	NAP	ˇ	ˇ	ˇ	
	Life expectancy	ˇ	ˇ	ND	ˇ	
Financial State	* Financial resource	ˇ	ˇ	ˇ	ˇ	Receipts from subsidies and assistance Self-financing resources Receipts from taxes

NAP: no appropriate

NA: not available

ND: no data

*is the additional indicator in this study

5.2.3 SVIF

In the light of the above definitions and applications of each theme, this study has developed a specific socioeconomic vulnerability indicator framework for estimating the socioeconomic vulnerability of different communities to climate change, as shown in Figure 5.2.

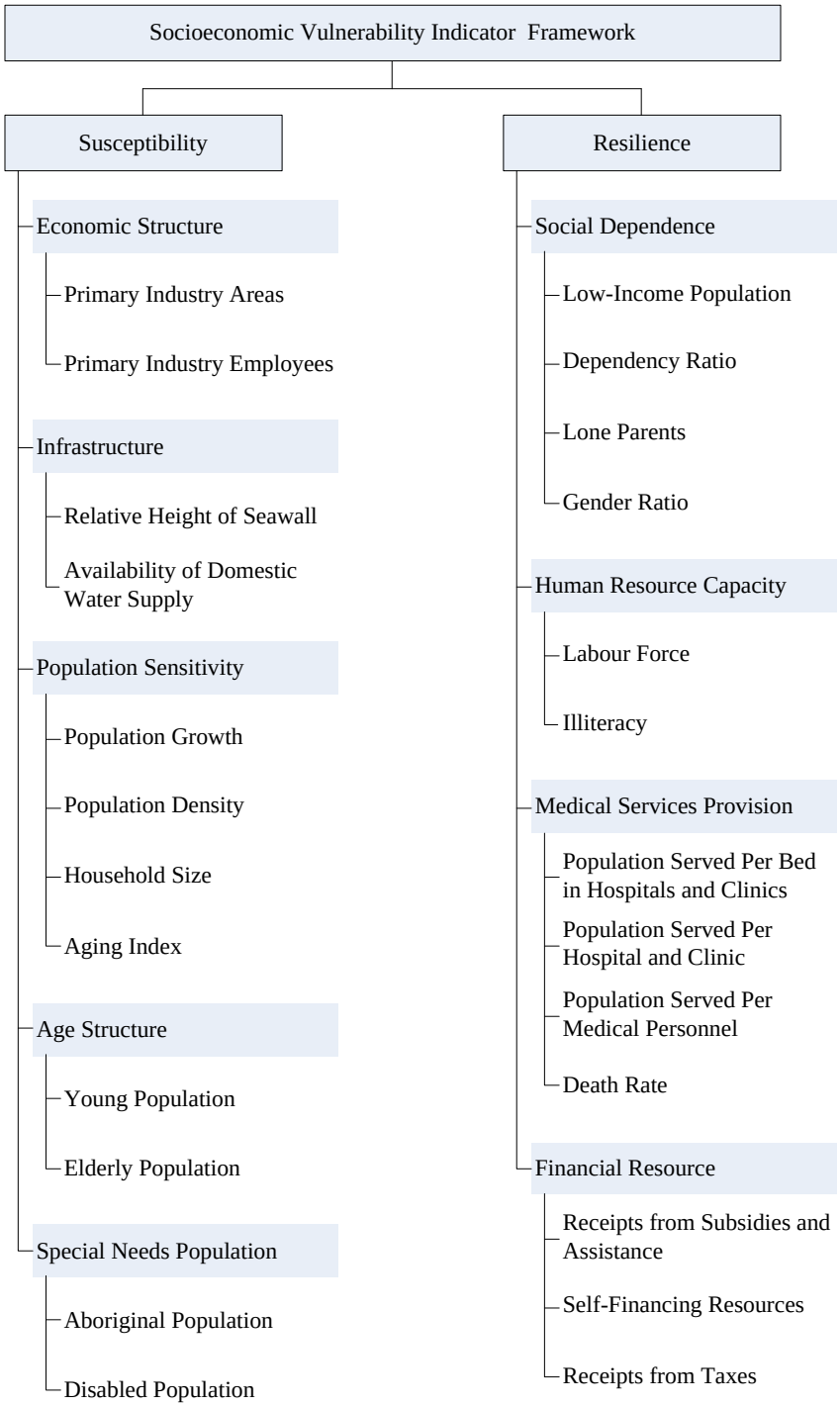


Figure 5.2: The overview of the SVIF for assessing the vulnerability of the four coastal communities to climate change

The two-dimensional structure includes five themes related to climate susceptibility, as shown in the left hand column of Figure 5.2. The key themes (economic structure, infrastructure, population sensitivity, age structure, special needs population) are represented by 12 indicators. In addition, the resilience dimension contains four themes as shown in the right hand column. Thirteen indicators are employed to express the four key themes (social dependence, human resource capacity, medical services provision, financial resource). Each theme is then composed of two to four indicators in order to create a more comprehensive figure, following the suggestion of Malone and Engle (2011) and Moss *et al*., (2001). The grouping and the appropriate indicators used here for the theoretical arguments of socioeconomic vulnerability are discussed below:

1. Economic Structure: As noted in Section 4.2.2, previous studies over the last decade have highlighted that agriculture and aquaculture are the major primary industries within coastal areas of Taiwan (Yao and Chen, 2009; Lin and Kao, 2006; Liu, 2012). Consequently, as a result of the high susceptibility of the areas and populations engaged in agriculture and aquaculture to flood and drought (which cause significant impacts on annual productions and incomes: Adger, 1999; Cutter *et al*., 2003; Cutter *et al*., 2009; Adger *et al*., 2004), this study has used the following indicators to represent the susceptibility of resource-dependent economic structure of the case studies:
   - primary industry areas
   - primary industry employees
2. Infrastructure: Several studies (Boruff *et al*., 2005; Malone and Engle, 2011; Moss *et al*., 2001; Adger *et al*., 2004; Cutter *et al*., 2008) have pinpointed that available infrastructure can protect community safety and property from potential climate change impacts. In the context of Taiwan, this factor is extremely important. However, as Hsu *et al*. (2010) point out coastal susceptibility to storms, surges and sea level rise can increase dramatically where the height of seawall is lower than the height of wave run-up. Furthermore, availability of clean water is important because people have been affected due to changes in water availability under the threat of climate change (Wang *et al*., 2004; Wu, 2009; Li and Chen, 2010; Chen *et al*., 2011). Therefore, factors related to infrastructure sensitivity are represented by the following indicators:

- relative height of seawall
- availability of domestic water supply

3. Population Sensitivity: the majority of research in climate change vulnerability assessment has focused on population distribution and population structure (Cutter *et al*., 2003; Boruff *et al*., 2005; Cutter *et al*., 2009; Vincent, 2004; Adger *et al*., 2004). In the context of Taiwan, this is a vital factor, given that the social network and urban carrying capacity are overloaded as a consequence of excessive population concentration, population growth, and crowd degree (Wu *et al*., 2008; Chen *et al*., 2011; Ya, 2013). Moreover, Chen *et al*. (2010) and Lin (2011) highlight that Taiwan will become an aging society in 2018, and that such an aging society is more sensitive to natural hazards. Hence, the following indictors can be used to evaluate population sensitivity:
    - population growth
    - population density
    - household size
    - aging index
4. Age Structure: As shown in Section 3.4.2, it is widely recognised that the elderly and children are particularly susceptible to impacts of climate change (Boruff *et al*., 2005; Messner and Meyer, 2005; Cutter *et al*., 2003; Ngo, 2001; Dwyer *et al*., 2004; Tapsell *et al*., 2002; Cutter *et al*., 2009; Cutter *et al*., 2000). In Taiwan this is also true: the young population (aged under 15) and the elderly (aged 65 and over) are recognised as most susceptible to climate change in Taiwan (MOI, 2011). In addition, Taiwanese academics suggest that the young population lacks sufficient resources, knowledge, and experience to protect themselves and also note that the elderly are vulnerable to hazards due to their limited mobility, social networks and poor physical conditions (Li and Chen, 2010; Wang *et al*., 2013; Chen *et al*., 2011; Pai *et al*., 2010; Chen *et al*., 2010). Therefore, the two following indicators are used to estimate the age structure:
    - young population
    - elderly population

5. Special Needs Population: A number of studies (Cutter *et al*., 2003; Dwyer *et al*., 2004; Cutter *et al*., 2009) have been conducted using people with deformity or illness, different language and culture as subjects to express the communities' susceptibility to climate change. In the context of the Taiwanese society, the aboriginal community and their ancestors have been living on Taiwan before Han immigration in the 17th century. This aboriginal community consists of sixteen tribes in Taiwan, and it is a special needs population group with the government having provided subsidies to improve the group's life and education (Wang, 2007; Li, 2006; Chen, 2008; Chen *et al*., 2011). In addition, Taiwanese academics have also highlighted that the population with intellectual disabilities or multiple disabilities is a special needs population due to the fact that they need more comprehensive services including assistance with residential and medical care (Lin *et al*., 2002; Li, 2003; Wang, 2004; Chen *et al*., 2011; Pai *et al*., 2010; Lin, 2011). These two groups are the most susceptible to the impacts and issues related to preparedness, which are protection and evacuation. Therefore, the special needs population can be evaluated by the following two indicators:

   - aboriginal population
   - disabled population

6. Social Dependence: It is widely acknowledged that the economically and socially marginalised groups are highly dependent on social services, such as poverty and physical limitations (for example: Adger *et al*., 2004; Malone and Engle, 2011; Cutter *et al*., 2009; Vincent, 2004). In the context of Taiwan, Taiwanese academics (Hu and Sun, 2008; Wang *et al*., 2013; Li *et al*., 2009; Wu and Huang, 2011; Chen *et al*., 2011; Pai *et al*., 2010; Ya, 2013) suggest that the resilience of underprivileged groups (low-income and dependent population) and single parent families is relatively low to external influences. Moreover, Werritty *et al*., (2007), Chou and Lu (2010) and Pong (2010) suggest that the response and recovery of female population are restricted by the lower salary and family care responsibility, and therefore natural hazards have stronger influences on women than men. Based on these points, social dependence is represented by the following indicators:

   - low-income population
   - dependency ratio

- lone parents
- gender ratio

7. Human Resource Capacity: A review of the literature indicates that the capacity to adapt to climate change is significantly dependent on the ability of the community to understand and undertake adaptation actions (Malone and Engle, 2011; Moss *et al*., 2001; Cutter *et al*., 2003; Cutter *et al*., 2009; Adger *et al*., 2004). In this study, the hazard prevention and recovery capacity of communities are considered as the important criteria in disaster-prone areas, given recent studies of vulnerability by academics in Taiwan. Huang *et al*. (2012), Chen *et al*. (2013), and Chen *et al*. (2011), for example, suggest that the operating response and recovery measures, such as basic precaution, hazard relief and reconstruction may be subject to the restrictions of low labour force and poor literacy. Therefore, the human resource capacity category can be measured by the two indicators:
   - labour force
   - illiteracy
8. Medical Services Provision: An increasing number of recent publications and empirical studies highlight the direct link between medical services and communities' resilience to climate change (Lorenzoni *et al*., 2006; Cutter *et al*., 2003; Malone and Engle, 2011; Moss *et al*., 2001; Dwyer *et al*., 2004; Cutter *et al*., 2009; Adger *et al*., 2004). In the context of Taiwan, National Health Insurance ensures medical treatment is available across the whole nation, but the unequal distribution of medical resources between rural and urban areas is significant (Tsai *et al*., 2006; Su *et al*., 2010; Chen *et al*., 2011). Furthermore, Hong and Lin, (2010) and Sun and Liu, (2006) suggest that death rate correlates closely with illness, aging, access to medical resources, and inadequate medical treatment. For these reasons, medical services provision is represented by the following indicators:
   - population served per bed in hospitals and clinics
   - population served per hospital and clinic
   - population served per medical personnel
   - death rate

9. Financial Resource: As Adger *et al.* (2004) suggest insufficient financial resources may affect the government's ability to respond to hazards because adaptation actions are frequently costly. Therefore, this thesis suggests that there is a direct link between the available financial resources and adaptive capacity to climate change in Taiwan. Generally, tax is the main source of independent revenue for local government (Xu, 2007; Jang, 2003; He, 2002). Moreover, the budgets for emergency planning and post-disaster reconstruction are highly dependent on independent revenue sources of local governments and subsidies from central government (Yau *et al*., 2010; Wang, 2012). Therefore, the proportion of central government subsidies and self-financing resources in the annual budget can be used to express the financial autonomy of a local government (Lin and Chai, 2003; Xu, 2001; Huang and Kuo, 2007; Li and Lin, 2006; Hsu, 2011). These following indicators are employed to evaluate the financial resource:

    - receipts from subsidies and assistance
    - self-financing resources
    - receipts from taxes

These practical indictors demonstrate the sensitivity and coping-adaptive capacity of community, a simple difference between the sensitivity as a positive value and coping-adaptive capacity as a negative value to vulnerability of climate change. This approach, therefore, agrees with Kuhlicke *et al*., (2011), Ahsan and Warner (2014), Cutter *et al*. (2002), where all indicators were scaled so that positive values indicated higher vulnerability; negative values indicated decreased vulnerability by their definition prior to uniform transformation of the original values. Table 5.2 illustrates the relevant calculation, unit, and nature of vulnerability of these indicators. The '+' sign means the indicator has a positive impact (increase) on socioeconomic vulnerability, and the '-' sign indicates that the indicator has a negative impact (decrease) on socioeconomic vulnerability.

Table 5.2: The description, calculation, and vulnerability trends of vulnerability indicators in the SVIF

Sector	Indicator	Calculation	Unit	Vulnerability (+) or (-)	Data Source
Economic Structure	Primary Industry Areas	[(farming area + aquaculture area)/total area]*100%	%	+	A; B
	Primary Industry Employees	[(number of farm employees + number of fishery employees)/total workforces]*100%	%	+	A; B
Infrastructure	Relative Height of Seawall	(seawall height/wave height)*100%	%	-	D
	Availability of Domestic Water Supply	(number of subscribers of tap water in served area/total population)*100%	%	-	E
Population Sensitivity	Population Growth	[(population of this year-population of last year)/population of last year]*1000‰	‰	+	A; B; C
	Population Density	total number of population/km^2	person	+	A; B; C
	Household Size	number of population/number of households	person	+	A; B
	Aging Index	(number of population aged 65 and older / number of population under age 15)× 100%	%	+	A; B; C
Age Structure	Young Population	(number of population under age 15/total population)*100%	%	+	A; B; C
	Elderly Population	(number of population aged 65 and older/total population)*100%	%	+	A; B; C

Special Needs Population	Aboriginal Population	(number of aborigines/total population)*100%	%	+	A; B
	Disabled Population	(number of disabled population/total population)*100%	%	+	C
Social Dependence	Low-Income Population	(number of low-income population/total population)*100%	%	+	C
	Dependency Ratio	[(number of population under aged 14+ number of population aged 65 and older)/number of population aged 15 to 64]*100%	%	+	A; B
	Lone Parents	[(number of divorced population+ number of widowed population)/total population]*100%	%	+	A; B; C
	Gender Ratio	(number of male/number of female)*100%	%	-	A; B; C
Human Resource Capacity	Labour Force	(number of population aged 15 to 64/ total population)*100%	%	-	A; B
	Illiteracy	(number of illiterate population age 15 and over/number of population aged 15 and over)*100%	%	+	A; B; C
Medical Services Provision	Population Served Per Beds in Hospital and Clinic	(total population s/number of beds in hospitals and clinic)*100%	person	+	A; B
	Population Served Per Hospital and Clinic	total population/number of hospitals & clinics	person	+	A; B
	Population Served Per Medical Personnel	total population/ number of registered medical personnel	person	+	A; B

	Death Rate	(number of deaths/total population)*1000%	‰	+	A; B; C
Financial Resource	Receipts from Subsidies and Assistance	(receipts from subsidies and assistance/ annual expenditures)*100%	%	+	A; B
	Self-Financing Resources	[(annual revenue- receipts from subsidies and assistance) / annual expenditures]*100%	%	-	A; B
	Receipts from Taxes	(receipts from taxes/annual expenditures)*100%	%	-	A; B

Data Source:

A: Department of Budget, Accounting and Statistics, Pingtung County Government. http://www.pthg.gov.tw/planfas/cp.aspx?n=E7A49CB60D00DE3C

B: Department of Budget, Accounting and Statistics, Yunline County Government. http://www4.yunlin.gov.tw/accounting/home.jsp?mserno=201310140002&serno=201310140003&serno3=201404250001&menudata=AccountingMenu&contlink=ap/unitdata.jsp

C: Department of Household Registration, Ministry of the Interior. http://www.ris.gov.tw/en/web/ris3-english/end-of-year

D: A study of adaptation capacity of coastal disasters due to climate change in order to strengthen southwest area of Taiwan. Taipei: Water Resource Agency.

E: Taiwan Water Corporation. https://www.water.gov.tw/02results/res_c_main.asp?bull_id=125

5.2.4 Standardisation of Indicators

All variables were standardised in order to compare the vulnerability level between the four townships. This standard practice in the literature (for example, see: Li, 2014; Tapsell *et al*., 2002; Siagian *et al*., 2014; Zhou *et al*., 2014; Ge *et al*., 2013; Li and Chen, 2010). The original value (*x*) for each indicator was standardised by converting the values to standard scores (*z* score), according to the following formula which was used in previous research:

$$z = \frac{x - \mu}{\sigma}$$

where ***x*** is the original value from each indicator,

$\boldsymbol{\mu}$ is the mean of the original data,

and $\boldsymbol{\sigma}$ is the standard deviation of the original data.

Normalisation transforms data into compatible or comparable forms. It ensures that data are converted to a form compatible with a chosen standard or baseline (Olsthoorn *et al*., 2001). The normalisation was used to fit variables to relative positions between 0 and 100 to display the evaluating score (*p* score). If the indicator is negatively correlated with vulnerability, the evaluating score is (1-*p*) × 100, while if the indicator is positively correlated with vulnerability, the evaluating score is *p* × 100. Therefore, a higher *p* score indicated higher vulnerability. All of the scores are shown in Appendix F.

5.3 Results

The susceptibility dimension within this framework is composed of economic structure, infrastructure sensitivity, population sensitivity, age structure, and special needs population as indicated in this section. The resilience dimension is represented by social dependence, human resource capacity, medical services provision, and financial resources. The original values, standard scores, uniformity scores, and evaluating scores of indicators are shown in Appendix F, and the interpretations of the analysis are provided below.

5.3.1 Susceptibility

Economic structure

Figure 5.3 reveals considerable differences between the townships and shows that vulnerability values for primary industry areas and primary industry employees for Kauho Township are the highest. Although the vulnerability of other coastal townships is lower, the original values of primary industry areas and employees are all over 50% across all the four townships. This implies that all the townships rely heavily on primary economic activities such as, agriculture and aquaculture. Therefore, the author would suggest that the economic structures of these four townships are potentially susceptible to climate change, and Kauho Township is significantly more vulnerable than the others.

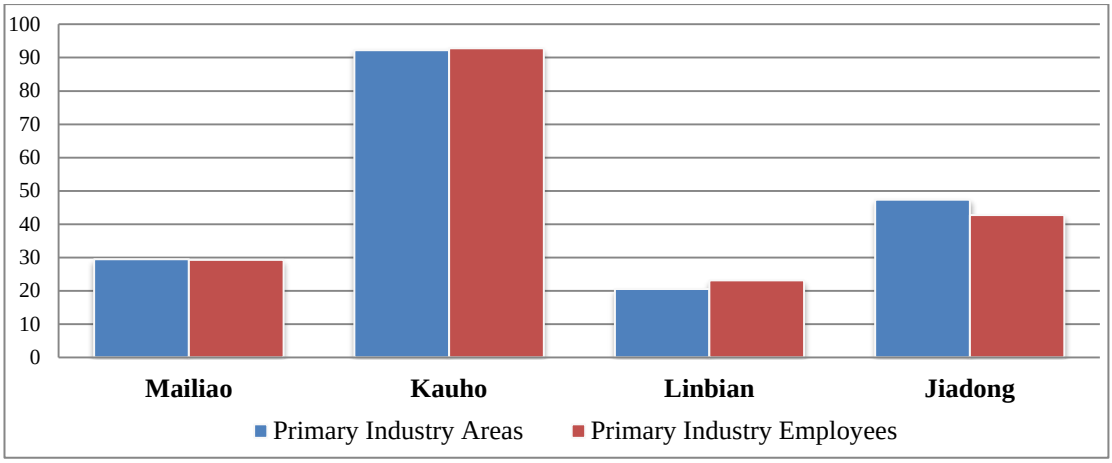


Figure 5.3: Vulnerability of economic structure in the four townships – *showing that Kauho is the most vulnerable because of its primary industry base*

Infrastructure

According to Figure 5.4, Jiadong is relatively more vulnerable than the other townships with regards to the relative height of seawall (blue) and the availability of domestic water supply (red). It is also apparent that the infrastructure in Yunlin County (Mailiao and Kauho Township) is more capable of protecting coastal communities from the impacts of climate change. In contrast, insufficient infrastructure increases susceptibility to coastal communities in Linbian and Jiadong Townships.

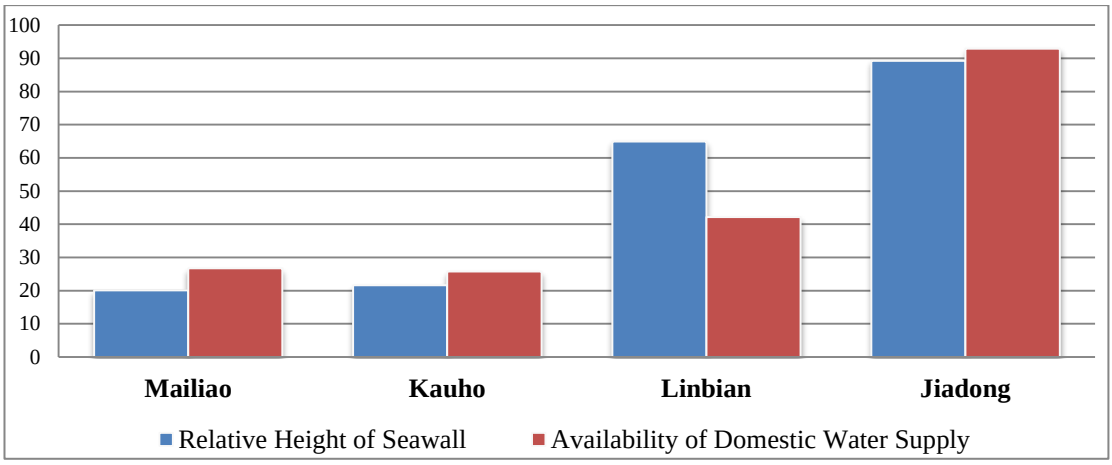


Figure 5.4: Vulnerability of infrastructure in the four townships – *showing that Jiadong is considerable more vulnerable than the other townships*

Population sensitivity

Figure 5.5 shows susceptibility related to population structure. The high population growth rate (blue) contributes to vulnerability in Mailiao and the high population density (red) increases vulnerability in Linbian. The key vulnerability factor appears to be the size of household (green) in Kauho. Lastly, the high aging index (purple) is a significant problem in Kauho, Linbian and Jiadong. Consequently, this study suggests that aging communities and excessive population concentrations are key factors increasing susceptibility to climate change along the southwest coast of Taiwan. It also reveals differences in susceptibility between the different coastal townships.

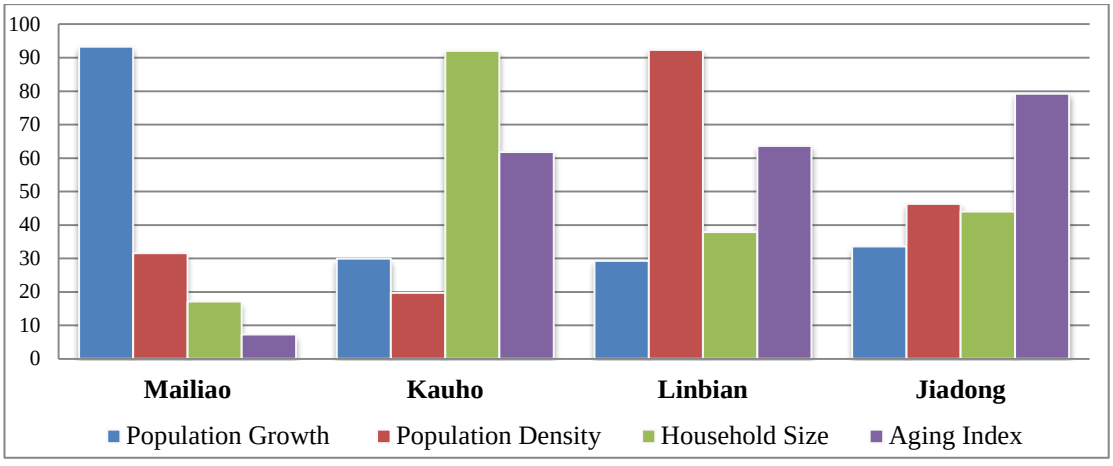


Figure 5.5: Population sensitivity to climate change in the four townships – *showing that all townships have some features which make them vulnerability but that Kauho and Linbian are most vulnerable overall in relation to population characteristics*

Age structure

Figure 5.6 reveals the age structure of the four townships. It shows that the key vulnerability factor is the high young population (blue) in Mailiao, and that a large proportion of elderly people (red) is a significant problem in Kauho, Linbian and, Jiadong. This high proportion of an elderly population corresponds with the indicator of aging index, of course (Figure 5.5). The more likely explanation of this age structure lies in the urban-rural divide in the population structure in Taiwan (Li and Chen, 2010), as noted in Section 4.2.2. According to these findings, the two susceptibility factors relating to age structure potentially both contribute significantly to increasing community vulnerability to climate change.

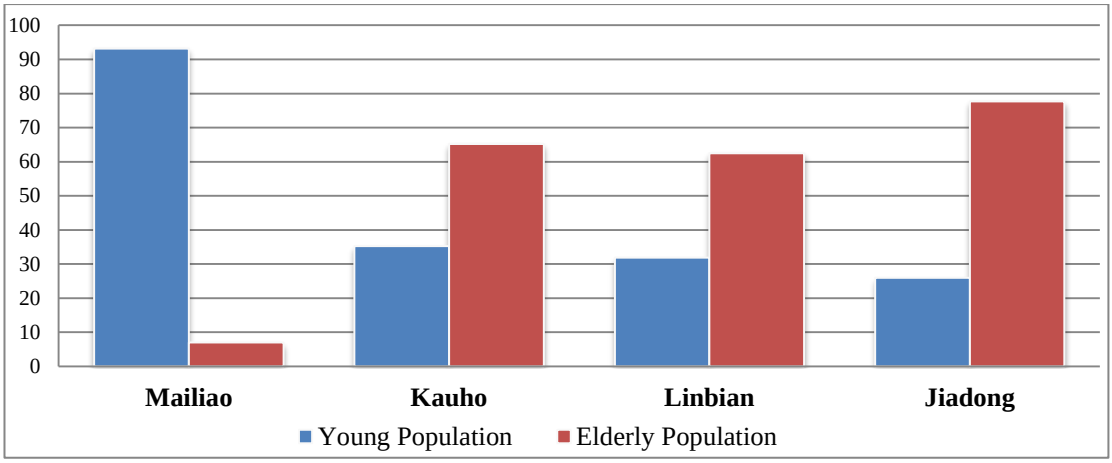


Figure 5.6: Vulnerability based on age structure in the four townships – *showing that Mailiao is most vulnerable as a result of its large young population; but the other three cases are characterised by large elderly populations which are also vulnerable to climate change*

Special needs population

Figure 5.7 shows the different vulnerability factors and levels concerning special need populations in the four townships. With respect to the Mailiao, the aboriginal population is the main susceptible factor (89.95). Regarding the disabled population, there are significant differences between the different coastal townships, with the highest values occurring in Kauho (90.13). Consequently, these findings support the claim, reported above in Section 3.4.2, that difference in susceptibility between the different coastal townships along the southwest coast of Taiwan.

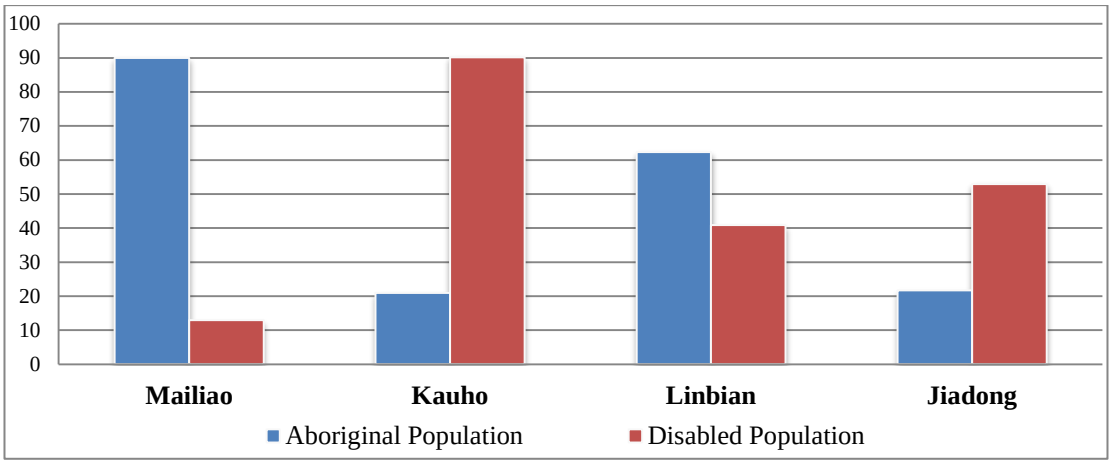


Figure 5.7: Vulnerability related to the special needs population in the four townships – *showing that Mailiao and Kauho are most vulnerable as a result of their large aboriginal and disabled populations, respectively*

5.3.2 Resilience

Social dependence

Figure 5.8 demonstrates the vulnerability factors for social dependence for the coastal communities. First of all, the large low-income population results in a significant vulnerability in Jiadong (92.60), and the high dependency ratio (red) is a negative element to community resilience in Mailiao (89.52) and Jiadong (55.67). According to these findings, lone parents (green) and the gender ratio (purple) both contribute to a significant decrease in community resilience to climate change, especially in Linbian and Jiadong. In summary, Jiadong Township is the most vulnerable in terms of social dependence. It may be assumed that there may a direct link between this high social dependency and climate change vulnerability, especially given the high numbers of single parents and female in these townships.

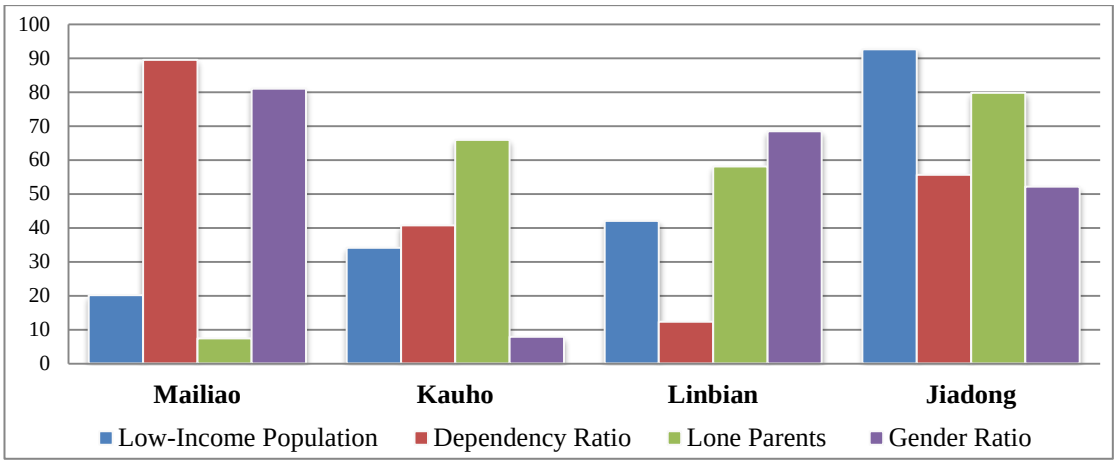


Figure 5.8: Vulnerability related to social dependence in the four townships – *showing that all townships have some features of social dependence which make them vulnerable to climate change; Mailiao and Jiadong have more aspects related to social dependence which indicate higher levels of vulnerability*

Human resource capacity

Regarding the effect of human resource capacity on climate change vulnerability, Figure 5.9 reveals that the low labour force (blue) is the main vulnerability factor in Mailiao (89.14) and Jiadong (56.39). The significant potential vulnerability to climate change in Kauho is high illiteracy (red). Consequently, the findings also imply that Linbian Township is relatively more resilient to climate change, and this study also suggests that a small labour force is key to decreasing the resilience of coastal community to climate change.

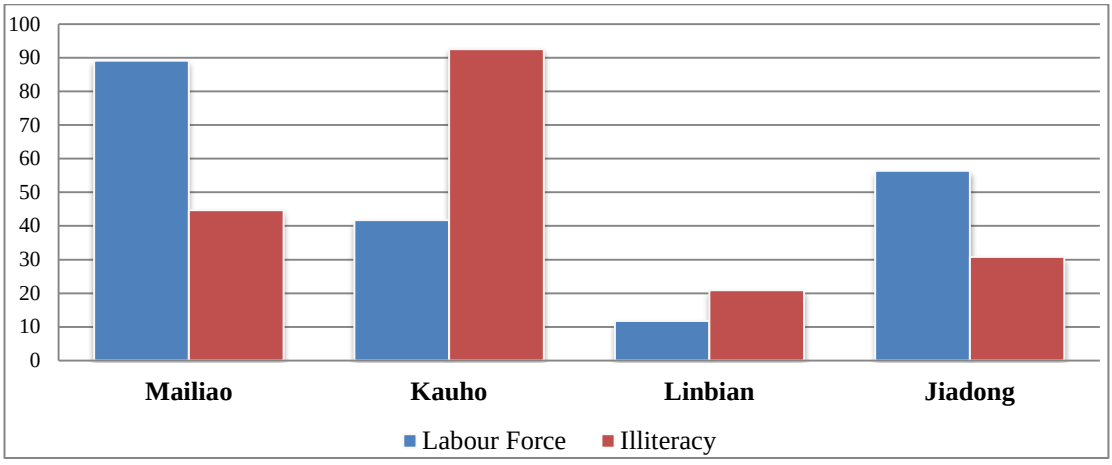


Figure 5.9: Vulnerability related to the human resource capacity in the four townships – *showing that Mailiao and Kauho are more vulnerable as a result of the characteristics of their labour force and illiteracy rates, respectively*

Medical services provision

Figure 5.10 reveals a clear relationship between medical resources and the socioeconomic vulnerability to climate change. The results indicate that Kauho Township is the most vulnerable according to the former (blue, red, green), whilst Miliao is the most resilient because of its better medical resources and low death rates (purple). Furthermore, it is explicit that Kauho, Linbian and Jiadong Townships are more vulnerable to climate change in terms of their provision of medical services. In these townships it could be assumed that such provision is important and it is suggested that there may a direct link between this low medical services provision and high climate change vulnerability, especially given the insufficient medical resources and high death rate in these townships.

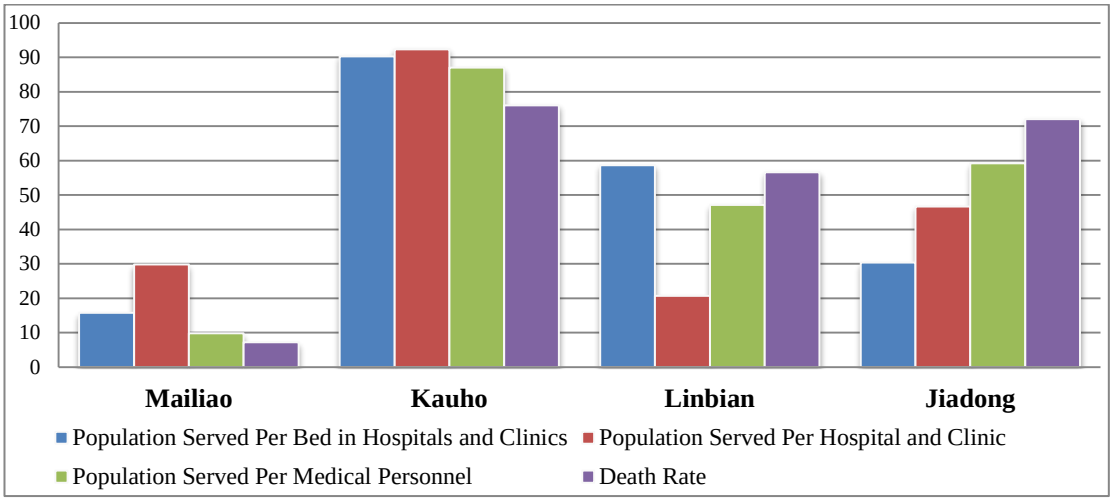


Figure 5.10: Vulnerability related to medical services provision in the four townships – *showing that Mailiao has significantly lower vulnerability in relation to medical services provision than the other three townships*

Financial resources

Figure 5.11 shows that, from the perspective of financial resources, Kauho might be considered the most vulnerable coastal township to climate change, considering the number of receipts of subsidies and assistance from the central government (blue), and insufficient self-financing resources (red) and receipts from taxes (green). It may lead to the adaptation framework and actions not being effectively implemented, owing to severe financial shortages and financial dependency in Kauho Township. Furthermore, inadequate self-finance and receipts from taxes may decrease resilience to climate change in Mailiao. According to these findings, the three resilience factors relating to

financial resources are potential resilience capacities of coastal communities to climate change.

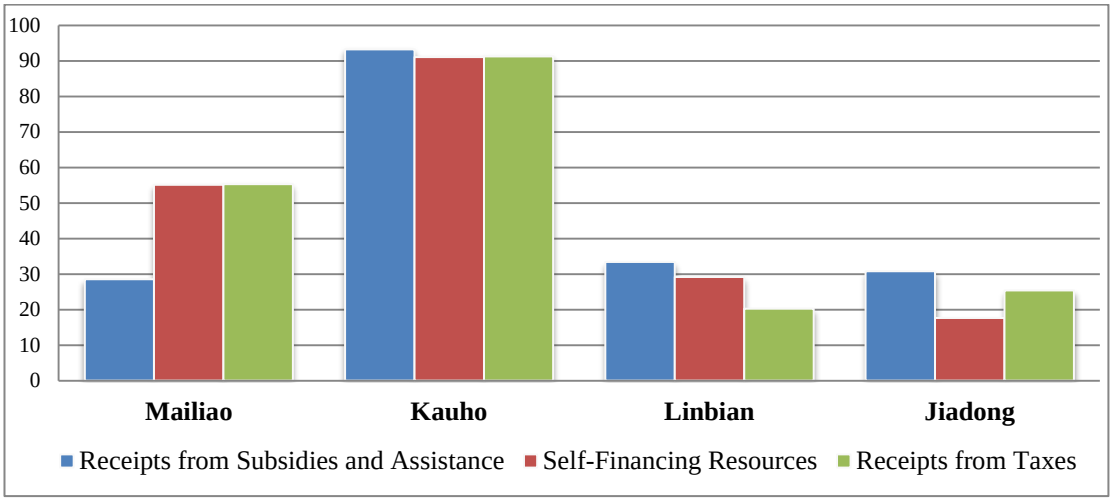


Figure 5.11: Vulnerability related to financial resources in the four townships – *showing that Kauho is much more vulnerable than the other three townships*

5.3.3 Differential Overall Socioeconomic Vulnerability between the Townships

In summary, this section has verified the validity of the SVIF. It, has shown numerous potential factors, and different levels of vulnerability through the results of the empirical assessment (Table 5.3), rather than showing collectively whether the accurate overall vulnerability is high or low. The findings presented here are primarily concerned with the factors which shape vulnerability and show which can provide useful information to policymakers likely to reduce vulnerability and facilitate adaptation rather than having some less meaningful aggregate of vulnerability. Therefore, this study divides roughly the level of vulnerability into three dimensions (Table 5.3). The two key findings for the case study townships are summarised as follows:

- Faced with increasing frequency of extreme weather events, the vulnerability of all these coastal communities will relate to their susceptible economic structures, inadequate infrastructures, excessive concentrations of population, aging societies, high social vulnerable groups and, insufficient medical resources.
- Kauho is the most vulnerable township and Mailiao is relatively resilient. Specifically, the vulnerability characteristics are distinct in the two townships. Firstly, Kauho's vulnerability relates to its simple economic activities, lack of medical services and financial support. Conversely, the vulnerability of the Mailiao

comes from its population structure, such as excessive population growth, a high young population and dependency.

Table 5.3: The overall level of socioeconomic vulnerability in the four cases – *showing the specific vulnerability factors of each township*

		Mailiao	Kauho	Linbian	Jiadong
Economic Structure	Primary industry area	*	***	*	**
	Primary industry employees	*	***	*	**
Infrastructure	Seawall height	*	*	**	***
	Domestic water supply	*	*	**	***
Population Sensitivity	Population growth	***	*	*	*
	Population density	*	*	***	**
	Household size	*	***	**	**
	Aging	*	**	**	***
Age Structure	Young population	***	**	*	*
	Elderly population	*	**	**	***
Special Needs Population	Aborigines	***	*	**	*
	Disabled	*	***	**	**
Social Dependence	Low-income	*	*	**	***
	Dependency	***	**	*	**
	Lone parents	*	**	**	***
	Sex ratio	**	*	**	**
Human Resource Capacity	Labour force	***	**	*	**
	Illiteracy	**	***	*	*
Medical Services Provision	Hospital bed	*	***	**	*
	Hospital and clinic	*	***	*	**
	Medical personnel	*	***	**	**
	Death rate	*	***	**	**
Financial Resource	Subsidies and assistance	*	***	*	*
	Self-financing resources	**	***	*	*
	Taxes	**	***	*	*

***** represents low levels of vulnerability (*q* score under 35.00)

****** represents medium levels of vulnerability (*q* score between 35.01 to 70.00)

******* represents high levels of vulnerability (*q* score over 70.01)

5.4 Discussion

These findings have demonstrated that the SVIF not only can underscore the specific vulnerability characteristics of the different townships, but it also can differentiate between the levels of vulnerability of the townships. It also explains why people can be more or less vulnerable to risks within the similar physical exposure. Therefore, this section explores the salient driving factors of socioeconomic vulnerability (Section 5.4.1) and the implications of socioeconomic vulnerability analysis in detail (Section 5.4.2).

5.4.1 Driving Factors of Socioeconomic Vulnerability of Coastal Communities

Factor 1: industrial structure and infrastructure

The SVIF indicates that simple economic structures and high resource-dependent industries (Cutter *et al*., 2003; Cutter *et al*., 2009; Adger *et al*., 2004) are the critical factors in the four cases, Kauho and Jiadong Townships are relatively more vulnerable to climate change. More importantly, as fish ponds, farms and high density residential areas lie behind seawalls in Taiwan, the findings support the previous studies (Malone and Engle, 2011; Moss *et al*., 2001; Adger *et al*., 2004; Cutter *et al*., 2008) which suggest that there is a direct connection between infrastructures and susceptibility of coastal communities to climate change. According to the results of the SVIF, Jiadong Township is the most vulnerable in relation to this aspect because the relative height of seawall is lowest. Here, the seawall height is 5.65m but wave height of storm surge is 8.05m, it implies that existing seawalls and embankments might not be able to shield and protect the local primary industries.

In addition, the results show that the rate of filtered water supplies in the four townships is relatively low compared with the Taiwanese national rate (91.56%) (Taiwan Water Corporation, 2014). The main reason could be that the local residents would rather pump groundwater than use water from the public waterworks for commercial and domestic needs. Sustained groundwater pumping triggers groundwater depletion and land subsidence in the coastal areas. Although the four townships have been defined as groundwater control zones to stabilise groundwater use and recharge groundwater level using engineering technology to slow down the rate of land subsidence (WRA, 2006), permanent geological damage has been done and the water layers have still not returned to their original levels.

Factor 2: population density and aging

These findings concur with previous studies (Cutter *et al*., 2009; Vincent, 2004; Tapsell *et al*., 2002; Dwyer *et al*., 2004; Adger *et al*., 2004) that suggest that population distribution and structure closely correlates with the susceptibility of communities to climate change, especially the density and age of the population. Firstly, these results show that high population density and over-crowding of coastal areas are the critical susceptibility factors. More specifically, the population density in Linbian and Jiadong and the size of households in Kauho and Jiadong are significantly higher than the national averages 645.81 person/km² and 2.82 person/household respectively. Vulnerability of these densely populated areas may be exacerbated by the location of communities in hazard-prone areas, stress on infrastructure, and increased risks of diseases in the aftermath of hazards.

It is interesting that though the population has a positive growth in Mailiao, the other three townships have a negative growth rate and an aging society. One explanation for this is that the petrochemical industry area in Mailiao attracts young workers from other counties. Though an increasing population growth rate may effectively decrease the aging index, the high young population ratio is another potential susceptibility factor to climate change in Mailiao. By contrast, the percentage of young population in Kauho, Linbian and Jiadong is lower than the national average (14.32%) but the elderly population is higher than the national average (11.53%). So, the three townships are seen to have an aging society (Figure 5.5), and the author suggests that insufficient employment opportunities could be the possible reason for this in these coastal townships. Li *et al*. (2010) and Chen *et al*. (2010) highlight that high ratio of elderly and young population cause problems of labour shortage, low quality of labour force, and increase stress on the social welfare in Taiwan.

Factor 3: social vulnerable groups

This thesis research suggests that the underprivileged populations predominate in coastal communities and could be more vulnerable to climate change (Cutter *et al*., 2003; Dwyer *et al*., 2004; Cutter *et al*., 2009), especially the disabled, dependents, and lone parents. The results also highlight two types of underprivileged populations who are vulnerable because two dissimilar reasons in the context of the Taiwanese society. Firstly, a partial explanation for the potential vulnerability in Mailiao and Linbian may lie in the accessibility of the aboriginal population to adaptation relevant information,

which could be due to cultural and language constraints (Wang, 2007; Chen *et al*., 2011). Secondly, the size of the high disabled population has to be taken into account in climate change adaptation of Kauho, Linbian, and Jiadong because the physiological barriers and intellectual disabilities limit their self-protection ability (Li and Chen, 2010; Lin, 2011).

Furthermore, the author would concur with the arguments of previous studies (Boruff *et al*., 2005; Morrow, 1999; Adger *et al*., 2004; Tapsell *et al*., 2002; Cutter *et al*., 2009) which suggests that social capacity closely correlates with the potential vulnerability, especially high dependency ratio and lone parents in the context of Taiwan. These populations lack financial and information resources, and are highly dependent on social support and networks in adaptation and recovery (Clark *et al*., 1998; Chambers, 2006; Dwyer *et al*., 2004; Tsai, 2011). While the dependency being relatively high in the proportion of economically active and inactive communities, the significance and composition are completely different in Mailiao and Jiadong. Mailiao has a large young population and Jiadong, a predominant elderly population (Figure 5.6). The problem of a large proportion of single parents is most likely to have been caused by the high rate of divorce in the three rural townships (MOI, 2011). The issue is quite significant because it reduces resilience and recovery from natural hazards as the high numbers and rate of single parent families are increasing in Taiwan.

Factor 4: limited resources

These results of SVIF would concur with the suggestion of previous studies (Malone and Engle, 2011; Moss *et al*., 2001; Cutter *et al*., 2009; Adger *et al*., 2004) that insufficient resources and capacities to support the responses may be amongst the most significant problems facing coastal areas, especially human resources and medical services in the context of south west Taiwan. In the context of this lack of human resource capacity, Mailiao, Kauho, and Jiadong are more vulnerable to climate change. A possible reason of small labour force in these townships may be explained by considering their high dependence ratio (Figure 5.8). This decreases capacity to be resilient. In this context it is suggested that this may be a temporary is for Mailiao as its large young population will become the main work force in the near future. Furthermore, while the illiteracy ratio of population aged over 15 is dramatically high in Kauho Township, but it has gradually decreased in Taiwan. Therefore, an insufficient labour force seems a more significant factor with respect to climate change vulnerability.

With respect to ‘medical resources’ the three relevant indicators clearly demonstrate the unequal distribution of these within the coastal towns and suburbs of the southern-west coast of Taiwan. Furthermore, insufficient medical personnel, hospitals and clinics, and medical facilities in Kauho, Linbian, and Jiadong Township are also accompanied by high death rates. The result supports the direct connection between medical services provision and communities’ resilience to climate change (Adger *et al*., 2004; Lorenzoni *et al*., 2006). The author suggests a partial explanation for the high death rates could be the aging population in rural areas, and therefore these rural areas may need more medical resources.

Finally, the significance of financial resources in local vulnerability assessment framework has been confirmed. In Taiwan, the financial resources of different local governments (cross ref: Section 7.5.3: enhancing financial capacity of local governments) vary according to the population size and economic structure (Xu, 2007; Jang, 2003). This suggests that financial pressures are critical to the communities’ resilience in Kauho Township, compared with other townships. This may be explained by considering an industrial structure highly dependent on primary industries (Figure 5.3) and an excessive aging population (Figure 5.5).

In summary, the above findings raise several important implications for coastal community socioeconomic vulnerability to climate change in this south west area of Taiwan. The first issue concerns industrial structure and infrastructure. In the areas of the case studies these are resource-dependent industries and therefore are particularly vulnerable. Therefore, the opinions of Cutter *et al*. (2003), Liu (2012), and Moss *et al*. (2001) are relevant here. These suggest that a robust and diverse industrial structure not only can improve access to markets and additional resources, but also can provide financial support to cope with the impacts of climate change. Secondly, this study suggests that population density and aging may be long-term issues for social vulnerability to climate change. However, it is suggested here that the potential susceptibility of the young population may be temporary because this section of society can be considered as a future labour force.

Thirdly, the author considers that these socially vulnerable groups may also affect labour force participation and other socioeconomic outcomes when responding to external hazards in coastal areas of Taiwan. Finally, an aging society, with insufficient medical resources, may exacerbate communities’ vulnerability to climate change.

Therefore, the author recommends that adequate medical care and resources are necessary to increase coastal communities' resilience by being able to promptly attend to physical injuries from natural hazards.

5.4.2 Implication of Socioeconomic Vulnerability Analysis

The above summary from the four case studies verified and highlighted the specific vulnerability factors of coastal disaster-prone areas to climate change in Taiwan. This section integrates the findings from the four case studies and presents crucial findings concerning the thesis' research objective of 'analysis':

- Explain the role of socioeconomic vulnerability of communities in adaptation in the context of the SW coast of Taiwan.

The SVIF not only has ascertained and exhibited the internal properties which are able to intensify or restrict the vulnerability, but also has demonstrated who is vulnerable and why they are vulnerable.

Characterising and sourcing the potential susceptibility and resilience factors to climate change

The results of the study support the opinion that inherent vulnerability is implicit in the social and economic structure of a population, and these measurable variables or proxies can be used to create more credible and understandable information and to highlight definite location-specific vulnerabilities (Li, 2014; Ahsan and Warner, 2014; Kriegler *et al*., 2012; Malone and Engle, 2011; Hinkel, 2011). In this study, numerous typologies of socioeconomic vulnerabilities have been presented to determine valuable factors which may produce social and economic equitability in an adaptive capacity (Table 5.3). The SVIF in this study has empirical support both at the theoretical and applied level. The indicators were able to be quantified on a scale of 0 to 100 using standardised values, which enabled identification of different levels of relative vulnerability across the four cases (Table 5.3). This suggests that the approach is both valid to academics and policy-makers. The development procedure of the SVIF corresponds with the theoretical framework and research objectives, and the critical factors identified anticipate potential vulnerabilities of human settlements to climate change. The SVIF also provides an insight to help local governments better identify the unique vulnerability elements of vulnerable places, sectors, and communities in terms of these typologies (Cutter *et al*., 2008; Lin *et al*., 2008; Williamson *et al*., 2012; Polsky *et al*.,

2007). Therefore, the SVIF is a practical method in exploring and explaining ‘who are vulnerable’ and ‘why they are vulnerable’.

The author would concur with the suggestion of previous research, which highlights that indicators have the capability of identifying specific characteristics of vulnerability as well as simplifying the complex reality (Adger *et al*., 2004; Wongbusarakum and Loper, 2011; Vincent, 2004; Moss *et al*., 2001; EEA, 2004). Generally speaking, coastal communities will be potentially vulnerable to climate change according to their industrial structure and infrastructure, population density and aging population, social vulnerable groups, and insufficient human and medical resources. These are the common socioeconomic vulnerability factors of the four townships. More specifically, the results of the SVIF clearly highlight the geographic inequality of socioeconomic vulnerability across the four cases. The rural community is highly vulnerable to climate change because of its fragile economic structure (Kauho, Jiadong), its inefficient supply of public infrastructure (Linbian, Jiadong), its aging population (Kauho, Linbian, Jiadong), high social dependence (Kauho, Linbian, Jiadong), and insufficient medical resources (Kauho, Linbian, Jiadong). By contrast, the industrial structure and infrastructure of Mailiao seems more adaptable to potential impacts. However, in this case its large young population and excessive population growth are its critical vulnerability factors. The remarkable differences between coastal urban and rural development may therefore help explain the different socioeconomic vulnerability factors between these coastal communities.

In summary, the performance of the SVIF has been verified. In particular, it has laid the groundwork for understanding the particular vulnerability factors in specific areas and communities. From the spatial view, the SVIF is capable of answering the two questions of “who is vulnerable” and “why they are vulnerable”. From the temporal aspect, Ge *et al*. (2013) suggest that these given socioeconomic vulnerability factors should be measured annually to monitor whether the future trend of socioeconomic vulnerability increases or decreases over time. It may be of interest for future research to understand future trends of socioeconomic vulnerability and whether the existing policies effectively decrease the prevailing socioeconomic vulnerabilities to climate change.

Defining the orientation and priority of adaptation options

Although eliminating socioeconomic vulnerability cannot directly reduce the frequency and intensity of weather-related hazards, it may contribute to reduce susceptibility,

improve resilience and the recovery capacity of human society. Therefore, the analytic results shown in Table 5.3 highlight the specific socioeconomic vulnerability factors to climate change in the individual cases. These show that widely different socioeconomic vulnerabilities can exist in similar environmental and geographic characteristics under the parallel adaptation framework, such as Mailiao and Kaoho Township.

This thesis would concur with the suggestion of previous studies that the comprehensive understanding and identified socioeconomic vulnerability can not only provides a lens which enables decision-makers to orientate and formulate adaptation policy which targets the key susceptible and resilient sectors (Downing *et al*., 2005; Vincent, 2004; Eriksen and Kelly, 2007; Moss *et al*., 2001; Adger *et al*., 2005), but also help to develop more tailored and applicable adaptation policy to different context-specific aspects of vulnerability (Khan, 2012; Turner *et al*., 2003; Khailani and Perera, 2013; Ahsan and Warner, 2014; Zahran *et al*., 2008; Kriegler *et al*., 2012; Zhou *et al*., 2014; Kuhlicke *et al*., 2011; Ellemore, 2005; Eakin and Luers, 2006; Birkmann, 2007; Malon and Engle, 2011). For example, the sectors of population sensitivity (Figure 5.5) and age structure (Figure 5.6) demonstrate the diverse variables of socioeconomic vulnerability in the four coastal townships, the high population growth and young population in Mailiao Township and the low population growth and aging population in other three townships. These distinct susceptible factors therefore suggest the need for different forms of assistance and support to respond to climate change. Therefore, such findings should enable local governments and the researcher to determine the critical sectors and therefore prioritise principal adaptation actions in their local adaptation policy framework.

In summary, socioeconomic vulnerability assessment can be viewed as a ‘bridge’ that links the environmental change and human society to adaptation policy. This information also assists policymakers in prioritising the adaptation sectors of different local adaptation framework to climate change, and determining tailored adaptation policies with scientific outputs from the perspective of place-based. However, this study focuses on the socioeconomic and not environmental vulnerability. The author suggests that an expanded indicator framework including both socioeconomic and environmental vulnerability would provide more comprehensive information, to orientate and prioritise developing adaptation policies. Furthermore, the findings also highlight that socioeconomic vulnerability is changing over time and therefore, future research is

obviously required. It is suggested that such research could be designed to measure and reveal the long-term trends and changes of socioeconomic vulnerability over time. It would provide long-term and detailed monitoring, the results of which may support or deviate from current findings and trends.

5.4.3 Wider Application of Indicator System in Assessing Vulnerability

Although the SVIF may be used effectively in the vulnerability assessment, there are a number of considerations which are required when applying this assessment system. In this study, the author advances three aspects which need to be considered before using the SVIF to assess the vulnerability. This includes consideration of an appropriate scale, applicable indicators, and a threshold.

Appropriate spatial scale

The first of these critical aspects is the appropriate spatial scale of the indicator framework. As Ahsan and Warner (2014) and Hinkel (2011) emphasise the definite determination of a scale is based on the purposes of the vulnerability assessment. In recent years, vulnerability analysis has embraced different spatial aspects to develop distinct assessment models and frameworks, such as notional, regional, local, and household scales (Eakin and Bojorquez-Tapia, 2008; Vincent, 2007; Zahran *et al*., 2008; Ge *et al*., 2013; Eriksen and Kelly, 2007; Cutter *et al*., 2003; Zhou *et al*., 2014; Kuhlicke *et al*., 2011; Brooks *et al*., 2005; Birkmann, 2007). Generally, the national indicator framework has been conducted globally because national data is easy to access at the broad statistical level, but the spatio-temporal pattern of vulnerability is difficult to detect at larger scales (Zhou *et al*., 2014). Conversely, a local and household indicator framework is capable of reflecting the local context, but available datasets are limited (Zahran *et al*., 2008). Therefore, the two scales of indicator framework have specific pros and cons. Which scale of indicator framework is most suitable depends on the research objectives.

Concerning the research objectives, this study adopted a local scale indicator framework in order to highlight the specific potential characteristics of socioeconomic vulnerability in the different local communities. This study has proved that the local indicator framework can reveal more detailed information. However, the major limitation is that a considerable number of the proposed indicators are unable to be employed in this study due to insufficient data. Table 5.1 shows that the dataset of indicators at county level is

more readily available and accessible than at the township level. Examples are such as income, unemployment, property, and mortality. The study stresses that most of the proposed indicators are adapted to a broader scale, especially the indicators relating to private properties and economic activities. A partial explanation for this may lie in the fact that except for the population census, statistical dataset of economic issues are not as comprehensive or detailed in Taiwan as population census.

Turner *et al*. (2003), Cutter, (2000), and Polsky *et al*. (2007) stress that the local and household indicator framework is more effective in helping identity specific vulnerability characteristics and patterns at the local level. The particularly vulnerable elements have been revealed in this study. These include the age structure (Figure 5.6) and the uneven distribution of medical services provision (Figure 5.10). The author suggests that different scales of indicator frameworks are required for different functions and purposes. Whilst ranking and measuring the overall vulnerability from a large scale indicator framework may be credible, the local scale indicator framework, such as that presented here, is more appropriate for exploring particular essential factors.

Consequently, although this study demonstrates that the local indicator framework can be practically implemented and reveal useful results, it also highlights that insufficient indicators and datasets can result in significant limitations for local indicator framework development. Owing to limited secondary national census data at local levels in these cases, the author suggests that future research could be conducted to gather data related to economic factors through questionnaire surveys, specifically. The field research may be able to eliminate the major limitation of accessible data and increase the number of assessable indicators in local indicator framework, even though it is time-consuming and expensive.

Applicable indicators

'Contextualisation' was viewed as the fundamental concept to select indicators and develop an indicator framework for a specific socioeconomic context (Birkmann, 2007; Kuhlick *et al*., 2011; Krishna, 2001), and therefore the second essential aspect is the selection of appropriate and representative indicators. As Malone and Engle (2011) highlight vulnerability is dynamic and varied. They also suggest vulnerability should be represented by multiple indicators as appropriate indicators may be dissimilar in different contexts. The indicator selection for this study also concurs with the opinion

that not all proposed indicators are appropriate or capable of identifying specific socioeconomic vulnerability concerning distinct social circumstances (Rygel *et al*., 2006), governance scales (Adger *et al*., 2004; Birkmann, 2007), hazard events, and cases (Kuhlicke *et al*., 2011; Cutter *et al*., 2003). Therefore, the author would agree that a 'one-size-fits-all' indicator framework may be ineffective in identifying and understanding the factors that contribute to localised vulnerability (Cuter and Finch, 2008; Zhou *et al*., 2014).

Moreover, this study also emphasises that selective principles and flexible indicator frameworks are needed not to embrace representative indicators rather than a group of unrelated proposed indicators. Therefore, a two-dimensional hierarchical framework is adopted in this study, with clear definitions and relationships between individual dimensions, sectors, and indictors (Figure 5.2). These, are flexible and adjustable to add indispensable indicators according to specific circumstances. For example, financial resources and conditions can affect governments' capacity for pre-disaster planning and preparedness and post-disaster reconstruction (Adger *et al*., 2004). This study employed these indicators because the sector of financial resources is able to reflect the resilience to climate change. In addition, the three selection principles (representativeness, acceptability and accessibility) play a critical roles for judging appropriate indicators in this study, and some proposed indicators were eliminated because they may generate misunderstanding (e.g. housing units, birth rate) or unable to reflect the real circumstances (e.g. mobile homes) in terms of Taiwanese society (cross ref: 5.2.2). Previous studies (Malone and Engle, 2011; Cutter *et al*., 2003; Zhou *et al*., 2014; Rygel *et al*., 2006; Boruff *et al*., 2005) suggest that the statistical approach (Multicollinearity Test, Principal Components Analysis, Factor Analysis) also can be employed to select the applicable indicators, it is difficult to test or verify the relationship between theory and indicators (Luers *et al*., 2003). Although these statistical approaches were not conducted to the indicators selected in this research, the multiple indicators outlined in each section provide an objective profile and a clear reflection of the actual situation. For example, the high 'aging index' and 'elderly population' both demonstrate that aging population is a potential factor influencing vulnerability to climate change in rural areas. The four indicators related to 'medical services provisions' not only showed that insufficient medical services may lead to high death rate in rural area, but also revealed the problem of insufficient medical resource in rural areas in Taiwan. Consequently, the

complex socioeconomic context and causation can be clarified and verified through the different representative indicators.

In summary, the author suggests that the proposed indicator framework and selection of indicators should be theory-driven and based on the local context, and not arbitrarily determined or merely blindly using collected indicators. The SVIF can be modified to include a broader range of available datasets or to address different research purposes. As such it is a flexible research tool to be applied in assessing the specific vulnerability characteristics of different areas and is much more useful than a 'one-size-fits-all' indicator framework. In this study, a specific SVIF (Figure 5.2) was developed according to proposed indicators from relevant literature and local circumstances, and therefore some inappropriate indicator was deleted and paraphrased. Likewise, the unused and representative indicators were able to broaden the framework and provide more background information (Table 5.1). Nevertheless, perhaps future research could combine statistical analysis and objective judgements from stakeholders to select appropriate indicators, with such as the Delphi Survey (Brooks *et al.*, 2005), Focus Group Discussions (Ahsan and Warner, 2014), and Analytic Hierarchy Processes (Chen *et al.*, 2011). These methods could clarify the relative weighting of the indicators. However, these methods are costly and time-consuming and therefore lay well beyond the scope of this particular research.

Threshold

This study has also demonstrated that the lack of a well-defined threshold for individual indicators is a critical limitation (Eakin and Luers, 2006; Luers, 2005; Mastrandrea and Schneider, 2004; Dessai *et al.*, 2004). This issue has arisen because identifying the threshold of socioeconomic vulnerability is complicated. All variances of human systems rather than just the risk of climate change have to be considered (Dessai *et al.*, 2004; Eakin and Luers, 2006; Birkmann, 2007). The author would concur with opinion of previous studies (Rygel *et al.*, 2006; Cutter *et al.*, 2003; Li and Chen, 2010; Li, 2014) that average values can be viewed as an alternative way to judge the level of vulnerability without a convincing standard. Therefore this study adopted average values of four cases to measure and compare the relative vulnerability between these selected cases (Section 5.2).

Although the average values enabled the researcher to identify the relative vulnerabilities between the four cases, this may have led to an overestimation or

underestimation of socioeconomic vulnerabilities. For example, the results show a wide range of vulnerabilities in labour force in the four cases, though the original values are closer (Appendix F). Furthermore, Kauho Township might be the most vulnerable area to climate change according to the brief summary in Table 5.3. While a simple tripartite division was adapted as the standard of judgment of the potential vulnerability level, and the author suggests that strong thresholds or standards can determine credible vulnerability level. As the results of this study imply, the use of average values could be an alternative method to compare the relative vulnerability, but it is considered that this approach may not be a strong standard to define and judge the actual socioeconomic vulnerability levels (low, medium, high) to potential climate change.

In conclusion, the results of this study support the argument that lack of well-defined and fixed threshold values is a deficiency in the SVIF. As a result, the generalisation of overall socioeconomic vulnerability may be limited. Whilst the results reveal some important differences in vulnerability between the townships, it is suggested here that future research is necessary to determine with certainty a credible and universal baseline for judging the socioeconomic vulnerabilities in terms of safety, early-warning, and danger thresholds.

5.5 Summary

In summary, vulnerability analysis makes a valuable contribution to climate change studies, highlighting the information of specific vulnerability characteristics, and enabling policymakers to develop optimal adaptation policies. These adaptation policies and actions may be more applicable to cope with impacts of climate change with regard to specific circumstance of individual communities or areas. The scrutiny of the indicator framework within the case studies provided the following primary implications of the SVIF for local adaptation policy planning for the coastal areas of south west Taiwan.

This chapter suggests a SVIF based on a place-based perspective can adequately assess the socioeconomic vulnerability of a coastal community. Moreover, the three principles of representativeness, acceptability, and accessibility were used to select practicable indicators and the standardisation was suggested to calculate the relative vulnerabilities between the four cases. Based on the results of standardisation, various factors related to the susceptibility and resilience of the different coastal communities and townships have

been found. As such, it has been demonstrated that the SVIF is capable of identifying the potential susceptibility and resilience to climate change concerning the socioeconomic structure and infrastructure sensitivity between different coastal townships. Although there has been no determination of ranking and overall vulnerability level without precise thresholds, these empirical results have verified that SVIF is a practical and flexible tool to answer the two questions: ‘who is vulnerable’ and ‘why they are vulnerable’ in township level.

Whilst the users and researchers of the SVIF face several obstacles such as appropriate scale, applicable indicators, and thresholds, this study has still proposed a practical way of conducting a socioeconomic vulnerability assessment. In particular, the SVIF has enabled analyse of vulnerability on a case-by-case basis in order to recognise key factors and put forward explanations. Finally, it is considered that the main value of the SVIF has been its insight into the nature of socioeconomic vulnerability to climate change and the fact that this can be used to identify the orientation of adaptation policies and, therefore, the prioritisation of the adaptation sectors and the informing of the public in local adaptation frameworks.

Chapter Six The "Awareness" Component of the AAA framework

6.1 Introduction

An increasing number of recent publications and empirical studies have shown that hazard experiences may influence public perception of climate change and highlight the importance of public awareness of climate change for adaptation. On the whole there has been relatively little change in public attitudes and progress in improving public awareness of climate change in Taiwan compared with the amount of research which has been undertaken on the scientific modeling of climate change and adaptation. Therefore, this chapter discusses public awareness of climate change and flood experiences in the coastal study areas of Taiwan, and focusing in the factors that may affect individual perceptions, such as their personality and flood experiences (Figure 6.1). As such, it therefore addresses the 'awareness' component of the AAA framework.

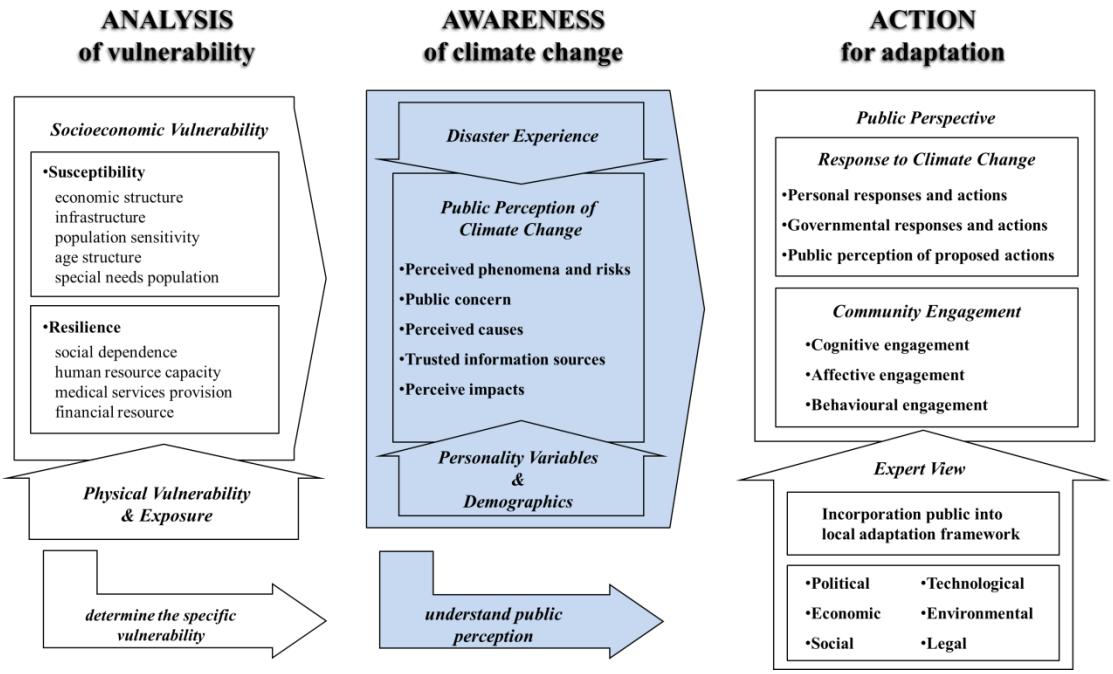


Figure 6.1: Awareness of climate change in AAA framework (cross ref: Figure 3.1)

The chapter begins with a presentation of some of the results from the questionnaire survey. The first sections (Section 6.2 and Section 6.3) present an outline of public perception of climate change and the contextual information of flood experience. Within these sections a range of simple bar and pie charts along with simple statistics

summarise the key findings which are briefly explained in the text. Section 6.4 discusses the implications of these findings, and a synthesis of results is used to inform the development of a conceptual model for demonstrating the extent of Taiwanese public 'awareness' of climate change. It should be noted that the detailed sample statistics are provided in Appendix G, and the full data from the public questionnaire related to this are shown in Appendix H.

6.2 Public Perception of Climate Change in Taiwan

6.2.1 Phenomena of Climate Change

Figure 6.2 shows that most respondents considered flood, temperature change, and extreme rainfall were the tangible phenomena which related to climate change, rather than other environmental and human factors. Specifically, the public were most concerned about flood (22.7%), temperature change (15.8%), and super typhoons (10.9%). Unsurprisingly, flood is viewed as the most frequent and harmful climatic event to coastal communities of Taiwan. 13.3% of respondents noted a substantial change of this compared with lower percentages associated with sea level rise (11.7%), and extreme rainfall (10.8%) observations in the coastal case study areas. Flood (17.9%), extreme rainfall (13.6%), and extreme temperature change (12.4%) were the hazards which respondents noted had affected the coastal communities most negatively.

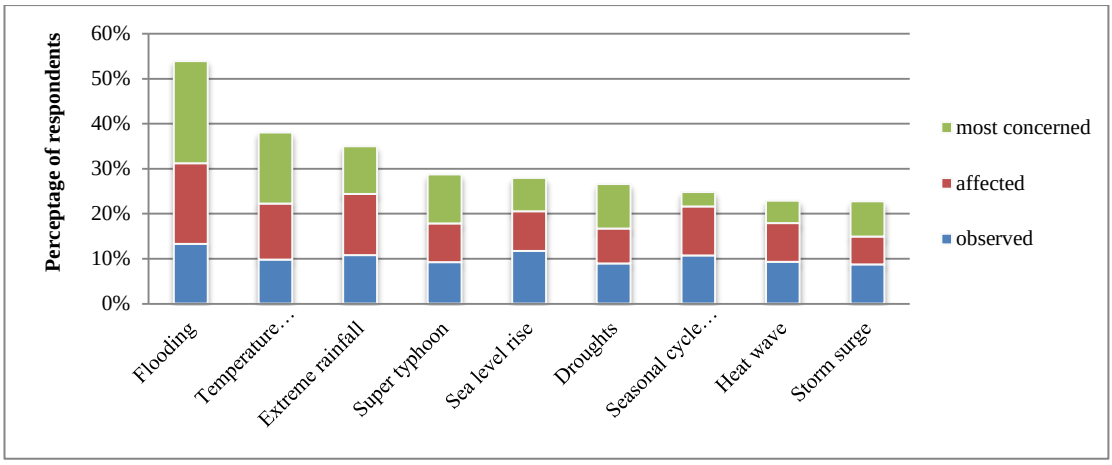


Figure 6.2: Public perception of weather related-phenomena – *showing that flood is the phenomena which is of most concern to the public*

6.2.2 Concern

Level of public concern about climate change

Figure 6.3 demonstrates that the vast majority (77.1%) is concerned about climate change and only a tiny minority are not. Therefore, it is certain that climate change is a vital issue in Taiwan.

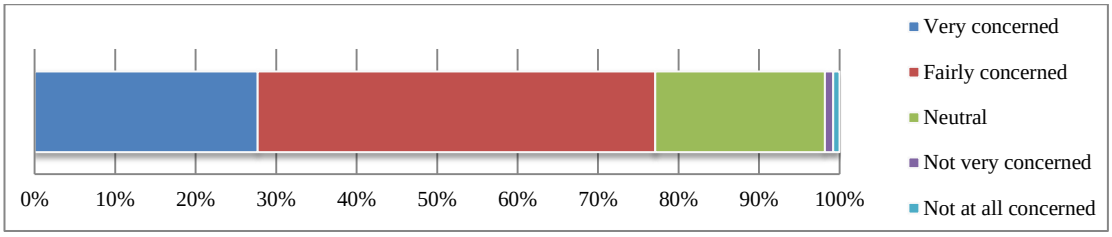


Figure 6.3: Level of public concern about climate change – *showing that nearly 80% of the public are concerned about climate change in Taiwan*

Demographic level of concern about climate change

The demographics, which include age, gender, residence, residence length, education, occupation, income, are considered significant elements related to public concern about climate change. These factors are discussed in Section 6.5. The results of a Chi-square test for 'Goodness of fit' show that there is a significant difference ($p=0.000<0.001$) between public concern about observed and expected frequencies related to climate change with H_0 being rejected (Table 6.1). The Mann-Whitney test and Kruskal-Wallis test were used because the sampled population was not normally distributed and the data are nominal or ordinal as indicated in Section 3.5.2.

Table 6.1: The distribution of respondents' levels of concerned about climate change – *showing the sampled population is not normally distributed*

	Observed frequency	Expected frequency	Residual
Very concerned	143	103.2	39.8
Fairly concerned	255	103.2	151.8
Neutral	109	103.2	5.8
Not very concerned	5	103.2	-98.2
Not at all concerned	4	103.2	-99.2
χ^2 (4, n=516) = 427.760, *p*: 0.000<0.001***			

The personal characteristics in relation to the level of concern about climate change are as follows:

1. **Age:** Figure 6.4 shows that older people are more concerned than the young. The results of the Kruskal-Wallis test (Table 6.2) indicate that there are significant differences between the various age groups, and the Dunn post hoc test shows that respondents over 35 years old are more concerned about climate change than those under 34 years.

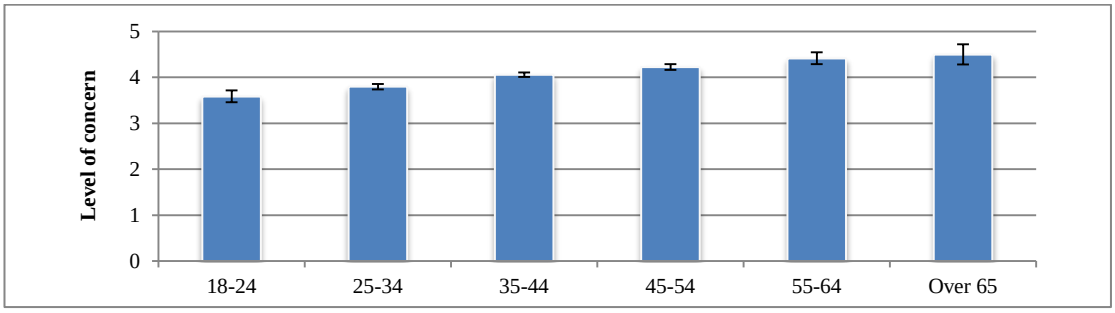


Figure 6.4: Level of general concern about climate change, by age – *showing that concern for climate change increases with age and that the elderly is more concerned about climate change than other age group*

Table 6.2: Age in relate to concern about climate change – *showing that a significant difference between age groups*

	H test	Post Hoc (Dunn test)
Age:		
18-24 , 25-34, 35-44, 45-54, 55-64, Over 65	χ^2 (5): 46.654 (p=0.000<0.001)***	1. 35-44>18-24, 25-34 2. 45-54>18-24, 25-34, 35-44 3. 55-64>18-24, 25-34, 35-44 4. over 65>18-24, 25-34
*p<0.05, **p<0.01, ***p<0.001		

2. **Gender:** Figure 6.5 indicates that females are slightly more concerned about climate change than males, reflecting the results of other, including Hsu (2013), McCright (2010) and Capstick *et al*. (2013). However, the results of Mann-Whitney test (Table 6.3) show no significant difference between males and females.

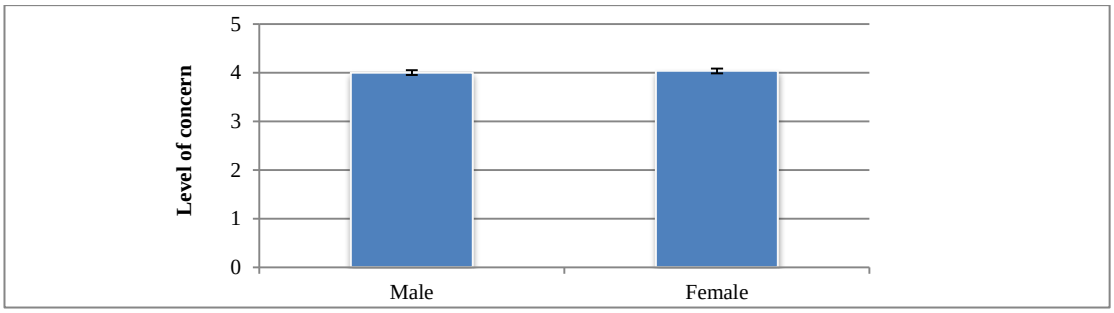


Figure 6.5: Level of general concern about climate change, by gender – *showing that females and males both are concerned about climate change*

Table 6.3: Gender in relate to concern about climate change – *showing no significant difference between the gender groups*

	N	Mean Rank	Sum of Ranks	U test
Gender				
Male	227	253.88	57630.50	31752.5 (p=0.498>0.05)
Female	289	262.13	75755.50	n.s.
*p<0.05, **p<0.01, ***p<0.001 ns: no significant difference				

3. **Residence:** Figure 6.6 shows that the people who live in Linbian Township are more concerned about climate change than the other three townships. The Kruskal-Wallis test (Table 6.4) reveals that there is also a significant difference between different areas. The Dunn post hoc test shows that there is more concern in Linbina than Mailiao, and in Jiadong than Mailiao.

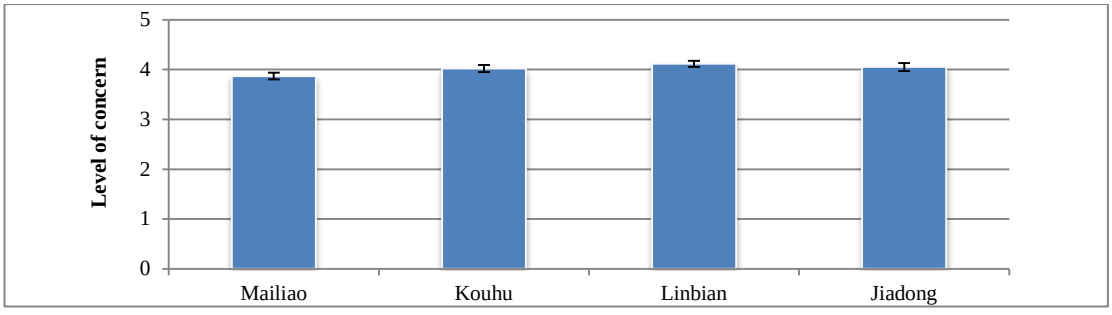


Figure 6.6: Level of general concern about climate change, by residence – *showing slight differences between residents from the different townships and also that respondents from Linbian are most concerned about climate change*

Table 6.4: Residence in relate to concern about climate change – *showing a significant difference between residence groups*

	H test	Post Hoc (Dunn test)
Residence:		
Mailiao, Kouhu, Linbian, Jiadong	χ^2 (3): 8.333 (p=0.04<0.05)*	1. Linbian>Mailiao 2. Jiadong>Mailiao
*p<0.05, **p<0.01, ***p<0.001		

4. **Length of residence:** Figure 6.7 suggests that people who have lived longer in their home districts are generally more concerned about climate change. However, the result of the Kruskal-Wallis test (Table 6.5) indicates that there are no significant differences.

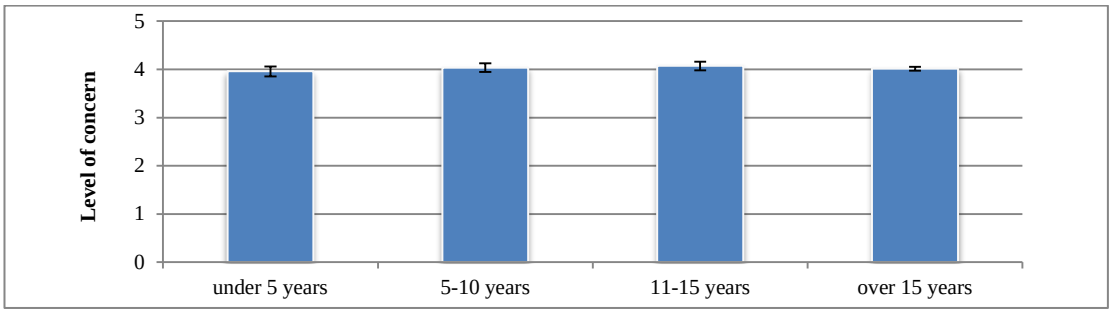


Figure 6.7: Level of general concern about climate change, by length of residence – *showing that those residents who has lived longest in a location are more concerned about climate change*

Table 6.5: Length of residence in relate to concern about climate change – *showing no significant difference between the length of residence groups*

	H test
Length of residence:	
Under 5 years (A), 5-10 years (B), 11-15 years (C), Over 15 years (D)	χ^2 (3): 0.713 (p=0.870>0.05) n.s.
*p<0.05, **p<0.01, ***p<0.001 ns: no significant difference	

5. **Educational degree:** Figure 6.8 shows that people who have high educational qualifications are more concerned about climate change than others. Surprisingly however, the group with an education level of 'primary or under' is the most concerned about climate change. The results of Kruskal-Wallis test (Table 6.6) show a statistically significant correlation to level of educational degree, and the Dunn post hoc test indicates that there is more concern in people with education at primary or under than BSc levels, in higher degrees such as MSc than senior (vocational) and BSc.

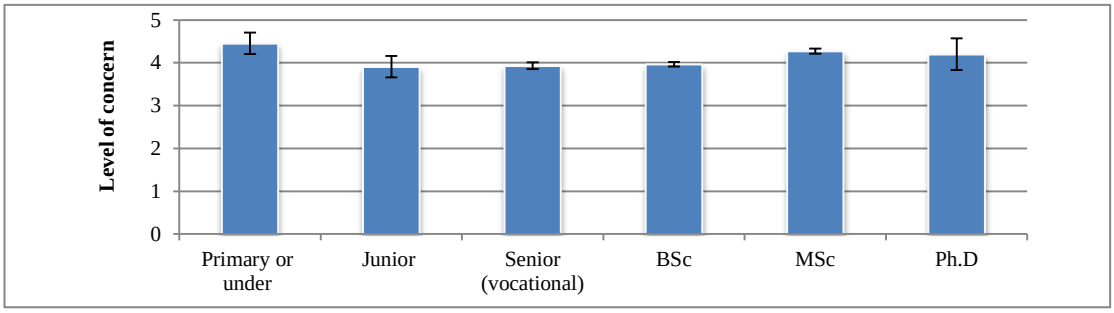


Figure 6.8: Level of general concern about climate change, by educational degree – *showing that respondents with the lowest and highest educational statuses are more concerned about climate change than other groups*

Table 6.6: Educational level in relate to concern about climate change – *showing a significant difference between the groups with different educational levels*

	H test	Post Hoc (Dunn test)
Educational level:		
Primary or under, Junior, Senior (vocational), BSc, MSc, Ph.D	χ^2 (5): 16.47 (p=0.005<0.01)**	1. Primary or under>BSc 2. MSc>Senior (vocational), BSc
*p<0.05, **p<0.01, ***p<0.001		

6. **Occupation:** Figure 6.9 reveals that the group made up of homemakers, educators, retired, and civil servants are more concerned about climate change than the other groups. This is confirmed by the Kruskal-Wallis test (Table 6.7) which indicated significant differences between respondents from different occupation groups. Furthermore, the Dunn post hoc test reveals that educators, civil servants, and

homemakers show more concerned about climate change than the other occupational groups.

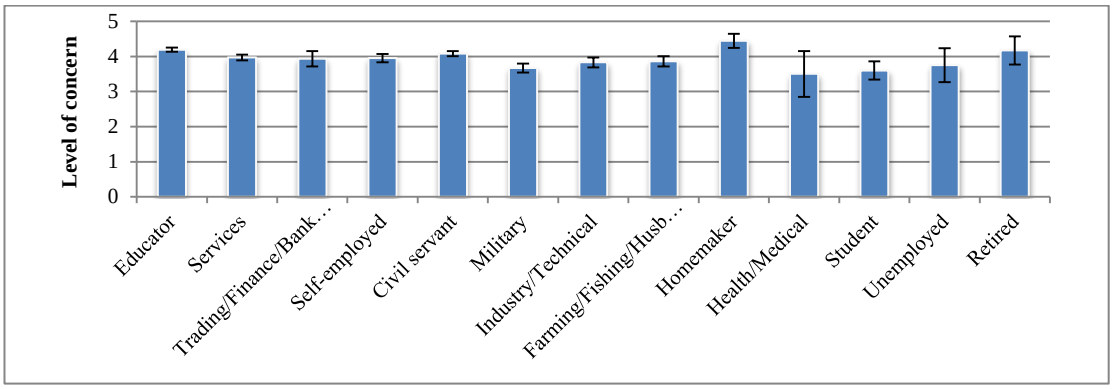


Figure 6.9: Level of general concern about climate change, by occupation – *showing that respondents with certain occupations (educator, civil servant, homemaker, retired) are more concerned about climate change*

Table 6.7: Occupation in relate to concern about climate change – *showing a significant difference between the occupational groups*

	H test	Post Hoc (Dunn test)
Occupation:		
Educator, Services, Trading/Finance/Banking, Self-employed, Civil servant, Military, Industry/Technical, Farming/Fishing/Husbandry, Homemaker, Health/Medical, Student, Unemployed, Retired	χ^2 (12): 27.222 (p=0.007<0.01)**	1. educator>services, military, self-employed, student, farming/fishing/husbandry, 2. civil servant>military 3. homemaker>services, self-employed, civil servant, military, student industry/technical, farming/fishing/husbandry,
*p<0.05, **p<0.01, ***p<0.001		

7. **Annual income of household:** Figure 6.10 shows that respondents whose annual household incomes are greater than £15,000 are more concerned about climate change than those with lesser incomes. The results of the Kruskal-Wallis test (Table 6.8) shows statistically significant differences between annual household income

groups, and the respondents with high annual household income (over £15,000) were more concerned.

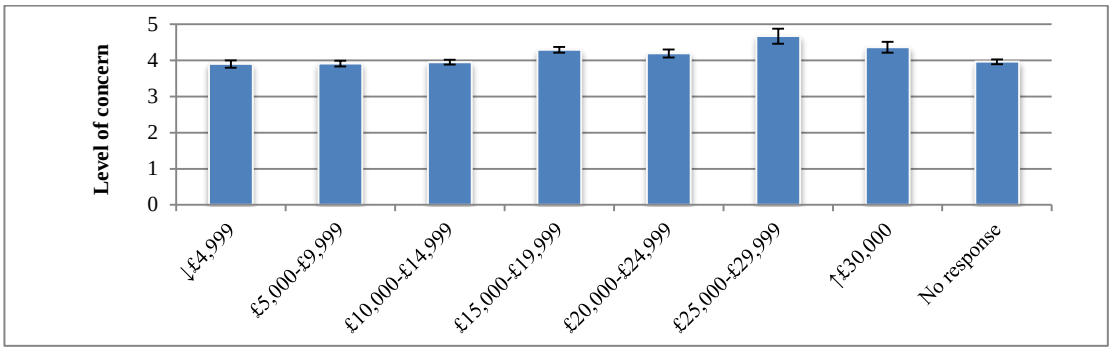


Figure 6.10: Level of general concern about climate change, by annual income of household – *showing that respondents with higher annual household incomes (over £25k) are more concerned about climate change*

Table 6.8: Annual household income in relate to concern about climate change – *showing a significant difference between the annual household income groups*

	H test	Post Hoc (Dunn test)
Annual income of household:		
↓£4,999, £5,000-£9,999, £10,000-£14,999, £15,000-£19,999, £20,000-£24,999, £25,000-£29,999, ↑£30,000, No response	χ^2 (7): 23.333 (p=0.001≤0.001)***	1. £15,000-£19,999>↓£4,999, £5,000-£9,999, £10,000-£14,999, no response, 2. £20,000-£24,999>£5,000-£9,999, 3. £25,000-£29,999>↓£4,999, £5,000-£9,999, £10,000-£14,999, no response, 4. ↑£30,000>↓£4,999, £5,000-£9,999, £10,000-£14,999, no response.
*p<0.05, **p<0.01, ***p<0.001		

8. **Flood experiences:** Figure 6.11 depicts that people who have flood experiences are more concerned about climate change than those who have not had such experience. The Mann-Whitney test was conducted to evaluate whether people who have experienced property loss, have been physically affected or where floods have

affected their surroundings are more concerned about climate change. The results in Table 6.9 show that a significant differences for group of property loss (people who have experienced property loss are more concerned about climate) and group of physical effect (people who have experienced of physical effect more concern about climate).

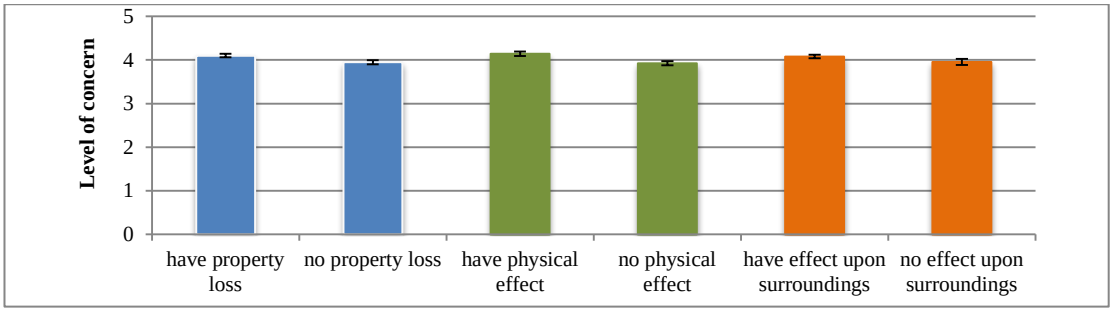


Figure 6.11: Level of general concern about climate change, by flood experiences – *showing that respondents who have suffered losses associated with a previous flood experience are more concerned about climate change*

Table 6.9: Flood experience in relation to concern about climate change – *showing a significant difference between the groups with different direct flood experiences and losses (property loss, physical effect), but showing no significant difference between the groups in the context of general effects upon surroundings*

		N	Mean Rank	Sum of Ranks	U test
Property loss	Yes	290	265.16	76896.00	28229 (p=0.031<0.05)*
	No	217	239.09	51882.00	
Physical effect	Yes	256	276.18	70702.00	27218 (p=0.001≤0.001)***
	No	254	234.66	59603.00	
Effect upon surroundings	Yes	402	251.96	101288.00	16297 (p=0.077>0.05) n.s.
	No	91	225.09	20483.00	
*p<0.05，**p<0.01，***p<0.001 ns: no significant difference					

Importance of climate change to other issues

In spite of the majority acknowledging that climate change is a significant issue, the author also wondered how the respondents would prioritise the importance of climate

change, compared with other common issues in Taiwan. Figure 6.12 shows that respondents tend to be most concerned about environmental issues (green: 56.1%) and economic development (blue: 29.5%). The level of concern about climate change is considerably lower (red: 14.1%).

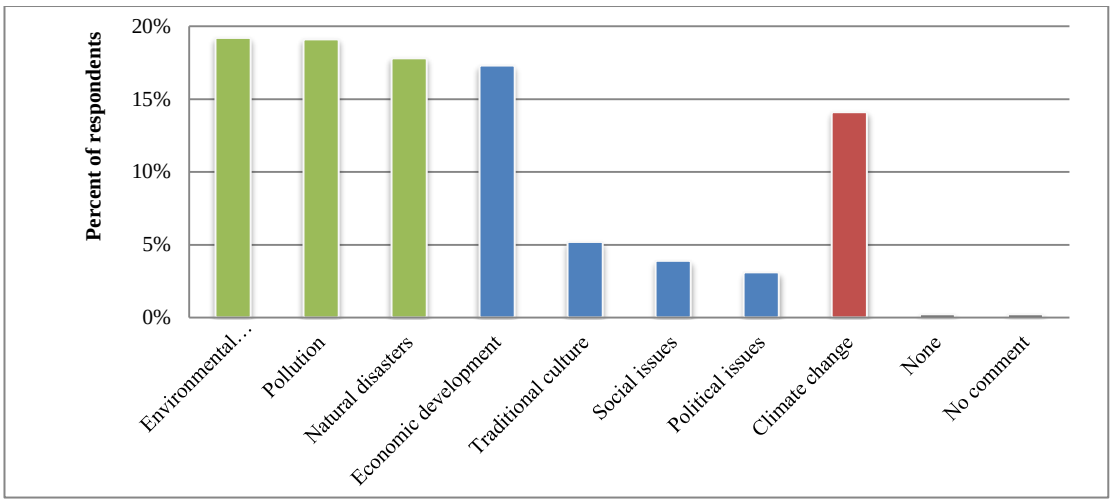


Figure 6.12: The ranking of public concern about issues in Taiwan – *showing that environmental issues are of most concern to the public; climate change is also shown to be an important issue for the public*

Concern about the different types of impacts of climate change

It is widely accepted that the climate change has negative impacts on environmental, economic, and human systems. Regarding public concern of the potential impacts of climate change, responses are shown in Figure 6.13, colour coded by type of impact: physical impacts (green), socioeconomic impact (blue), and environment impact (orange). According to the chart, it is obvious that the biggest concern is physical impacts, which accounts for 42.6% of all the impacts. Socioeconomic impacts are the next largest, 32.8%, followed by environmental impacts, 24.7%. Therefore, the author suggests that the general public is most concerned about impacts of climate change when these directly affect their interests and safety.

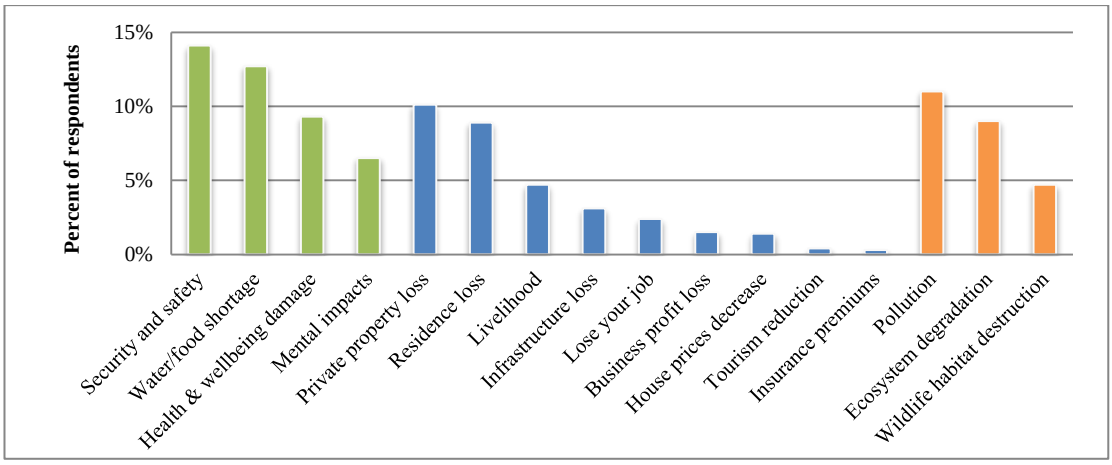


Figure 6.13: Public concern of the potential influences of climate change – *showing that physical impacts are of most concern to the public*

6.2.3 Perceptions relating to the causes of climate change

The findings shown in Figure 6.14 demonstrate the extent to which the public believes that climate change in Taiwan is caused by human activities or natural processes. This reveals that only a small percentage of respondents thought natural processes are responsible, with just over a third agreeing that climate change is caused by human activities. Most respondents believe that climate change is caused by a combination of both natural processes and human activities.

Further analysis focused on whether public concern about climate change and flood experiences have influenced opinions on the causes of climate change. Figure 6.15 shows that if people are concerned about climate change, they tend to support the opinion that climate change is entirely caused by humans. The people who are unconcerned about climate change, by contrast, believe that climate change is a natural process. Additionally, Figure 6.16 indicates in relation to the responses which suggested human activity was the driver, there was a higher percentage of respondents with flood experience than those with no flood experience. However, there is no statistically significant correlation between public concern and public belief in the causes of climate change, and between flood experiences and public belief in the causes of climate change (Table 6.10).

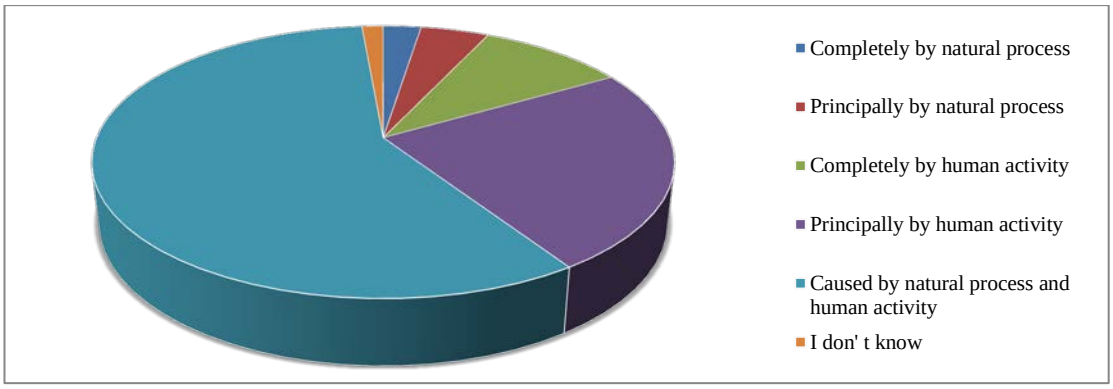


Figure 6.14: Public perception of the causes of climate change – *showing that pubic believes that climate change is caused by a combination of both natural processes and human activities*

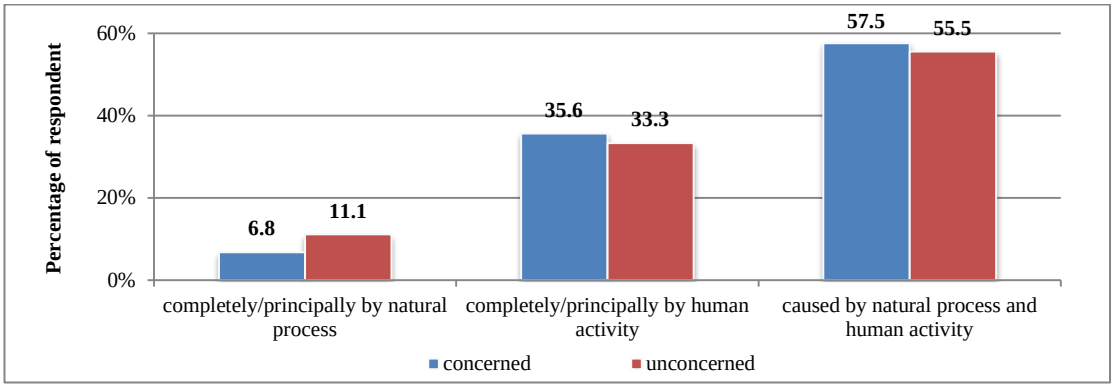


Figure 6.15: Public belief in the causes of climate change in relation to concerned and unconcerned respondents – *showing that respondents who concerned about climate change tend to support the opinion that climate change is entirely caused by humans*

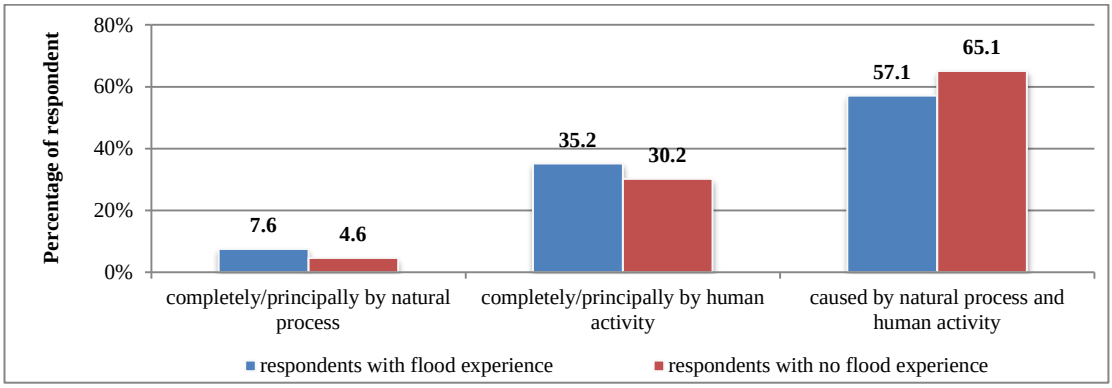


Figure 6.16: Public belief in the causes of climate change in relation to flood experience – *showing that respondents with flood experience tend to support the opinion that climate change is entirely caused by humans*

Table 6.10: Correlation between public concern and public belief in the causes of climate change, and between flood experiences and public belief in the causes of climate change – *showing no significant difference for either correlation*

		Belief about cause about climate change
Concern	χ^2	1.905 (4, n=509)
	Cramer's V	0.043
	Approx. Sig	0.753>0.05 n.s.
2 cells (22.2%) have expected frequencies less than 5. The minimum expected cell frequency is 64		
Flood experiences	χ^2	2.180 (2, n=506)
	Cramer's V	0.066
	Approx. Sig	0.336>0.05 n.s.
0 cells (0%) have expected frequencies less than 5. The minimum expected cell frequency is 6.12		
*p<0.05，**p<0.01，***p<0.001		

6.2.4 Trusted Information Sources about Climate Change

Regarding the trusted information sources about climate change, responses are shown in Figure 6.17 and colour-coded according to the different types of information source. This indicates that the most trusted information source is the mass media (green 47.4%: newspaper/magazine, TV/radio, internet) which nearly half of the respondents felt most reliable. Respondents then considered information from independent organisations (blue 24.3%: environmental groups/NGOs, international organisations) and scientific information sources (orange 16.6%: academic publication, school/university, scientists, libraries) the next most reliable. The relatively low percentage for the latter is surprising given personal experiences (yellow 5.9%: friends/family, self-experiences) and government interventions (red 5.2%: local government, governmental agency).

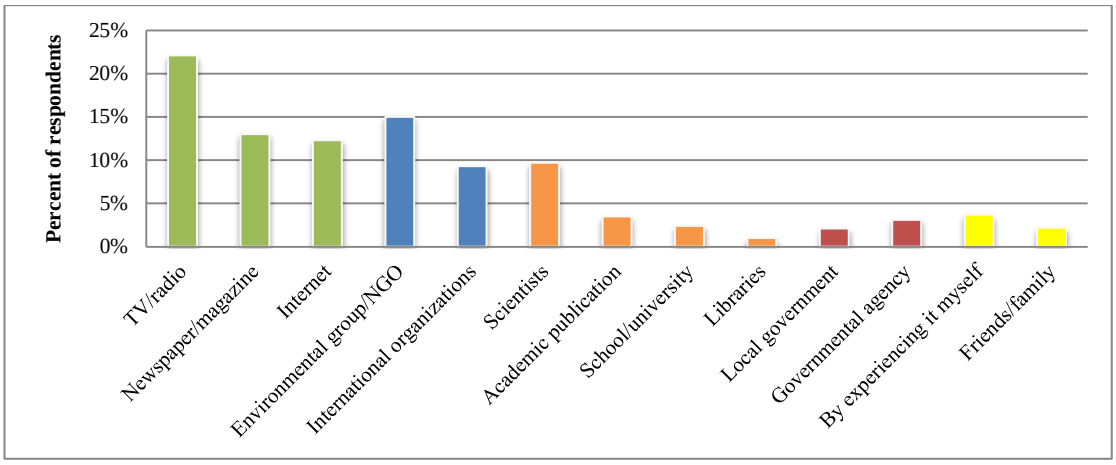


Figure 6.17: The rank of trusted information sources about climate change – *showing that mass media is the most trusted information source*

6.2.5 Perceived Impacts of Climate Change

Figure 6.18 shows that a substantial number of survey respondents had perceived or experienced damaging impacts of climate change. A small group considered that they would be impacted by climate change within the next 10-50 years. Only 0.4% agreed that they would never experience such impacts.

There was further analysis on whether public concern about climate change and flood experiences influenced opinions about expected impacts of climate change. Figure 6.19 shows that if people are concerned about climate change, they tend to agree that they had experienced the impacts of climate change (81.7%), but only a half of people who are unconcerned about climate change agreed with this (55.6%). Public concern about climate change seems to be closely connected to perceived impacts of climate change (Table 6.11). Figure 6.20 indicates that the percentage of respondents with flood experience (79.8%) and no flood experience (73.9%) are similar when responding to the option relating to people already experienced the impact of climate change. Moreover, there is no obvious connection between flood experiences and public perception of the impacts of climate change (Table 6.11).

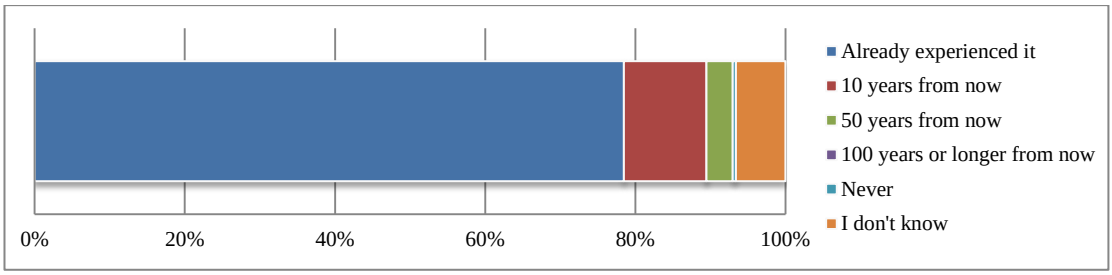


Figure 6.18: Public perception of expected impacts of climate change – *showing that most respondents perceived damaging impacts of climate change*

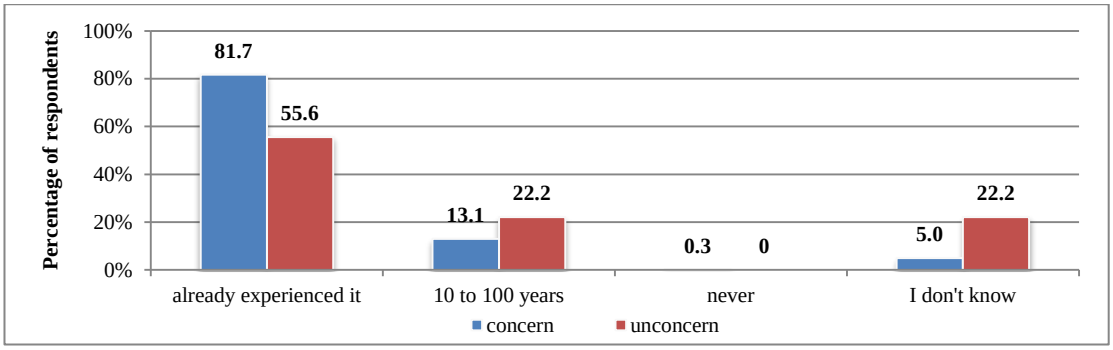


Figure 6.19: Public perception of expected impacts of climate change in relation to levels of concern respondents – *showing that respondents who are concerned about climate change agree that they had experienced the impacts*

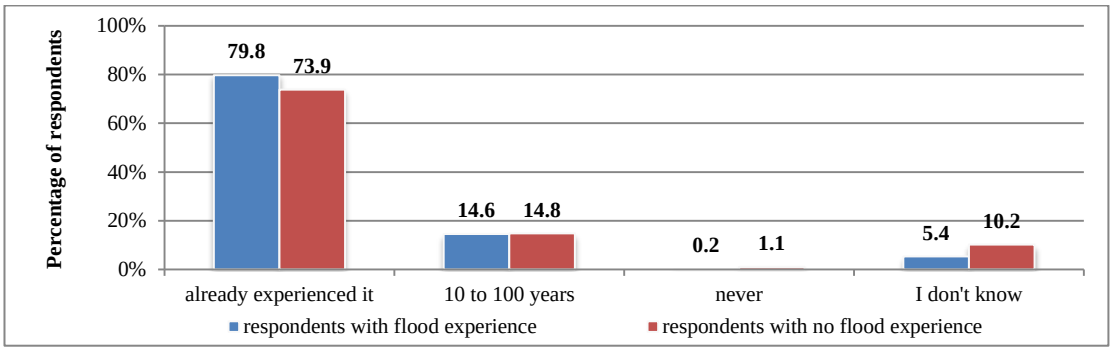


Figure 6.20: Public perception of expected impacts of climate change in relation to flood experience – *showing that respondents with previous flood experience agreed that they had experienced the impacts of climate change*

Table 6.11: Correlation between public concern and public perception of expected impacts of climate change, and between flood experiences and public perception of expected impacts of climate change – *showing a significant difference between public concern and perception of climate change impacts and no significant difference between those with flood experience and perceived impacts of climate change*

		Perceived impact
Concern	χ^2	14.113 (6, n=516)
	Cramer's V	0.117
	Approx. Sig	0.028<0.05*
5 cells (41.7%) have expected frequencies less than 5. The minimum expected cell frequency is 0.03		
Flood experiences	χ^2	4.553 (3, n=513)
	Cramer's V	0.094
	Approx. Sig	0.208>0.05 n.s.
2 cells (25%) have expected frequencies less than 5. The minimum expected cell frequency is 0.34		
*p<0.05，**p<0.01，***p<0.001		

6.3 Flood Experiences

6.3.1 Personal Experiences

Types of flood experiences

Figure 6.21 shows the percentage of the three types of flood experienced by participants. This reveals that approximately half of the respondents have suffered direct impacts of flood, notably property loss (56.2%) and personal physical harm (49.6%). However, a much greater proportion (77.9%) agreed that flooding had resulted in impacts upon their surroundings.

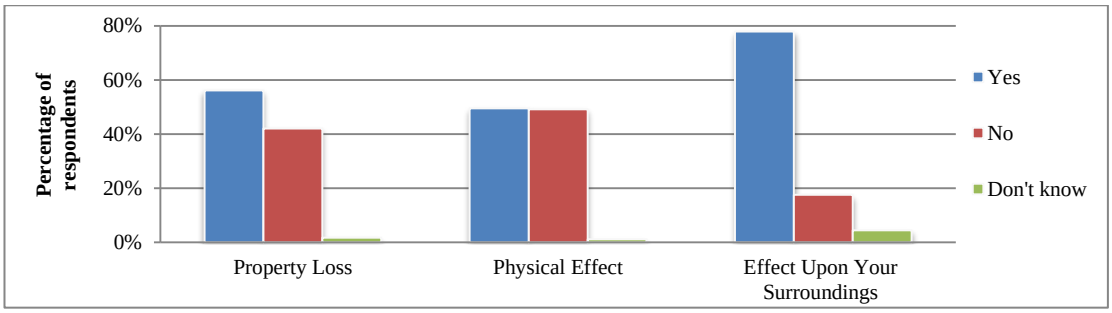


Figure 6.21: Flood experiences of respondents – *showing that respondents have suffered a range of different flood experiences*

Maximum financial loss

Figure 6.22 shows just over half of the respondents had suffered no loss or under £4,999 (green) worth of loss related to flooding and a very limited numbers of respondents had lost between £5,000 to £19,999 (blue). However, flooding had caused a significant loss (more than £20,000) to a small group (6.6%) of respondents (red). Lastly, nearly 30% (orange) answered "no response" and "I don't know". One possible reason may be that financial questions are particularly sensitive and a private matter to Taiwanese.

Furthermore, it is obvious that most respondents who have incurred significant losses related to flood events are concentrated in Jiadong and Linbian (Figure 6.23). A possible explanation for this is the impacts on aquaculture production in these areas which focuses on fish species (such as *Epinephelus lanceolatus*) of high value. For example, Chen *et al.* (2013) suggest that the Morakot Typhoon caused about ten million pounds of damage to the aquaculture industry in Linbian and Jiadong Township in 2009.

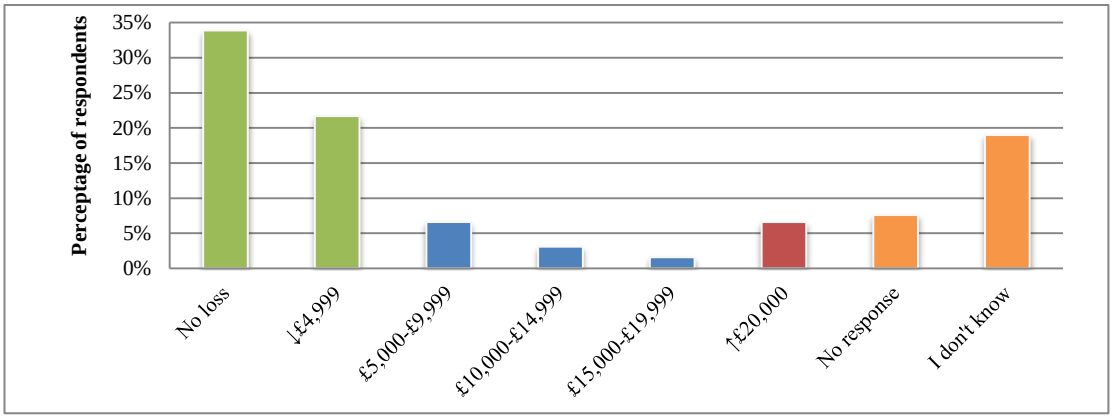
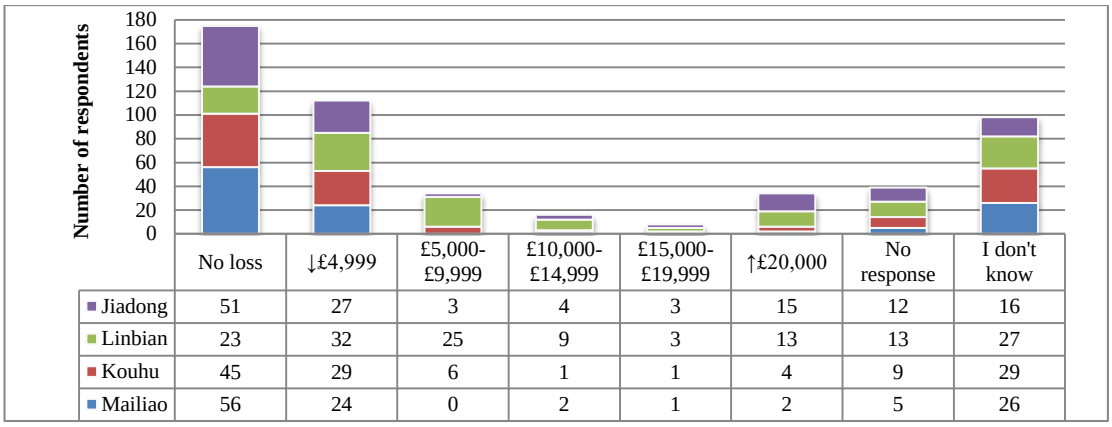


Figure 6.22: Maximum financial losses from flood – *showing few respondents with losses of more than £5,000*



	No loss	↓£4,999	£5,000-£9,999	£10,000-£14,999	£15,000-£19,999	↑£20,000	No response	I don't know
Jiadong	51	27	3	4	3	15	12	16
Linbian	23	32	25	9	3	13	13	27
Kouhu	45	29	6	1	1	4	9	29
Mailiao	56	24	0	2	1	2	5	26

Figure 6.23: Maximum financial losses from flood in the four townships – *showing that low levels of losses were similar across the four townships, but that at higher levels of loss (over £5,000), most respondents were from Linbian*

6.3.2 Causes of Flood

Figure 6.24 shows the results of potential causes of flooding from the public's perspective, colour-coded by type of cause. Most respondents agreed that artificial factors (green; 40.3%) and natural factors (blue; 37.5%) were the major reasons of flooding rather than the relevant factors of climate change (orange; 21.1%), such as land subsidence, inadequate drainage systems, and typhoons.

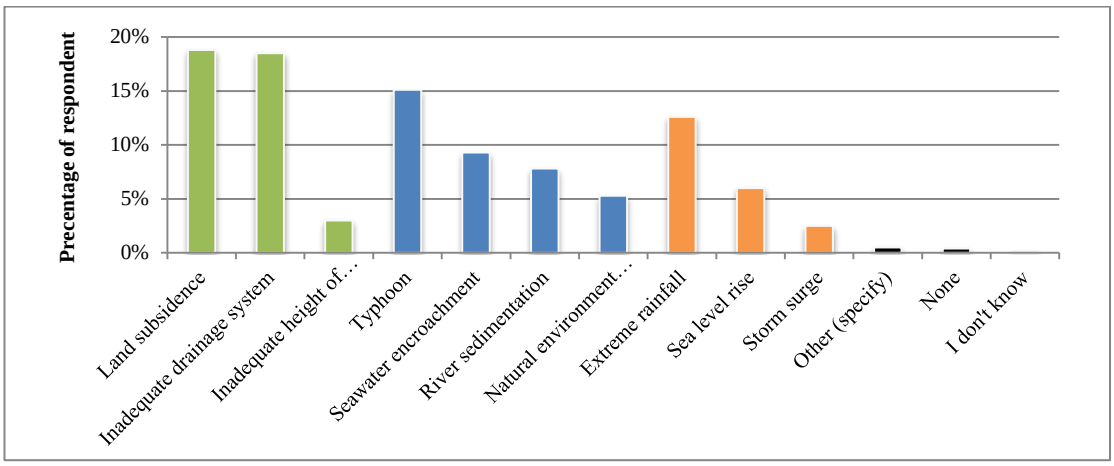


Figure 6.24: Public perception of causes of flood – *showing that a combination of a range of both artificial factors and natural factors are the key reasons of flooding*

6.3.3 Expected Trends in Flooding

<u>Public perception of flood events in the future</u>

In relation to this topic, the relevant question consisted of six simple sliders representing flood frequency and intensity by 2025, 2050, and 2100. Figure 6.25 shows that most of the respondents thought that the frequency and intensity of flood events in their residential areas will increase this century. As a further comparison, these findings demonstrate that the respondents with flood experiences are more aware of flood risks in the near future than the respondents with no flood experiences (Figure 6.26; Figure 6.27). In addition, although the two groups of respondents are both in agreement on the potential trends of flooding, it is worth mentioning that more than 20% of participants expressed that they are not sure about the frequency and intensity of flood risks in the future. Unsurprisingly, all are unsure about the frequency and intensity of flood events by 2050 and 2100.

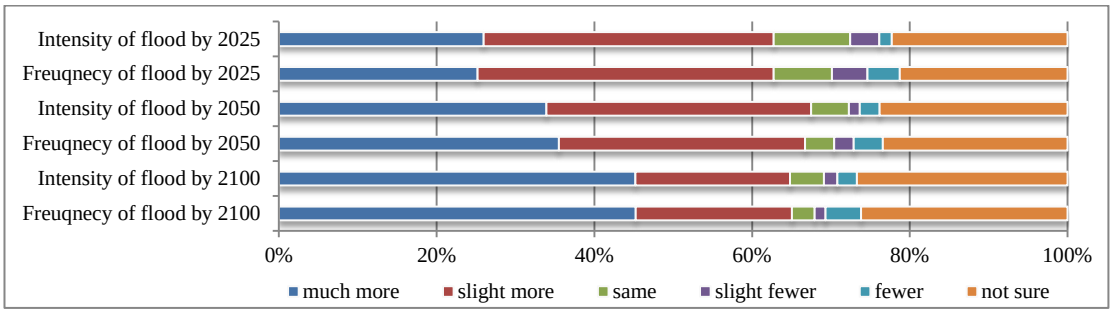


Figure 6.25: Expected frequency and intensity of flood risk by 2025, 2050, 2100 – *showing that most respondents agreed that the frequency and intensity of flood events will increase*

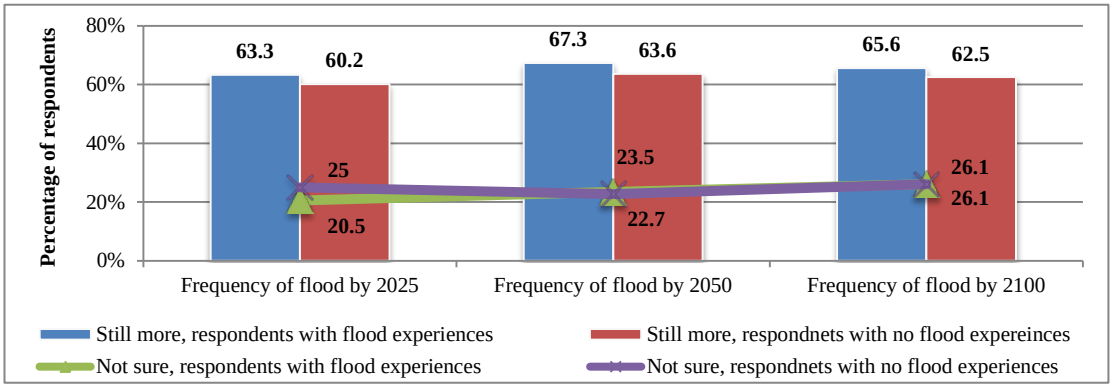


Figure 6.26: Expected frequency of flood risk in relation to flood experiences by 2025, 2050, and 2100 – *showing that the respondents with flood experiences are slightly more aware of flood risks*

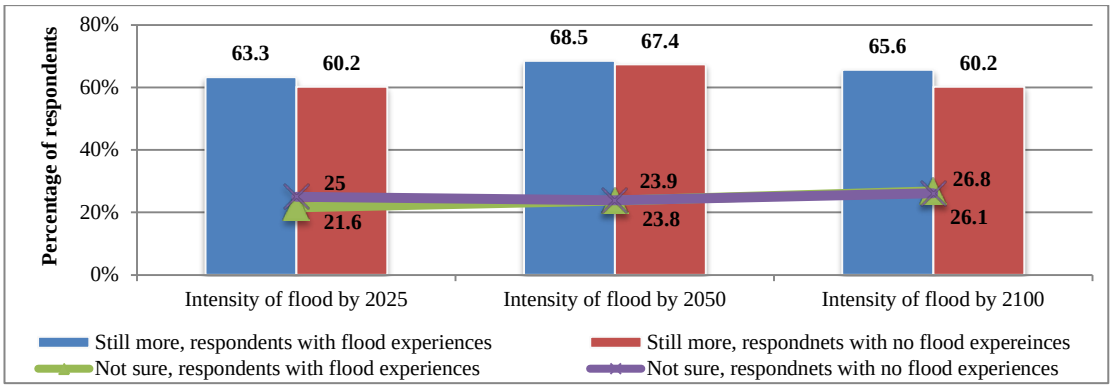


Figure 6.27: Expected intensity of flood risk in relation to flood experiences by 2025, 2050, and 2100 – *showing that the respondents with flood experiences are slightly more aware of flood risks*

However, different opinions about the causes and expected trends of flood were given in the expert workshop. The experts suggested that unpredictable extreme weather events are the major cause. Furthermore, the experts argue that the flood events will be effectively reduced in the near future. This, they considered will occur because of the extensive government budgets (£1.5 billion) devoted to improving drainage systems. They also considered that the new specific regulations (such as the Comprehensive River Basin Governance Regulation) should promote improved watershed management practices against natural hazards. Nevertheless, Central government representatives did acknowledge difficulties involved in setting flood prevention and protection standards due to the unpredictability of extreme weather and rainfall (Appendix I: 1.1).

6.3.4 The Effect of Flood on Public Perception of Climate Change

Figure 6.28 implies that flood experiences have significantly influenced public perception of climate change, these findings relate to earlier statements. More specifically, more than 80% of the general public believes that climate is changing, are concerned about climate change, and are keen to receive relevant information. Flood experiences have also triggered a negative impression with respect to climate change, for around 70% of the respondents who think that climate change is inevitable and will lead to disastrous consequence. Although a small group of respondents think that it is impossible to tackle climate change and it is too late to take any action due to flood experiences, nearly two-thirds of the respondents are willing to respond with actions themselves. Finally, more than 60% respondents consider that current measures and

actions are insufficient and of limited efficacy. Specifically, the results of Mann-Whitney Test (Table 6.12) highlight an interesting aspect that there is no significant difference between people with flood experiences and people with no flood experience in all of these statements. The potential explanations for this are discussed in Section 6.4.4.

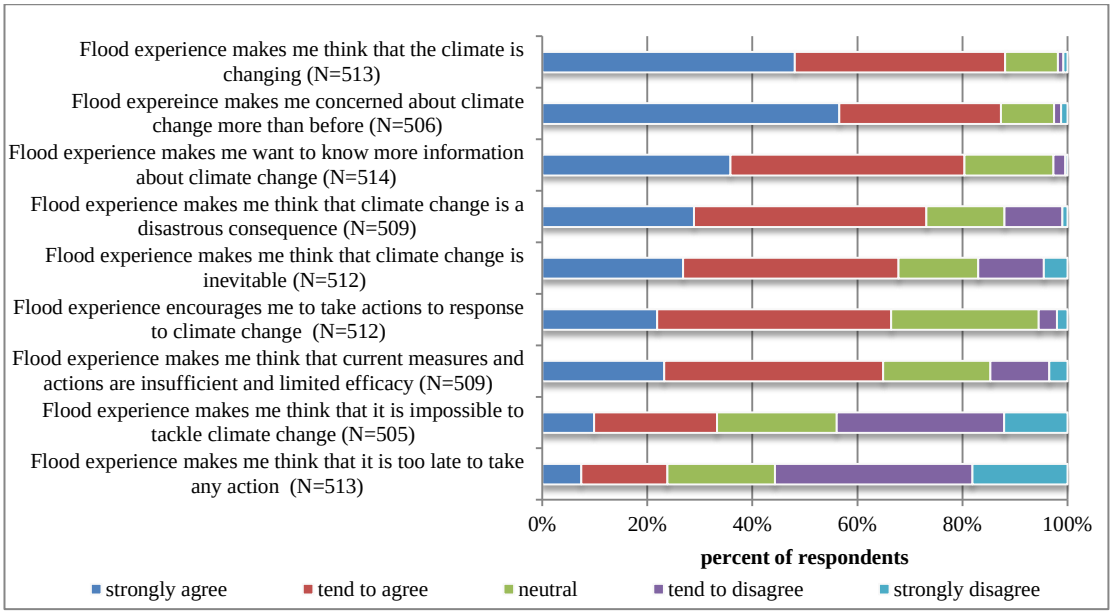


Figure 6.28: Potential influences of flood experiences on public perception about climate change – *showing that the specific effects of flooding are critical on public perception of climate change*

Table 6.12: Flood experiences in relation to public perception of climate change – *showing no significant difference between the flood victims and non-flood victim groups*

	N	Mean Rank	Sum of Ranks	U test
Flood experience makes me think that the climate is changing				
Flood victim	423	260.80	110320.50	16579.5 (p=0.075>0.05)
Non-flood victim	88	232.90	20495.50	n.s.
Flood experience makes me concern about climate change more than before				
Flood victim	417	255.11	106382.50	16632.5 (p=0.233>0.05)
Non-flood victim	86	236.90	20373.50	n.s.
Flood experience makes me want to know more information about climate change				
Flood victim	423	261.03	110417.00	16483 (p=0.068>0.05)

Non-flood victim	88	231.81	20399.00	n.s.
Flood experience makes me think that climate change is inevitable				
Flood victim	422	257.40	108624.00	17765 (p=0.578>0.05)
Non-flood victim	88	246.38	21681.00	n.s.
Flood experience makes me think climate change is a disastrous consequence				
Flood victim	419	255.26	106952.00	18438 (p=0.502>0.05)
Non-flood victim	88	248.02	21826.00	n.s.
Flood experience makes me think that it is impossible to tackle climate change				
Flood victim	417	254.29	106039.00	16976 (p=0.422>0.05)
Non-flood victim	86	240.90	20717.00	n.s.
Flood experience makes me to take actions to response to climate change				
Flood victim	422	258.34	109020.50	17368.5 (p=0.309>0.05)
Non-flood victim	88	241.87	21284.50	n.s.
Flood experience makes me think it is too late to take any action				
Flood victim	423	253.91	107402.50	17726.5 (p=0.466>0.05)
Non-flood victim	88	266.06	23412.50	n.s.
Flood experience makes me think that current measures and actions are insufficient and limited efficacy				
Flood victim	419	256.74	107572.00	17290 (p=0.335>0.05)
Non-flood victim	88	240.98	21206.00	n.s.
*p<0.05; **P<0.01; ***P<0.001 ns: no significant difference				

6.4 Discussion

This section considers the implications of the findings presented in the previous sections, notably regarding public concern about climate change and concern levels related to different demographics (Section 6.4.1), improving public understanding of climate change (Section 6.4.2), and public perception of the climate related risks and phenomena influencing their perceptions of climate change (Section 6.4.3), and the effects of hazard experiences on public perception (Section 6.4.4). Section 6.4.5 provides some recommendations for improving public knowledge and perceptions of climate change based on the results from this research.

6.4.1 What Factors Affect the Public Concern about Climate Change?

The findings of this thesis are entirely consistent with Taiwanese (Hsu, 2013) and global research (Leiserowitz, 2007; Capstick *et al*., 2015b) which suggest that levels of concern about climate change are significantly high (Capstick *et al*., 2013; Moser and Tribbia, 2006; Yu *et al*., 2013; Capstick*et al*., 2015a). These previous studies, conducted across many other parts of the world, including the UK, the US, China, and other developed countries, pinpoint that scientific certainty, media and policymaker attention, and observed impacts may increase the public concern about climate change. Despite increased levels of concern about climate change in Taiwan, climate change is not a priority issue, compared with other issues. The results of this study (Figure 6.12) are consistent with this and other recent research elsewhere such as that by Chou (2013), Lorenzoni *et al*. (2007), Zsamboky *et al*. (2011), Poortinga and Pidgeon (2003), Leiserowitz (2007), Whitmarsh (2009), Lorenzoni and Hulme (2009), Lorenzoni and Pidgeon (2006), Capstick *et al*. (2015a), which reveal that the general public is more concerned about environmental issues, natural disasters, and economic development more than climate change. This thesis demonstrates that different respondents' profiles influence their concern about climate change in Taiwan. The detailed discussion is as follows:

Age:

The thesis findings (Figure 6.4; Table 6.2) show that older people are more concerned about climate change than the young in the four cases. These findings are consistent with results of previous research by Capstick *et al*. (2013) and Hsu (2013), referring to studies in the UK and Taiwan. The author suggests that people aged 35 and over may be more concerned about climate change in Taiwan. This result may be explained by considering their previous hazard experiences and also their own personal observations of weather-related events, as Sheridan's (2007) observes. In contrast to older people, Howe *et al*. (2013) and Fortner *et al*. (2010) suggest that young public might be unable to identify uncertain and intangible issues through a lack of personal experiences and observations, but they should have multiple information sources (e.g. educational system, internet, mass media) to access the relevant information on climate change. Therefore, the author suggests that young people who less concerned about the issue of

climate change in Taiwan may have this view because of insufficient or ineffective education and information about climate change.

Location of residence:

From the perspective of the location of residence of respondents, the findings (Figure 6.6; Table 6.4) of this study indicate that the respondents who live in Kouhu, Linbian, and Jiadong are more concerned about climate change than the respondents in Mailiao. It is known that these three rural townships are vulnerable to climate change because of their high resource-related industry (Figure 5.3), insufficient infrastructure (Figure 5.4) and medical services (Figure 5.10). Consequently, these may influence the people's views and give rise to more concern about climate change in these townships. As noted by Roncoli (2006), climate change may be more closely connected with the livelihoods of local communities in rural areas.

Other previous studies (such as those by Bravo and Marelli, 2007; Lebel, 2013; Gifford *et al*., 2009) also highlight that rural residents have significant perception of the local climate, as they are generally more concerned about environmental issues than communities from industrialised areas. As Section 5.3.1 reveals primary industrial activities are the main economic sectors in Kouhu, Linbian, Jiadong. However, these primary industries (agriculture and aquaculture) are clearly highly dependent on the natural environment and related resources. Therefore, the author would concur with the viewpoint that the specific economic activities and communities' livelihood may influence their concern about climate change. In addition, the frequent and disastrous flood events in Linbian and Jiadong in recent years may also be a possible reason for increasing concern about climate change (Chanson, 2010; Shieh *et al*., 2009). The results of flood experiences in relation to the level of concern about climate change verify this opinion.

Educational degree:

The study has revealed interesting results associated with respondents with different educational degrees (Figure 6.8 and Table 6.6) indicates that the groups of low-educational degree (primary or under) and high-educational degree (MSc and Ph. D) are both the most concerned about climate change. In this context, firstly, it should be noted that there has only been compulsory education in Taiwan (generally from 7 years

old) for 9 years from 1968, and 12-year compulsory education only from 2014 (MOE, 2015). Therefore, the group of respondents with an education level of primary or less who are highly concerned with the issue of climate change comprises mostly the elderly. Compared with low-education groups, the more highly educationed groups are more generally concerned about climate change. This may be because they are able to access a variety of information sources and also be better equipped intellectually to understand and appreciate knowledge about climate change.

Occupation:

This study shows that there are different levels of concern regarding climate change associated with people from different occupation groups. Figure 6.9 and Table 6.7 show that educators, civil servants, and homemakers are more concerned than others. These results are consistent with those of Hsu (2013). This author had highlighted that civil servants and managers were the most concerned about climate change in a more general survey of public perception on climate change in Taiwan. The findings from this study imply that those with occupations (educators, civil servants) which require high-educational degrees may more concerned. The author thinks that the reason for homemakers being more concerned about climate change may relate to gender because most homemakers are wives or females in Taiwanese society. Whilst the influence of the value orientation of different genders on environmental concern has been recognized by Dietz *et al*., 2002 and Shields and Zeng (2012), the general findings presented here relating to gender study in relation to public concern about climate change (Table 6.3), however, go against this view.

Annual incomes:

The findings (Figure 6.10; Table 6.8) suggest that the groups with high household incomes (more than £15,000) are more concerned about climate change than those from low annual income households (less than £14,999). Studies based on a variety of socio-economic contexts elsewhere (Kahn and Kotchen, 2010; Pidgeon, 2012; Scruggs and Benegal, 2012) emphasise that the business cycle and changing economic conditions may influence public concern of environmental issues. This viewpoint has been supported by Brulle *et al*. (2012) and Lorenzoni *et al*. (2007), based on studies in western-style highly developed economies. These authors suggest that low income has a

negative impact on public concern for climate change with the general public attaching greater importance to unemployment, economic prosperity and financial concerns rather than climate change. The results of this study, from a very different country situation, clearly support these findings, indicating that climate change may not be the top priority to low income households. Furthermore, there are potentially serious implications of this. The author suggests that if the low-income people are not concerned about the issue of climate change, they are likely to be more vulnerable to the potential impacts from future climate change because their low resilience capacity (cross ref: Section 5.4.1).

Flood experiences:

The findings of this study (Figure 11; Table 9) indicate that direct flood experiences are an essential contributing factor for increasing public concern about climate change. These results support the views of Mortreux and Barnett (2009) and Spence *et al*. (2012) who state that communities' whose security and properties have been affected by environmental changes, and residents have increasingly been exposed to physical impacts of climate change (Arctic Climate Impact Assessment, 2004), might be highly concerned about climate change. Given the findings reported by this study, the author would concur with the opinion of Spence *et al*. (2011) which suggests that flood experiences are significantly related to the way that individuals perceive climate change, especially those with firsthand experiences of flood events.

In summary, these findings lead us to believe that the level of public concern about climate change is dramatically high in Taiwan. Furthermore, this study has demonstrated that not only the high-income and highly-educated communities, but also the elderly and less educated communities, are more concerned about climate change. The author speculates two potential explanations for this. Firstly, communities with high socioeconomic status (high income and high-education) may have better access to information sources or be more capable of understanding scientific evidences about climate change. In contrast, experiences of weather-related hazard events and personal observation may tend to increase the concern of low socioeconomic communities', such as the elderly and the less educated. Therefore, the author also suggests there is a direct correlation between public concern about climate change and different socioeconomic

status and hazard experiences. This implies that socioeconomic characteristics not only play significant role in community vulnerability but also influence their concern about climate change. The local adaptation frameworks need to develop ways to increase effectively different communities' concern. Disappointingly, while Taiwanese universities and different levels of schools have offered curriculums on climate change, young communities and students show little concern about climate change. Therefore, future research should place more emphasis on exploring the awareness of young communities to climate change, and should try to establish the influence of various education programmes and materials on young communities and students' perceptions of climate change.

6.4.2 How to Improve Public Understanding of Climate Change?

The results (Figure 6.14) are consistent with Capstick *et al*. (2015a), in that most respondents agreed that climate change is caused by both natural processes and human activities. These results imply that the general public suspects that climate change is partly anthropogenic in origin in Taiwan. Based on others' research from across the world, studies have shown that the general public tended to have a limited understanding of the contribution of human activities' to climate change during the 1990s (Lorenzoni and Pidgeon, 2006). However, more recent studies have shown that the public has gradually begun to acknowledge the influence of anthropogenic activities (Lorenzoni *et al*., 2006; Whitmarsh, 2009). Indeed, over the last decade, research conducted in the UK (Whitmarsh *et al*., 2011; Whitmarsh, 2009), Australia (Sutton and Tobin, 2011), the US (Leiserowitz *et al*., 2010) and China (Wang and Li, 2012; Yu *et al*., 2013) has suggested that most people now believe climate change is completely caused by human activity. Although the Taiwanese public (33.7%) has endorsed this idea, it is less so than in most other countries (Pelham, 2009) including, South Korea (92%), Japan (91%), Thailand (70%), Malaysia (63%), Canada (61%), China (58%), American (49%), and the United Kingdom (48%). While there is a high level of public concern about climate change in Taiwan, the results presented here (Table 6.10) do not support the findings of Capstick *et al*. (2013), which suggest that levels of concern about climate change are related to public perception of the causes of the change.

Previous research (Egan and Mullin, 2014) pinpoints the gap between the scientific consensus and the public's beliefs about the cause of climate change. This includes research from the Pew Research Center (2009) which states that 84% of scientists thought that the earth is getting warmer because of human activity while only a half of the general public endorsed the idea in the U.S. This implies that the consensus about the causes of climate change amongst experts and scientists is anthropogenic (Doran and Zimmerman, 2009), but lay-people are more skeptical of the idea that it is a human-induced problem (Whitmarsh, 2009; Ratter *et al*., 2012). Patt and Dessai's (2005) suggest that the uncertain perception of the cause may be due to the interaction of humans and the natural system is complicated to laypeople. The uncertainty and skepticism of the causation of climate change might be the key barrier for the public's willingness to support or undertake adaptation actions (Bichard and Kazmierczak, 2012; Alexander *et al*., 2012; Buys *et al*., 2012; Taylor *et al*., 2014). So, a clear understanding of anthropogenic climate change may result in raising personal responsibility to reform behaviour and willingness to act (Weber, 2010). In summary, the author advices that the scientific evidence is a critical determinant for improving public perception of climate change in Taiwan and much can be learnt from others' research to inform general public through various information sources.

Whilst Lorenzoni and Hulme (2009) suggest that relevant information could be used to raise the public resistance and response to climate change, as noted above, not all information sources are trustworthy (Weber and Stern, 2011). While information sources on climate change are multiple, the author would concur with suggestion of Upham *et al*. (2009), Weber (2010), and Weber and Stem (2011). This suggests that climate change information which is deemed to come from credible information sources will be more acceptable to public: this aspect needs to be taken into account when designing and developing suitable communication programmes and activities.

Unsurprisingly, the results (Section 6.2.4) from this study are remarkably consistent with those in the wider academic literature which suggest that TV is the most trusted of the media sources (Hargreaves and Thomas, 2002). However, the media is the most common information source with moderate trust in the England (Whitmarsh, 2009), the US (Lorenzoni *et al*., 2006), and China (Wang and Li, 2012). In a Taiwanese setting

Hsu (2013) suggests that the mass media (such as TV, newspaper and internet) is the most trusted information source on climate change, and suggests that the main reason for this is the relatively limited availability from other information sources. However, the internet is another trustworthy information source in Taiwan. In contrast, elsewhere, in Peru, Orlove *et al*. (2004) indicate that the internet might not be able to facilitate an equitable flow of information of climate change across all social groups as a result of technological and economic limitations. Based on such studies, therefore, the internet may be not such a good communication tool for sharing information with elderly and economically vulnerable groups. By contrast, people tend to distrust messages which come from government sources (Earle, 2004). The author would concur with Whitmarsh's (2011) suggestion, that the public have lost their faith in the government as a result of recent experiences of weather-related hazard events. She suggests that a decrease in the public trust in official information from central and local governments have come about as a result of the public considering governments to be both irresponsible and inactive in such circumstances.

Significantly, Stamm *et al*. (2000), Fortner *et al.* (2000), Whitmarsh (2011), and Parker *et al.* (2011) underline media coverage may cause incorrect perceptions and behaviour toward climate change. The surveys in the US (Antilla, 2005; Boykoff and Boykoff, 2004) and the UK (Whitmarsh, 2009) suggest that uncertainty and skepticism about climate change may partly stem from mixed messages in the media. There are number of possible explanations for this, such as simplified translation from scientific reports, incorrect interpretation affect public understanding, reporting is inconsistent with public experience (Gifford, 2011; Taylor *et al.*, 2014), exaggerated and radical media coverage may lead to a falling-off of concern (Hargreaves *et al.*, 2003; Pidgeon, 2012). Whilst there is no explicit evidence from this study to suggest that these are prevalent issues in Taiwan, the author still suggests that the cooperation between mass media, scientists and governments could be a practical way that can provide accurate scientific analysis and simplified and visualised information or data (O'Neill and Hulme, 2009; Roncoli, 2006; Dessai *et al.*, 2005), understandable interpretation with familiar language (Lowe *et al.*, 2006; Whitmarsh, 2008; Santha *et al.*, 2014; Roncoli, 2006; Chou, 2013; Moser and Tribbia, 2006) and increase the accessibility of relevant information to the general public.

6.4.3 Is Public Concern Over Climate Change and Personal Observation of Local Weather Events related to Public Perception of Climate Change?

As noted above, the findings from this study (Figure 6.18) support the opinion that most people acknowledge that climate change is happening and will continue to affect their lives (Dunlap, 1998; Wang and Li, 2012; Capstick *et al*., 2015a). Nevertheless, previous studies suggest that the idea of prominent personal threats from climate change is indefinite to the general public in the US and the UK in the last decade (Bord *et al*., 2000; Lowe *et al*., 2005), and the skepticism is still high in these countries (Leiserowitz, 2005; Eurobarometer, 2009). One possible explanation for this is that the influences of climate change are geographically and temporally different by multiple hazards (Moser, 2010). Consequently, the general public's views on climate change are likely to be influenced by emotions, values and viewpoints from unforgettable hazardous events (Keller *et al*., 2006; Marx *et al*., 2007; Loewenstein *et al*., 2001), rather than scientific evidence (Weber and Stern, 2011).

The results of this study (Figure 6.13) are consistent with other global research (Pew Research Center, 2006; Krosnick *et al*., 2006; Leiserowitz *et al*., 2005; Bord *et al*., 2000; Eurobarometer, 2005; Palmgren *et al*., 2004; Leiserowitz 2007; Lorenzoni *et al*., 2006), that suggests that the impacts of climate change related to personal security and economic development have higher priority. This argument is supported by the frequent flood events which have threatened personal safety in recent years in the case study areas of Taiwan (Section 6.3.1). Therefore, this research supports previous research (Reynolds *et al*., 2010; Taylor *et al*., 2014; McCright, 2009; O'Connor *et al*., 2002; Zahran *et al*., 2008), which suggests conflating the risk of climate change with environmental problems, pro-environmental values, and significant loss of life and economic benefit may be able to engender public attention and produce positive influence on the public perception of climate change.

There are a number of possible explanations for climate change being perceived as a distant issue to the public which may be relevant to the Taiwanese case studies but which need further research. Possible reasons which have been cited include the public's opinion that other contemporary issues are more critical, and that their regions are unaffected (Upham *et al*., 2009), that immediate risks are considered to be more

important than the future risks (Hardisty and Weber, 2009), different individual standards and values (Lindenberg and Steg, 2007; Nordlund and Garvill, 2002; Stern, 2000), and different perceptions on climate change exist between communities and scientists (Weber, 2010). Previous research (McCright, 2010; Capstick *et al*., 2012; Leiserowitz, 2007; Whitmarsh, 2011; Lorenzoni *et al*., 2007; Upham *et al*., 2009; Howe *et al*., 2013) proposes that specific circumstances may affect public perception of climate change.

Moreover, previous studies (Taylor *et al*., 2014; Egan and Mullin, 2014; Weber and Stern, 2011; Hertwig *et al*., 2004) show that public concern and individual experiences of extreme weather events may strengthen awareness of climate change. The results of this study, as shown in Table 6.11, show a connection between public concern about climate change and how the public perceive impacts of climate change. However, there is no clear linkage with flood experience in Taiwan, as might have been expected. This may be because climate change was not considered a major cause of flooding (Section 6.3.2): indeed most respondents considered artificial factors and natural factors to be the main cause. Therefore, this thesis would concur with the opinion of previous studies (Krosnick *et al*., 2006; Li *et al*., 2011; Semenza *et al*., 2008), which indicate that public concern about climate change may highly relate to perception of the impacts of climate change.

Srang-iam (2013) highlights that these direct observations and repeated weather phenomena or hazards may play an important role in influencing public perception of climate change. The results (Figure 6.2) of this study show that flooding was the most tangible hazard related climate change, with experiential learning influencing public perception. This implies that people gave a lot of weight to recent or repeated hazard events and personal observations (Hertwig *et al*., 2004; Marx *et al*., 2007; O'Connor *et al*., 2005; Myatt *et al*., 2003). Furthermore, these local respondents also were aware of changes in other phenomena, notably extreme rainfall, temperature and seasonal cycle change, The valuable interpretation from this is that these phenomena can be directly observed (Whitmarsh, 2009; Lorenzoni *et al*., 2006; Hinds *et al*., 2002; Dunlap, 1998, Lebel, 2013) or these phenomena are intimately related with local livelihoods (Roncoli, 2006). As shown by Figure 6.2, changes in the frequency of extreme rainfall, seasonal

cycle change, and temperature change may have significant effect on individuals and people whose livelihood depends on the weather (e.g. farmers and aquaculture fishermen) in rural areas.

Although these significant changes have been recognised by Taiwanese communities and have increased the salience of climate change, previous studies (Weber, 2010; Weber and Stern, 2011; Keller *et al*., 2006) query whether laypeople can accurately identify the changes by personal observation, or they are misled by memorable extreme events. Particularly, this may be true if the observations are well spaced in time and personal memory of past events might be faulty (Weber, 2010). In the case of flood events in South West Taiwan, this is relevant because of the annual average of flooding was a factor of 7.4 times different between 2000 and 2009. False impressions of climate change may be created by the general public who lack a clear connection between direct experiences and reliable evidence (Eiser, 2004). Therefore, Kelman and West (2009) suggest that valuable public observations cannot be a panacea for climate change adaptation, and, as such they indicate climate change still needs to be cross-validated by instrumental observations (Lebel, 2013).

Some public observation of local phenomena and events in this study have been corroborated by the results of scientific instrumental observations in Taiwan, such as sea level rise, extreme rainfall, and temperature changes (as evidenced by Hsu *et al*., 2011). Indeed, these local communities' observations and experiences can be combined with scientific forecasts and analysis to enhance the relevance between local hazards and global climate change (Roncoli, 2006; Lebel, 2013). Therefore, the integration of risk experiences, public observation, and scientific information about the causation of climate change might be able to create concrete public understanding and perception about climate change. Consequently, this research would concur with that of Santha (2014) and others in suggesting that local knowledge is an important component influencing climate change adaptation. Building on this, many authors suggests that community-based adaptation needs to be based on both local and scientific knowledge through cooperation of scientists with communities in order to reduce the cognitive bias of lay people (Berkes, 2009; Kahneman, 2003; Marx *et al*., 2007).

6.4.4 Does the Hazard Experience Affect the Public Perception of Climate Change?

As mentioned above, as coastal communities have been suffering frequently from flood events, it is likely that this has built up a catastrophic sensation of climate change to most residents in the flood-prone areas over the years. The results suggest that the Taiwanese public believes that extreme rainfall, sea level rise, and storm surge are examples of phenomena generally deemed related to climate change, and are not merely just the direct cause of flooding (Figure 6.24). This is consistent with a previous study in Taiwan (Lee and Chi, 2014) which suggested that, for houses below ground level, water flowing from overflowing embankments was the main cause of flood. Indeed, generally it is likely that most Taiwanese believe that the floods in coastal areas are man-made and that adequate infrastructure is the key solution. Contrary to this, previous findings in the UK (Department for Environment, Food & Rural Affairs, 2002; Capstick *et al*., 2015a), have suggested that the public considered recent flood events were due to climate change. Therefore, future research should place more emphasis on exploring public awareness of flooding in Taiwan, in order to find the gap between public and experts' perceptions on flooding.

Moreover, although the majority in Taiwan agrees that the frequency and intensity of floods will increase, the risk perception of flood victims seems slightly higher than the rest (Figure 6.26, Figure 6.27). These results are line with the opinions of Grothmann and Reusswig's (2006) who suggest that individual hazard experiences might affect public perceptions of hazards. It is possible that the victims not only have perceived the greater risk of flood, but also have felt great sense of dread and serious threats to their life (Ho *et al*., 2008; Harries, 2012; Bradford *et al*., 2012). Furthermore, these results of this study show a quarter of respondents were not sure about the frequency and intensity of flood in the future, where lack of visible signs and scientific evidences could be the possible reason (Burningham *et al*., 2008). To sum up, disaster experiences are suggested to be good predictors of risk perception, but the risk perception of the public may be uncertain without tangible evidence.

While climate change itself cannot be experienced directly, the public may learn and perceive relevant climatic impacts associated with direct experiences. Previous studies

suggest a connection between hazard experiences and public perception of climate change and adaptation, such as increasing the belief in climate change (Deryugina, 2013; Egan and Mullin, 2012; Li *et al*., 2011; Salick and Ross, 2009; Newsham and Thomas, 2011), public concern about climate change (Marx *et al*., 2007; Grothmann and Reusswig, 2006; Trope and Liberman, 2010; Weinstein *et al*., 2000; Reser *et al*., 2014; Weber, 2006;), and willing to take adaptation behaviour (Shackley and Deanwood, 2002; Spence *et al*., 2011; Deressa *et al*., 2009; Brulle *et al*., 2012). Therefore, it is important to understand how flood experiences influence public perception of climate change and adaptation action in Taiwan.

Firstly, flood experiences have deeply affected public perception of climate change in Taiwan, increasing their belief in climate is change and increasing their concern for climate change, leading them to need more relevant information (Section 6.3.4). One widely acceptable explanation is that personal experiences and impacts of climate change might be an extremely effective motivator to encourage general public to acquire more relevant information and improve their understanding of climate change (Fortner *et al*., 2000; Weber, 2010). Therefore, the findings of this study support those of previous studies (Wagner, 2007; Zsamboky *et al*., 2011; Harvatt *et al*., 2011; Wagner, 2007; Mortreux and Barnett, 2009) that flood experiences can be seen as an elicitation. As such these are able to influence the public concern about climate change and also generate greater knowledge and response.

Additionally, the results of Section 6.3.4 assert that flood experiences have created an indelible impression of climate change on the public (Payne and Pigram, 1981; De Man and Simpson-Housley, 1988; Burningham *et al*., 2008; Werritty *et al*., 2007), and increased the public's willingness for undertaking actions to respond to the inevitable impacts of climate change and to protect themselves (Wong and Zhao, 2011; Harries, 2012; Lamond *et al*., 2009; Soane *et al*., 2010; Whitmarsh, 2008; Lorenzoni and Pidgeon, 2006). Nevertheless, Harries (2012) highlights that direct hazard experiences may also decrease public willingness to take up action as a result of mental barriers, such as anxiety and avoidance. The results from Section 6.3.4 question this opinion because only a limited proportion of the public thinks it is impossible and time is lacking to tackle flooding associated with climate change in Taiwan. Therefore, these

findings imply that although hazard experiences might produce the pessimistic idea about climate change, it still can be viewed as a salient influence in the case of perceived threat from climate change.

Lastly, the study also notices that the results from this study (Table 6.12) show remarkable consistency amongst the people with flood and no flood experience. These results may be explained by those with no direct flood experiences being influenced by indirect experiences and information, through hearing and reading about others' various experiences (Weber, 2010; Lowe, 2006) and from virtual experiences (Werritty *et al*., 2007; Reser *et al*., 2014) from media coverage or motion pictures. Therefore, future research should investigate any correlation between such direct and indirect factors (e.g.: particular media reports, personal observation, and experiences sharing from friends and family members) on the public's perception of climate change.

6.4.5 Developing a Conceptual Model of Public Awareness of Climate Change

This section presents a comprehensive conceptual model (Figure 6.29) for evaluating and representing the connection between public perception, demographics, and flood experiences in Taiwan. Furthermore, a significant understanding of public awareness of climate change was obtained from above discussions and hypothesis verification (Table 6.13).

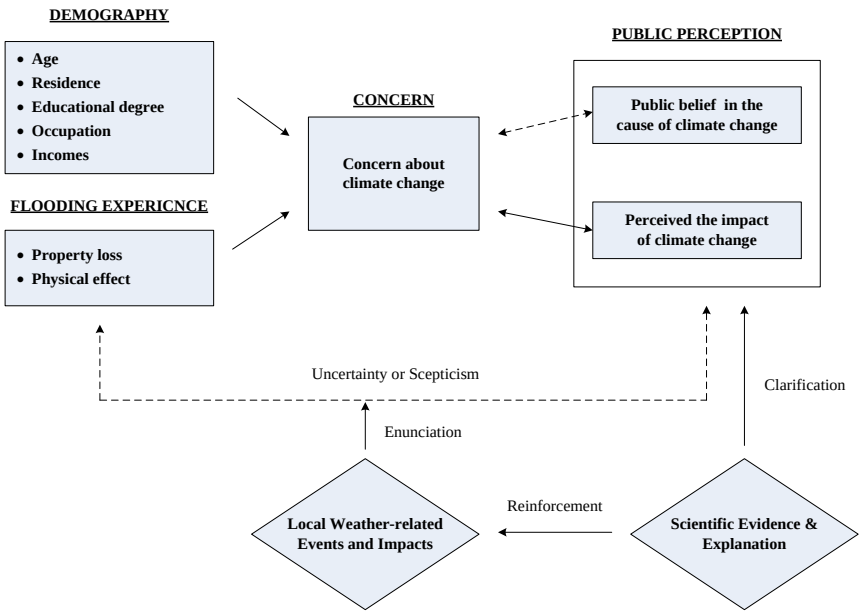


Figure 6.29: The conceptual model of public awareness of climate change

Table 6.13: Hypothesis verification of public awareness of climate change

Variable	Hypothesis	Verification
Age	A significant difference between different ages in relation to concern about climate change.	**Supported***
Gender	A significant difference between gender in relation to concern about climate change	Unsupported
Residence	A significant difference between different types of residences in relation to concern about climate change	**Supported***
Length of residence	A significant difference between different lengths of residence in relation to concern about climate change.	Unsupported
Education	A significant difference between different educational levels in relation to the level of concern about climate change.	**Supported***
Occupation	A significant difference between different occupations in relation to the level of concern about climate change.	**Supported***
Income	A significant difference between different annual incomes in relation to the level of concern about climate change	**Supported***
Flood experiences	A significant difference between different flood experiences in relation to the level of concern about climate change.	**Partially Supported***
	A significant correlation between flood experiences and belief about causation of climate change	Unsupported
	A significant correlation between flood experiences and perceived impacts of climate change	Unsupported
	A significant difference between flood victim and non-food victim in relation to conception of climate change	Unsupported
Concern	A significant correlation between concern about climate change and belief about causation of climate change	Unsupported
	A significant correlation between concern about climate change and perceived impacts of climate change	**Supported***

This conceptual model suggests three vital findings related to public awareness of climate change: 1. Several demographic variables and direct experiences of flood events may influence levels of public concern relating to climate change; 2. Although most people are concerned about climate change, this is not correlated to public belief in the specific cause of climate change, and; 3. Direct flood experience may increase public awareness of climate change, but direct flood experience and weather related events may not the unique factor in influencing public perception of climate change in Taiwan.

The second crucial idea focuses on the public understanding of the cause(s) of climate change. Although most people have begun to express some concern about the issues of climate change, and are aware of frequent weather-related events and harmful impacts have increased in recent years, the public still argue about the real causes of climate change. This implies that the public concern related to climate change and weather-related events may be not conducive to increased public understanding of the causes. Furthermore, Taylor *et al*. (2004) suggest two potential factors may be able to increase public awareness of climate change: direct observation of weather-related events and its' subsequent impacts; and these local weather-related events are considered as the result of climate change. In this study (Section 6.2.1), several salient weather-related events and specific phenomena related to climate change have been observed by the general public, such as flooding, but the anthropic factors were considered as the major cause by the Taiwan public. Therefore, the author would concur with the opinions of Keller *et al*. (2006), Weber (2010), Whitmarsh (2008) and Leiserowitz (2006) who suggest that climatic events have produced remarkable impacts and disastrous consequences which have made an indelible impression on coastal communities.

Finally, this research (Section 6.4.4) suggests that personal observations of weather-related events and impacts, and direct hazard experience may be incapable of developing adequate and complete public understanding of climate change without the tangible scientific evidence and accessible explanation. Previous studies (Reser *et al*., 2014; Deryugina, 2013; Egan and Mullin, 2012; Capstick *et al*., 2015b) highlight that it is important to clarify the direct and explicit connection between these repetitive and salient weather-related events and the inevitable process of climate change, which may be able to strengthen the public perception, concerns, responses, and engagement with climate change. Therefore, this thesis underscores the importance of tangible evidence and scientific demonstration to clarify public uncertainty and skepticism of anthropogenic climate change in Taiwan, especially the causation of climate change.

In conclusion, even though this research has the undeniable merit of offering a valuable insight into public awareness of climate change, the design of the present study is not without limitations. Its major limitation concerns the specific weather-related events of

the case study are. The survey was conducted in coastal and land subsidence areas where flooding was considered by the researcher as a key representative event of climate change. However, weather-related hazards are distinctive in different geographies and areas in Taiwan. Therefore, the generalisation of the results to other populations with different hazard experiences may be limited. The author suggests that broadening the analysis of the influence of different weather-related hazard experiences (e.g. sea level rise, mud slide) on public awareness of climate change should be undertaken to determine the potential influences of other climatic hazards on different communities' perception of climate change in Taiwan.

6.5 Summary

This chapter describes the flood experiences and public awareness of climate change, and the interaction between these for populations residing in the coastal flood-prone areas of Taiwan. Flooding provides some of the most observed events, the phenomena of most concern in relation to climate change, and the hazard which has most frequently affected coastal communities in recent years (Section 6.2.1). To sum up in relation to the flood experiences from the questionnaire survey, the majority of respondents had suffered direct and indirect impacts from flood (Section 6.3.1), and expressed concern that the frequency and intensity of flood risks are expected to increase over the century (Section 6.3.3). However, the questionnaire respondents did not regard climate change as the main cause of the local floods in the coastal areas (Section 6.3.2). Indeed, there is no statistically significant difference in the public perception of climate change between the group of people with flood experience and that with no flood experience in the flood-prone areas (Section 6.3.4).

Regarding public awareness of climate change, the majority of the respondents were concerned about climate change and its subsequent negative effects, especially the physical and socioeconomic ones (Section 6.2.2). A substantial number of communities also recognised impact from climate change (Section 6.2.5). However, environmental issues, natural disasters, and economic development remain their primary concern. In addition, it is clear that public opinion in Taiwan considers natural processes and human activities to be both major causes of climate change (Section 6.2.3). Lastly, the

interview respondents were clear in that they considered trustworthy information sources to be the media, NGOs, and scientists rather than the government (Section 6.2.4).

This section also verified these underlying hypotheses and developed the conceptualisation of public awareness of climate change in Taiwan. Firstly, the different socioeconomic backgrounds and direct experiences of flood victims potentially influence public concern of climate change. People who are concerned about climate change are also more likely to state that they have experienced the impacts of climate change. Significantly, this study indicated that most of its respondents have had hazard experiences and have been able to directly observe significant changes in local climatic phenomena or hazard events. However, direct and indirect experiences and experiential learning did not appear to contribute to increased public perception of climate change in this study. As stated previously, this research suggests that increasing public confidence in the scientific interpretation and acceptable evidence of climate change may effectively improve public perception of climate change. In considering the great influence of public awareness on the issue of climate change adaptation, the following chapter discusses the role of public perception, public understanding, and public concern in community engagement in climate change adaptation in Taiwan (Section 7.5.2).

Chapter Seven The 'Action' component of the AAA framework

7.1 Introduction

This chapter in focusing on the 'action' component of the AAA framework is informed by results from the public questionnaire as well as the expert workshop and follow-up questionnaire. It covers responses related to climate change, community engagement in adaptation actions, and critical issues related to the local adaptation framework and action from the PESTLE aspects (Figure 7.1). Results from the public perspective regarding personal and governmental actions, efficacy and the prioritization of proposed actions are demonstrated in Section 7.2. Section 7.3 explores cognitive, affective, and behavioural factors that may influence community engagement in adaptation actions. The full data from the public questionnaire related to this are shown in Appendix H. Section 7.4 summarises the views of the experts and covers governmental actions and community engagement. It highlights the political, economic, social, technological, legal and environmental issues related to the local adaptation framework. Finally, Section 7.5 discusses the implications of these findings, focusing on public participation in response actions, critical factors of community engagement, and the challenges and opportunities relating to the local adaptation frameworks in Taiwan.

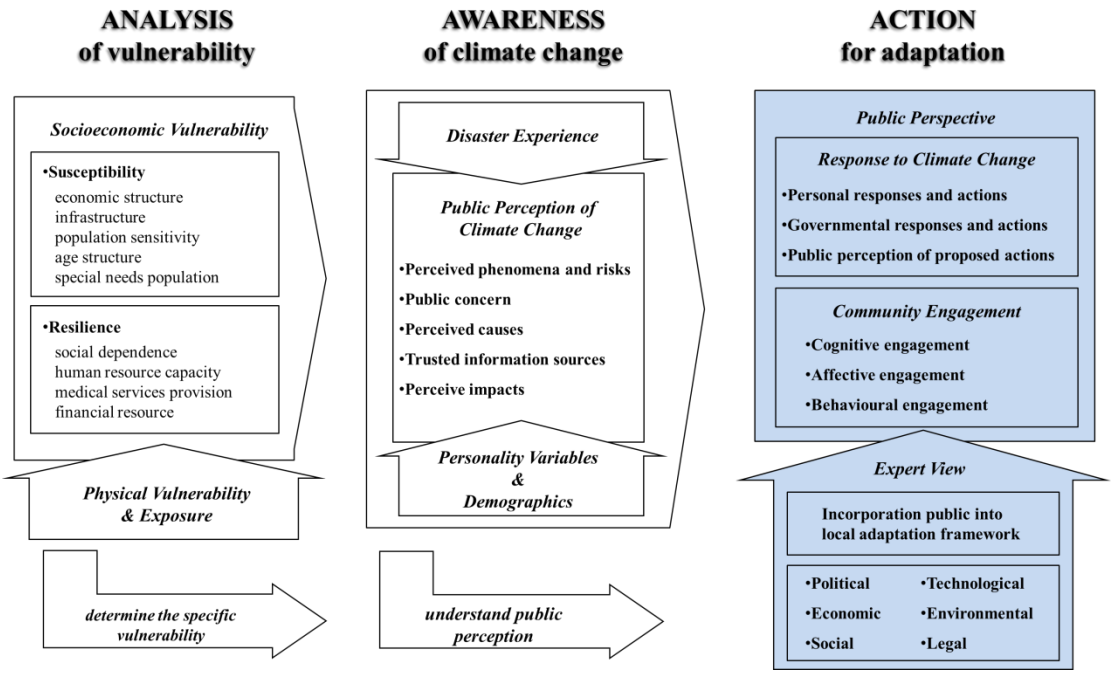


Figure 7.1: Action for adaptation in AAA framework (cross ref: Figure 3.1)

7.2 Public Perception: Response to Climate Change

7.2.1 Personal Responses and Actions

Time to take action

Whilst Section 6.2.1suggested that most respondents have observed and affected some phenomena related to climate change, they also perceived or experienced the damaging impacts of climate change (cross ref: Section 6.2.5). Flood experience and perception appears to encourage the Taiwanese to consider a need to take action to respond to climate change (cross ref: Section 6.3.4). Figure 7.2 shows that the majority of the questionnaire respondents thought that they need to take action now to adapt to climate change whilst only 3.2% thought that they need to do so within the next 10-100 years. However, an even smaller group, (0.6%) were of the opinion that they did not need to take any action at all and 3.3% 'did not know'.

Further analysis focused on whether public concern about climate change and flood experiences influenced opinions on when people expected action will be taken in future. Although we know that most respondents expressed concern about climate change (cross ref: Section 6.2.2), nearly half of the participants who were unconcerned about climate change said 'I do not know' in relation to the expected time to take action (Figure 7.3). Compared with Section 6.3.1 regarding flood experiences, almost 90% of flood victims and non-flood victims agreed that the public need to take action now to respond to climate change (Figure 7.4). Nevertheless, it must be noted that no statistical evidence for the connection between these variables.

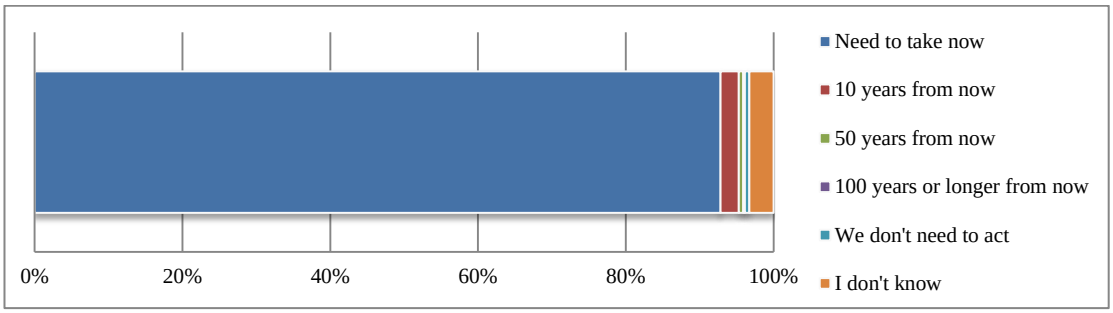


Figure 7.2: Expected time to take action to respond to climate change according to respondents – *showing that respondents recognised that they need to take immediate action*

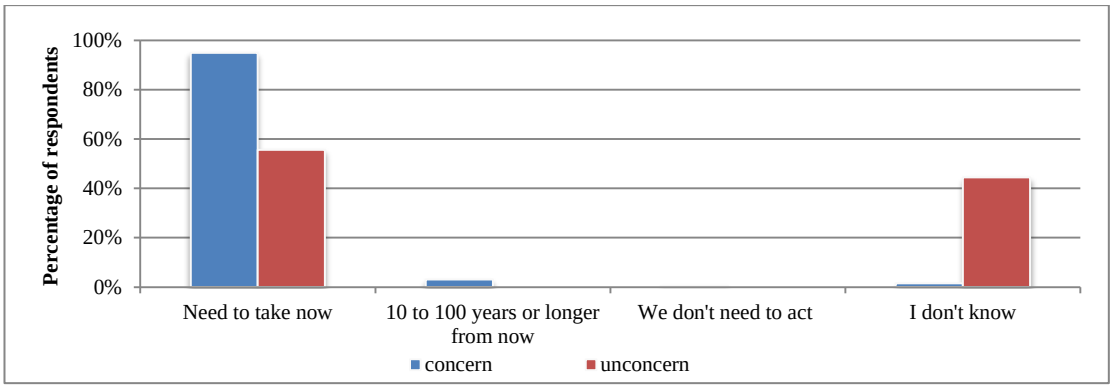


Figure 7.3: The expected time to take action in relation to concerned and unconcerned respondents – *showing that respondents who were concerned about climate change tend to support the opinion that they need to take immediate action*

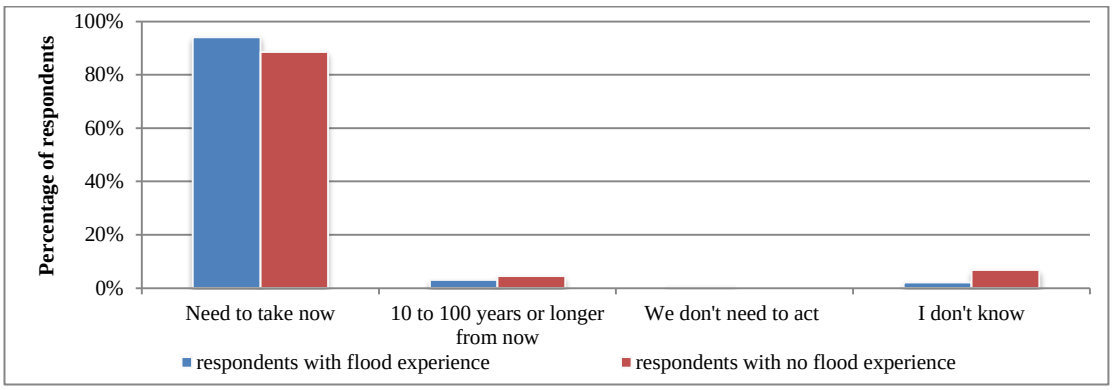


Figure 7.4: Respondents' expected time to take action in relation to flood experience – *showing that flood victims and non-flood victims both supported the opinion that they need to take action now*

Personal actions that have been taken and their motivations

The survey results in Figure 7.5 show that most respondents suggested they have already taken personal actions in their daily routine to adapt to climate change. Such actions include recycling (25.8%), turn off unwanted lights (22.2%), use energy-conserving facilities (15.3%), and bring own bags or self-prepared tableware (15.1%). However, it appears that the major motivation factors for taking these personal actions related to a range of factors other than those which were climate change specific. These included reasons related to individuals' concern for environment protection (27.6%), as well as matters related to personal habits (17.3%), and saving money (16.8%). Only a small group of respondents (8.1%) took the above actions in order to tackle climate change (Figure 7.6).

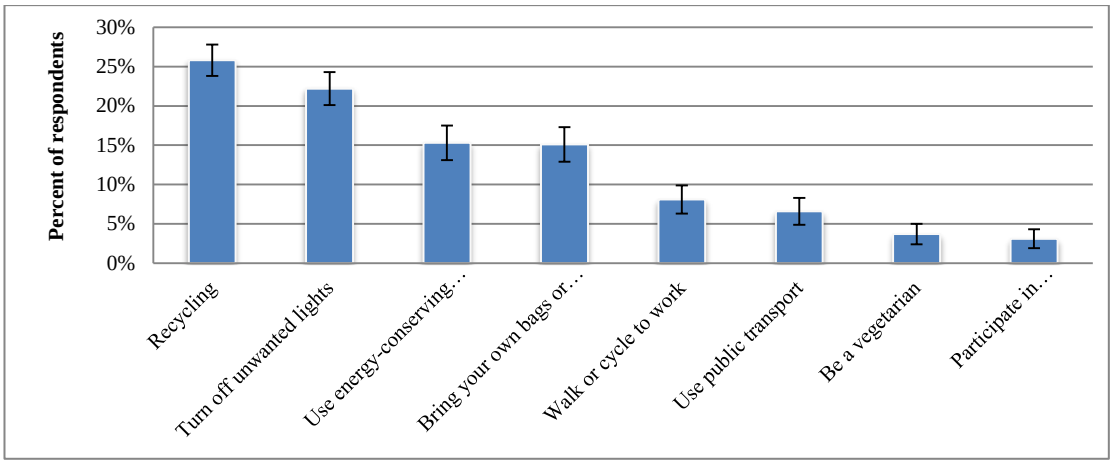


Figure 7.5: Types of personal actions taken by respondents – *showing that a range of relevant personal actions have been taken, particularly recycling and energy conservation*

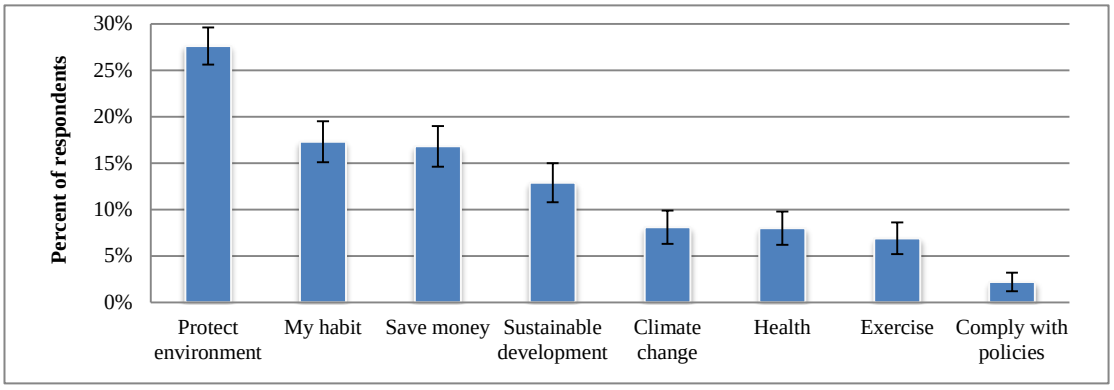


Figure 7.6: The factors motivating respondents to take actions – *showing that climate change is not the critical motivator for personal actions*

7.2.2 Governmental Responses and Actions

Governmental actions

Previous results (Section 6.3.4) demonstrated that more than 60% respondents consider that current measures and actions are insufficient and of limited efficacy. However, this section shows a very poor knowledge of government actions by the respondents. Figure 7.7 shows that nearly half (red) either thought that no government actions had been taken to respond to climate change (21.7%) or were unware of such actions (24.6%). Nearly a 20% of the respondents were aware that some monitoring and scientific investigation actions have taken place in relation to climate change. Fewer respondents (18.1%) were aware that government efforts to combat current impacts had been implemented. However, some respondents (15.2%) considered that there were fewer

actions preparing for future impacts. Furthermore, some representatives did recognise that some specific actions such as solar farms, hydro-system improvement, drainage system improvement, and road upraising had already been implemented in their county and they were aware that these would help prepare for climate change and make communities more resilient.

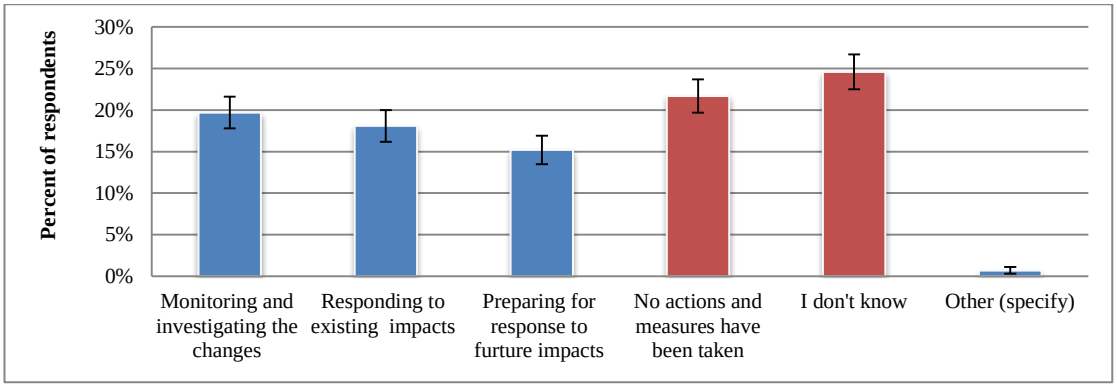


Figure 7.7: Public perception of existing governmental actions – *showing that most respondents had limited knowledge of government actions*

Institutional arrangements

The responses shown in Figure 7.8 are colour-coded by different types of needs. This reveals that more than half of respondents required more information (green), including understandable information (22.5%), dependable information sources (20.2%), and salient information (13.4%). These could be the possible reasons why Taiwanese distrust in informational from government (cross ref: Section 6.2.4). Almost a quarter (blue) expressed the need for a transparent process of decision-making (13.6%) and trustworthy policymakers (10.2%), and some representatives (orange) supported a definite role (11.5%) and incentives for public involvement (7%). The respondents considered effective communication and participation were their needs from government and associated official organisations.

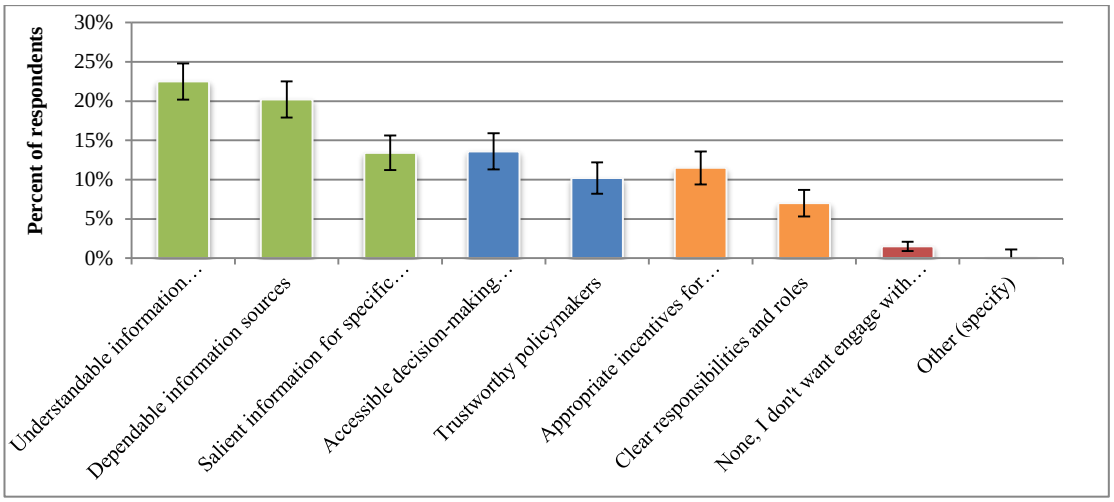


Figure 7.8: Public needs from institutional arrangements – *showing that the respondents indicated there are many information needs for the public, particularly the need for understandable and dependable information*

7.2.3 Public Perception of Proposed Actions

Efficacy of actions

Figure 7.9 shows the respondents' views regarding the proposed actions they considered would be most effective in helping tackle climate change. Most respondents believed that these particular actions can effectively tackle with climate change. These responses can be divided into two main types (Figure 7.10), colour-coded by type of action, including adaptation (blue) and mitigation (green) actions. The results reveal that the respondents thought that mitigation actions (saving the earth's resources, developing renewable energy, planting more trees) are more effective than adaptation ones. Furthermore, the public acknowledged that information transmission (education) and prevention actions (predication, emergency and warning systems), protection actions (more defences/improvements in current infrastructures) and the accommodation actions (compensation and disaster relief, increasing the flexibility of house and city design, industrial restructuring and transformation) would be the more appropriate practical actions. However, the respondents do not seem to support carbon tax and natural disaster insurance, and retreat as an action, including the removal of artificial buildings and facilities from natural environments and the relocation of residents and towns.

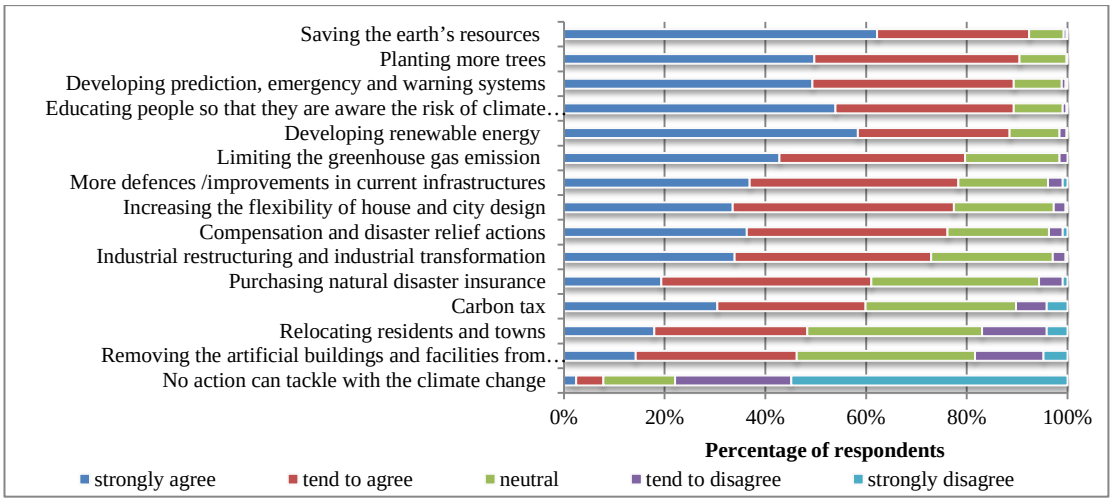


Figure 7.9: Efficacy of proposed response actions according to respondents – *showing that most respondents indicated that these actions can effectively tackle climate change*

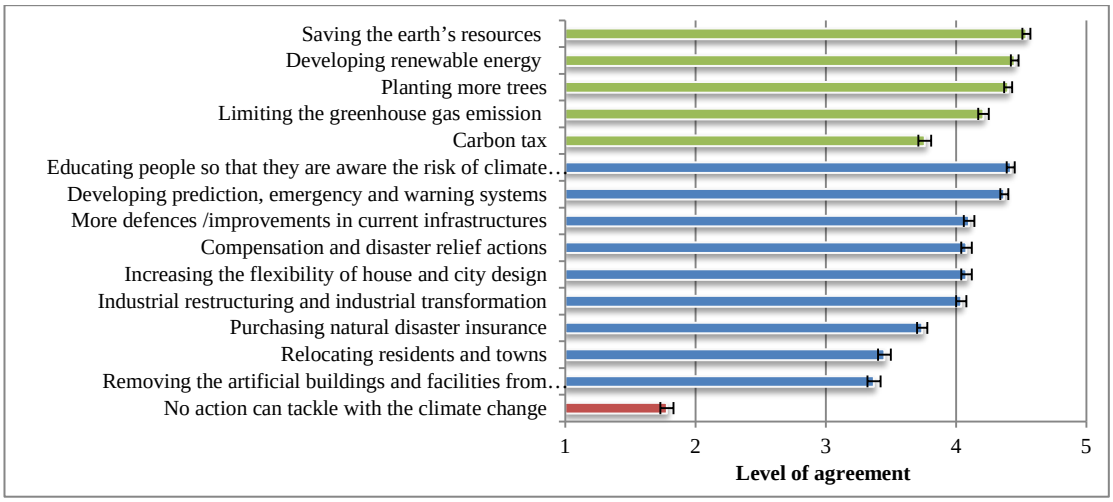


Figure 7.10: Efficacy of proposed response actions in relation to mitigation and adaptation actions – *showing that respondents suggested that mitigation actions are more effective than adaptation ones*

Priority of actions

Figure 7.11 demonstrates the respondents' views regarding priority actions. The survey results show that respondents thought that educating people, prediction, emergency and warning systems, compensation and disaster relief actions, saving resources, planting trees, and more defences/infrastructure improvement should be implemented immediately. Furthermore, they considered that medium-term and long-term actions should include: developing renewable energy, increasing the flexibility of house and city design, industrial restructuring and industrial transformation. However, these results also consistent with previous section in that the respondents generally did not consider

some proposed actions, such as removing artificial buildings and facilities from natural environments, relocating residents and towns, purchasing natural disaster insurance, and carbon tax, as ineffective. The potential explanations for this are discussed in Section 7.5.1.

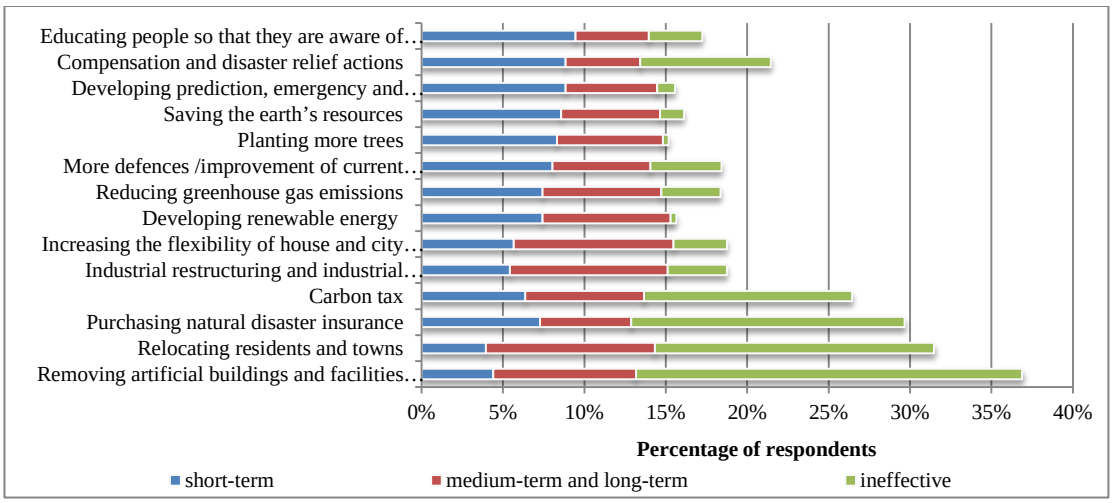


Figure 7.11: Priority of proposed response actions according to respondents – *showing that the public generally considers that carbon tax, insurance, relocating, and removing artificial facilities are ineffective actions*

7.3 Community Engagement in Local Adaptation Action

7.3.1 Cognitive Engagement

Figure 7.12 reveals that many cognitive factors may be relevant to community engagement in climate change adaptation actions. These include respondents' beliefs that climate is changing, human activities affect climatic systems, and humans should be responsible for climate change. Furthermore, there is a clear and widespread recognition that climate change is likely to have an impact on the natural environment. Some respondents also considered that climate change will also affect human society, vulnerable groups, and individuals. Moreover, those respondents that also supported the idea of sustainable development and believed that it is necessary to take adaptation actions, considered that they could do a lot to respond to climate change. The unpredictability of climate change was also well recognised by the respondents who also generally considered its impacts to be inevitable as well. Lastly, a small group of respondents agreed that climate change has benefits to specific communities and its impacts are irreversible.

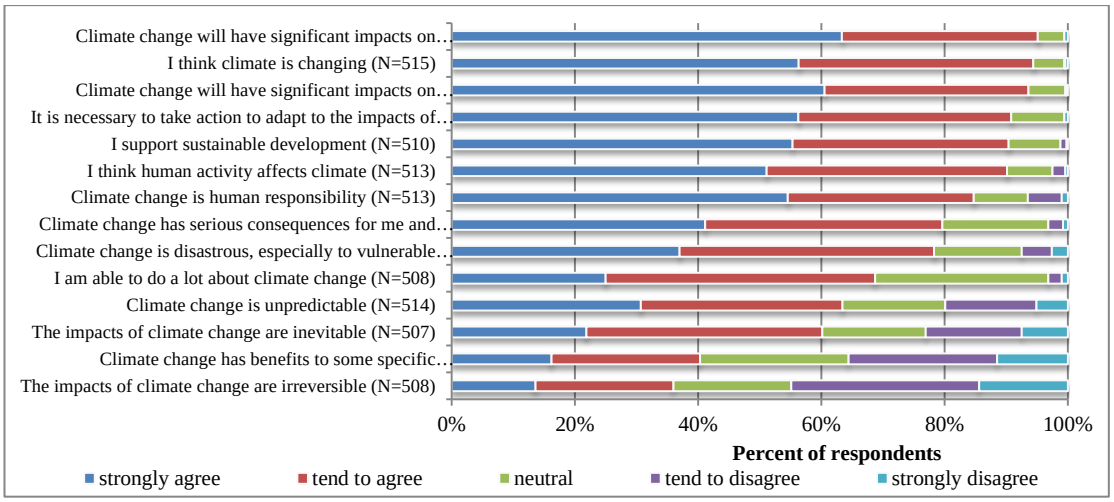


Figure 7.12: Cognitive factors in relation to community engagement in local adaptation – *showing that cognitive factors are significant to community engagement in local adaptation*

7.3.2 Affective Engagement

Figure 7.13 shows that affective factors are significant, and are likely to influence community engagement in climate change adaptation. Most respondents were concerned about climate change, and its impacts on individuals, natural environment, and human society. Furthermore, the majority also recognised climate change is a real problem and considered its impacts not to be overstated. This they considered, appeared to be linked to their direct experience, and their fear of its impacts. Moreover, most people agreed that the general information and science of climate change is certain. They were also affected by relevant reports in the media, and trusted the scientific evidences. Although they believe current actions will have effect on climate change, only one-third respondents trusted that the government will protect the people.

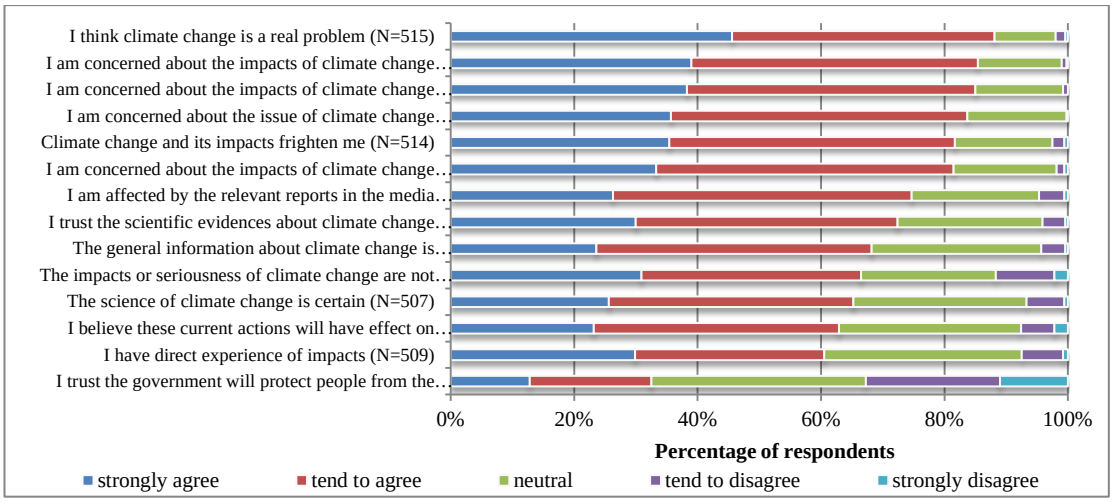


Figure 7.13: Affective factors in relation to community engagement in local adaptation – *showing that affective factors are significant to community engagement in local adaptation*

7.3.3 Behavioural Engagement

Figure 7.14 demonstrates the main constraints and barriers limiting community engagement in local adaptation. According to these results, the limited public support for climate change response actions (people are not doing enough) was the major barrier. Subsequently, inadequate information and communication about climate change adaptation actions, irreconcilable conflicts between economic development and climate change adaptation measures, the cost of relevant actions, giving priority to other issues, and not knowing what actions can be taken were seen as the critical barriers by the respondents. Furthermore, it is worth mentioning that more than a half of the respondents disagreed that time restriction, changing lifestyle, and these actions make their life more inconvenient are the significant constraints.

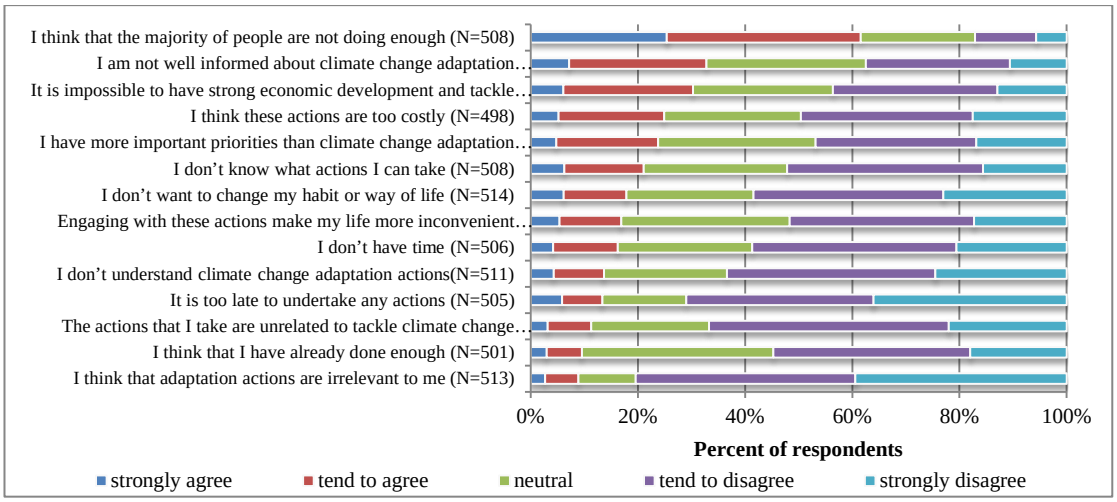


Figure 7.14: Behavioural factors constraint community engagement in local adaptation – *showing that many constraints and barriers limit community engagement in local adaptation*

7.4 Expert Views: Community Engagement and the Critical Issues of Local Adaptation Framework

This section presents the results of the final empirical stage of this research. It includes comments from experts and local executors on the implementation of local adaptation actions and community engagement, as well as a discussion of potential issues. See Appendix I for more detailed information concerning the discussions and opinions related to the expert workshop. A summary of the results from the follow-up questionnaire can be found in Appendix J.

7.4.1 The Status of Local Adaptation Actions and Community Engagement

Governmental actions and community engagement

As discussed in Section 2.4, public participation plays an important role in the practical application of adaptation actions. The experts agreed this with opinion and argued that "the Taiwanese public is unaware or unfamiliar with climate change adaptation" and "most people seem to consider mitigation actions as adaptation actions". For example, "most people think that the carbon emission reduction, recycling, energy conservation are key adaptation actions (Appendix I: 2.1)."

The local government representatives reported that common coastal adaptation actions include protection, retreat, and accommodation adaptation and noted that these, have been developed and implemented in all the counties (Figure 7.15). Surprisingly, they

noted that all these actions lacked an explicit community engagement mechanism (Figure 7.16). There was general concern that the public are ignorant about local adaptation actions, noting the "insufficient publicity" and "lack of effective communication and information platforms" as possible reasons in both counties (Figure 7.17).

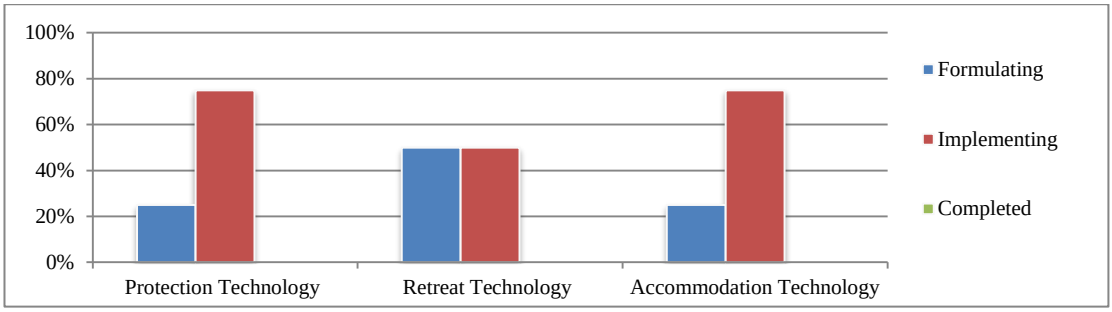


Figure 7.15: Existing phase of the three main adaptation actions – *showing that all three kinds of adaptation action have been addressed, but that the implementation phase was the dominant phase particularly for protection and accommodation technology*

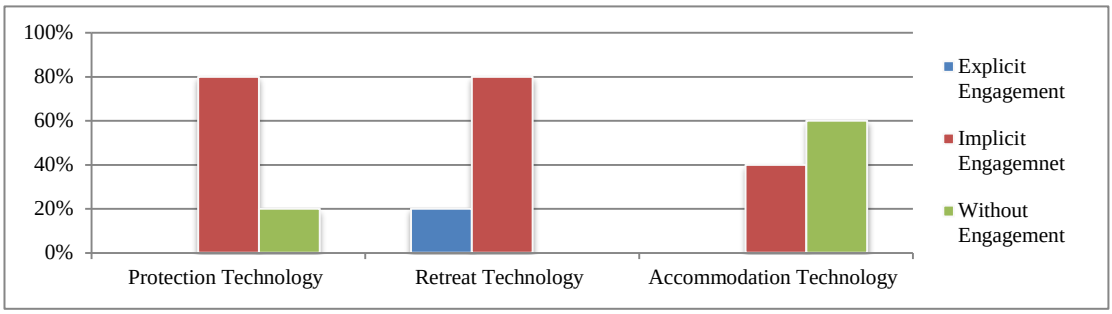


Figure 7.16: Three types of adaptation actions that involved community engagement – *showing that explicit community engagement* mechanism is insufficient in local adaptation frameworks

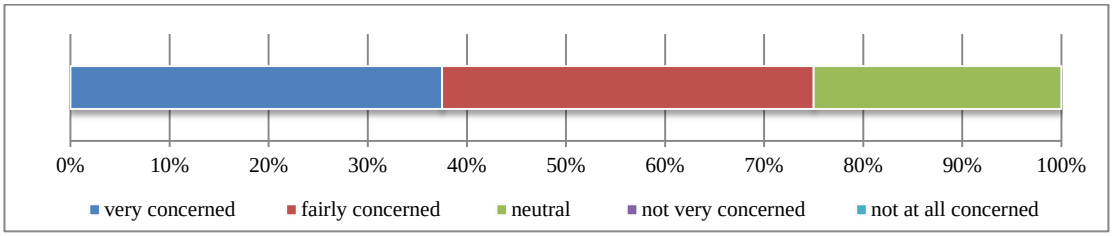


Figure 7.17: Concern of experts in relation to public unawareness of local adaptation actions – *showing that most experts were clearly concerned about the lack of public awareness*

These experts even suggested in the workshop that "these adaptation actions may be

inconsistent with the needs of local communities or may be ineffective and inexecutable due to a community's unwillingness to co-operate (Appendix I: 2.2)." In relation to raising public understanding and concern, some participants suggested ways to increase these. These included the "provision of understandable information by mass media such as the internet and the TV and the need for coordination with the educational departments and community education centres (Appendix J: Comment Box 2)."

Improving community engagement in the local adaptation framework

Most local government representatives were uncertain whether these implemented adaptation actions have increased public awareness and understanding (Figure 7.18). One participant from Pingtung County said: "relevant information is difficult to access and understand for the general public." Moreover, some significant barriers to community engagement were highlighted. These include comments such as "they don't have time", there is "limited information and public understanding", and also "low public concern". In order to increase community engagement, the interviewees suggested that "further plans and actions related to communities' should be developed. These, it was suggested, should include actions related to matters such as emergency notification and evacuation action as priorities in Pingtung County." Not only "understandable information and communication' were suggested but also there were comments that "flexible approaches" would be needed to increase community engagement in future.

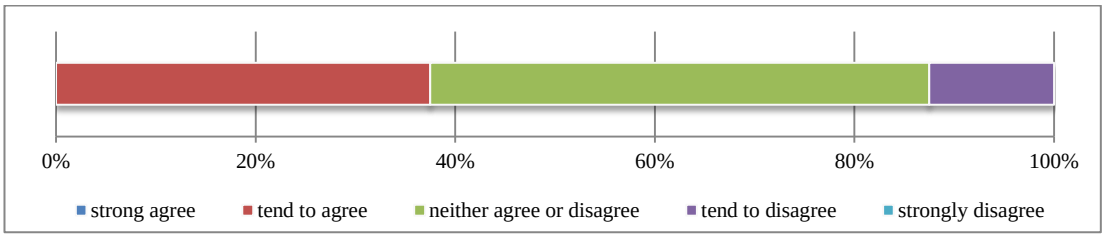


Figure 7.18: Experts views regarding existing adaptation actions and their ability to increase community awareness and understanding – *showing that representatives were not clear as to whether implemented actions have increased public awareness and understanding of climate change*

7.4.2 The Potential Issues of the Local Adaptation Framework from the PESTLE Perspectives

Political aspects-institutional arrangements

The academic representatives in the expert workshop suggested that the local adaptation frameworks and actions all follow the guidelines within the national adaptation strategy, particularly with respect to the organisational structure of the local government. The remainder of the responses related to political aspects focused on institutional arrangements. In this context, the workshop attendees proposed that "interdepartmental cooperation and coordination" and "clear roles and responsibilities of different departments" are the main issues in local adaptation frameworks (Appendix I: 3.1).

Although two interviewees believed that interdepartmental coordination has not been demonstrated in the Pingtung County adaptation framework, the majority agreed that it had been. Indeed, two participants provided a couple of examples stating that "the interdepartmental green energy promotion office" and "the information platform of disaster prevention" have both been developed to incorporate different departments in Pingtung County (Figure 7.19). Moreover, considering the "government's resources are limited" and "compound disasters from climate change", a large number of local government respondents agreed that interdepartmental coordination in the local adaptation framework is effective way to respond to climate change (Figure 7.20).

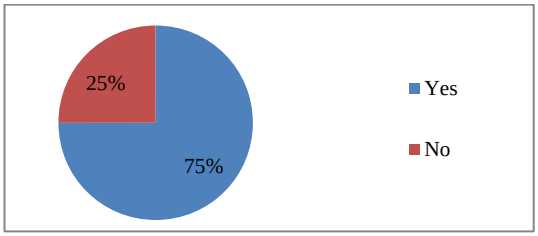


Figure 7.19: Interdepartmental coordination in the local adaptation frameworks – *showing that most representatives agree that interdepartmental coordination had been used in the development of local adaptation frameworks*

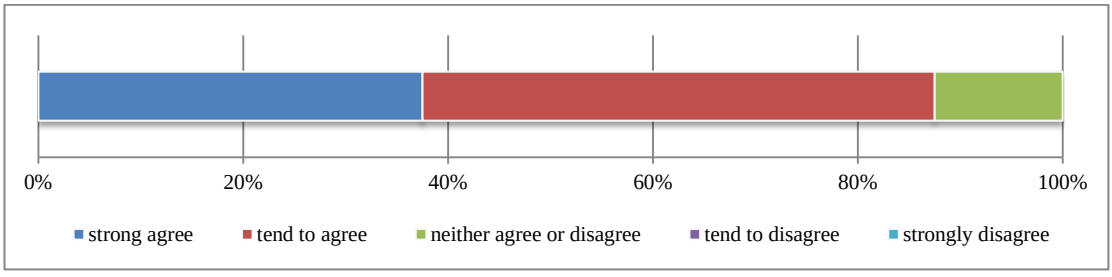


Figure 7.20 : Interdepartmental coordination is effetive to respond to climate change – *showing that representatives were unclear as to whether interdepartmental coordination is effective in responding to climate change in their county*

Many participants agreed that the role and responsibility of the different departments within local governments are clear in the context of local climate change adaptation. Two respondents said that "the roles and responsibilities have been roughly divided into departments" and "the role and responsibilities are clear for dealing with natural disasters" in the Pingtung County (Figure 7.21). In contrast, one representative suggested that "it is clear to respond to flood, but it is not clear for other natural disasters (Figure 7.22)."

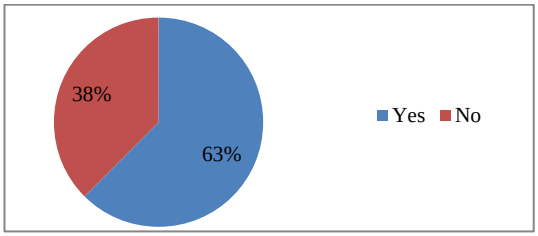


Figure 7.21: Clear roles and responsibilities in the local adaptation frameworks – *showing that most representatives agreed that the roles and responsibilities of different departments are clear in local adaptation frameworks*

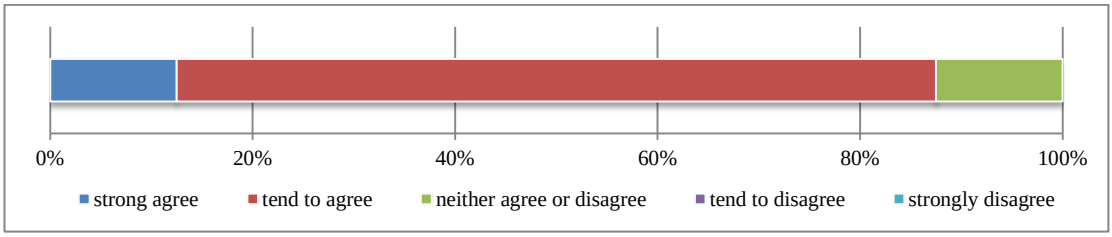


Figure 7.22: Clear roles and responsibilities are effective to respond to climate change – *showing that representatives agreed that the clear roles and responsibilities in the local adaptation framework make for an effective response to climate change*

Economic aspects – economic incentives and financial support

The economic issues discussed within the expert workshop focused on economic incentives and financial support. This was because the experts from the local and central governments proposed that "the budget and revenue of local governments are insufficient to implement adaptation actions (Appendix I: 3.2)." As such, they suggested that insufficient financial support is the key constraint for local adaptation.

Figure 7.23 shows that all representatives of both counties agreed that their finances are insufficient to support existing actions, and two interviewees suggested that "reasonable distribution of financial resources amongst different departments and "financial support from central government" are necessary. They all agreed that sufficient financial source

is necessary in order to “effectively support the implementation of adaptation actions”, one interviewee from Pingtung County said (Figure 7.24).

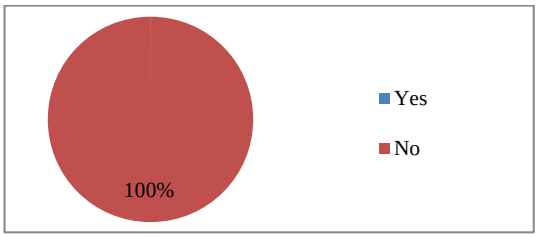


Figure 7.23: Sufficient financial support and budget in the local adaptation frameworks – *showing that all representatives agreed that the current financial support and budgets are insufficient for the local adaptation frameworks*

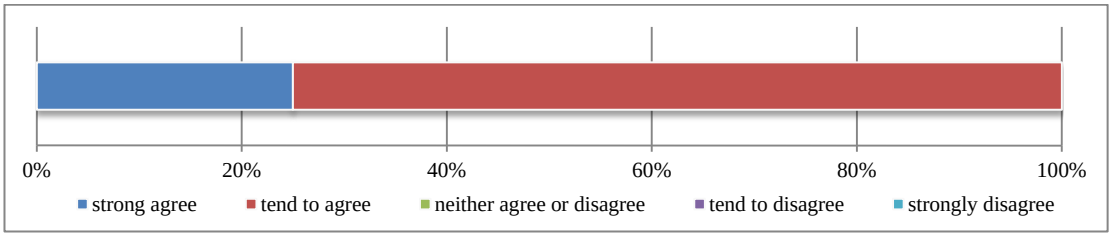


Figure 7.24: Sufficient financial source and budget are effective to respond to climate change – *showing that most representatives agreed that further financial support and budgets are necessary to respond to climate change*

A central government expert suggested that “the carbon tax” and “the international and regional cooperation fund” could be potential revenue sources to support adaptation actions (Appendix I: 3.2). However, all local interviewees stated that these two financial resources had not yet been used to support their local adaptation frameworks (Figure 7.25). They all agreed that such finances could support long-term actions in the counties, with one interviewee suggesting the “user pays principle”. This principle calls upon users of natural resource or polluters to bear the costs, so is a more broadly based principle than just the polluter pays’ principle. (Figure 7.26). This financial mechanism has a high level of public acceptance for local government to develop various taxes.

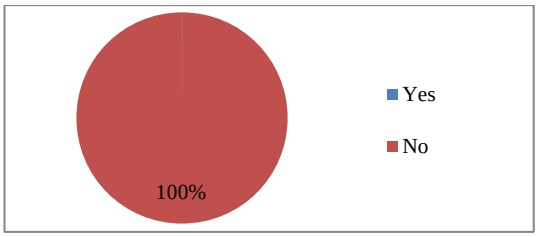


Figure 7.25: Cooperation funds or carbon tax in the local adaptation frameworks – *showing that all representatives disagreed that international or regional cooperation funds or carbon tax had been used in the local adaptation frameworks*

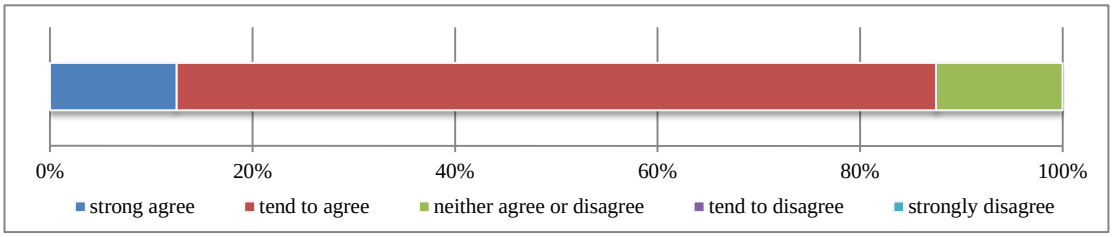


Figure 7.26: Cooperation funds or carbon tax are effective to respond to climate change – *showing that most representatives agreed that above funding sources would be effective in helping climate change response in their county*

Social aspects – public participation

The experts from academia and central government claimed that "public participation is beneficial to climate change adaptation," and therefore the discussion in the workshop related to social issues focused on "developing communication programmes" and "increasing the public awareness" as the most urgent priority for local adaptation (Appendix I: 3.3). Although more than a half of the representatives recognised that increasing public awareness is important to local adaptation, the three interviewees from Pingtung County Government stated that the integrated framework had not developed any actions to help increase public awareness of climate change adaptation (Figure 7.27). Moreover, a large number of representatives from both counties agreed that increasing public awareness is needed because "without a complete public understanding and perception of climate change, public behaviour may increase the impacts of climate change" (Figure 7.28).

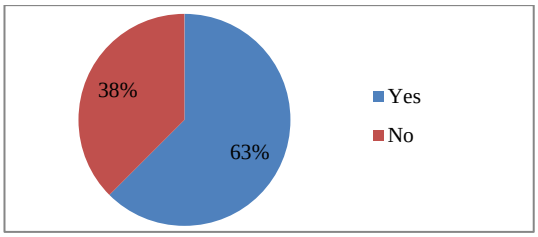


Figure 7.27: Increasing public awareness in the local adaptation frameworks – *showing that most representatives supported the need for increased public awareness in local adaptation frameworks*

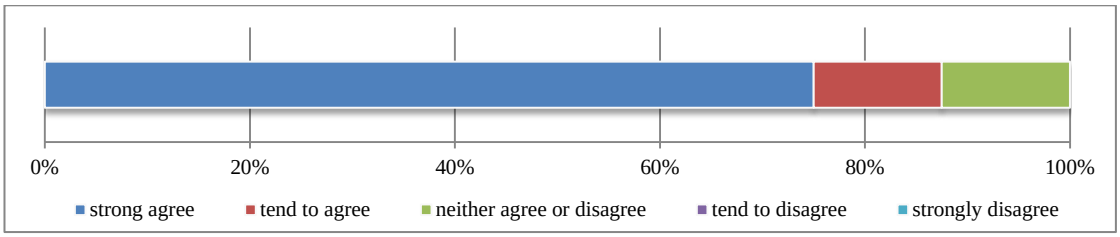


Figure 7.28: Increasing public awreness is effective to respond to climate change – *showing that most representatives agree that increasing public awareness would be effective in responding to climate change in their county*

Additionally, three quarters of representatives in Pingtung suggested that specific programmes have been employed to communicate with public on their water control programme. They provided the examples of the introduction of "public hearings and consultative councils" with general public and local communities (Figure 7.29). However, one representative remained concerned that "communication is difficult because the public are unconcerned about public issues (Figure 7.30)."

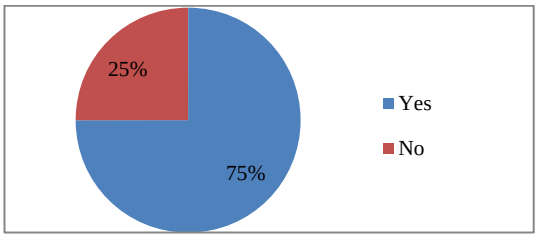


Figure 7.29: Communication programme in the local adaptation frameworks – *showing that most representatives agreed that communication programmes had used in the local adaptation framework to communicate with the public*

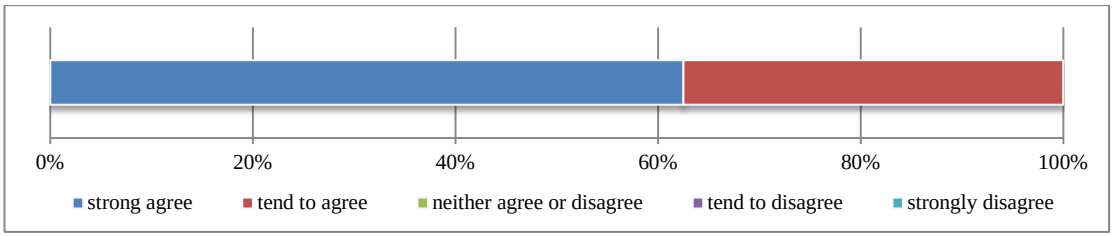


Figure 7.30: Communication programme is effective to respond to climate change – *showing that more than a half of representatives agreed that communication programmes are effective to respond to climate change in their county*

Technological aspects – scientific information used in developing adaptation actions

The central government expert considered that the expertise and research infrastructure is sufficient for climate change research in Taiwan. The technological issues discussed within the workshop emphasised the role that scientific information has played in informing adaptation actions. Most experts suggested that "relevant scientific data is contributive to develop long-term and effective policies and measures" (Appendix I: 3.4). Therefore, it was decided that questioning related to "using scientific data and databases" and "developing defensive infrastructure, preventive actions and emergency preparedness" would be critical issues for the follow-up questionnaire.

Figure 7.31 demonstrates that most representatives agreed that the scientific data and databases have been used to inform local adaptation frameworks. Three interviewees from Pingtung County provided a range of examples illustrating their use of relevant scientific databases. These included their "integrated GIS and GPS database, a biodiversity database and a monitoring system of river drainage." While these interviewees did not provide the detail information and specific actions, their responses are consistent with local adaptation actions in the two counties (cross ref: Appendix D, E). Despite all the representatives' support of scientific data and databases, one interviewee highlighted the need to consider that "the interpretation of experts is needed in local adaptation" and suggest that 'frequent change of personal may influence the interaction between scientific data and adaptation policy formation" (Figure 7.32). This implies that the scientific data is sufficient but the critical problem is local governments need experts to interpret these data and then develop appropriate actions.

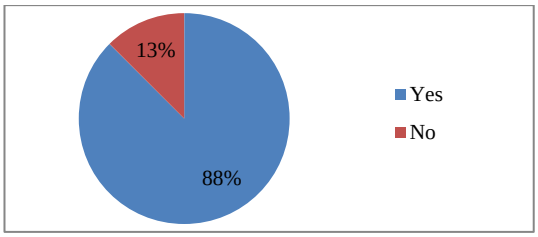


Figure 7.31: Scientific data and database in the local adaptation frameworks – *showing that most representatives agreed that scientific data and databases had been used in the development of local adaptation frameworks*

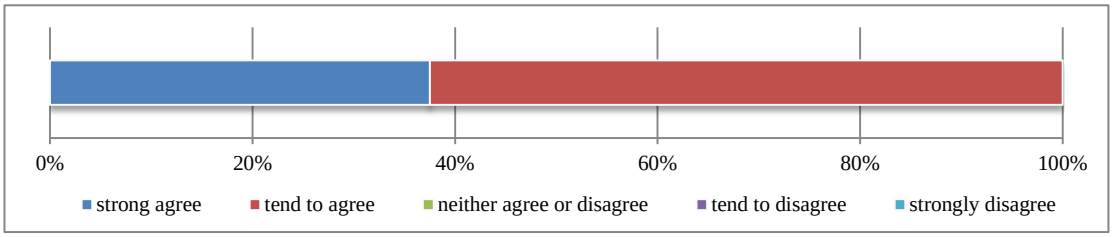


Figure 7.32: Scientific data and database are effective to respond to climate change – *showing that all representatives agreed that scientific data and databases are effective in facilitating a response to climate change in their county*

There were further discussions relating to developing defensive infrastructure, preventive actions and emergency preparedness. In this context, all representatives stated that protection, preventive actions and emergency preparedness have been developed or are being undertaken in the counties. In the case of Pingtung County this included "the impact assessment system, the reinforcement of building, the monitoring system of rainfall and water level, the community-based flood risk management programme, the comprehensive maintenance of river drainage system, and the emergency evacuation planning" (Figure 7.33). Participants all considered that these actions can effectively protect local communities (Figure 7.34).

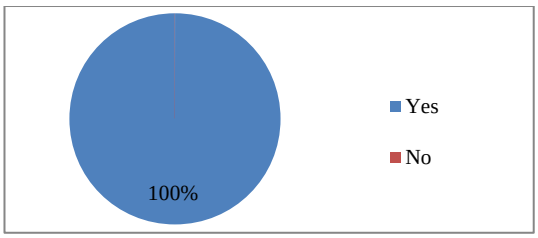


Figure 7.33: Protection, preventive actions and emergency preparedness in the local adaptation frameworks – *showing that all representative agreed that these approaches had been addressed in relevant local adaptation frameworks*

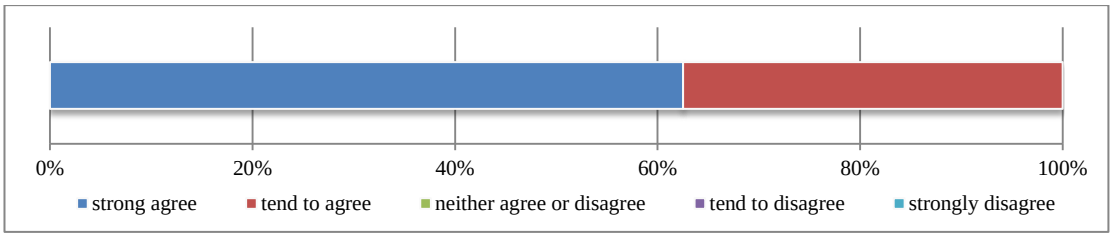


Figure 7.34: Protection, preventive actions and emergency preparedness are effective to respond to climate change – *showing that all representatives agreed that these approaches are effective in their county*

Legal aspects – relevant management regulations and laws

Management regulations and laws for climate change adaptation were considered within the discussions on legal issues in the expert workshop. The experts recognised that "a lack of an exclusive law and associated administrative departments to deal with climate change adaptation" and "integrating adaptation notion into current management plans and projects" are significant issues to local adaptation (Appendix I: 3.5). Indeed, three quarters of the local government representatives expressed concern about this lack of a specific law or administrative department in both of the counties. One interviewee from Pingtung County even doubted that "whether the legal and management departments in the local government are capable of developing specific laws for climate change" (Figure 7.35). It is worth noting that two interviewees from this county stressed that "a dedicated national legal framework is of a higher priority than the administrative organisational structure in dealing with climate change adaptation" (Figure 7.36).

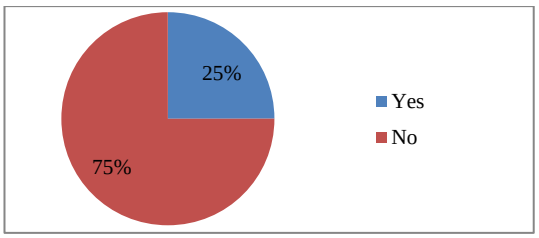


Figure 7.35: Specific laws and administrations in the local adaptation frameworks – *showing that a quarter of representatives agreed that specific laws and administrations had been used in the development of local adaptation frameworks*

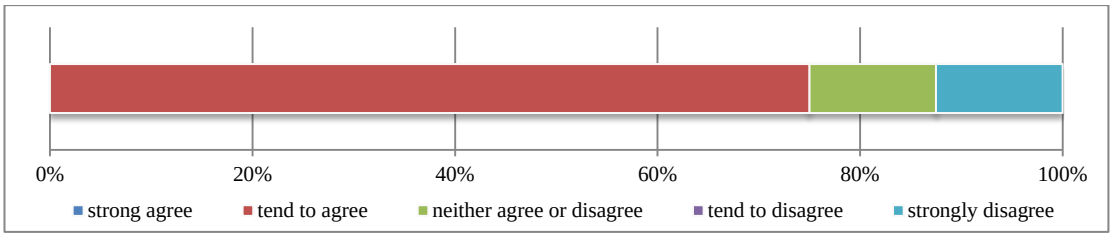


Figure 7.36: Specific laws and administrations are effective to respond to climate change – *showing that most representatives agree that specific laws and administrations would be needed fr effective response to climate change in their county*

Although an exclusive law on climate change adaptation has not been developed in Taiwan, all experts suggested that incorporating elements of climate change adaptation into the National Land Planning Act (draft) and the Coastal Act (draft) could improve adaptive capacity (Appendix I: 3.4). Over half of the local representatives agreed that the idea of integrating adaptation into current management plans and projects has been used in the local adaptation frameworks (Figure 7.37). In Pingtung County, such plans cover the entire county and include those relate to the evaluation of environmental capacity (e.g. national land use monitoring, assessing the carrying capacity), the development of water retention and permeable facilities (overall planning of hydrographic system, water supply and ground water use management), and the integrative flood prevention design (river basin comprehensive management, sedimentary management). One interviewee disagreed, considering such plans do not adequately address climate change and suggested that "incorporating adaptation into management plans needs a legal foundation." Finally, some participants (Figure 7.38) were unsure about integrating adaptation into management plans as an effective response, because "adaptation framework is just a beginning, and not all of these actions will effectively respond to climate change."

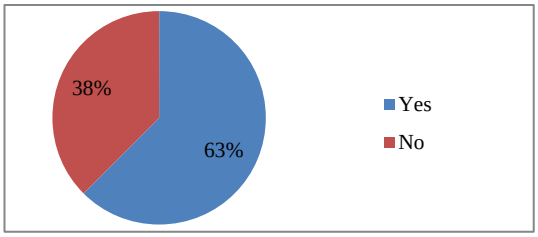


Figure 7.37: Integrating adaptation into management plans and projects in the local adaptation frameworks – *showing that most representatives agreed that adaptation had been integrated into management plans and projects with in the local adaptation frameworks*

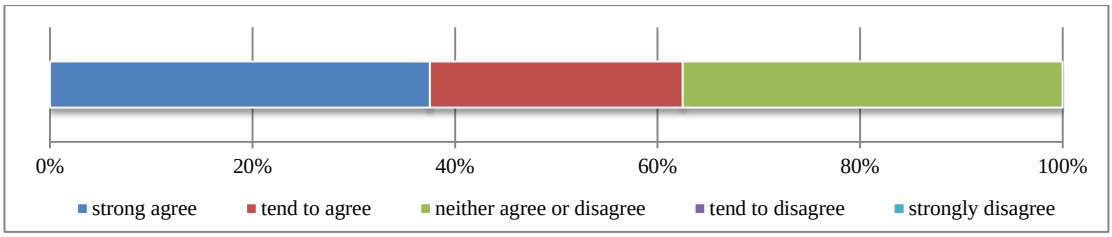


Figure 7.38: Integrating adaptation into management plans and projects are effective to respond to climate change – *showing that most representatives agreed that integrating adaptation into management plans would be effective in facilitating response to climate change in their county*

Environmental aspects – environment conservation and human society protection in adaptation actions

Academic experts recognised that approaches which respect and work with the natural environment are the best way for protection against climate change impacts. In this context, all respondents considered that developing adaptation actions must take account of environment conservation and human society protection related to environmental issues. It is known that the planning of coastal defensive infrastructure (sea wall) has been undertaken for the medium term (25 years) in western coastal areas in Taiwan. However, the academic experts suggested that the future protective standard should be formulated under a longer-term planning horizon of at least 50 years (Appendix I: 3.6). They suggested, however, that developing artificial protection constructions must be undertaken in the context of specific features of the locality, including requirements for the local community and its geographic characteristics. Academic experts suggested that existing hard structures (e.g. embankments, dikes, seawalls) on the coasts in Taiwan focus on public safety protection and disaster prevention rather than environmental and ecological protection. They considered that ecological engineering methods and environmental constructions may be the best way to effectively protect both the people and the natural environment, with examples of such approaches including green belts, flood detention pools and beach nourishment. Therefore, the “take accounting of disaster prevention and environmental protection in developing adaptation” and “artificial infrastructure involved protection and environmental friendliness” are significant issues in the local adaptation (Appendix I: 3.6).

Figure 7.39 shows that most participants considered that the objective of disaster

prevention and environmental protection has been taken into account in developing adaptation actions in their adaptation frameworks. Examples from Pingtung County included actions related to comprehensive national land monitoring, comprehensive watershed management, and the forestation which help prevent disaster and protect natural environment. The majority also agreed that “these actions can increase the effectiveness of climate change adaptation (Figure 7.40).

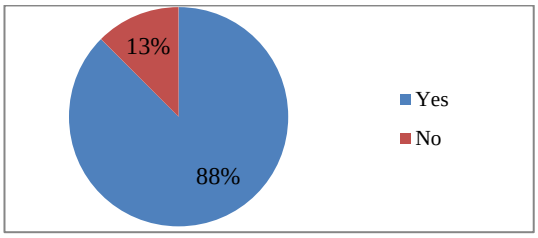


Figure 7.39: Disaster prevention and environemntal protection in the local adaptation frameworks – *showing that most representatives agreed that disaster prevention and environmental protection had used in the local adaptation frameworks*

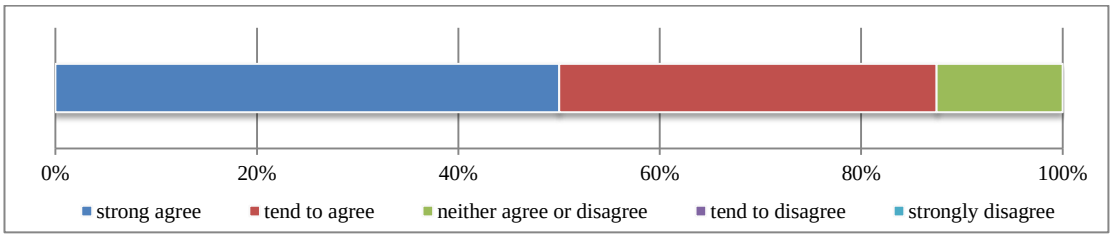


Figure 7.40: Disaster prevention and environemntal protection are effective to respond to climate change – *showing that most representatives agreed that disaster prevention and environmental protection are effective in responding to climate change in their county*

Furthermore, although a large number of representatives agreed that artificial infrastructures are environmental friendly and able to protect local communities in the two counties, there is no further evidence provided in their responses and known local adaptation actions (Appendix D, E). In Taiwan, central and local government work together to build a construction project of coastal defences, and one interviewee from Pingtung County suggested that “local governments are incapable of developing comprehensive environmental measures because local governments only consider the cost (Figure 7.41).” These results imply that the development of comprehensive action needs the cooperation between central and local government. While local government may be incapable to develop comprehensive measures, these representatives all agreed

that this could be an effective way of responding to climate change (Figure 7.42).

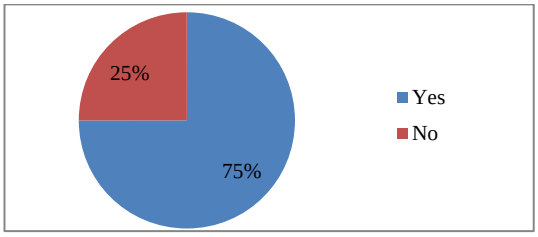


Figure 7.41: Environmental protection and environmentally friendly infrastructure in the local adaptation frameworks – *showing that most representatives agreed that artificial infrastructures should involve environmental protection and be environmental friendly in the local adaptation frameworks*

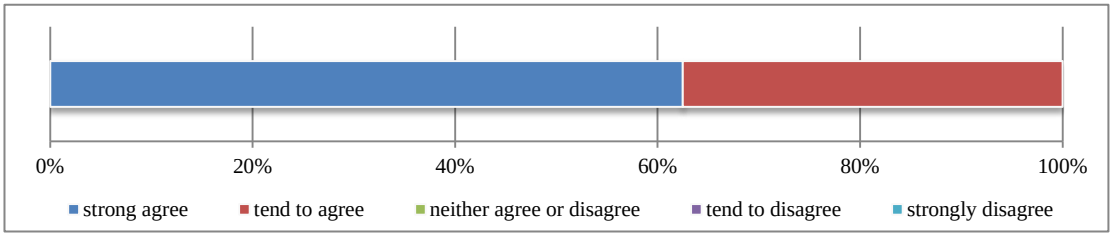


Figure 7.42: Environmental protection and environmentally friendly infrastructure are effective to respond to climate change – *showing that all representatives agreed that artificial infrastructures as a form of environment protection and as being environmental friendly should be effective in responding to climate change in their county*

7.5 Discussion

This section discusses the findings in relation to personal actions and motivation factors, governmental actions and arrangements and the efficacy and priority of response actions. It then provides a conceptual model (Section 7.5.1) to demonstrate the effective factors to increase public participation in response to climate change, public perception of proposed actions and its possible restrictions. Section 7.5.2 provides the cognitive, affective, and behavioural dimensions related to community engagement in adaptation. Finally, the challenges and suggestions for the development of local adaptation frameworks in Taiwan are discussed in Section 7.5.3.

7.5.1 Public Participation in Response Actions to Tackle Climate Change

Individual actions and personal motivations

This study's findings are similar to Capstick *et al.* (2013), in that most people

considered a need to undertake response actions immediately. This study supports that most Taiwanese believing that climate change can be stopped, mitigated and resisted (cross ref: Section 6.3.4), or their personal observation (cross ref: Section 6.2.1), concern (cross ref: Section 6.2.2), perception of climate change as a human-caused problem (cross ref: Section 6.2.3) and impacts of climate change (cross ref: Section 6.2.5), and hazard experiences (cross ref: Section 6.3.4). Moreover, the findings of this study reveal that flood victim and non-flood victim both agreed to take actions now (Figure 7.4). However, people remain uncertained about when they should undertake actions if they are unconcerned about climate change (Figure 7.3).

Regarding personal actions, the findings of this study (Figure 7.5) indicate several personal actions have been taken, consistent with surveys in Australia (Sutton and Tobin, 2011) and Taiwan (Chou, 2013). However, these data lend support to the idea of Norton and Leaman (2004), Poortinga and Pidgeon (2003), and Stamm *et al* that the most personal actions relate to energy conservation and environmentally responsible behaviours. These results reflect the findings previously discussed and shown in Figure 6.12, which revealed that respondents tend to be most concerned about environmental and economic issues. Therefore, these results can be used to explain that these personal actions are taken for environmental and economic reason, rather than climate change.

Considering the key factors motivating the Taiwanese public to take actions, the author would concur with the opinion of other regarding the co-benefits of addressing climate change (Bedsworth and Hanak, 2013; Kousky and Schneider, 2003; Bain *et al*., 2015), suggesting that climate adaptation should be integrated with actions addressing other issues (Apuuli *et al*., 2000; de Bruin *et al*., 2009; Veraart *et al*., 2010; Burton *et al*., 2002) in order to effectively motivate public support and participation in appropriateresponse actions in Taiwan. For example, Figure 6.12 shows that public were more concerned about environmental and economic issues than climate change and therefore, the author suggests that adaptation actions should be developed alongside ones related to environmental conservation (Kroemker and Mosler, 2002; Lubell *et al.*, 2009; Zahran *et al.*, 2008; Millard-Ball, 2012; Weber, 2010) and economic benefits (Creyts *et al*., 2007; Carter and Culp, 2009; Drummond, 2010; Fortner *et al.*, 2010). This study, therefore, suggests that these aspects are strong motivations for public participation, especially for those who are skeptical about climate change or adaptation actions in Taiwan.

Governmental actions and arrangements for public participation

While specific national and local adaptation frameworks and actions have been developed and conducted in Taiwan, it is interesting that the result shown in Figure 7.7, is entirely consistent with Moser and Tribbia (2006) and Capstick *et al*. (2015). This indicates that governments are generally ill-prepared for climate change from the public view. The author thinks that this may be due to the lack of public participation, previously noted (Section 7.4.1). In order to increase participation, the author suggests that sufficient and effective information communication (cross ref: Section 6.4.2) is required along with transparent decision-making processes. This finding is consistent with that provided in Section 6.2.4, which suggests that the effective and practical communication way can improve public understanding and participation in Taiwan. It also implies that providing understandable scientific anaylsis and information for lay people (through mass media, for example) is more important than vague or nonexistent policies from governments.

In terms of a transparent process of decision-making, this study appears to support the observation of previous studies (Poortinga and Pidgeon, 2003; Whitmarsh *et al.*, 2005; Myatt *et al.*, 2003; Chou, 2013; Sovacool *et al.*, 2015) suggest that stakeholders should be and indeed want to be involved in the decision-making process. It would seem that small-scale interactions and deliberative processes may be important to engage the community in discussion, decision making, and in comparing different perspectives for adaptation (Blackstock *et al*., 2009; Measham *et al*., 2011; Raymond and Robinson, 2013). It is also suggested that consultation processes earlier in the development of adaptation responses could be an opportunity for the public to express their interests and concerns (Myatt *et al*., 2003).

Public perception of response actions and constraints

These findings of this study (Figure 7.10) support the opinion of Whitmarsh (2009) in that the Taiwanese public consider that actions relating to environmental conservation and natural resources recovery are most effective to tackle climate change. However, these findings support the claim of the expert workshop (Section 7.4.1) and previous studies (Capstick *et al*., 2013; Hsu, 2013; Alló and Loureir, 2014), that most people think of mitigation actions as adaptation actions. This supports the opinions of Leiserowitz (2007), who suggests that the general public consider information transmission (educating people) and preventive actions (prediction, emergency and

warning systems) are more effective adaptation actions (Figure 7.9). However, from the results of this study shown in Figure 7.11, retreat and accommodate actions were considered as medium and long-term actions, such as immigration, city planning, and industrial restructuring. It may be due to the public appearing to perceive that these actions may cause great economic loss and disproportionate costs to local communities' livelihoods without these being part of a comprehensive development strategy and programme. This idea is similar to that noted in previous research (Alexander *et al*., 2012; Leiserowitz, 2007; Chou, 2013; Hsu, 2013)

Previous research has also found that a general ignorance and lack of public trust about the effectiveness of proposed actions (Gifford, 2011; Kroemker and Mosler, 2002), and is an obstacles to public acceptance of specific actions (Alexander *et al*., 2012; Gifford, 2011; Lorenzoni and Pidgeon, 2006; Lorenzoni *et al.*, 2007; Terwel *et al.*, 2009). As a result, the latter researchers suggest this may dampen the public's adoption of proposed responses. This view can also be surmised from this study's findings relating to the efficacy and priority of proposed adaptation actions (Section 7.2.3). Therefore, this section outlines two possible constraints which may restrict the efficacy of adaptation actions and public willingness to participate in actions. Firstly, although land-use change and relocation of property and infrastructure are recommended as effective options by others elsewhere, such as Few *et al*. (2007), the results of this study suggest that the Taiwanese public thinks these actions may be ineffective in responding to climate change. This study also supports the opinion of Alexander *et al*. (2010) that these actions may impose significant pressures on affected communities, and the public will not support these responses if these actions directly affect them personally.

Secondly, these results are consistent with a recent survey that found taxation and potential costs have significant negative effect on public acceptance of relevant policies (Bolsen and Cook, 2008), such as those relating to natural disaster insurance and carbon tax (Figure 7.11). Elsewhere studies indicate that such financial barriers results in most of public not being able to get house insurance (Bickerstaff *et al*., 2004) or strongly opposing carbon taxes, such as in America (Leiserowitz, 2007), Taiwan (Hsu, 2013) and Chian (Yu *et al*., 2013). This study supports the suggestion of Ferry (2016), a fund from the Taiwanese government to cover losses to private property from flood is popular, especially in the agricultural sector. This also may be the key reason for the low public acceptance of disaster insurance because the public are able to can receive protection

without having to buy insurance. The findings of other Taiwanese research (Shih and Yang, 2012; Hsu, and Shih, 2015) also suggests public acceptance of high environmental taxes is significantly lower than that for other policies in Taiwan.

Developing a conceptual model of public participation in response to climate change

A clear picture has developed from the previous discussions in terms of public participation in response to climate change in Taiwan. As a result, a model is presented in Figure 7.43 which conceptualizes the key factors that directly affect public participation and perception to response actions. This is relevant to proposed response actions (Section 7.2.3) and builds on the findings from Section 7.2.1 and 7.2.2. This model demonstrates four critical findings: 1. personal factors provide stronger motivations for taking responses rather than adapting climate change; 2. governments have to provide adequate information and develop transparent decision-making processes for public participation; 3. actions relating to mitigation, prevention and protection are a priority for the immediate future; 4. actions relating to retreat and accommodation options and taxation and insurance mechanisms may be constrained by potential costs and their influences on community life and livelihoods. In conclusion, the incentives and technological solutions (house and city design, renewable energy) receive more public support than those related to behaviour changing measures (carbon tax, immigration) in Taiwan. Moreover, the author notices that increasing public awareness and understanding about planned adaptation actions is a more urgent priority than changing and modifying behaviour or lifestyles in Taiwan.

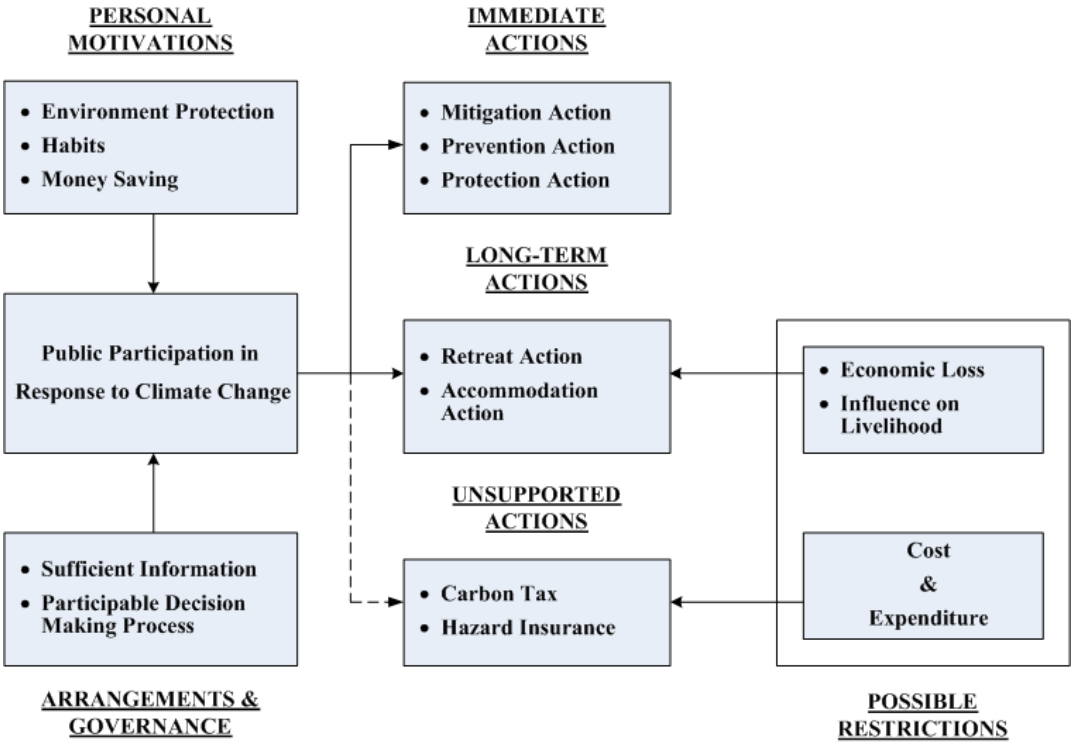


Figure 7.43: Conceptualisation of public participation in response to climate change

7.5.2 Critical Factors of Community Engagement in Taiwan

Cognitive factors

Previous studies (Capstick *et al*., 2012; Spence *et al*., 2011; Weber, 2010; Lebel, 2013) suggest that adequate public cognition of climate change may affect their willingness to engage in climate change adaptation. The following sections discuss associated cognitive factors: public perception, public understanding, and public attitude in community engagement in climate change adaptation in Taiwan.

Perception: Gifford (2011), and McCright and Dunlap (2010) suggest that the perception deficit of climate change may easily lead to active denial of the problem and relevant response actions. The findings (Figure 7.12) from this and the previous chapter prove that the Taiwanese public clearly understand climate to be changing (cross ref: Section 6.2.1), are aware of the potentially disastrous consequences of this (cross ref: Figure 6.13) and the human activities affecting climate (cross ref: Section 6.2.3). Section 7.2.1 also shows they attribute human responsibility for climate change. Together, this study suggests these perceptions have encouraged the public to engage with adaptation actions.

Understanding: Bord *et al.* (2000), Gifford (2011), Bulkeley and Newell (2010) suggest that a lack of understanding or misunderstanding about the extent and consequence of climate change may be a constraint on community engagement. However, Figure 6.13 in the previous chapter showed that the Taiwanese public has acknowledged the significant impacts of climate change on the natural environment, human society and their personal lives and so they consider there is a need to take action now (cross ref: Section 7.2.1). Figure 7.12 also revealed some awareness that these impacts are unpredictable, inevitable, and recoverable. These results support findings by Kroemker and Mosler (2002) and Lorenzoni and Pidgeon (2006) who suggest that the understanding of potential consequences of climate change is highly relevant at both personal and societal levels, and that understanding of the environment is important for community engagement. Therefore, the author would concur with Gifford (2011) and Kroemker and Mosler (2002) who suggest that people are likely to take actions if they explicitly understand the potential impacts and consequences of climate change.

Attitude: The findings related to public attitudes are consistent with the suggestion of Lorenzoni *et al.* (2007) that individual actions and collective actions are influenced by individual pro-environmental values and self-efficacy. In contrast to Gifford's (2011) research, this study demonstrates that individual attitudes to climate change are significant in influencing community engagement with adaptation actions in Taiwan. This probably arises because the Taiwanese public have recognised that they are able to do a lot to respond to climate change, support the idea of sustainable development (Weber, 2010; Lubell *et al*., 2009), and are aware that it is necessary to take action to adapt to the impacts of climate change (Figure 7.12). For this reason, this study would support to the opinion of Bickerstaff *et al*. (2004), which highlights that people may be willing to engage with adaptation actions when they recognise their moral obligations and responsibilities for climate change.

Affective factors

Leiserowitz *et al.* (2001) and Weber (2010) suggest that the public response to the uncertainty of climate change is an emotional reaction, and affective factors are important in influencing public attitudes towards climate change adaptation (Dietz *et al*., 2007; O'Connor *et al*., 1999; Gifford, 2011). The following sections discuss associated affective factors, namely the role of public concern, feeling, uncertainty/skepticism, and trust in community engagement in climate change adaptation actions in Taiwan.

Concern: The findings shown in Figure 7.13, build on the findings in Chapter 6 (cross ref: Sections 6.2.2). The figure shows that these findings relating to public concern about climate change are consistent with the opinions of Lorenzoni and Pidgeon (2006), Whitmarsh, (2008), Dobson (2003), and Macnaghten (2003). These suggest that people generally appear to like to engage in adaptation actions if they are particularly concerned about the risk of climate change (Figure 6.3) or are worried about risks to their own personal life, community, and the environment (Figure 6.13). Therefore, the author supports the argument that public concern about climate change and its impacts on human welfare, natural resource and environment, and individual are likely provide powerful motivation for community engagement in Taiwan.

Feeling: The results (Figure 7.13) show that the public's fear of climate change and its' impacts and direct experiences play an important role in community engagement in Taiwan. This finding also supports the view that information which is alarming and possibly horrifying may increase public willingness to act and may help remove public denial, distrust, and negligent (Ruiter *et al.*, 2003; Weber, 2010), because most respondents were affected by the relevant reports in the media, the most trusted information sources (cross ref: Section 6.2.4). While Vess and Arndt (2008), O'Neill and Nicholson-Cole (2009) stress that excessive negative feelings may lead to public inaction, this suggestion of this study is supported by other research that shows public emotions and experiences regarding climate change may be able to produce effective ways to communicate and motivate the public to undertake actions (Gifford and Comeau, 2011; Moser, 2007; Lowe *et al*., 2006; Lorenzoni *et al.*, 2006).

Uncertainty/Skepticism: Building on Section 6.2.4, Figure 7.13 provides evidence, to support the view that the public believes that climate change is real and relevant information and scientific evidence are true. These are the key factors for affective engagement. This finding is consistent with research around community engagement, which shows that eliminating the uncertainty and skepticism about climate change may increase community engagement and individual behaviour change (Few *et al.*, 2007; Norgaard, 2006; Poortigna, *et al.*, 2011; Bulkeley and Newell, 2010; Stoll-Kleemann *et al.*, 2001). Therefore, these results imply that scientific evidence is a useful tool to eliminate uncertainty and one possible explanation for this is that scientific evidence is trusted information sources about climate change in Taiwan (cross ref: Section 6.2.4).

Trust: As noted in Section 6.2.4, trust is essential for a healthy relationship between citizens, scientists and government (O'Connor *et al.*, 1999; Rohrmann and Renn, 2000; Gifford, 2011), especially for community engagement in adaptation actions (Lowe *et al.*, 2006; Lin *et al.*, 2008; Bulkeley and Newell, 2010). The findings from this study, shown in Figure 7.13, support these general observations and the suggestions of Weber (2010) and Foddy and Dawes (2008), that public willingness to act can be formed associated with public reliance on the scientific evidences and the efficacy of actions. However, others suggest that some of the public mistrusts governments on environmental issues (Poortinga and Pidgeon, 2003; Terwel *et al*., 2009).

Behavioural factors

Lorenzoni *et al*. (2007), Sutton and Tobin (2011), and Whitmarsh and Lorenzoni, (2010) consider that numerous barriers to changing individual behaviours and lifestyles have emerged in relation to community engagement. This section identifies some of these potential barriers and constraints that may limit community engagement in adaptation actions in Taiwan: inequity, cost and economic development, powerlessness, and habit.

Inequity: The finding of this study supports the suggestion from Aquino *et al.* (1992), that inequity may result in declining public participation. Figure 7.14 shows that the Taiwanese people agreed that they think that where others having not done enough this is a key barrier for community engagement. However, they also agreed that whether or not the public has not done enough on adaptation is irrelevant. A possible explanation is that the public ascribes responsibility for implementing adaptation actions to national and international levels and not to individuals (Poortinga *et al.*, 2006; Taylor *et al.*, 2014). Therefore, the study highlights the importance of co-responsibility of climate change adaptation because people may take actions when they perceive responsibilities and the benefit to others (Howgate and Kenyon, 2009). Moreover, the author would concur with previous research (Lorezoni *et al.*, 2007; Gifford, 2011), which suggests that developing joint actions to cooperate with governments, businesses, industries, and communities may be able to strengthen community engagement in adaptation actions, such the solar farm project in Pingtung which is a cooperation between private company, local and central government, with local communities also involved in implementing associated action.

Cost and economic development: These findings (Figure 7.14) support the theory that

most people are loss-averse or do not like additional expenses (Gifford, 2011; Lorenzoni *et al.*, 2007). They also suggest that the recognition of potential loss of economic and industrial activities may lead to the people being unwilling to change their behaviour (Canadell *et al*., 2007; Keller *et al*., 2004). Therefore, this study's findings may imply that the additional cost (through for example, natural disaster insurance) and the possible economic downturn (through for example, carbon tax) to adopt proposed actions could be a great barrier to community engagement in climate change adaptation. The study also echoes previous findings (cross ref: Section 7.2.3) in that the public considers the above two proposed actions are ineffective. Therefore, the author agrees that climate change adaptation actions must take account of the interests of the community, as well as economic development aspects in order to increase community engagement.

Powerlessness: Building on Section 6.4.2 and Section 7.2.2, these findings (Figure 7.14) support the view that people are not well informed (Lin *et al.*, 2008; Grothmann and Patt, 2005; Aitken *et al.*, 2011; Myatt *et al.*, 2003; Lowe *et al.*, 2006) and they do not know (Kroemker and Mosler, 2002; Butler and Pidgeon, 2011; Dessai and Sims, 2010), what action can be taken, substantial effects of actions, and how to act. This finding also relates to the previous observations, which note that the Taiwanese public is eager to obtain more information and relevant education about climate change. Consequently, this study suggests that, by providing relevant information about climate change and adaptation actions, this will not only increase public perception and understanding but may also be able to increase their capacity to participation in adaptation.

Habit: Personal habits and lifestyles can be significant barriers to community engagement. Previous studies suggest that these are extremely difficult to modify permanently as the public tend to be often reluctant to change (Maio *et al*., 2007; Carrus *et al*., 2008; Eriksson *et al*., 2008; Lorenzoni *et al*., 2007; Bulkeley and Newell, 2010). However, the findings of this study show that known constraints, such as no time to do, habits and lifestyle changes, were actually not acknowledged as major barriers to community engagement in Taiwan (Figure 7.14). A possible reason could be that the public do not understand what are the potential influences of specific adaption programmes on their habits (Bord *et al*., 1998). Alternatively, they may consider that their personal actions (Figure 7.5) are so-call adaptation actions, and they already have taken these actions to respond to climate change.

In summary, this section has discussed and highlighted that cognitive, affective, and behavioural factors can effectively affect community engagement in climate change adaptation actions. Although these were verified by the study findings, and so it could be surmised that these could effectively increase community engagement in climate change adaptation action in Taiwan, the author still maintains that better communication of information on climate change and adaptation action is still likely to be the most effective way in promoting cognitive and affective engagement. Previous research suggests several practical methods which could be applicable to the case studies. These include suggestions that communication processes have to be in place to define the efficiency of specific adaptation actions and their possible influence on the public. As such this should provide tailored and targeted actions to specific communities, and help understand the values of particular audiences.

Lastly, whilst some significant barriers to community engagement have been identified in this study, previous studies point to possible solutions to overcome these. This study recommends that there is a need for responsibilities to be clearly defined and for the elimination of any inequality and inequity between individuals, industries and governments in relation to climate change adaptation Furthermore, this study suggests that policymakers should introduce relevant information and practical actions that may strengthen public confidence and response to climate change adaptation, and formulate adaptation actions, having considered the issues related to the capital outlays associated with the period of payback, subsidies and premiums, and cost-effectiveness of actions, and the influence on local communities.

7.5.3 The Challenges and Opportunities Relating to the Local Adaptation Framework in Taiwan

Strengthening the connection between different levels of governance

The Taiwanese adaptation framework, detailed in Section 4.3.1, appears consistent with the suggestions of previous studies that recommend that multilevel governmental frameworks are needed (Bulkeley and Betsill, 2005; Amundsen *et al*., 2010; Biesbroek *et al.*, 2009; Gustavsson *et al.*, 2009; Dahl, 1961; Tompkins and Adger, 2005). However, this study also supports suggestions from the literature (Hajer and Versteeg, 2005; Gustavsson *et al.*, 2009; Mickwitz *et al.*, 2009; Ivey *et al.*, 2004; Amundsen *et al.*, 2010; Measham *et al.*, 2011; Duncan and Toatu, 2004) which note the challenges posed by

such multilevel governance frameworks. Indeed, this study suggests that a multilevel governance framework can create issues associated with the clear definitions of the institutional roles as well as the responsibilities of specific actors. Such frameworks can also give rise to difficulties in communication and coordination between relevant departments.

These problems, however, may be minimised by an appropriate national adaptation framework and the interdepartmental organisations in the local adaptation framework (Section 7.4.2: political aspects). This study highlights the importance of the national adaptation framework in assigning clear roles and responsibilities to different departments within climate change adaptation in Taiwan. This national framework also defines how the definition of a core team within local government for overseeing the development and implementation of the local adaptation framework can facilitate, cooperate and coordinate interdepartmental affairs. Moreover, this agrees with the suggestions of Biesbroek *et al* (2010) who indicate that interdepartmental units can have a valuable role in managing the integration of adaptation into sectoral policy. This study (Section 7.4.2: political aspects) demonstrates that interdepartmental organisations or departments had developed for cross-functional communication in implementing specific adaptation actions, such as the green energy promotion office and the disaster prevention information platform in the Pingtung County. The present study conforms with previous studies' suggestion that national frameworks can clearly define roles (Hovik and Reitan, 2004; Biesbroek *et al.*, 2010) and resolve conflicts between agents to engender collective actions (Cash *et al.*, 2006).

Although the Taiwanese adaptation framework has taken a step in the direction of defining the roles and responsibilities at different institutional levels and the interdepartmental coordination, it may be worth considering the recommendations of Leary *et al.* (2008) and Næss *et al.* (2005) who suggest that private organisations and local actors, such as community organisations, local cooperatives, trade associations, informal associations, and traditional institutions should be involved. Obvious examples include many religious organisations and private institutions which have resettled flood-victims and provided supplies when flood disasters have occurred in the past in Taiwan (Zheng, 2012). The findings of this study, however, reveal a weak cooperation regime outside local government as well as unclear responsibilities of local communities and other external organisations in relation to the local adaptation

frameworks.

Enhancing financial capacity of local governments

The results (Section 7.4.2: economic aspects) point to similar financial issues in the two counties, and are consistent with the observations of many researchers (including, for example: Pini *et al.*, 2007; Dessai *et al.*, 2005; Leary *et al.*, 2008; Boswell *et al.*, 2012; Aall and Groven, 2003; Bjørnæs, 2004; Crabbé and Robin, 2006) who suggest that local adaptation is frequently constrained because of limited financial capacity and budgetary constraints. Considering the distinct income levels and vulnerability to climate impacts in the different areas, the author is in complete agreement with the suggestions of Bruggink (2003), Bäckstrand and Lövbrand (2007), and Measham *et al.* (2011). These authors suggest that the distribution of costs of local adaptation actions is a complex issue. Take the four case studies as example, the annual revenue of the Mailiao Township (£8,700,000) is significantly higher than other three rural townships (Kauho: £4,200,000; Linbian: £3,200,000; Jiadong: £3,500,000). The budget allocations from central government concerning industry structure (tax exemption for primary industry) and population structure (local government with high level of population can obtain more budget from central government) in different local governments in Taiwan. These findings, in the context of the information provided in Chapter 5 (cross ref: Figure 5.3; Figure 5.5), show that low population growth, aging, and major economic activity is agriculture and aquaculture are the key reasons for insufficient financial capacity in these three rural townships. Insufficient financial capacity may cause the development of local infrastructures (Measham *et al.*, 2011; Brackertz and Kenley, 2002) or self-perpetuating and fixes (Crabbé and Robin, 2006) unable to be carried out. Therefore, Figure 5.4 demonstrated that the insufficient infrastructure increases susceptibility to coastal communities in Linbian and Jiadong Townships.

This rationale is supported by Leary *et al*. (2008), who suggest that stable support and adequate distribution of financial resources to local adaptation are important, and greater financial assistance from central governments or other multiple sources and innovative approaches have to be taken into account so that more adaptation actions could occur in impoverished areas. Given the suggestions in the wider literature, consideration could be given to a range of mechanisms to improve the financial resources available for coastal adaption in the two counties in Taiwan. For example, these could include general funds, bonds, taxes and fees, government grants, carbon

offset programs, self-funding and revolving fund programs, volunteer and public resources, private grants and investment, as suggested by Næss *et al.* (2005), Giddens (2011), and Boswell *et al.* (2012). An area of future research is needed to investigate many of the above strategies, and in particular, effective methods for improving financial capacity of local governments.

So, considering that climate change is a global issue and a comprehensive scientific database is important to understand the trends of climate change at global, regional, and local levels, this study suggests that international research programmes, inter-regional cooperation and cross-border cooperation may be able to strengthen the adaptive capacity of those with weak financial capacity and budget. The author would concur with the suggestion of Biesbroek *et al.* (2010), that the international (e.g. Global Environment Facility, Green Climate Fund) and regional (e.g. Climate Change Fund from Asian Development Bank) cooperation programmes with other countries may provide assistance to countries with less financial resources to conduct research programmes. However, Taiwan faces great challenges and pressures from the Chinese government in relation to its participation in international affairs and organisations which remain unresolved. For example Taiwan has not been formally involved in the UNFCCC and the Kyoto Protocol. Therefore, how to overcome this external challenge is a significant topic in the context of the need for international and inter-regional cooperation.

Improving the public communication and awareness

The results of the public questionnaire (Section 6.4; Section 7.2.2) and expert interviews (Section 7.4.2: social aspects) complement each other in relation to social aspects. Each emphasises the importance of public awareness and public communication to trigger successful local adaptation. This also echoes the previous discussion from a public perspective in Section 6.4.2 and Section 7.5.1 which suggests the importance of information communication with public in increasing public awareness of climate change and public participation in adaptation actions. Together these results, therefore, lead the author to believe that various programmes are necessary to advance, communicate, explain and apply knowledge and information with the public for local adaptation.

A useful suggestion of Moser and Dilling (2007) and Biesbroek *et al.* (2010) that

dialogue way of information and knowledge transmission may be effective in improving the public communication and awareness, such as educational programmes, campaigns, stakeholder platforms and events, as interactive communication modes which enrich the process of double loop learning may be worth considering. Section 6.4.2 in the previous chapter suggested the claim that web-based tools can become the main tools. This is particularly relevant considering the high computer literacy, and that information can be cheaply and easily stored and updated, and the Internet is globally accessible (Biesbroek *et al.*, 2010). Surprisingly, the local representatives also recommended similar communication modes but, as yet, the local adaptation frameworks lack effective and specific communication strategies in Taiwan. Therefore, the findings of this study highlight the need for research to investigate and develop effective public communication in climate change adaptation.

Enhancing the interaction between scientific input and policy development

The findings relating to technological issues in the two local adaptation frameworks accord with those from larger studies (Dimitrov, 2006; Haas, 2004; Miles *et al.*, 2001; Mitchell *et al.*, 2005; Biesbroek *et al.*, 2010; Fogel, 2004; Cash *et al.*, 2003; Cash and Moser, 2000), in which it is suggested that sufficient data and accurate predictions of future climate are critical to trigger and support the development of adaptation policies and actions formation. However, Dessai *et al.* (2009) and Adger *et al.* (2009) have discovered adaptation strategies and actions can be formulated in the absence of accurate and precise climate predictions, it may be too late to take actions after the scientists can anticipate climatic crises well. In the context of insufficient data and inaccurate prediction of climate change in the future, the author suggests that the scientific information about risk and vulnerability assessment, context-specific and local knowledge of impacts, and practical options and responses are more important than accurate global climate forecast in local adaptation framework of Taiwan.

Although this study demonstrates that the scientific database is sufficient, it supports the observations of Dessai *et al.* (2005) and Crabbé and Robin (2006) that lack of local expertise to formulate adaptation can be a potential problem in local adaptation. In order to promote adaptive capacity at the local level, this study recommends the adoption of two practical suggestions from previous other studies. Firstly, the author would concur with the idea of Biesbroek *et al.* (2010) that the national adaptation strategies should provide the infrastructure and expertise to guide sub-level governments and potential

users of climate information, including information on vulnerabilities and options and government responses. The main reason is that the national government has more resources than local governments and relevant expertise can facilitate the integration between the national database and local circumstances to develop the appropriate adaptation actions for different areas.

Secondly, it may be worth considering the suggestion of Biesbroek *et* al. (2010), Guston (2001), Miller (2001), Measham *et al.* (2011), Preston and Kay (2010), and Hoppe (2005), that specialist organisations or research institutes can be established to cope with this gap to facilitate the interactions between science and policy in Taiwan (e.g. the United Kingdom Climate Impacts Programme, the Commonwealth Scientific and Industrial Research Organisation, and the National Climate Change Adaptation Research Facility). These organisations are important 'bridging' or 'boundary' organisations which means that they can provide scientifically-based recommendations relating to adaptation in order to inform appropriate adaptation policies and actions for a range of sectors and local governments. The Taiwan Climate Change Projection and Information Platform Project (TCCIP) may be considered as such. This body, which was coordinated by National Science and Technology Center for Disaster Reduction (NCDR), has started to be used as an integration platform in terms of climate change research and application, providing climate change data for impact assessments and adaptations, and supporting the national adaptation policy framework. Compared with the UKCIP, the CSIRO, and the NCCARF (Table 7.1), however, the TCCIP is a temporary task group (similar to NCCARF) which is currently working on one of three major climate change projects. Moreover, the TCCIP is working with governments, research institutes, and universities, but cooperation with NGOs and private sector is inadequate (Table 7.1).

Consequently, it is suggested here that a specialist permanent organisation or institute would seem like a suitable and practical way to link the scientific information of climate change and the development of adaptation actions. It may be appropriate that the TCCIP should expand research network to communicate and connect with the private sector and civil society with a view to building better adaptive capacity to climate change.

Table 7.1: The known specialist organisations (UKCIP, CSIRO, NCCARF, TCCIP) for adaptation policies and actions development

	UKCIP Source: United Kingdom Climate Impacts Programme (2016)
Mission	Decision-making for adaptation; Exchanging knowledge & ideas; Creative adaptation.
Team	Expert in climate change and impact, vulnerability analysis, knowledge exchange, training and communication. A diverse range of research institutions and organisations, universities, governments, businesses.
Establishment	Established in 1997 and based at Environmental Change Institute at University of Oxford.
	CSIRO Source: Commonwealth Scientific and Industrial Research Organisation (2015)
Mission	Delivering the climate knowledge Australia needs to respond to a variable and changing climate; Working in partnerships to better prepare for climate change and extreme events.
Team	CSIRO is working in partnership with governments, industries, and the communities to help Australia better prepare for and respond to extreme events.
Establishment	CSIRO is established in 1916 and constituted and operated under the Science and Industry Research Act 1949.
	(NCCARF) Source: National Climate Change Adaptation Research Facility (2016)
Mission	Support decision makers throughout Australia as they prepare for and manage the risks of climate change and sea-level rise.
Team	NCCARF is working with government, universities, NGOs and the private sector (businesses and communities).
Establishment	NCCARF is currently working on a three year programme (2014-17) and based at Griffith University on the Gold Coast.
	TCCIP Source: Taiwan Climate Change Projection and Information Platform (2016)
Mission	Producing climate change data for impact assessments and

	adaptations; Supporting national adaptation policy framework.
Team	TCCIP is working with several agencies of national government, research centers and institutes, and universities.
Establishment	TCCIP is currently working in phase 3(2016-2018) from 2010, and is coordinated by National Science and Technology Center for Disaster Reduction (NCDR) and funded by Ministry of Science and Technology.

Developing the specific legislative directive for climate change adaptation

The findings of this study relating to legal issues support the recommendation of Measham *et al.* (2011) and Amundsen *et al.* (2010). They suggest that the local governance system is usually the legally responsible and legitimate unit for managing climate change impacts. Section 7.4.2 on the legal aspects proposes the development of a specific law for climate change adaptation is an urgent priority in Taiwan. Previous studies (Wild River, 2006; Ivey *et al.*, 2004; Adger, 2003; Smith *et al*., 2009; Boswell *et al.*, 2012) suggest that the authority of local governments can be established through statute, such as legislative acts, executive orders, court decisions, and agency rulemaking. More importantly, it may be worth considering the contribution of the legislation for incorporating adaptation and hazard management into planning (Measham et al., 2011), engaging with the broader governance network to establish the necessary institutional arrangements in the development of new policies and measures (Adger, 2003), and adjust the competing interests between stakeholders in local adaptation framework (Measham *et al*., 2011). Therefore, this study suggests that a clear legal basis and specific legislation are necessary to strengthen the enforcement and status of the local adaptation framework.

Concerning human society and environment in policy development

The results (Section 7.4.2: environmental aspects) support the suggestion of Sovacool *et al*. (2015) and Bunce *et al*. (2010) that conflict between environmental interests and livelihoods of local communities may occur in adaptation actions. As displayed in Figure 7.10, the Taiwanese public believes that protective action is effective and recommends more infrastructure, such as sea walls and drainage systems to improve human resilience. However, it is well recognised that these expensive and large-scales technical measures, if implemented, can often involuntarily undermine the biodiversity

conservation of an area, thus contributing to its environmental degradation (Hsu *et al*., 2007; Yang *et al*., 2010). Likewise, there is evidence from elsewhere that adaptation actions which rehabilitate or protect natural resources and the environment may encroach on local communities' livelihoods (Sovacool *et al*., 2015), because their traditional fishing areas or farms may be transformed into reserved areas. Therefore, the results regarding environmental matters support the conclusion that natural environment conservation and human society protection should be joint main objectives in local adaptation (Section 7.4.2: environmental aspects).

Therefore, the author clearly supports the recommendation from Dimitrov (2006) and Næss *et al.* (2005) that a comprehensive understanding of the environmental implications is important such as, extent, causes, and consequences, in order to inform the formulation of adaptation actions. This, it is suggested, may avoid the proposed adaptation measures and actions from creating even greater unforeseen negative effects than those associated with the impacts of climate change. There should also be an attempt to minimise possible conflict of interests between communities and environment through processes such as, environmental risk assessment and full stakeholder participation. Such processes enable policymakers to develop appropriate adaptation policies and actions and eliminate the conflict (Jones, 2001; Few *et al*., 2007; Bormann *et al*., 2012).

For example, stakeholder participation plays a critical role in the Solar Farm Project in Taiwan, the project was proposed by the Pingtung County Government and the solar power companies after disastrous floods and sludge which submerged land and fishponds in Linbian and Jiadong Township (WRA, 2012; Land Subsidence Prevention and Reclamation Corps, 2012). This project links private businesses, government, and local communities' efforts to improve local victims' life quality, to help local industry transformation, and to solve problems of groundwater extraction. The author suggests that the project embraces multiple objectives concerning environmental conservation, economic development, and local communities' livelihood, which is the element for success. Nevertheless, this study supports the suggestions from Leary *et al*. (2008) that the development of actions in relation to environment conservation and human society depends on strong institutions and access to financial resources, because these actions require new incentives, reforms of ownership, education, training and more vigorous enforcement of regulations.

7.6 Summary

This chapter has presented the key outputs of the research. Section 7.2 contained a synthesis of the main findings in relation to the climate change response actions; Section 7.3 showed the key factors of community engagement in climate change adaptation actions from the public perspective; Section 7.4 provided an overview of the local adaptation actions and community engagement, and a summary of critical issues of the local adaptation framework from experts' perspectives. With regard to the second objective of the thesis, the findings from Section 7.2 were used as a lens to explore the salient characteristics related to public responses and develop the conceptualisation of public participation in response to climate change from the four case studies in Taiwan. This identified the influences of personal motivations and governmental arrangement on public participation in Taiwan, different prioritisation of proposed actions, and possible restrictions on inefficient actions from the public perspective (Section 7.5.1).

The findings suggested that although the public has taken many forms of personal action, mitigation, prevention and protection actions were preferred compared with retreat and accommodation actions (Section 7.2.3). It is suggested this is because climate change adaptation is not a major motivator compared with the idea of environment protection, habits and money saving. Moreover, the cost and additional influences may obstruct the public participation in retreat and accommodation actions in response to climate change. These results implied that transparent and appropriate information, accessible processes and interactive communication between the governments and the public are the most significant factors to increase public participation in climate change adaptation in Taiwan. Deliberative engagement techniques or mechanisms are necessary in order to strengthen public understanding of adaptation planning and public willingness to participate and support actions.

Furthermore, the findings in Section 7.3 showed the key factors of community engagement in local adaptation. These empirical findings identified the underlying support and potential obstacles for the community willingness to engage in adaptation action. This includes public perception, understanding, attitude, concern, feeling, and uncertainty/skepticism, which were contributive to community engagement. However, public distrust of government, inequity, cost and economic development, and powerlessness were major obstacles to community engagement in local adaptation

(Section 7.5.2).

Lastly, this study showed that the public has taken individual actions but community engagement in adaptation action is limited. Moreover, the research results showed existing challenges in the local adaptation framework of Taiwan (Section 7.4), and several possible opportunities were presented in terms of the PESTLE perspectives in Section 7.5.3: strengthening the connection between different levels of governance, enhancing financial capacity of local governments, improving the public communication and awareness, enhancing the interaction between scientific input and policy development and developing a specific legislative directive for climate change adaptation, concerning human society and environment in policy development.

Chapter Eight Conclusion

8.1 Introduction

The aims of this research, outlined in Section 1.3, were "*to develop and evaluate the Analysis-Awareness-Action Framework for coastal area of Taiwan*" and "*to discuss and recommend improvements in the local adaptation framework in Taiwan*". This chapter revisits these aims in order to draw conclusions relating to: the identification of socioeconomic vulnerability; the evaluation of public awareness of climate change; the evaluation of public participation and community engagement; and the improvements in local adaptation framework. Several implications of this research for the future climate change adaptation are the suggested. Finally, this chapter outlines the contribution of this research to the theory and practice of the AAA framework in Taiwan and identifies further areas of investigation stimulated by this research.

8.2 Main Concluding Comments

8.2.1 "Analysis" - Socioeconomic Vulnerability

With respect to the first thesis objective, "*develop and undertake an analysis of community vulnerability to climate change with respect to socioeconomic factors*", case study investigations examined:

- Development of a socioeconomic vulnerability indicator framework (SVIF)
- Coastal community susceptibility and resilience to climate change.

The context of coastal community vulnerability in Taiwan was outlined in Chapter 4. This identified several factors which contribute to community vulnerability to climate change. The study then developed a specific SVIF to identify and explore a better understanding of the specific factors of socioeconomic vulnerability of different coastal communities in Taiwan. This incorporated both susceptibility and resilience aspects and included 9 key themes (economic structure, infrastructure sensitivity, population sensitivity, age structure, special needs population, social dependence, human resource capacity, medical services provision, financial resource) which were represented by 25 indicators (cross ref: Section 5.2.3).

The SVIF was then applied within a desk study to assess and compare the relative overall socioeconomic vulnerability of four townships in two counties in SW Taiwan. This study revealed that the chosen indicators were able to demonstrate location-specific susceptibility and resilience of coastal communities to climate change. For example, the methodology revealed that Kauho Township was relatively more vulnerable than the other three townships (cross ref: Section 5.3). This study also showed that rural communities along this particular coast are more vulnerable because of their resource-dependent industries, aging society and high social dependence which makes them particularly sensitive to climatic variations. In addition, insufficient public infrastructure and medical resources also are the characteristics which pose the most severe potential risks to rural communities in relation to climate change. By contrast, excessive young population and population growth were recognised as the potential vulnerable factors of coastal township with multiple industrial structures, such as Mailiao (cross ref: Section 5.4.2). As a result of such findings, the study suggested that the SVIF was able to identify the driving factors determining the socioeconomic vulnerability of the coastal communities: highly resource-dependent industry, insufficient infrastructure capable of protecting communities, high population density and aging, underprivileged groups and limited human and medical resources (cross ref: Section 5.4.1).

8.2.2 "Awareness" - Public Awareness of Climate Change

Concerning the second thesis objective, "*evaluate and conceptualise public awareness of climate change*", case study investigations examined:

- The relevant factors of public awareness of climate change;
- Flood experience and its effect on public awareness.

In light of the study's findings related to public awareness, high levels of public concern about climate change were expressed (cross ref: Section 6.2.2). The questionnaire revealed that a large majority of the Taiwanese public were of the view that climate change is happening, and were concerned about the potential impacts of this on their lives (cross ref: Section 6.2.5). Many had experienced and observed recent hazards and climatic events such as floods, extreme rainfall, changes in seasonal weather pattern, and temperature change (cross ref: Section 6.2.1). Public concern about climate change

varied according to personal backgrounds and direct hazard experience (cross ref: Section 6.2.2). This study suggested that respondents aged over 35, rural residents, those with a low level of education (primary education or less) and high-educational degree (MSc and Ph. D), educators and homemakers, high annual household incomes, and flood-victims are more concerned about climate change. Surprisingly, young people and students are less concerned about climate change than other groups in Taiwan.

However, the questionnaire revealed that the Taiwanese public is more concerned about other issues (e.g. environmental protection, pollution, natural disasters, and economic development) than climate change (cross ref: Section 6.2.2). Moreover, this study has demonstrated that the public is uncertain about the causes of climate change and is skeptical about the anthropogenic nature of climate change. It also showed that those who are concerned about climate change are more likely to agree that it is of anthropogenic origin, and are more likely to say that they are already feeling its effects (cross ref: Section 6.2.3). This evidence supports the notion that public concern and awareness of climate change has increased, but insufficient public understanding in Taiwan. This study suggested that the Taiwanese public has received relevant information about climate change from mass media (e.g. newspaper/magazine, TV/radio, internet) or has had first-hand flood experience, but the scientific evidence provided to them of anthropogenic climate change is insufficient (cross ref: Section 6.2.4).

Regarding experience of the flood events in Taiwan, most respondents in the study areas had been directly or indirectly affected by flooding (cross ref: Section 6.3.1), The public suggested that man-made, inadequate infrastructure is the direct cause of flood in coastal areas rather than the relevant phenomena of climate change (cross ref: Section 6.3.2). The study also revealed a significant gap between public and expert views about future flood events: the public considered the frequency and intensity of flood events in their residential areas will increase in the near future, but experts argued that the flood events will be reduced because of watershed management practices (cross ref: Section 6.3.3). Finally, the majority of survey respondents agreed that an experience of flooding is associated with higher levels of public awareness of climate change and public participation in adaptation responses (cross ref: Section 6.3.4).

8.2.3 “Action” - Public Participation and Community Engagement

In light of the third thesis objective, "*identify factors influencing public participation and community engagement in local adaptation*", case study investigations examined:

- The motivations and limitation in public responses to climate change;
- Cognitive, affective and behavioural factors in community engagement.

In light of the case study findings related to the former, most questionnaire respondents perceived there is already a need to take action to respond to climate change, and most of the public suggested that they had already taken several personal actions relevant to climate change in their daily life. Unsurprisingly, those who are concerned about climate change are more likely to take actions now. However, the issue of climate change is still not a primary public concern in Taiwan. As a result, certain personal actions which had been undertaken, though relevant to climate change, had been done for environmental and economic reasons, rather than as an explicit response to climate change (cross ref: Section 7.2.1).

Notably, while national and associated local adaptation frameworks and actions have been developed in Taiwan, this study has shown that most respondents were unaware of any governmental responses and actions to climate change. The evidence from the questionnaire indicated that a lack of effective institutional arrangements was a key factor in explaining the low public awareness of and participation in local adaptation actions. In particular, such arrangements included a lack of sufficient and appropriate information, as well as the limited participatory and transparent decision-making process (cross ref: Section 7.2.2).

With respect to actions addressing climate change (Section 7.2.3), there was a number of interesting findings. Firstly, most respondents suggested various preventive and protection actions which could be most effective and in most immediate need (Figure 7.10). These included the need for better prediction and warning systems, education about climate change, and more protection facilities. In contrast, they considered long-term actions to include 'retreat' and 'accommodate' actions, such as city planning and industrial restructuring (cross ref: Figure 7.11). They suggested this because they considered these relied on a comprehensive planning system to be in place. It is important to note that the Taiwanese public also doubted the effects of several proposed adaptation actions to climate change adaptation. In this context, respondents stressed

that the carbon tax, disaster insurance, relocating residents, and removing artificial buildings are ineffective response actions to climate change (cross ref: Section 7.5.1).

While national and local adaptation frameworks have been developed and coastal adaptation actions are now being implemented in Taiwan, the expert workshop and follow-up survey demonstrated that experts and local government officials are still aware that explicit community engagement is still insufficient in local adaptation (cross ref: Section 7.4.1). From the public perspective, the findings of the questionnaire showed that cognitive, affective, and behavioural factors are likely to significantly affect community engagement in local adaptation, as outlined in Section 2.5.3. The study demonstrated that cognitive (cross ref: Section 7.3.1) and affective (cross ref: Section 7.3.2) factors appeared are more likely to increase effective community engagement. However, statistical analysis revealed that some factors, which relate to behavioural engagement, are the strongest restrictions, limiting community engagement in local adaptation (cross ref: Section 7.3.3).

8.2.4 Improvements in Local Adaptation Framework

With respect to the fourth thesis objective, "*to derive recommendations for local adaptation framework improvement*", case study investigations explored:

- Challenges of local adaptation framework.

Emerging from Section 4.3 was the recognition that there are a broad range of cooperative organisations and comprehensive strategies within the Taiwanese adaptation frameworks associated with climate change. It is well known that the functioning of adaptation frameworks and actions may be easily influenced or affected by internal forcing factors or contextual issues. Qualitative interviews using a PESTLE analysis generated consistent results from the representatives of central government, academic and local government. The following summarises some of the key contextual issues from these discussions (cross ref: Section 7.4):

> *Political*:
>
> Local adaptation is very much dependent on adequate institutional arrangements. The Taiwanese adaptation framework for climate change is based on a complex multilevel governmental framework. In general, the roles and responsibilities of actors in formatting and implementing adaptation actions are well-defined

according to their responsibilities (cross ref: Section 7.4.2: political aspects). Moreover, the interdepartmental arrangements seem often to contribute effectively to interdepartmental coordination. For example, the interdepartmental Green Energy Promotion Office and the Information Platform of Disaster Prevention demonstrate such coordination.

Economic:

As identified previously (cross ref: Section 7.4.2: economic aspects), the experts and officials agreed that insufficient finances and budgets are common problems for local adaptation framework development and implementation. While several possible financial sources (e.g. carbon tax, cooperation fund, environmental tax) have been suggested in this study, the national budget is still the main financial support to climate change adaptation. However, this is clearly limited.

Social:

It can be concluded that the experts agreed with the public that social issues associated with adaptation (such as: information transmission and communication) are increasing public awareness and helping to develop communication (cross ref: Section 7.4.2: social aspects). In turn the experts considered this would eventually help trigger actual public participation in adaptation actions in Taiwan.

Technological:

Significant advances in the science of global climate change have been achieved in the Taiwanese adaptation framework (cross ref: Section 7.4.2: technological aspects). In the light of the interview findings it is proposed here that insufficient local expertise is a critical problem in local adaptation. In this context it is suggested that science translators are necessary to facilitate the interaction between science and the development of appropriate adaptation actions.

Legal:

The local governance systems include the responsible actors for implementing adaptation actions in Taiwan. However, the lack of a specific statute or legislative process in establishing the authority of local governments in climate change adaptation was identified as a further critical issue within the cases study research (cross ref: Section 7.4.2: legal aspects). More specifically, the need to

develop an overarching and specific law or regulation seems even more important than establishing a competent agency to respond to climate change.

Environmental:

The Taiwanese adaptation framework attempts to protect and provide for greater resilience of both the natural and human environment in response to local climate change adaptation. However, as previously identified within the discussion on public perception (cross ref: Section 7.4.2: environmental aspects), there is a potential conflict between the balancing of environmental interests and livelihoods which is likely to be a further critical constraint for successful local adaptation.

8.3 Applied Implications of Study Findings

8.3.1 Applied Implications of the SVIF Findings

It is suggested that the SVIF is a useful tool to identify specific vulnerable factors and determine the relative magnitude of vulnerability for coastal areas in Taiwan (cross ref: Section 5.4.2). The work on the outcome-based indicators of socioeconomic vulnerability demonstrates that socioeconomic data may help our understanding of vulnerability. Indeed, these indicators and variables offer a better understanding and explanation of ‘who are vulnerable’ and ‘why they are vulnerable’. These specific vulnerable factors used in this study were able to demonstrate the potential susceptibility and resilience of coastal communities to climate change as well as indicating where there is a need for policy change to reduce community vulnerability in the near future. Therefore, the SVIF provides useful location-specific messages for policy makers in terms of prioritising investments and formulating more tailored and appropriate adaptation actions to context-specific aspects of vulnerability.

Quantitative socioeconomic vulnerability indicators are a theoretically sound and technically feasible way of assessing vulnerability. This study has provided some contributions to the development of quantitative assessment of vulnerability: a sound theoretical foundation, and a significant correlation between contributing indicators and vulnerability. This study has constructed a two-dimensional framework for calculating susceptibility and resilience based on a clear definition of vulnerability and theoretical framework (cross ref: Section 5.2.1). Furthermore, while indicator selection is a

subjective process, this research also introduced a set of principles to select appropriate indicators (cross ref: Section 5.2.2), and interpreted the theoretical arguments for their functional relationship with vulnerability (cross ref: Section 5.2.3).

However, the complicated development process of the SVIF in this study indicated that further improvements in data, indicators, and threshold are desirable (cross ref: Section 5.4.3). While the local indicator framework has revealed detailed and specific information, the results of indicator selection concur with previous research that it is important to consider available data and indicators. Results of the indicator selection in this study show a large number of the proposed indicators were unable to be used because of data availability. However, whilst detailed data is limited at the township level in Taiwan (cross ref: Table 5.1), the remaining indicators are still be able to reflect a complex reality.

The findings of this study suggest that there is merit in the development of indicator groups according to the local specific context rather than producing a one-size-fits-all, index-based approach. Given the findings, it may be worth considering further suggestions, investigating other potential proxies and indicators which can be used to expand the SVIF (for example: unemployment, income, infant mortality, and maternal mortality). These potential proxies and indicators may be able to explore more detail and accurate information about specific community vulnerability to climate change.

8.3.2 Applied Implications of the Public Questionnaire Findings

The results of the public questionnaire are consistent with global studies that have shown that high public acceptance of and concern about climate change, and willingness of coastal communities to participate in local adaptation (cross ref: Section 6.2.2). These findings extend the work of others, particularly by identifying direct connections between personal backgrounds and climate change concern. The findings are consistent with earlier findings suggesting from Hsu (2013) in Taiwan that communities with high annual incomes and education levels are more concerned about climate change because, it is suggested, they are more capable of accessing and understanding climate change relevant information (cross ref: Section 6.4.1). On the other hand, the current study also found evidence that suggest that personal experiences and observation of weather-related hazard events can increase public concern about climate change (cross ref: Section 6.4.3), especially elderly, rural residents, and less

educated communities. In relation to the views of young people and students (which demonstrates such lowest concern), this research suggests that education and associated actions related to climate change are necessary. Such findings underscore the importance of socioeconomic conditions and disaster experiences in public awareness of climate change in Taiwan.

On a range of measures, survey respondents have agreed with the reality of climate change and its' impacts, and suggested climate change is relevant to public lives, highlighting the importance of climate change responses to coastal communities. However, some challenges need to be overcome in order to improve public understanding of climate change and public participation in local adaptation. Firstly, this study tested the public perception of the causes of climate change, and revealed that lay-people are sceptical of the anthropogenic nature of climate change, and demonstrated that public concern about climate change interrelates with public understanding of its cause (cross ref: Section 6.4.2). Clearly, the author then agrees that scepticism of anthropogenic climate change is likely to be a significant barrier for public participation. In terms of improving public understanding and engagement with climate change adaptation, this study suggests that a combination of accessible mass media and reliable information sources can effectively improve public understanding (cross ref: Section 6.4.2). In Taiwan, it could be important that this includes increasing public understanding of anthropogenic climate change and addresses public distrust of the information from government.

Secondly, the fact that climate change is not a priority for the public in Taiwan, may be a potential constraint for public participation in local adaptation (cross ref: Section 6.2.2). These findings point to the need to develop adaptation policies or actions with co-benefits in order to increase the values of adaptation actions and engage the public (cross ref: Section 7.5.1). Alternatively, multiple issues within climate change adaptation may be relevant as, if all the co-benefits and multiple issues are taken into account in formulating adaptation actions, there is a stronger case for climate action. These added benefits, notably the health and economic ones, may help to persuade the general public participates in these actions.

With respect to actions addressing climate change, these findings stress that the public narrowly favour an emphasis on mitigation over adaptation (Figure 7.10). Moreover,

various characteristics related to intent, role of government, spatial scale, timeframe, function (cross ref: Section 2.3.2) have to be considered when adaptation actions are being developed, these known international examples can support the findings of this study and provide application suggestions for the development of adaptation action in Taiwan. For example, a combination of preventative and protection actions is desirable to the general public. While these technological adaptations can protect the environment and humans, it may be worth considering that the effectiveness of these is highly dependent on financial support and effective legislation, regulation and education system. Given that the retreat and accommodate actions are generally regarded as tactical and strategic long term adaptation actions, these long-term actions are implemented to modify and transform human society, the development process should consider the potential economic loss and influences on local communities' livelihood that might constrain public support or participation in these actions. However, significant pressures and costs associated with adaptation on communities are the key constraints, respectively (cross ref: Section 7.5.1).

Lastly, the findings of questionnaire suggest that factors relating to cognitive, affective, and behavioural engagement have a considerable effects on community participation in local adaptation (cross ref: Section 7.3). These findings lead us to consider that a more constructive dialogue and participatory process is needed with the public around climate change matters (cross ref: Section 7.5.2). For example, such dialogue and communication need to incorporate a fuller scientific explanation, and that evidence should be provided with simplified or visualised representation such as, cartoon and comic for children and in-depth coverage for general public. Furthermore, using familiar language is important and trusted information sources are vital in dialogue and participatory process. In this context, it is suggested that, considering the different cultures, ethics, and literacy levels in Taiwan, use of language in communication about climate change on media should be tailored to specific audiences. For example, most people use Mandarin, but the elderly only speak Taiwanese and the Taiwanese aborigines have their own language. Significantly, this study values highly tailored actions to specific communities both to mitigate against and adapt to climatic events. However, this needs more research to understand the different local linguistic and cultural contexts in Taiwan and how these may influence adaptation.

8.3.3 Recommendations of Improvements in Local Adaptation Framework in Taiwan

Although this study has provided a number of challenges for implementing the local adaptation frameworks in Yunlin and Pingtung County (cross ref: Section 7.4), the opportunities to improve the local adaptation framework practices more widely along the Taiwanese coast have been recognised.

Political:

Taiwanese adaptation frameworks (cross ref: Section 4.3.1), involving different levels of governance and departments, need help to develop and subsequently utilise inter-department coordination in order to implement management actions to facilitate local adaptation, as suggested in Section 7.4.2. This research recommended further strengthening of the connection between the different levels of governance as well as improvements in the participation of local actors in this multiple governance system. In this context, this study (cross ref: Section 7.5.3) suggests that these community organisations, local cooperatives and associations, NGOs, and traditional institutions seem a significant missing part in the local adaptation frameworks. Therefore, it is recommended that adaptation framework embrace these local organisations to ensure the adaptation framework operation incorporate both top-down and bottom- up perspectives. These community organisations and NGOs in Taiwan, such as, the Green Citizens' Action Alliance, the Taiwan Environmental Information Association, the Taiwan Environmental Protection Union, can help to develop and implement adaptation actions, and participate in international environmental conference (e.g. Earth Summit; Conferences of the Parties).

Economic:

In order to enhance financial capacity for developing more adaptation actions impoverished areas, additional funding sources and the involvement of the private sector are needed (cross ref: Section 7.4.2). This study suggests that engaging private actors and NGOs in the adaptation actions, and the participation in international or inter-regional cooperation or research programmes for information and resources sharing. These would not only effectively support the development and implementation of local adaptation

through increased financial capacity but would also enable Taiwan to benefit and learn from others' experiences and expertise. This wider engagement would also help to build a more comprehensive adaptation framework (cross ref: Section 7.5.3).

Social:

Given that public understanding and community engagement are significantly insufficient in local adaptation framework in Taiwan (cross ref: Section 7.4.2), this study (cross ref: Section 7.5.3) suggests that a range of different dialogue communication and interactive communication modes (*i.e.* educational programmes, campaigns, stakeholder platforms) should be employed to improve public communication. In the case of Taiwan, educational programmes and stakeholder platforms would be particularly important, given the limited current information and the weak participation process (Figure 7.8). This would help raise public awareness and willingness to participate through increased public understanding. It would also help and establish a better connection between the public and the local adaptation framework for each coastal county area.

Technological:

Considering experts suggested that the design of existing coastal defensive infrastructure is incapable of withstanding the impacts of climate change in near future (cross ref: Section 7.4.2), local adaptation frameworks in Taiwan currently should focus on improving the relatively weak context-specific information in terms of vulnerability, impacts of climate change, and adaptation options, instead of only utilizing accurate and precise global climate forecasts (cross ref: Section 7.5.3). It is further recommended that the expertise and research infrastructure from central government along with the development of specialist organisations should be further developed to help better evaluate local circumstances and enable the formulation of more realistic specific adaptation actions. This should help to trigger more effective interaction between scientific inputs and local adaptation. While the TCCIP can play a role as a 'bridging' organisation in Taiwan, this temporary task group needs to strengthen its connection with the private sectors and with communities, perhaps taking its lead from other specialist organisations and research institutes in countries elsewhere (cross ref: Section 7.5.3).

Legal:

A lack of a specific legislative directive for climate change adaptation is a critical issue for local adaptation in Taiwan, as noted above (cross ref: Section 7.4.2). It is therefore recommended that developing such an act or directive could help better define and clarify the responsibilities of the different departments and governmental levels (cross ref: Section 7.5.3). This study suggests that the placing of a level of joint responsibility on participating and relevant departments and governances, would help develop a broader governance network, and would help to adjust competing interests in local adaptation. However, at the present time, it is difficult to develop such legislation in Taiwan because sturdy opposition from interest groups (fishermen, local residents, business). Therefore, the Taiwanese government may need to involve these interest groups in the legislative process in order to develop comprehensive legislation concerning environmental conservation and economic development.

Environmental:

Finally, this research reveals a potential conflict between environmental conservation and human protection in local adaptation (cross ref: Section 7.4.2). Indeed, an awareness of this may reduce public support and participation in adaptation actions, as evidenced in many other countries, such as in the UK where 'birds v.s. people' debates are common (Ballinger, 2015). It may be worth considering that formulating adaptation actions should consider both human society and environment. Adaptation actions with multiple objectives related to environment restoration, economic development, and livelihood may eliminate the potential conflict of interest. However, the need for a balanced approach is fraught with difficulties, ranging from the need to balance various needs, including those related to environment conservation and the livelihoods of local communities (cross ref: Section 7.5.3). Such approaches also need to consider sustainable development. At the present time, developing green energy industry seems an effective approach in Taiwan through the cooperation between private businesses, government, and local communities, but strong institutional and financial support will be necessary.

8.4 Contribution of this Research

This research is set within the context of wider research into the role of the community and public engagement in adaptation frameworks are designed to help develop more effective climate change adaptation. Previous to this research, there had not been any comprehensive evaluation of bottom-up community engagement and perspectives in Taiwanese coastal climate change adaptation. As such, this research is an original contribution (Figure 3.1). It has involved diverse methodologies including methods for evaluating vulnerability analysis (cross ref: Section 3.4), public awareness of climate change and public participation in responses for climate change adaptation (cross ref: Section 3.5), and is has also explored critical issues of local adaptation framework (cross ref: Section 3.6). This study has demonstrated that the AAA framework, the chosen framework for the study, is a practical and useful tool for evaluation of local adaptation frameworks in a Taiwanese, South Asian setting (cross ref: Section 2.2.2). It provides a coherent and structured insight to help provide an understanding of socioeconomic vulnerability, public awareness, community engagement and potential challenges in local adaptation frameworks as well as providing grounding future improvements in empirical findings for climate change adaptation. Although the AAA framework is simple and logical, its wider application, as a practical tool for other areas, is likely to need strong support from government and the private sector. This would enable the development of well-defined objectives for each component of the framework and would also facilitate the considerable data needs to be met. Furthermore, the author suggests that use of the AAA framework should be considered elsewhere in countries most vulnerable to climate change, although, modifications would be required to reflect the local contexts of these other areas.

Through delivering the objectives of this research (stated in Section 1.3), several specific areas of contribution can be identified. These relate to the conceptual basis of climate change adaptation, its delivery in practice, and the implications at the local level:

- This research has identified salient socioeconomic vulnerability factors of coastal communities and specific susceptibility and resilience of different communities to the impacts of climate change on the southwest coast of Taiwan (cross ref: Section 5.4.1), even in the context of the relatively limited local data availability on some factors. Furthermore, the creation of the SVIF in this study supports the notion of vulnerability, and helps to operationalise a conceptual framework of socioeconomic

vulnerability analysis. In turn, this should facilitate a greater range of localities and contexts to be investigated within other areas of Taiwan and the elsewhere.

- The conceptual model of "public awareness of climate change" developed through this research (cross ref: Section 6.4.5), provides an original contribution to the detailed explanation concerning the influences on public awareness of climate change in Taiwan. Despite, Taiwan's different cultural setting compared with many parts of the world where such studies have previously been undertaken, there is considerable consistency with previous research in relation to the importance of public awareness in successful climate change adaptation. The understanding, knowledge, flood experience, and personal background, as detailed in Section 2.5.4, have influenced public awareness of climate change. This study also provides practical suggestions to increase public concern and improve public perception of climate change which should be of relevance to tangible scientific evidences and accessible explanations.

- The research has provided a contribution to the literature which attempts to identify the particular motivations for and constraints to public participation in adaptation responses (cross ref: Section 7.5.1). It also has, for the first time, identified the key influences on community engagement in adaptation in Taiwan. These effectively translate the findings of this research from theoretical findings to practical benefits which could include the use of the findings to inform the formulation and prioritisation of climate change adaptation policies.

- While Taiwan still cannot participate in the UNFCCC or other international organisations to address the most pressing environmental problems, Taiwan has published a National Communication and has developed a national adaptation framework in response to climate change and has expressed a wish to work with international community. The research has provided greater understanding of both national and local adaptation frameworks and their interrelationships in the context of Taiwan. These findings (cross ref: Section 7.5.3) offer insight into the specific challenges and opportunities of the Taiwanese adaptation framework, and therefore may contribute to enhancing the success of climate change adaptation in Taiwan and elsewhere, especially island states or developing countries.

- This research comes at a time when the current nature and future development of

climate change adaptation in Taiwan and elsewhere is under the spotlight. Therefore, the timelines of this this research means that it may also offer some contributions to this current debate relating to the way forward for local climate change adaptation in both Taiwan and in other Asian countries, particularly those with similar social, cultural and political profiles, such as Japan and China.

8.5 Further Research

This study has identified a number of areas for further investigation. These areas present potential developments of the research presented in this thesis. These are as follows:

- Firstly, this research has focused on the development and operation of the AAA framework along a 1,100 km stretch of coastal area in Taiwan. Whilst this coastal area was particularly chosen because of its potential vulnerability (cross ref: Section 4.2), it would be beneficial to assess its wider applicability outside this developmental context. In the Taiwanese context for example, this could include the megacity of New Taipei City, Taichung City, Tainan City, and Kaohsiung City, a mountain area such as Nantou County, and an off-island area such as Penghu County, Kinmen County. This would enable a comparison to be made to demonstrate the difference and consistency between these cases. It would also enable a deductive study to be undertaken to refine the core ideas to develop a generic model applicable to a variety of contexts in Taiwan. Furthermore, a wider application in different countries is a consideration for future research.

- Secondly, this research has presented an assessment of socioeconomic vulnerability only during a specific time period. It would therefore be useful to undertake a longer-term longitudinal study. This would facilitate better understanding of how the local adaptation actions influence on community susceptibility and resilience over time. Given a lack of a performance survey of existing adaptation actions in the Taiwanese adaptation framework, this might be a practical tool to evaluate the future performance and the effectiveness of adaptation actions against the impacts of climate change.

- Thirdly, this research has stressed the specific susceptibility and resilience of different communities to climate change, but has not ranked the vulnerability levels of all coastal communities. Future research could be undertaken to investigate more

representative indicators for a broader range of coasts and then determine a credible standard for defining vulnerability levels across the entire Taiwanese coast.

- Fourthly, as discussed in Section 6.4.1, this thesis has explored public concern about climate change in relation to different personal variables. The observed differences in the levels of concern between participants leads us to believe that further research might usefully extend into exploring the reasons for the specific effects of personal variables on public awareness of climate change. Moreover, as the results from the flood and non-flood victims are consistent (cross ref: Section 6.4.4), so future research should investigate whether and what indirect factors are influencing non-flood victims' perception of climate change.

- Fifthly, there are aspects relating to climate change communication and information which require further study. In particular, the content and most appropriate method of delivery of climate change information and communication for local communities and actors concerning different cultures, ages, and ethics in Taiwan, requires further investigation to increase effectively public participation in local adaptation.

- Sixthly, it may be of interest for future research to investigate the influence of different weather-related hazard experiences (e.g. sea level rise, mud slide) on public awareness of climate change in order to determine the influences of other climatic hazards on communities' perception of climate change in Taiwan.

- Finally, this research has focused on government adaptation actions and associated adaptation frameworks. It does not explore in any depth the actions that are taken or may be taken by separately by local communities or by local actors themselves in response to climate change. Therefore, research on these additional adaptation actions is obviously required as these could be used to understand motivations for these actions as well as the adaptive capacity and sustainability of public/private actions compared with government actions.

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APPENDIX A. SURVEY STRUCTURE OF PUBLIC QUESTIONNAIRE

Information for you about the survey

This 12 pages questionnaire is part of a study being carried out by Hao-Tang Jhan, a postgraduate researcher in Earth and Ocean Science School, Cardiff University, UK. The study focuses on communities' flood experience, awareness of climate change, and engagement with adaptation in south-west coastal area in Taiwan. The questionnaire consists of 6 sections with different types of questions (single-choice, multiple-choice, Likert-scale five-point). Please read each question and answer carefully, and then tick the appropriate option on the checklist. Any information you give is strictly confidential, your response will not be individually identified and traced back to you. The questionnaire should take you no more than 20 minutes to complete. There are no right or wrong answers to these questions and professional knowledge is not necessary, just note what you think.

Please do not hesitate to contact us via the details below if you have any further questions or concerns.

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Part A Personal Background

1. Age

□ 18-24 □ 25-34 □ 35-44 □ 45-54 □ 55-64 □ 65+

2. Gender

□ Male □ Female

3. Residence

Township _____ Postcode_____

4. Length of Residence

□ Under 5years □ 5-10 years □ 11-15 years □ Over 15 years

5. Educational Level

□ Primary or under □ Junior □ Senior (vocational)
□ BSc □ MSc □ Ph. D

6. Occupation		
□ Education	□ Services	□ Trading/Finance/Banking
□ Self-employed	□ Official	□ Military
□ Industry/Technical	□ Farming/Fishing/Husbandry	□ Homemaker
□ Health/Medical	□ Mass Communication	□ Student
□ Unemployed	□ Retired	□ Other(specify)_____

7. Annual income of household							
□	↓£4,999	□	£5,000 - £9,999	□	£10,000 - £14,999	□	£15,000 - £19,999
□	£20,000 - £24,999	□	£25,000 - £29,999	□	↑£30,000	□	no response

Part B Flood Experience

8. Please tick the following statements apply to your flood experience?			
	Yes	No	Don't know
a. My home or other properties have been damaged	□	□	□
b. I have been directly affected, e.g. can not to work, injury	□	□	□
c. Other people within 1 km of where I live have experienced property damage	□	□	□

9. If yes, can you estimate your maximum financial loss in a single flood event?							
□	No loss	□	↓£4,999	□	£5,000 - £9,999	□	£10,000 - £14,999
□	£15,000 - £19,999	□	↑£20,000	□	no response	□	I don't know

10. Based on your knowledge and experience, please tick the factors that you think are the most relevant causes of flood in your home district. (tick up to 3)		
□ Sea level rise	□ Extreme rainfall	□ Natural environment degradation
□ Storm surge	□ Land subsidence	□ River sedimentation
□ Typhoon	□ Saltwater intrusion	□ Inadequate drainage system
□ Inadequate height of embankment		□ Other (specify)_____
□ None		□ I don't know

11. How intense this flood will be in your home district? Please tick the boxes that reflect your opinion about the changes of frequency and intensity of flood by 2025, 2050, and 2100.

Frequency							**Intensity**					
6 much more	5 slightly more	4 same	3 slightly less	2 much less	1 don't know		6 much more	5 slightly more	4 same	3 slightly less	2 much less	1 don't know
□	□	□	□	□	□	Flood by 2025	□	□	□	□	□	□
□	□	□	□	□	□	Flood by 2050	□	□	□	□	□	□
□	□	□	□	□	□	Flood by 2100	□	□	□	□	□	□

12. Using your flood experience or known information about flood to answer this section. To what extent do you agree with the following statements?

	6 strongly agree	5 tend to agree	4 neutral	3 tend to disagree	2 strongly disagree		1 don't know
a. Flood experience makes me think that the climate is changing	□	□	□	□	□		□
b. Flood experience makes me concerned about climate change than before	□	□	□	□	□		□
c. Flood experience makes me want to know more information about climate change	□	□	□	□	□		□
d. Flood experience makes me think that climate change is inevitable	□	□	□	□	□		□
e. Flood experience makes me think that climate change is a disastrous consequence	□	□	□	□	□		□
f. Flood experience makes me think that it is impossible to tackle climate change	□	□	□	□	□		□
g. Flood experience encourages me to take actions to response to climate change	□	□	□	□	□		□
h. Flood experience makes me think that it is too late to take any action	□	□	□	□	□		□
i. Flood experience makes me think that current measures and actions are insufficient and limited efficacy	□	□	□	□	□		□

Part C Public Perception

13. Are you concerned about any of the following issues in your home district? (tick up to 3)

□ Economic development □ Pollution □ Political issues
□ Social issues □ Climate change □ Environmental protection
□ Traditional culture □ Natural disasters □ None
□ No comment □ Other (specify) _____

14. To what extent are you concerned about climate change?

□ very concerned □ fairly concerned □ neutral □ not very concerned □ not at all concerned

15. Do you think which one is the best description of the cause of climate change?

□ Completely caused by natural process □ Principally caused by natural process
□ Completely caused by human activity □ Principally caused by human activity
□ Caused by natural process and human activity □ I don' t know
□ No, climate is not changing □ Other (specify) _____

16. Which sources of information about climate change would you trust? (tick up to 5)

□ Newspaper/magazine □ Environmental group/NGO □ Academic publication
□ TV/radio □ Friends/family □ School/university
□ Scientists □ Local Government □ Governmental Agency
□ International organizations □ Libraries □ By experiencing it myself
□ Internet □ None □ Others(specify)_____

17. When will you expect to experience the impacts of climate change?

□ Already experience it	□ 10 years from now	□ 50 years from now
□ 100 years or longer from now	□ Never	□ I don't know

18. Scientists demonstrate many known phenomena are caused by climate change. Please tick the phenomena that you have observed, had affected you, and you most concerned with based on your personal experience.

	you have observed	had affected you	you most concerned
e. g. Climate Change	˅	˅	˅
a. Sea level rise	□	□	□
b. Seasonal cycle change	□	□	□
c. Extreme rainfall	□	□	□
d. Heat wave	□	□	□
e. Flood	□	□	□
f. Storm surge	□	□	□
g. Super typhoon	□	□	□
h. Temperature change	□	□	□
i. Droughts	□	□	□
j. Ocean acidification	□	□	□
k. Other (specify) _____	□	□	□

19. Please tick the main influences of climate change that you are most concerned with. (tick up to 5)

□ Private property loss	□ Business profit loss	□ Pollution
□ Water/food shortage	□ Mental impacts	□ Lose your job
□ Insurance premiums	□ Residence loss	□ Health & wellbeing damage
□ Infrastructure loss	□ Tourism reduction	□ Livelihood
□ Security and safety	□ Ecosystem degradation	□ Wildlife habitat destruction
□ House prices decrease	□ None	□ Other (specify)_____

20. When should people have to take actions to tackle climate change?

□ Need to take now	□ 10 years from now	□ 50 years from now
□ 100 years or longer from now	□ we don't need to act	□ I don't know

21. Over the past week, have you taken any of the following actions? (tick up to 3)

□ Recycling	□ Walk or cycle to work	□ Use public transport
□ Bring your own bags or self-prepared tableware	□ Use energy-conserving facilities	□ Participate in environment protection action
□ Be a vegetarian	□ Turn off unwanted lights	□ Other(specify)_____

22. What are the key motivations that encourage you to take the above actions? (tick up to 3)

□ Save money	□ Exercise	□ Climate change
□ Protect environment	□ Comply with policies	□ Health
□ Sustainable develop	□ My habit	□ Other(specify)_____

23. Do you know what types of actions or measures are being implemented to cope with climate change in your home district? (tick up to 3)

□ No actions and measures have been taken
□ Monitoring and investigating the changes and influences of climatic events only
□ Preparing for response the impacts of climate change in the near future
□ Taking action now to deal with existing and future impacts of climate change
□ I don't know
□ Other (specify)_____

24. The issue of institutional arrangement is an essential in community engagement. What factors of institutional arrangement would encourage you to participate with local climate change adaptation? (tick up to 3)

□ Understandable information and guidance	□ Clear responsibilities and roles
□ Salient information for specific communities	□ Dependable information sources
□ Accessible decision-making process	□ Trustworthy policymakers
□ Appropriate incentives for communities	□ Consistent governance arrangements

□ None, I don't want engage with local climate change adaptation
□ Other(specify)_____

25. Please indicate what extent do you agree with these following response actions would be effective to tackle with climate change in Taiwan.

	6 strongly agree	5 tend to agree	4 neutral	3 tend to disagree	2 strongly disagree		1 don't know
a. More defences/improvements in current infrastructures	□	□	□	□	□		□
b. Removing the artificial buildings and facilities from natural environment and habitat	□	□	□	□	□		□
c. Planting more trees	□	□	□	□	□		□
d. Purchasing natural disaster insurance	□	□	□	□	□		□
e. Developing prediction, emergency and warning systems	□	□	□	□	□		□
f. Relocating residents and towns	□	□	□	□	□		□
g. Educating people so that they are aware the risk of climate change	□	□	□	□	□		□
h. Compensation and disaster relief actions	□	□	□	□	□		□
i. Increasing the flexibility of house and city design	□	□	□	□	□		□
j. Limiting the greenhouse gas emission	□	□	□	□	□		□
k. Developing renewable energy	□	□	□	□	□		□
l. Saving the earth's resources	□	□	□	□	□		□
m. Carbon tax	□	□	□	□	□		□
n. industrial restructuring and industrial transformation	□	□	□	□	□		□
o. No action can tackle with the climate change	□	□	□	□	□		□

26. The question focuses on the priority of response actions. The question will ask about your general perception of appropriate implement timing in each specific response action. Please tick when you think these actions should be implemented as indicated in the table below

	5 short-term (within 10 years)	4 medium-term (10-50 years)	3 long-term (over 50 years)		2 ineffective action	1 don't know
a. More defences/improvement of current infrastructure	□	□	□		□	□
b. Removing artificial buildings and facilities from natural environment	□	□	□		□	□
c. Planting more trees	□	□	□		□	□
d. Purchasing natural disaster insurance	□	□	□		□	□
e. Developing prediction, emergency and warning systems	□	□	□		□	□
f. Relocating residents and towns	□	□	□		□	□
g. Educating people so that they are aware of the risk of climate change	□	□	□		□	□
h. Compensation and disaster relief actions	□	□	□		□	□
i. Increasing the flexibility of house and city design	□	□	□		□	□
j. Reducing greenhouse gas emissions	□	□	□		□	□
k. Developing renewable energy	□	□	□		□	□
l. Saving the earth's resources	□	□	□		□	□
m. Carbon tax	□	□	□		□	□
n. industrial restructuring and industrial transformation	□	□	□		□	□

Part D Cognitive Engagement

27. This section investigated public knowledge, awareness and attitude about climate change may influence public engagement with local climate change adaptation. To what extent do you agree with these following statements?

I <u>want to engage</u> with local climate change adaptation because ……

	6 strongly agree	5 tend to agree	4 neutral	3 tend to disagree	2 strongly disagree		1 don't know
a. I think climate is changing	☐	☐	☐	☐	☐		☐
b. Climate change is disastrous, especially to vulnerable groups (e.g. poverty)	☐	☐	☐	☐	☐		☐
c. I think human activity affects climate	☐	☐	☐	☐	☐		☐
d. Climate change is human responsibility	☐	☐	☐	☐	☐		☐
e. Climate change has benefits to some specific communities	☐	☐	☐	☐	☐		☐
f. Climate change has serious consequences for me and my family	☐	☐	☐	☐	☐		☐
g. Climate change will have significant impact on natural environment	☐	☐	☐	☐	☐		☐
h. Climate change will have significant impact on human society	☐	☐	☐	☐	☐		☐
i. The impacts of climate change are inevitable	☐	☐	☐	☐	☐		☐
j. The impacts of climate change are unrecoverable	☐	☐	☐	☐	☐		☐
k. Climate change are unpredictable	☐	☐	☐	☐	☐		☐
l. I am able to do a lot about climate change	☐	☐	☐	☐	☐		☐
m. I tend to sustainable development	☐	☐	☐	☐	☐		☐
n. It is necessary to take action to adapt to the impacts of climate change	☐	☐	☐	☐	☐		☐

Part E Affective Engagement

28. This section explored public concern, feeling, skepticism and trust about the issue of climate change may influence public engagement with local climate change adaptation. To what extent do you agree with these following statements?

I <u>want to engage</u> with local climate change adaptation because ……

	6 strongly agree	5 tend to agree	4 neutral	3 tend to disagree	2 strongly disagree		1 don't know
a. I am concerned about the issue of climate change	☐	☐	☐	☐	☐		☐
b. I am concerned about the impacts of climate change on me personally	☐	☐	☐	☐	☐		☐
c. I am concerned about the impacts of climate change on human society	☐	☐	☐	☐	☐		☐
d. I am concerned about the impacts of climate change on wildlife and the natural environment	☐	☐	☐	☐	☐		☐
e. Climate change and its impacts frighten me	☐	☐	☐	☐	☐		☐
f. I am affected by the relevant reports in the media	☐	☐	☐	☐	☐		☐
g. I have direct experience of impacts	☐	☐	☐	☐	☐		☐
h. I think climate change is a real problem	☐	☐	☐	☐	☐		☐
i. The information about climate change is reality	☐	☐	☐	☐	☐		☐
j. The impacts or seriousness of climate change are **<u>not</u>** overstated	☐	☐	☐	☐	☐		☐
k. The science of climate change is certain	☐	☐	☐	☐	☐		☐
l. I trust the scientific evidences about climate change	☐	☐	☐	☐	☐		☐
m. I trust the government will protect people from the impacts of climate change	☐	☐	☐	☐	☐		☐
n. I believe these actions will have effect on climate change	☐	☐	☐	☐	☐		☐

Part F Behavioural Engagement

29. This section investigated what factor can be a motivation or a barrier to limit public engagement with local climate change adaptation. To what extent do you agree with these following statements?

I <u>don't want</u> to engage with local climate change adaptation because ……

	6 strongly agree	5 tend to agree	4 neutral	3 tend to disagree	2 strongly disagree		1 don't know
a. I think that I have already done enough	☐	☐	☐	☐	☐		☐
b. It is **<u>impossible</u>** to have strong economic development and tackle climate change at the same time	☐	☐	☐	☐	☐		☐
c. I think that adaptation action is irrelevant to me	☐	☐	☐	☐	☐		☐
d. I have more important priorities than climate change adaptation actions	☐	☐	☐	☐	☐		☐
e. The actions that I take are unrelated to tackle with climate change	☐	☐	☐	☐	☐		☐
f. I am **<u>not</u>** well informed about climate change adaptation actions	☐	☐	☐	☐	☐		☐
g. I **<u>don't</u>** understand climate change adaptation actions	☐	☐	☐	☐	☐		☐
h. I **<u>don't</u>** know what actions I can take	☐	☐	☐	☐	☐		☐
i. I **<u>don't</u>** have time	☐	☐	☐	☐	☐		☐
j. I think these actions are too costly	☐	☐	☐	☐	☐		☐
k. I **<u>don't</u>** want change my habit or way of life	☐	☐	☐	☐	☐		☐
l. I think that the majority of people are not doing enough	☐	☐	☐	☐	☐		☐
m. Engage with these actions make my life more inconvenient	☐	☐	☐	☐	☐		☐
n. It is too late to undertake any actions	☐	☐	☐	☐	☐		☐

Thank you for completing this survey and your participation is very much appreciated

-END-

APPENDIX B. INTERVIEW OF FOCUS GROUP, THE EXPERT WORKSHOP

The critical issues of climate change adaptation and community engagement

The workshop is conducted in order to explore the critical issues of local adaptation action and the critical factors of community engagement. As you known, your participation in this workshop is voluntary and we value all of your opinions and views. Whatever we discuss today will be confidential and used only for this research. I would like to say that there are no right or wrong answers and we will simply be asking for your own opinions and experiences, please feel comfortable to say what you think. We also would like to know as many different views as possible, please feel free to disagree with someone else and share you own view.

During the discussion, we would like to take note and record the whole discussion. The reason for recording is we do not want to miss anything that is said. Please do not be concerned about this. Our discussion will remain completely confidential and the information will only be used for this research and the recording will be securely stored. This discussion will probably last about three hours.

Please do not hesitate to contact us via the details below if you have any further questions or concerns.

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I. EXPERTS' VIEWS On FUTURE TRENDS OF FLOOD

- The questionnaire analysis shows that most respondents thought that the frequency and intensity of flood will increase in the future. Do you think that **current local adaptation actions can effectively reduce flood in the near future**? Please specify.

II. EXPERTS' VIEWS ON COMMUNITY ENGAGEMENT WITH LOCAL ADAPTATION FRAMEWORK

Please specify and draw out these critical issues for community engagement with local adaptation action

- Do you know whether any communities participated in the formulation process of local adaptation actions? Whether there are any opportunities or barriers to engage the community with this process? Please specify.

- If the local adaptation actions are without community engagement, what are the possible consequences on the local adaptation actions? Please specify.

III. LOCAL ADAPTATION FRAMEWORK

The critical issues for local planning in adapting to climate change. Please specify and draw out these issues by PESTLE as follows:

1. From the **political perspective**, would you identify what you think are the critical factors for local planning actions in adapting to climate change which have led to the adaptation framework? Please specify. e.g.: drive from Central government: top-down (Adaptation Strategy to Climate Change in Taiwan; A Guide for Local Climate Change Adaptation Planning); drive occurring locally: bottom-up (Adaptation Plan to Climate Change in Pingtung County); inter-departmental cooperation and coordination.

    - Do you think the identification of roles and responsibilities among sectors of local governments are clear in coastal adaptation to climate change? Could you please describe briefly how to clearly identify the roles and responsibilities of different departments?

- Do you know any mechanism for inter-departmental and cross-jurisdictional coordination in local coastal adaptation action to climate change? Could you please describe briefly how to establish a practical mechanism or improve existing measures? Please specify.

2. From the **economic perspective**, would you identify what you think are the critical factors for local planning actions in adapting to climate change? Please specify. e.g.: economic incentive; financial planning; cost-effectiveness.

   - Do you think that funds are sufficient for adapting to climate change in coastal areas? Could you please describe briefly any current financial support?

   - Do you know any potential financing sources? Could you please describe briefly how to obtain it?

3. From the **social perspective**, would you identify what you think are the critical measures in local planning actions in adapting to climate change? Please specify. e.g.: education on climate change; information platform.

   - Do you think public participation is conducive to local coastal adaptation to climate change? Could you please describe briefly how to improve public participation in climate change adaptation?

   - Do you know of any incentive programmes that have been conducted to encourage community engage in local coastal adaptation to climate change? Could you please describe briefly how to establish or improve these programmes?

   - Do you think the public have fully received and understood the relevant information about climate change? Could you please describe briefly how to improve information and communication?

4. From the **technological perspective**, would you identify what you think are the critical factors for local planning actions in adapting to climate change? Please

specify. e.g.: interdisciplinary researches, expertise, facilities.

- Do you think that existing defensive infrastructure and facilities are sufficient to protect the local communities? Could you please describe briefly how to improve it?

- Do you think the scientific data of climate change is creditable to the public? Could you please describe briefly how to increase the public's confidence on the available information?

- Do you think the early warning systems, emergency preparedness, and response procedures are carried out effectively? Could you please describe briefly how to improve such systems?

5. From the **legal perspective**, would you identify what you think are critical factorsfor local planning actions in adapting to climate change? Please specify. e.g.: identification of roles and responsibilities among authorities, integrated and exclusive legal regime, specific administration.

   - Do you think the land use and development regulations and coastal laws can effectively reduce coastal vulnerability to climate change? Could you please describe briefly how to accelerate the legislative procedure for such regulations?

   - Do you think that integrating the adaptation notion into coastal zone management plans can respond effectively to the impacts of climate change in near future? Could you please describe briefly how to make it practical?

6. From the **environmental perspective**, would you identify what you think are the critical factors for local planning actions in adapting to climate change? Please specify. e.g.: uncertainty of impact, basic dataset.

   - Most respondents think that coastal protection engineering is the best way to defend coastal areas. Do you think that natural environment protection measures are more effective to respond to climate change than artificial

defensive infrastructures?

- Could you please describe briefly how to construct artificial infrastructures that take into account life and property protection and environmental friendliness?

APPENDIX C. QUESTIONNAIRE OF FOCUS GROUP, FOLLOW-UP QUESTIONNAIRE

Thank you for agreeing to take part in this interview today. This is a follow-up survey with officers from two local governments (Yunline and Pingtung County). The previous surveys were a public questionnaire on public understanding of governmental actions and arrangement in the two counties (2014) and a small expert workshop focusing on potential factors in local adaptation action (2014, National Kaohsiung Marine University). The project is being undertaken by Hao-Tang Jhan, a postgraduate student at Cardiff University, UK. This survey aims to understand local adaptation actions and explores differences between government and public perspectives on this topic. Our meeting today will take the form of semi-structure conversation to find out more about local adaptation action in your county. The direction of the interview will be largely determined by your answers and discussion. I will then ask you about the context of adaptation actions and situation of community engagement in the county. We'll also have an in-depth discussion to create a consensus about local adaptation framework based on the outputs of the previous opinions from expert workshop.

You are free to pull out at any time, and if during the interview you have reservations about talking, this is fine to tell me. Because I am not an expert, please so tell me everything you think is relevant on the subject. I would like to hear about your personal opinions; if not, that's fine too.

Thank you. I've got a few quick background questions to start us off:

Name of respondent: _____

Name of Organisation:_____

Position: _____

Years of Experience:

□ ↓5 years □ 5-9 years □ 10-14years □ 15-19 years □ ↑20 years

Education Degree:

□ Primary □ Junior □ Senior □ University/Collage □ MSc □ Ph.D

Specialty:

□ Marine Management □ City Planning □ Climate Change Adaptation

□ Ocean Engineering □ Hydraulic Engineering □ Marine Law

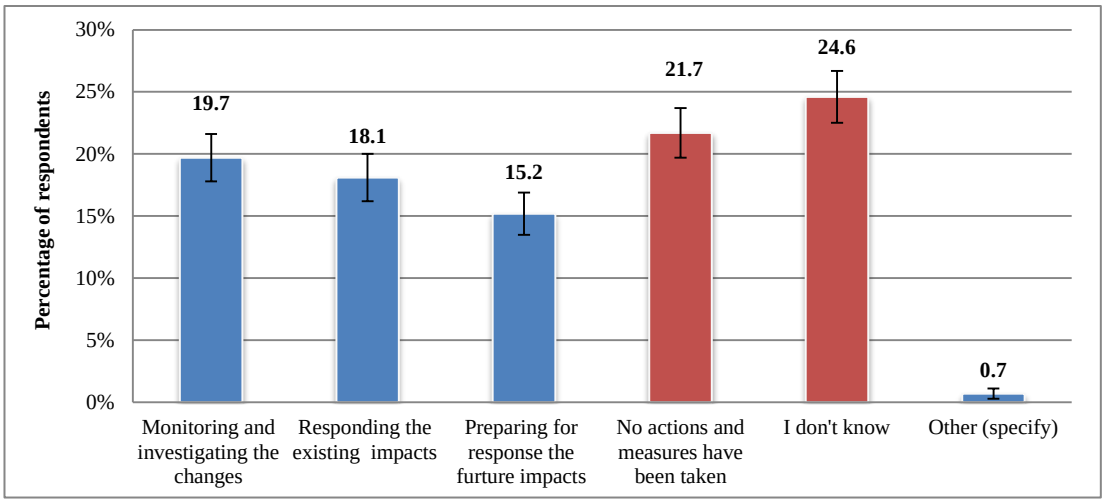
□ Marine Environment Protection □ Disaster Prevention

□ Other (specify) _____

I. GOVERNMENTAL ACTIONS

Introduction

For the first part of the survey, we are going to refer to the results of the public questionnaire. I am going to show you the initial results of the study which highlighted public awareness of governmental actions and showed different levels of community engagement with planned adaptation actions. Figure 1 shows the public is not very aware of local government adaption actions. However, I am aware your government has an adaptation strategy, so, I am interested in current status of adaptation actions, types of public engagement associated with these actions, and why the public appear not know about many of these implemented adaptation actions.



Respondents' knowledge of existing government actions.

Q1. According to the Climate Change Adaptation Project in Yunlin and Pingtung County, the author is aware that local governments have a published adaptation strategy with listed actions for eight issues.

1. Can you tick the existing phase of the three main adaptation actions to climate change in your county?

	Formulating	**Implementing**	**Completed**
Protection Technology ex: protective construction/facility	□	□	□
Retreat Technology ex: restricted-development, relocation programme, retreat area	□	□	□
Accommodation Technology ex: early warming system, insurance, new technology and regulation	□	□	□

2. Do you know whether the three types of adaptation actions involved community engagement in your county? Please tick those that apply.

	Explicit engagement	**Implicit engagement**	**Without engagement**
Protection Technology ex: protective construction/facility	□	□	□
Retreat Technology ex: restricted-development, relocation programme, retreat area	□	□	□
Accommodation Technology ex: early warming system, insurance, new technology and regulation	□	□	□

- **Explicit engagement actions:** These require a definite cooperation and collaboration with individual or local communities for successful implementing these actions or changing public behaviour.
- **Implicit engagement actions:** These have the potential to increase public awareness and understanding of climate change with passive public participation in these adaptation actions.
- **Without engagement:** There is no need for public engagement for these actions as these actions as they can be effectively undertaken to protect general public or increase their adaptive capacity to climate change.

Q2. Figure 1 shows that the local adaptation framework has developed and conducted many adaptation actions, but almost a half of local respondents are unfamiliar with these actions. Please answer these following questions:

1. Are you concerned about the finding (Figure 1) that a half of respondents do not know what actions are being implemented and no actions and measures have been taken?

□ very concerned	□ fairly concerned	□ neutral	□ not very concerned	□ not at all concerned

2. What do you think are the potential reasons that local communities are unaware and unfamiliar with these planned adaptation actions?

_____

_____

3. Do you have any suggestions to increase local communities' awareness and understanding of the local adaptation framework and actions?

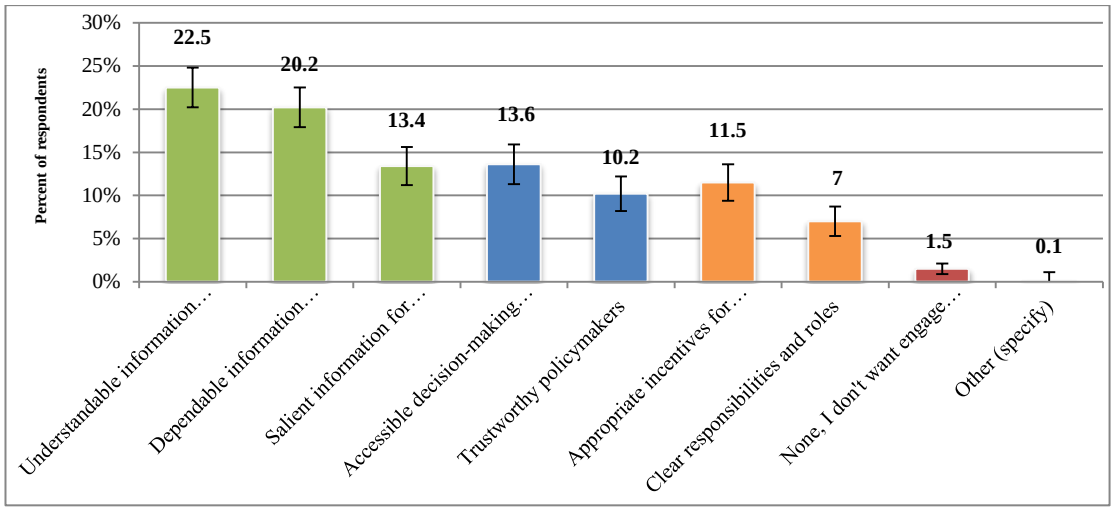
_____

_____

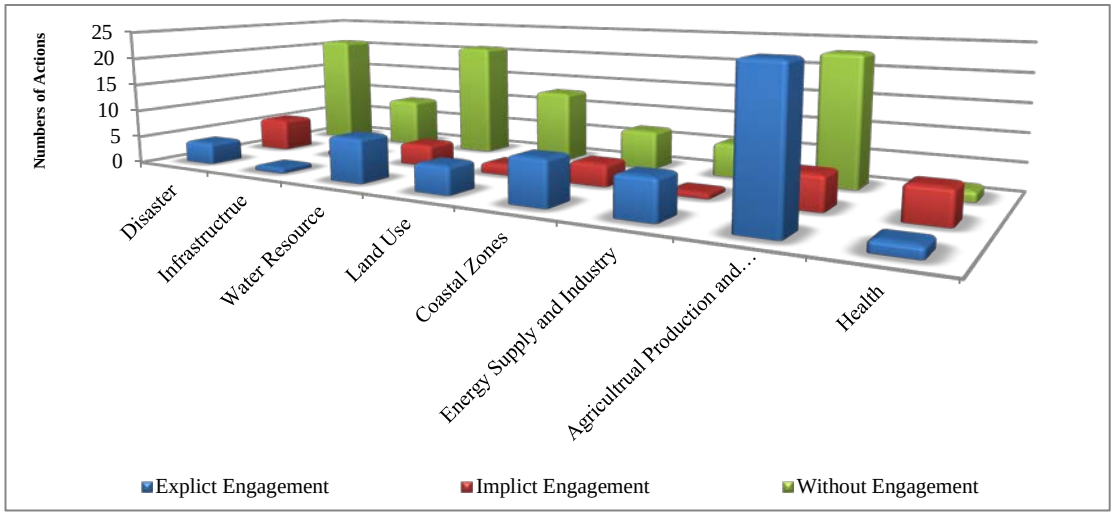
II. Institutional arrangements

Introduction

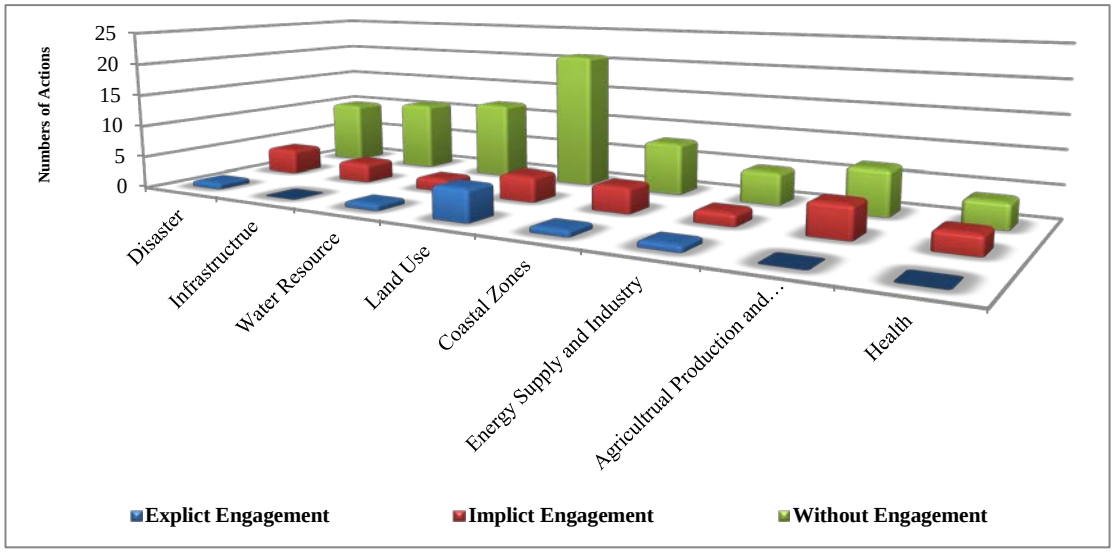
The second section gave you some figures to show you the potential factors which may be able to increase community engagement with adaptation actions (Figure 2) and different community engagement with planned adaptation actions (Figure 3&4). Although the local adaptation actions have been developed to increase public awareness, figure 2 indicates that the participation mechanism and information is still insufficient to public. So, in the following questions I am going to explore your views on community awareness and how to engage local community with adaptation actions.



Respondents' suggestions for future improved engagement



The nature of public engagement in proposed adaptation actions in Yunlin County



The nature of public engagement in proposed adaptation actions in Pingtung County

Source: Pingtung County Adaptation to Climate Change Project, 2012

Q3. It is known that some adaptation actions have been specifically implemented to increase local communities' awareness and understanding of climate change adaptation in your county.

1. To what extent do you agree/disagree that these adaptation actions have increased community awareness and understanding? Please tick the suitable answer and explain why / how have been successful or not?

□ strongly agree	□ tend to agree	□ neither agree or disagree	□ tend to disagree	□ strongly disagree

_____

_____

Q4. Figure 3 and 4 show that community engagement is limited, particularly for implementation rather than decision-making actions. Furthermore, Figure 2 also reveals that the public think that accessible decision-making process is important.

1. Do you know any difficulties or challenges associated with community engagement with adaptation actions in your county?

_____

_____

2. Do you know any further plans (actions) to engage with the community in future decision-making related to adaptation action in your county? Please specific it.

_____

_____

3. Do you have any further comments/suggests in relation to community engagement with local adaptation actions? Please specific it.

_____

_____

III. The potential problems in local adaptation framework from PESTEL perspectives

Introduction

For the third section of the survey, we are going to refer to the summarised results of the expert workshop. I am going to ask your opinions according to the expert's suggestions and comments on local adaptation framework and action.

Q5. From the ***political perspective***, the experts considered the main issues to be ***interdepartmental coordination*** and ***the roles and responsibilities of different departments in local government are clear*** in local adaptation frameworks.

1. Is the **idea of interdepartmental coordination** used in the local adaptation framework? Please provide examples.

□	Yes	□	No

_____

2. To what extent do you agree/disagree that this idea is effective to respond to climate change in your county? Please briefly explain your answer.

□	strongly agree	□	tend to agree	□	neither agree or disagree	□	tend to disagree	□	strongly disagree

_____

3. Is **the roles and responsibilities of different departments in local government are clear** in the local adaptation framework? Please provide examples.

□	Yes	□	No

_____

4. To what extent do you agree/disagree that **clear roles and responsibility** in local adaptation framework is effective to respond to climate change in your county? Please briefly explain your answer.

□	strongly agree	□	tend to agree	□	neither agree or disagree	□	tend to disagree	□	strongly disagree

_____

Q6. From the ***economic perspective***, the experts suggest that the cost-effectiveness of adaptation action is a key issue because the budget is temporal and limited. Therefore, the main issues are ***insufficient financial support*** and ***international or regional cooperation funds and carbon tax*** from central and local government.

1. Is the **financial support and budget sufficient** in the local adaptation framework? Please provide examples.

□ Yes	□ No

_____

2. To what extent do you agree/disagree that **sufficient financial source and budget** is effective to respond to climate change in your county? Please briefly explain your answer.

□ strongly agree	□ tend to agree	□ neither agree or disagree	□ tend to disagree	□ strongly disagree

_____

3. Is any **international or regional cooperation funds and carbon tax** used in the local adaptation framework? Please provide examples.

□ Yes	□ No

_____

4. To what extent do you agree/disagree that above **funding sources** are effective to respond to climate change in your county? Please briefly explain your answer.

□ strongly agree	□ tend to agree	□ neither agree or disagree	□ tend to disagree	□ strongly disagree

_____

Q7. From the ***social perspective***, the experts suggest that the public are only aware of disaster prevention, not adaptation. Therefore, the experts suggest that the ***increasing the public awareness*** and **encouraging better communication** are the top priority.

1. Is this idea of **increasing public awareness** used in the local adaptation framework? Please provide examples.

□ Yes	□ No

_____

2. To what extent do you agree/disagree that this idea is effective to respond to climate change in your county? Please briefly explain your answer.

□ strongly agree	□ tend to agree	□ neither agree or disagree	□ tend to disagree	□ strongly disagree

_____

3. The experts also suggest that the **programmes encouraging better communication** can be used. So, is any programme used in the local adaptation framework to communicate with public? Please provide examples.

□ Yes	□ No

_____

4. To what extent do you agree/disagree that such programmes are effective to respond to climate change in your county? Please briefly explain your answer.

□ strongly agree	□ tend to agree	□ neither agree or disagree	□ tend to disagree	□ strongly disagree

_____

Q8. From the ***technological perspective***, the experts suggest that a lack of understandable information and limited climatic anticipation may increase public misunderstanding of climate change. Therefore, this suggests a need for ***a reliable database and good use of scientific data*** and ***defensive infrastructure and facilities, as well as preventive actions and emergency preparedness***.

1. Is any **database and scientific data** used in the local adaptation framework? Please provide examples.

□ Yes	□ No

_____

2. To what extent do you agree/disagree that **scientific data and database** is effective to respond to climate change in your county? Please briefly explain your answer.

□ strongly agree	□ tend to agree	□ neither agree or disagree	□ tend to disagree	□ strongly disagree

_____

3. The experts also highlight the need for effective **defensive infrastructure and facilities, as well as preventive actions and emergency preparedness**. So, are these approaches developed in the local adaptation framework? Please provide examples.

□ Yes	□ No

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4. To what extent do you agree/disagree that these approaches are effective in your county? Please briefly explain your answer.

□ strongly agree	□ tend to agree	□ neither agree or disagree	□ tend to disagree	□ strongly disagree

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Q9. From the ***legal perspective***, the experts suggest that the effectiveness of law and regulation may reduce the vulnerability to climate change. Therefore, the experts considered the ***specific law and administration*** and ***integrating adaptation into management plans and projects*** is critical to local adaptation framework.

1. Is this idea of **specific law and administration** used in the local adaptation framework? Please provide examples.

□ Yes	□ No

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2. To what extent do you agree/disagree that **specific law and administration** is effective to respond to climate change in your county? Please briefly explain your answer.

□ strongly agree	□ tend to agree	□ neither agree or disagree	□ tend to disagree	□ strongly disagree

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3. The experts also suggest that **integrating adaptation into management plans and projects** is important when responding to climate change. So, is this idea used in the local adaptation framework? Please provide examples.

□ Yes	□ No

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4. To what extent do you agree/disagree that **integrating adaptation into management plans** is effective to respond to climate change in your county? Please briefly explain your answer.

□ strongly agree	□ tend to agree	□ neither agree or disagree	□ tend to disagree	□ strongly disagree

_____

Q10. From the ***environmental perspective***, the experts mention that natural environment protection is more effective for helping respond to climate change. The experts considered the ***disaster prevention and environmental protection*** and ***artificial infrastructure should involve both protection and be environmental friendly*** are significant.

1. Is this idea of **disaster prevention and environmental protection** both used in the local adaptation framework? Please provide examples.

□ Yes	□ No

_____

2. To what extent do you agree/disagree that **disaster prevention and environmental protection** is effective to respond to climate change in your county? Please briefly explain your answer.

□ strongly agree	□ tend to agree	□ neither agree or disagree	□ tend to disagree	□ strongly disagree

_____

3. The experts also suggest that constructing artificial infrastructure should involve both **protection and be environmental friendly**. So, is this approach used in the local adaptation framework? Please provide examples.

□ Yes	□ No

_____

4. To what extent do you agree/disagree that **<u>constructing artificial infrastructure involve both protection and be environmental friendly</u>** is effective to respond to climate change in your county?

□ Great Effective	□ Considerable Effective	□ Neutral	□ Little Effective	□ No Effective

APPENDIX D. LOCAL ADAPTATION ACTIONS IN YUNLIN COUNTY

Issue	Adaptation strategies and actions	Patterns of public engagement		
Disaster	**Strategy 1: Establishing the risk assessment of climate change and vulnerability indicators.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Determining the hazard-prone and environment sensitive areas.		ˇ	
	Developing the map of hazard-prone areas and the high risk areas considered as the priority areas.		ˇ	
	Estimating the vulnerability of compound disasters and scale of extreme disasters.		ˇ	
	Strategy 2: Coordinating among stakeholders on the comprehensive flood control plan to implement the early warming of heavy rain and the disaster prevention plan.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Developing the communication system of hydrologic regime and flood defense exercise.			ˇ
	Strengthening the system of flood prevention and rescue.			ˇ
	Improving the accuracy of rainfall prediction.			ˇ
	Integrating the relevant information of hydrologic regime to develop the decision support system.			ˇ
	Improving the early warning system of inundation in flood-prone areas.			ˇ
	Strategy 3: Other control and management measures	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Strengthening the adaptive capacity of medical sector to increase the ability of disaster emergency rescue.			ˇ
	Reviewing the coverage area of information collection facilities of hydrologic regime.			ˇ
	Strategy 4: Coordinating among stakeholders on the comprehensive flood control plan to implement the soil and water conservation and the disaster prevention plan of slope land.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Enforcement against the illegal activities and cases of slope land.			ˇ
	Reviewing and reinforcing the regulation of soil and water conservation plans and measures in development case of slope land.			ˇ
	Developing the safety and rainfall warning systems on slope land.			ˇ
	Comprehensive planning of drainage system in hillside communities.			ˇ
	Improving the regulation of environmental protection measures of slope land development.			ˇ
	Strategy 5: Coordinating among stakeholders on the comprehensive flood control plan to implement the flood control and river basin management plan.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Periodic observation, detection, and dredging of river channel.			ˇ
	Reviewing the discharge of pumping station, improving the old pumping facilities and pumping stations.			ˇ
	Developing the GIS dataset of rain water sewer systems.			ˇ
	Clearing and maintenance of rain water sewer systems.			ˇ
	Building the storing and infiltration facilities in current and new rain water sewer systems			ˇ
	Planning and installing the distributed detention basins.			ˇ
	Strategy 6: Integrating the climate change response and influence of disaster into the land use management planning.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Assessing the environmental carrying capacity and reviewing the characteristic features and development planning of different areas.		ˇ	
	Integrating the hazard-prone and environment sensitive areas and the idea of disaster prevention into land use planning in order to limit new development and utilisation areas.		ˇ	

Executing vulnerability assessment of major construction projects and regional development plans		ˇ	
Strategy 7: Coordinating among stakeholders on the comprehensive flood control plan to review the land use management planning.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
Reviewing the delimitation and management of riparian buffer areas.			ˇ
The areas of land readjustment and zone expropriation are used as demonstration areas of comprehensive flood control.			ˇ
Enforcing demonstration projects of settlement space and industrial adaptation in coastal flood-prone area.	ˇ		
Introducing stilt houses in flood-prone areas.	ˇ		
Strategy 8: Developing the information platform of high risk areas and strengthening the early warning system, training and exercise for disaster prevention and refuge.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
Integrating the available resources, and improving communities' emergency adaptability to disasters by education, training, and exercise.	ˇ		
Developing instant messaging software in high risk areas to increase the communities' adaptability.			ˇ
Developing self-dependent disaster resistant communities.	ˇ		

Issue	Adaptation strategies and actions	Patterns of public engagement		
Land Use	**Strategy 1: Integrating the water supply capacity into the Regulations for the Periodical Overall Review of Urban Planning and Urban Regeneration.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	The new city planning and large-scale base development should consider the energy supply.			ˇ
	Assessing the influence of climate change on urban development, energy use, and industrial development to develop useful references for land use planning.			ˇ
	Water use plan should consider the industrial areas.			ˇ
	Strategy 2: Architectural Planning and materials have to consider the heat island effect and global warming.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Enforcing the evaluation plan of current green building renewal and reconstruction.			ˇ
	Developing the autonomic regulation of public and private green building			ˇ
	Promoting the green building.	ˇ		
	Strategy 3: Planning the green belt and the blue belt in the city.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Developing and linking the green belt and blue belt in urban areas.			ˇ
	Strategy 4: Coordinating among stakeholders on the comprehensive flood control plan to review the water retention and permeable methods of the Regulations on Land Use Control.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Promoting the green buildings.	ˇ		
	Using the water-conservation index in green buildings to evaluate green buildings.			ˇ
	Developing incentives to encourage people to build infiltration and retention facilities in buildings.	ˇ		
	Integrating the Specifications for soil water content of green building into city design, and improving the design of energy saving, environmental friendly, and Soil Water Content of buildings.			ˇ
	Strategy 5: Reviewing the land use of river basins in city planning.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Designating retention basins to reduce the flood risk in urban areas.			ˇ
	Strategy 6: Integrating the climate change response and influence of disaster into the land use management planning.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Assessing the environmental carrying capacity.		ˇ	
	Integrating the hazard-prone and environment sensitive areas and the idea of disaster prevention into land use planning in order to limit the new development and utilisation areas.			ˇ
	Regular monitoring of the land use and land cover changes, and updating the dataset of GIS.		ˇ	
	Enforcing the Programme of land subsidence specific solutions and actions in Yunlin and Chunghua.			ˇ
	Strategy 7: Coordinating among stakeholders on the comprehensive flood control plan to review the land use management planning.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Reviewing the delimitation and management of riparian buffer areas.			ˇ
	The areas of land readjustment and zone expropriation are used as demonstration areas of comprehensive flood control.			ˇ
	Enforcing the demonstration projects of settlement space and industrial adaptation in coastal flood-prone areas.	ˇ		
	Introducing stilt houses in flood-prone areas.	ˇ		

Issue	Adaptation strategies and actions	Patterns of public engagement		
Coastal Zones	**Strategy 1: Integrating the climate change response and influence of disaster into the land use management planning.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Assessing the environmental carrying capacity.		ˇ	
	Integrating the hazard-prone and environment sensitive areas and the idea of disaster prevention into land use planning in order to limit the new development and utilisation areas.			ˇ
	Regular monitoring the land use and land cover changes, and updating the dataset of GIS.		ˇ	
	Enforcing the Programme of land subsidence specific solutions and actions in Yunlin and Chunghua.			ˇ
	Reviewing the delimitation and management of riparian buffer areas.			ˇ
	The areas of land readjustment and zone expropriation are used as demonstration areas of comprehensive flood control.			ˇ
	Enforcing the demonstration projects of settlement space and industrial adaptation in coastal flood-prone areas.	ˇ		
	Introducing stilt houses in flood-prone areas.	ˇ		
	Strategy 2: Biodiversity monitoring, species and, natural coastal environment conservation.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Developing a monitoring system and dataset of coastal biodiversity, regular monitoring and effectiveness evaluation for practices and policies adjustment.		ˇ	
	Strategy 3: Developing natural habitat conservation and nature reserves.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Wetland development and existing wetland conservation.			ˇ
	Conservation of existing nature reserves or potential hotspots of biodiversity.			ˇ
	Enforcing ecosystem restoration according to the ecological principles.			ˇ
	Strategy 4: Production adjustment and technique improvement.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Changing the farming fish species according to the weather condition in different areas.	ˇ		
	Investigating and monitoring the marine environment.		ˇ	
	Strategy 5: Industrial transformation or redevelopment programme in land subsidence areas.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Developing marine aquaculture.	ˇ		
	Changing the farmed fish species according to the weather condition in different areas.	ˇ		
	Investigation and land use change of the inappropriate aquacultural land.	ˇ		
	Promoting agricultural recreation and agricultural tourism.	ˇ		
	Promoting water-saving technology and water recirculation culture system.	ˇ		

Issue	Adaptation strategies and actions	Patterns of public engagement		
Water Resource	**Strategy 1: Coordination among stakeholders on the policy of sustainable management and utilization of water resource to develop the measurement of water adjustment.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Reviewing the water supply and demand and assessing the risk of unbalance of supply and demand to develop the response measures and water-efficient actions.			ˇ
	Understanding the risk of extreme weather and water supply change to develop the response measures.		ˇ	
	Developing the storing facilities of water			ˇ
	Developing the complete public water system			ˇ
	Investigating the effect of agricultural water transformation on integral water use.			ˇ
	Reviewing the cooperation mechanism between the Irrigation Association in Changhua and Yunlin County to increase the water use efficiency.			ˇ
	Promoting the market mechanism of water exchange and valuable water resource to save water.			ˇ
	Developing industrial, agricultural, and domestic water saving.	ˇ		
	Assessing the feasibility of self-sufficient in industrial water	ˇ		
	Developing the technique of efficient use and multiple reusing of water.			ˇ
	Developing the overall monitoring system and immediate dataset of groundwater.			ˇ
	Strategy 2: Developing early warning of water quality degradation.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Monitoring the water quality of reservoir and analysing the exacerbation.		ˇ	
	Strengthening the water quality management and evaluating the exacerbation and water supply to develop response measures.		ˇ	
	Promoting the water resource conservation and support programmes in nature reserve.			ˇ
	Strategy 3: Improving the water quality of river.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Developing the sewerage construction to reduce river pollution.			ˇ
	Strengthening the water quality monitoring and management, evaluating the exacerbation and water supply to develop response measures.		ˇ	
	Developing the plan of biogas utilization and generation to reduce pollution.	ˇ		
	Strategy 4: Investigating the situation of land subsidence to propose for solutions	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Investigating the condition of groundwater to develop the programme of groundwater extraction reduction.			ˇ
	Developing enforcement action against illegal draft-wells.			ˇ
	Strengthening the groundwater conservation and plugging the illegal drafting wells.			ˇ
	Developing recharge facilities of groundwater.			ˇ
	Strategy 5: Developing the industrial transformation and water saving irrigation in land subsidence areas.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Promoting the dry farming agriculture and developing the optimal cropping system.	ˇ		
	Developing the marine aquaculture.	ˇ		
	Promoting the irrigation facilities of dry farming agriculture.	ˇ		
	Water resource management and effective irrigation.			ˇ
	Developing facility agriculture.	ˇ		
	Coordination among stakeholders on the water saving programme and providing irrigation pipe	ˇ		

	Developing the technique of water recycling.			ˇ
	Strategy 6: Enhancing soil and water conservation in watershed and improving the strength and water purification of the water collection facilities.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Investigating the catchment areas and developing the management of creek and landslide.			ˇ
	Reviewing and reinforcing the regulation of soil and water conservation plans and measures in development case of slope land.			ˇ
	Maintenance and management of pumping system.			ˇ
	Improving the channel dredging of river.			ˇ
	Improving the technique of turbidity raw water treatment in water supply plant			ˇ

Issue	**Adaptation strategies and actions**	**Patterns of public engagement**		
Health	**Strategy 1: Investigating the vector mosquito, monitoring of illness, and health promotion for public.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Increasing the frequency and area of vector mosquito investigation to evaluate the epidemic season and area.		ˇ	
	Investigating the source of vector mosquito and case report and management in order to reduce the vector mosquito.		ˇ	
	Tracking survey, trend and epidemic analyses, and prevention, developing coping strategies.		ˇ	
	Strategy 2: Health education and promotion for aged and susceptible population.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Reminding public to keep warming themselves in cold current forecast	ˇ		
	Providing the information of medication safety and bold pressure measurement service for susceptible and elderly communities.	ˇ		
	Strategy 3: Decreasing fugitive dust from bare lands	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Monitoring the condition of bare lands and developing prevention methods.			ˇ
	Developing the early warning system and public enlightenment.		ˇ	
	Investigating the distribution and harm of fugitive dust and developing prevention methods in high risk areas.			ˇ
	Enforcing public enlightenment of health education		ˇ	
	Developing the integrative environment and health indicators.		ˇ	

Issue	Adaptation strategies and actions	Patterns of public engagement		
Agricultural Production and Biodiversity	**Strategy 1: The breeding for stress resistance.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Developing the stress resistant breeds in agriculture.			ˇ
	Coordinating with the department of central government to develop the stress resistant local breeds in Yunlin County.	ˇ		
	Strategy 2: Production adjustment and technique improvement.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Guiding farmers to adjust cropping time and crop rotation system.	ˇ		
	Developing facility agriculture.	ˇ		
	Developing organic agriculture.	ˇ		
	Improving the production system of livestock and poultry industry.	ˇ		
	Changing the farming fish species according to the weather condition in different areas.	ˇ		
	Investigating and monitoring the marine environment.		ˇ	
	Strategy 3: Developing the weather monitor, early warming, and emergency response system of agriculture.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Climatic information management and information communication.		ˇ	
	Developing the emergency response mechanism of agriculture.			ˇ
	Developing the information system of immediate products reserves to maintain food safety.			ˇ
	Strategy 4: Developing the post-disaster recovery system.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Enforcing the agricultural insurance.			ˇ
	Developing the Salvation Regulations for Agricultural Disasters			ˇ
	Strategy 5: Reviewing all of agricultural subside policies.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	A comprehensive review of agricultural subsidy policies.			ˇ
	Strategy 6: Developing production and marketing group and platform to expand the marketing channels of agricultural productions.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Using the stress resistant breeds and techniques to develop large-scale production and marketing.	ˇ		
	Expanding the export markets and developing international cooperation.	ˇ		
	Providing the dynamic information of products and marketing to develop response mechanism of supply and marketing.	ˇ		
	Cooperating with private companies to develop emerging markets.	ˇ		
	Strategy 7: Establishing the personnel training and platform of information communication.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Providing the education and relevant information in relate to the impacts of climate change on agriculture.	ˇ		
	Improving the information communication platform between Irrigation Associations, Agricultural Research and Extension Stations, Farmers' Associations, and the Agricultural Research Institute.		ˇ	
	Strategy 8: Adjusting the cultivation system for rational utilisation of water in agriculture.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Promoting the dry farming agriculture and developing the optimal cropping system.	ˇ		
	Promoting the irrigation facilities of dry farming agriculture.	ˇ		
	Improving the irrigation canals.			ˇ
	Developing the response mechanism of irrigation and the plan of water resource allocation for irrigation.			ˇ
	Strategy 9: Developing the measurement of water saving irrigation.	**Explicit engagement**	**Implicit engagement**	**Without engagement**

Water resource management and effective irrigation.			ˇ
Developing facility agriculture.	ˇ		
Coordination among stakeholders on the water saving programme and providing irrigation pipe	ˇ		
Developing the technique of water recycling.			ˇ
Strategy 10: Improving the drainage and flood prevention in farming areas	**Explicit engagement**	**Implicit engagement**	**Without engagement**
Improving the dredging of drainage channels.			ˇ
Increasing the effectiveness of flood detention of fish farms.			ˇ
Increasing the automation monitoring facilities of water regimen in coastal fish farms and drainage channels.			ˇ
Strategy 11: Investigating the land use of coastal areas and protecting the coastal erosion areas.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
Investigating the soil salinisation or the area, extent and trend of inundation.		ˇ	
Avoid the use of the marginal farmland and protect the erosion areas.			ˇ
Coordinating with the department of central government to develop the stress resistant local breeds in Yunlin County.	ˇ		
Strategy 12: Industrial transformation or redevelopment programme in land subsidence areas.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
Developing facility agriculture.	ˇ		
Developing the marine aquaculture.	ˇ		
Changing the farming fish species according to the weather condition in different areas.	ˇ		
Investigation and land use change of the inappropriate aquacultural land.	ˇ		
Promoting the agricultural recreation and agricultural tourism.	ˇ		
Promoting the water-saving technology and water recirculation culture system.	ˇ		
Strategy 13: Strengthening the biodiversity monitor and species conservation	**Explicit engagement**	**Implicit engagement**	**Without engagement**
Enforcing the programme of biodiversity sustainable use in Yunline County.			ˇ
Enforcing the programme of biodiversity conservation and non-native species management.			ˇ
Developing ecological resource investigation and wildlife conservation.		ˇ	
Strategy 14: Maintaining the habit environment and developing the natural reserves.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
Wetland development and existing wetland conservation.			ˇ
Conservation of existing nature reserves or potential hotspots of biodiversity.			ˇ
Enforcing the ecosystem restoration according to the ecological principles.			ˇ
Developing the ecological corridor and improving the habitat quality.			ˇ
Developing the investigation of farm pond conservation in Yunlin County.		ˇ	
Cooperating with NGOs, schools and local communities to develop the propaganda of ecological environment.	ˇ		
Strategy 15: Forestation and environmental greening to create a high quality of ecological environment.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
Forest land management and deforestation prevention			ˇ
Promoting the environmental greening and forestation in plain areas.	ˇ		
Evaluating the plan of forestation in mountain.			ˇ
Promoting the agricultural recreation and agricultural tourism.	ˇ		
Developing the green belt and ecological corridor in city			ˇ

Issue	Adaptation strategies and actions	Patterns of public engagement		
Energy Supply and Industry	**Strategy 1: Reducing the energy consumption and increasing the energy efficiency.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Developing the advocacy to promote climate change adaptation plan.	ˇ		
	Enforcing the development plan of energy and water saving agricultural facilities.	ˇ		
	Developing the training plan of energy management.	ˇ		
	Enforcing the evaluation plan of current green building renewal and reconstruction.			ˇ
	Developing the autonomic regulation of public and private green building			ˇ
	Promoting the green building.	ˇ		
	Strategy 2: Developing the multiple renewable energies.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Evaluating and developing the multiple application of different renewable energy.			ˇ
	Assessing and developing the agricultural wastes and energy crops in order to provide nation energy – independent.			ˇ
	Developing the plan of biogas utilization and generation to reduce pollution.	ˇ		
	Strategy 3: Comprehensive review of the suitability of production and transportation facilities of energy and industry sector under the threat of climate change.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Assisting industries to develop the analytical system of impacts of climate change on facilities and locations and its' vulnerability.	ˇ		
	Strategy 4: Developing a better operation and management to reduce the risks and increase adaptation capacity to climate change.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Promoting and strengthening the response and disaster relief capability of industries in high risk and susceptible areas to disasters.	ˇ		
	Strategy 5: Comprehensive review of the suitability of locations of energy and industry sector under the threat of climate change.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Assessing the impacts of climate change and vulnerability on facilities and locations of electric, petroleum, and gas service and its' vulnerability.		ˇ	
	Increasing the response and disaster relief capability of facilities in high risk and susceptible areas to disasters.			ˇ
	Strategy 6: Enhancing the support capability of county government to energy industries.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Strengthening the information communication between county government, electric company, petroleum company, and gas company.			ˇ

Issue	Adaptation strategies and actions	Patterns of public engagement		
Infrastructure	**Strategy 1: Reviewing the important infrastructures and assessing the potential impacts.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Reviewing the infrastructures and developing the maps of risk area.		ˇ	
	Updating the information system of bridge management.			ˇ
	Automatic monitoring of bridge.			ˇ
	Reviewing the location and design of flood control and drainage facilities of bridges and roads, and integrating the factors of climate change into the design.			ˇ
	Strategy 2: Maintaining the infrastructure to increase its' adaptive capacity.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Developing the appropriate standard to increase the infrastructure's capacity to prevent disasters.			ˇ
	Developing maintenance schedules of highways and bridges.			ˇ
	Strategy 3: Improving the infrastructure restoration and recovery.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Emergency repair and preparedness measures			ˇ
	Increasing the budget for infrastructure maintenance.			ˇ
	Exercise of road and bridge closure.	ˇ		
	Strategy 4: Improving the technique and human resource for infrastructure maintenance.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Planning of education and training of bridge inspection.			ˇ
	Developing the information system of road inspect operation.			ˇ

APPENDIX E. LOCAL ADAPTATION ACTIONS IN PINGTUNG COUNTY

Issue	Adaptation strategies and actions	Patterns of public engagement		
Disaster	**Strategy 1: strengthening the response capacity of central and local government to extreme weather events.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Dispersing the risk of disaster.			ˇ
	Improving the overall resilience.			ˇ
	Improving the response capacity of local government.			ˇ
	Developing emergency notification system.			ˇ
	NGO participation.	ˇ		
	Post-disaster waste management.			ˇ
	Improving the medical system.			ˇ
	Strategy 2: developing basic research of climate change for policy-making.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Developing vulnerability and risk assessment.		ˇ	
	Developing disaster potential areas.		ˇ	
	Strategy 3: strengthening the response capacity to impacts of climate change.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Integrating the national land use monitoring system.			ˇ
	Integrating early warming system.			ˇ
	Improving GIS system.			ˇ
	Integrating GIS database.			ˇ
	Strategy 4: integrating the impacts of climate change into major development programmes.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Vulnerability assessment of major development programmes on environment.		ˇ	
	Drawing the principle of major development programmes.		ˇ	

Issue	Adaptation strategies and actions	Patterns of public engagement		
Land Use	**Strategy 1: Reviewing the disadvantage and insufficiency of current spatial planning for climate change adaptation.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Social condition investigation and vulnerability assessment.		ˇ	
	Prime farmland management.	ˇ		
	Developing the concept of green infrastructure.			ˇ
	Public land management.			ˇ
	Principle of framing land development	ˇ		
	Strategy 2: developing supporting measures in relation to land use adaptation.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Management indicator system of land use adaptation.		ˇ	
	Developing the compensation mechanism.			ˇ
	Environmental taxes.			ˇ
	Organizational communication of land use adaptation.	ˇ		
	Follow-up monitoring of land development.		ˇ	
	Strategy 3: Improving the efficiency of flood management and adaptive capacity of land use in urban.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Developing the review mechanism of urban design.			ˇ
	Assessing the carrying capacity of urban.			ˇ
	Water retention facilities in urban.			ˇ
	Integrating the design of flood control in urban.			ˇ
	Strategy 4: integrating the concept of environmentally sensitive area into the designating and managing national land reserve.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Coordination among stakeholders on the Nation Land Plan.			ˇ
	Designating environment sensitive area.			ˇ
	Developing the management principle of natural reserve.			ˇ
	Empowering local government to investigate violations.			ˇ
	Improving the enforcement of the law.			ˇ
	Performance management.			ˇ
	Strategy 5: developing multiple objective and sustainable management of forestry and afforestation project.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Designating sensitive area of forest land.			ˇ
	Increasing reforested area.			ˇ
	Public participation in forestation and conservation.	ˇ		
	Strategy 6: Developing river basin comprehensive management.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Assessing the vulnerability of river basin to disaster.		ˇ	
	Sedimentary management.			ˇ
	Water quality management.			ˇ
	Non-urban land use in river basin.			ˇ
	Urban land use in river basin.			ˇ
	Improving the Communication between river basin organisations.	ˇ		
	Developing the demonstration project of river basin comprehensive management.			ˇ

Issue	Adaptation strategies and actions	Patterns of public engagement		
Energy Supply and Industry	**Strategy 1: Comprehensive reviewing the adaptation of production system location of energy industry to climate change.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Impact assessment of energy industry.		ˇ	
	Integrating industrial region and reviewing energy use.		ˇ	
	Strategy 2: decreasing climatic risk and improving adaptive capacity of industry managing environment.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Self protection of industry.			ˇ
	International cooperation.			ˇ
	Investing the relevant research.			ˇ
	Strategy 3: developing potential industries and research of industrial adaptation.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	New policy regime.			ˇ
	Personnel training.	ˇ		
	Renewable energy.			ˇ

Issue	Adaptation strategies and actions	Patterns of public engagement		
Water Resource	**Strategy 1: Sustainable use and conservation of water resource.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Overall planning of hydrographic system.			ˇ
	Water purification and ecological engineering methods.			ˇ
	Reservoir watershed.			ˇ
	Environment impact assessment of hydrographic system.		ˇ	
	Strategy 2: reviewing the water resource management policy.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Improving and maintaining water supply facilities.			ˇ
	Water supply and ground water use management.			ˇ
	Conjunctive use of surface and ground water.			ˇ
	Emergency response measures for water crisis.			ˇ
	Water right administration.			ˇ
	Total quantity control of water resource.			ˇ
	Water-saving measurement.			ˇ
	Strategy 3: developing integrated policy of industry development and water resource	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Tillage technique.	ˇ		
	Reviewing industrial water supply.			ˇ
	Sewage disposal.			ˇ
	Water footprint evaluation.		ˇ	

Issue	Adaptation strategies and actions	Patterns of public engagement		
Health	**Strategy 1: improving the performance and cooperation of environment and health department.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Strengthening the division structure of health department.			ˇ
	Integrating the emergency control and medical system.			ˇ
	Strategy 2: developing the impact and adaptation assessment on public health.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	The assessment of impacts of climate change on public health.		ˇ	
	Monitoring the adaptation of public health.		ˇ	
	Strategy 3: collecting the database of disease assessment and developing the public health monitoring system.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Integration of monitoring facilities for public health.			ˇ
	Developing health monitoring system。		ˇ	
	Developing control technique.			ˇ

Issue	Adaptation strategies and actions	Patterns of public engagement		
Coastal Zones	**Strategy 1: Improving the land conservation in coastal erosion areas.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	National land use monitoring on coastal areas.		ˇ	
	Investigating the cause of coastal erosion.		ˇ	
	Decreasing fugitive dust			ˇ
	Reforestation of forest shelter belt			ˇ
	Improving the coastal structures.			ˇ
	Developing the principles of coastal development.			ˇ
	Developing tsunami defense.			ˇ
	Strategy 2: Coastal habitats and wetlands conservation and restoration.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Coastal ecological investigation and conservation.		ˇ	
	Strategy 3: land subsidence retarding, landform and industry transforming in land subsidence areas.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Improving water supply in land subsidence areas.			ˇ
	Improving land use in land subsidence areas.			ˇ
	Improving construction form in land subsidence areas.			ˇ
	Strategy 4: Maintaining the coastal communities' humanistic environment, culture, and ecological landscape on coastal areas.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	The risk assessment of coastal community to climate change.		ˇ	
	Investigating the humanistic environment and culture of coastal community.	ˇ		

Issue	Adaptation strategies and actions	Patterns of public engagement		
Agricultural Production and Biodiversity	**Strategy 1: Maintaining food security and competitive advantages of agriculture, fishery, and animal husbandry.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Assessing food production.			ˇ
	Developing farmland conservation and farming system.			ˇ
	Research and development of agricultural technique.			ˇ
	Integrating available water resource for agriculture and aquaculture.			ˇ
	Strategy 2: developing the variation assessment of agricultural market and appropriate production and marketing system.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Monitoring the susceptive crop.		ˇ	
	Market analysis and production and marketing system of agriculture.		ˇ	
	Strategy 3: strengthening the management and connection between blue belt and green belt in natural reserve.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Integrating blue and green belt, and existing environmental conservation actions.			ˇ
	Investigating the ecological impacts in river.		ˇ	
	Strategy 4: Decreasing biodiversity loss due to the human disruption.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Human disturbance management.			ˇ
	Ecological rehabilitation and natural reserve management.			ˇ
	Strategy 5: Improving the vulnerability of biodiversity and risk assessment system.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Assessing the biodiversity and its' vulnerability.		ˇ	
	Developing database and monitoring system of biodiversity.		ˇ	

Issue	Adaptation strategies and actions	Patterns of public engagement		
Infrastructure	**Strategy 1: the consistency of building regulation and validation criteria between central and local government.**	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Developing principle of emergency reparation of road and bridge.			ˇ
	Restoring and disinfecting the environment in affected areas.			ˇ
	Disaster reserve fund of road and bridge.			ˇ
	Developing the suitable building regulation of infrastructure to local circumstance.			ˇ
	Strategy 2: establishing disaster prevention and risk management system of road and bridge.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Developing the impact assessment system of road and bridge.		ˇ	
	Recondition, reinforcement, and reconstruction of road and bridge.			ˇ
	Developing monitoring, prediction, early warming systems and comprehensive information platform of road and bridge.			ˇ
	Strategy 3: reviewing the design of current building and infrastructure, and evaluating the necessity of resilience reinforcement	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Strengthening the current building.			ˇ
	Evaluating the resilience of infrastructure.		ˇ	
	Developing design criteria of road drainage.			ˇ
	Strategy 4: Integrating government, industry, and academe to respond to climate change.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Developing new technique.			ˇ
	Appling renewable energy.			ˇ
	Developing innovative idea of adaptation.		ˇ	
	Strategy 5: integrating city planning and infrastructure planning for residential environment adaptation.	**Explicit engagement**	**Implicit engagement**	**Without engagement**
	Selecting new location for residence.			ˇ

APPENDIX F. DATA OF VULNERABILITY ASSESSMENT

Indicator	Township	Original data (*x* score)	Mean	Standard Deviation	Standard Score (*z* score)	Evaluating Score (*p* score)
Ratio of Primary industry Areas (+)	Mailiao	53.64	53.63578967	59.51393377	-0.538847928	29.50
	Kauho	75.06			1.425332503	92.30
	Linbian	50.56			-0.820828512	20.59
	Jiadong	58.80			-0.065656063	47.38
Ratio of Primary Industry Employees (+)	Mailiao	58.26	67.47508233	16.94807422	-0.54376	29.33
	Kauho	92.22			1.460149	92.79
	Linbian	55.03			-0.73424	23.14
	Jiadong	64.39			-0.18215	42.77
Relative Ratio of Seawall Height (-)	Mailiao	80.76	76.49127410	5.09089755	0.838681	20.08
	Kauho	80.48			0.784226	21.65
	Linbian	74.53			-0.38443	64.97
	Jiadong	70.19			-1.23847	89.22
Prevalence of Tap Water (-)	Mailiao	79.84	66.15009640	22.04978187	0.62107904	26.73
	Kauho	80.47			0.649414324	25.80
	Linbian	70.50			0.197052895	42.19
	Jiadong	33.79			-1.467546258	92.89
Population Growth Rate (+)	Mailiao	57.20	2.87966625	36.26286145	1.497916701	93.29
	Kauho	-16.25			-0.52764572	29.89
	Linbian	-16.88			-0.54481237	29.29
	Jiadong	-12.55			-0.42545861	33.53
Population Density (+)	Mailiao	512.63	699.18608024	388.16066241	-0.480612628	31.54
	Kauho	368.45			-0.85205749	19.71
	Linbian	1252.81			1.426270818	92.31
	Jiadong	662.85			-0.093600699	46.27
Volume of Household (+)	Mailiao	2.22	3.03325417	0.85668063	-0.948909811	17.13
	Kauho	4.24			1.407839848	92.04
	Linbian	2.77			-0.307723388	37.91
	Jiadong	2.90			-0.151206649	43.99

Aging Index (+)	Mailiao	55.79	130.41963139	51.14062116	-1.459275402	7.22
	Kauho	145.70			0.298711909	61.74
	Linbian	148.22			0.348082818	63.61
	Jiadong	171.97			0.812480675	79.17
Young Population Ratio (+)	Mailiao	18.80	13.02199597	3.877246093	1.490831486	93.20
	Kauho	11.56			-0.37713823	35.30
	Linbian	11.20			-0.470152043	31.91
	Jiadong	10.53			-0.643541213	25.99
Elderly Population Ratio (+)	Mailiao	10.49	15.50864186	3.41001771	-1.4717137	7.05
	Kauho	16.84			0.3910325	65.21
	Linbian	16.60			0.3198679	62.55
	Jiadong	18.10			0.7608133	77.66
Aborigines Population Ratio (+)	Mailiao	1.05	0.50469632	0.42746235	1.27847722	89.95
	Kauho	0.16			-0.80979976	20.90
	Linbian	0.64			0.31333411	62.30
	Jiadong	0.17			-0.78201157	21.71
Disabled Population Ratio (+)	Mailiao	6.06	7.64429516	1.39636151	-1.131077313	12.90
	Kauho	9.44			1.289105384	90.13
	Linbian	7.32			-0.231304849	40.85
	Jiadong	7.75			0.073276778	52.92
Low-Income Population Ratio (+)	Mailiao	1.41	1.92001341	0.60479863	-0.83705631	20.13
	Kauho	1.67			-0.40829752	34.15
	Linbian	1.80			-0.20108785	42.03
	Jiadong	2.79			1.44644168	92.60
Dependency Ratio (+)	Mailiao	41.43	39.94635193	1.18040331	1.25477276	89.52
	Kauho	39.67			-0.2355302	40.69
	Linbian	38.57			-1.1617881	12.27
	Jiadong	40.11			0.14254556	55.67
Lone Parents Rate (+)	Mailiao	11.71	13.78702044	1.43513845	-1.44784	7.38
	Kauho	14.38			0.410613	65.93
	Linbian	14.08			0.20458	58.10
	Jiadong	14.98			0.832647	79.75

Sex Ratio (-)	Mailiao	104.57	108.27049456	4.21269327	-0.87849	81.02
	Kauho	114.22			1.412442	7.89
	Linbian	106.25			-0.47993	68.44
	Jiadong	108.04			-0.05401	52.15
Labour force Ratio (-)	Mailiao	70.71	71.46936217	0.61718029	-1.23424343	89.14
	Kauho	71.60			0.20873938	41.73
	Linbian	72.20			1.18626585	11.78
	Jiadong	71.37			-0.1607618	56.39
Illiteracy Ratio (+)	Mailiao	4.59	4.98708454	2.98772215	-0.13354448	44.69
	Kauho	9.29			1.441801302	92.53
	Linbian	2.57			-0.80841211	20.94
	Jiadong	3.49			-0.49984471	30.86
Population Served Per Bed in Hospitals and Clinics (+)	Mailiao	149.73	2322.7469442	2168.6045371	-1.00203593	15.82
	Kauho	5,137.00			1.297725338	90.28
	Linbian	2,796.14			0.218295178	58.64
	Jiadong	1,208.12			-0.51398458	30.36
Population Served Per Hospital & Clinic (+)	Mailiao	1,743.88	2383.3884453	1206.9111558	-0.52987006	29.81
	Kauho	4,109.60			1.430272267	92.37
	Linbian	1,398.07			-0.81639565	20.71
	Jiadong	2,282.00			-0.08400655	46.65
Population Served Per Medical Personnel (+)	Mailiao	103.30	370.66617321	207.09503498	-1.2910498	9.83
	Kauho	604.35			1.12840353	87.04
	Linbian	355.87			-0.0714331	47.15
	Jiadong	419.14			0.23407941	59.25
Death Rate (+)	Mailiao	6.48	9.46787264	2.04402005	-1.4593255	7.22
	Kauho	10.91			0.70745071	76.04
	Linbian	9.81			0.16710145	56.64
	Jiadong	10.66			0.58477329	72.06
Dependence Ratio on Receipts from Subsidies and Assistance (+)	Mailiao	18.74	30.55127170	20.86931512	-0.56599234	28.57
	Kauho	61.81			1.497664421	93.29
	Linbian	21.59			-0.429452522	33.38
	Jiadong	20.07			-0.502219559	30.78

The Ratio of Self-Financing Resources (-)	Mailiao	59.07	61.27193453	17.11144651	-0.128938	55.13
	Kauho	38.19			-1.3487134	91.13
	Linbian	70.65			0.5482733	29.18
	Jiadong	77.17			0.92937807	17.63
Dependence Ratio on Receipts from Taxes (-)	Mailiao	53.43	55.32350690	14.08709759	-0.134388026	55.35
	Kauho	36.16			-1.360298153	91.31
	Linbian	67.05			0.832447162	20.26
	Jiadong	64.65			0.662239017	25.39

APPENDIX G. SURVEY SAMPLE STATISTICS & NATIONAL COMPARISON

This Appendix details the survey sample statistics for the 516 respondents for face to face questionnaire. It then provides a comparison of these statistics with the relevant available County statistics. The following Figures show selected demographic statistics for Mailiao, Kouhu, Linbian, and Jiadong Township compared to sample statistics from face to face questionnaire. All the statistics of the four townships are from the Directorate-General of Budget, Accounting and Statistics website.

	Count (N)	Valid (%)
1.Age		
18-24	46	8.9
25-34	130	25.2
35-44	175	33.9
45-54	119	23.1
55-64	36	7.0
Over 65	10	1.9
2.Gender		
Male	227	44.0
Female	289	56.0
3. Residence		
Mailiao	116	22.5
Kouhu	124	24.0
Linbian	145	28.1
Jiadong	131	25.4
4. Length of residence		
Under 5 years	23	4.5
5-10 years	90	17.4
11-15 years	70	13.6
Over 15 years	333	64.5
5. Educational degree		
Primary or under	11	2.1
Junior	11	2.1
Senior (vocational)	129	25.0
BSc	268	51.9
MSc	92	17.8
Ph.D	5	1.0

	Count (N)	Valid (%)
6. Occupation		
Educator	141	27.3
Services	77	14.9
Trading/Finance/Banking	14	2.7
Self-employed	38	7.4
Civil servant	108	20.9
Military	15	2.9
Industry/Technical	36	7.0
Farming/Fishing/Husbandry	37	7.2
Homemaker	16	3.1
Health/Medical	4	0.8
Student	20	3.9
Unemployed	4	0.8
Retired	6	1.2

7. Annual income of household		
↓£4,999	63	12.2
£5,000-£9,999	75	14.5
£10,000-£14,999	107	20.7
£15,000-£19,999	59	11.4
£20,000-£24,999	36	7.0
£25,000-£29,999	6	1.2
↑£30,000	22	4.3
No response	148	28.7

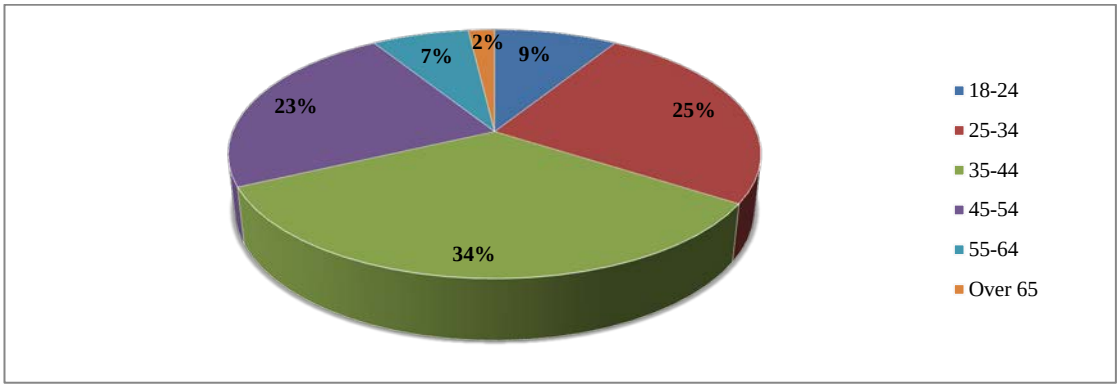

Figure 1: Age structure of respondents, public survey sample (N=516)

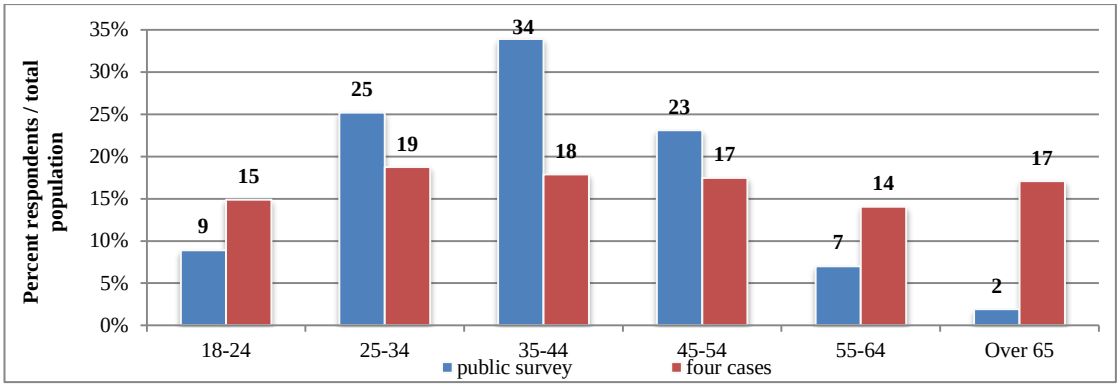

Figure 2: Age structure (%) of respondents and four townships residents (2013 estimates, over the age of 18).

Figure 1 shows that the age profile was as follows: 18-24 (8.9%, 46 respondents), 25-34 (25.2%, 130 respondents), 35-44 (33.9%, 175 respondents), 45-54 (23.1%, 119 respondents), 55-64 (7.0%, 36 respondents), over 65 (1.9%, 10 respondents). Figure 2 shows that the samples concentrate on the people who aged 25-54, it is because the people who aged 25-54 have higher willingness to complete the face to face questionnaire than young and elder groups.

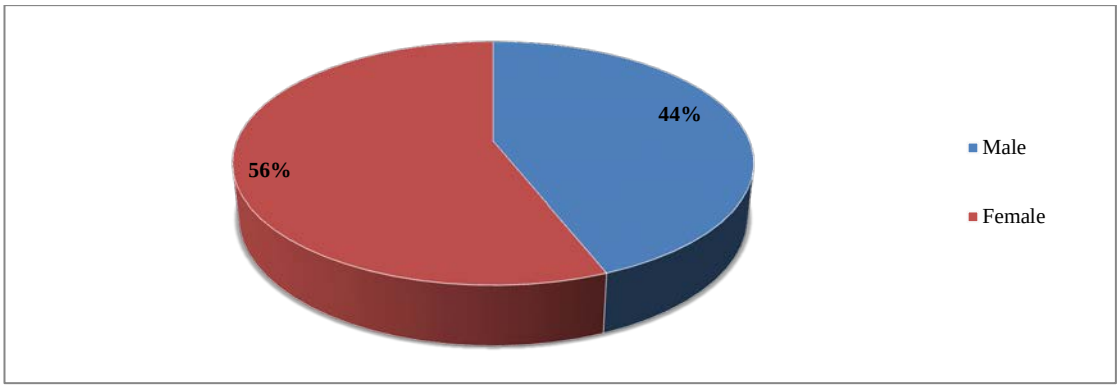

Figure 3: Gender profile of respondents, public survey sample (N=516)

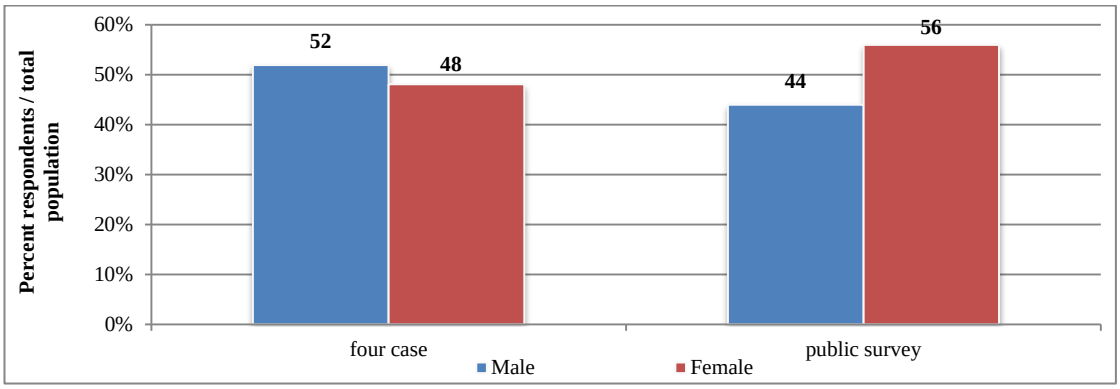

Figure 4: Gender profile (%) of respondents and four townships residents (2013 estimates, N=221,706)

Figure 3 reveals that a total of 56 percent of the sample was female (289 respondents) and 44 percent was male (227 respondents). Figure 4 shows that the male population is more than female population in the four cases but the percent of female is 56% in this investigation. The potential cause is the female have higher willingness to complete the questionnaire than male.

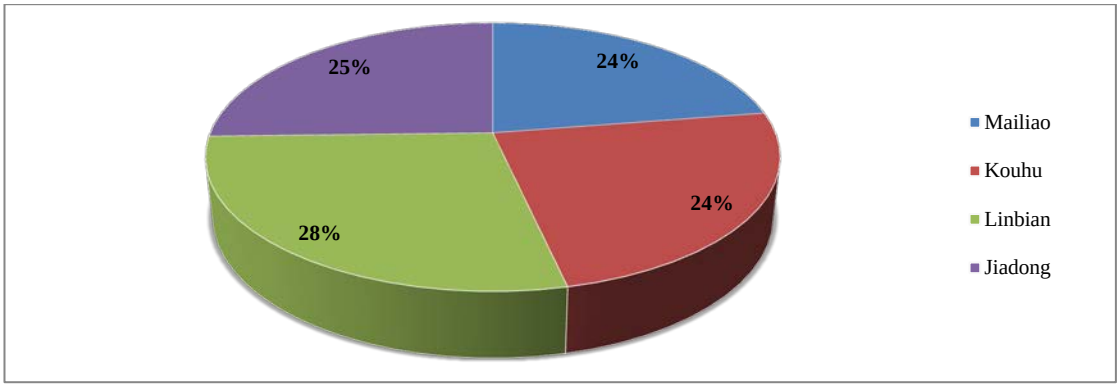

Figure 5: Residence distribution of respondents, public survey sample (N=516)

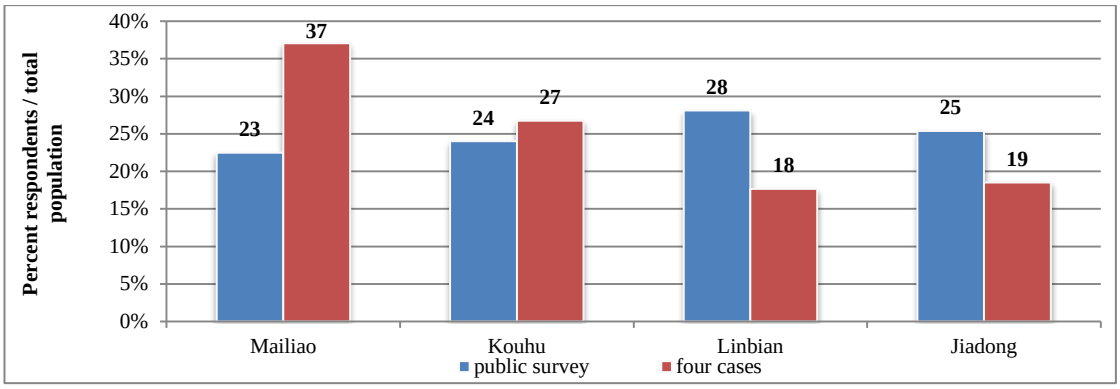

Figure 6: Distribution of respondents (%) and four townships residents (22013 estimates, N=221,706)

Figure 5 shows that 23 percent of the all respondents lived in Mailiao Township (116 respondents), and the remaining participants lived in Kouhu Township (24%, 124 respondents), Linbian Township (28%, 145 respondents), and Jiadong Township (25%, 131 respondents). Although the population in Mailio and Kouhu Township is higher than Linbian and Jiadong Township, but the same amount of questionnaires were conducted in the four townships so that the percent of respondent is very closer (Figure 6).

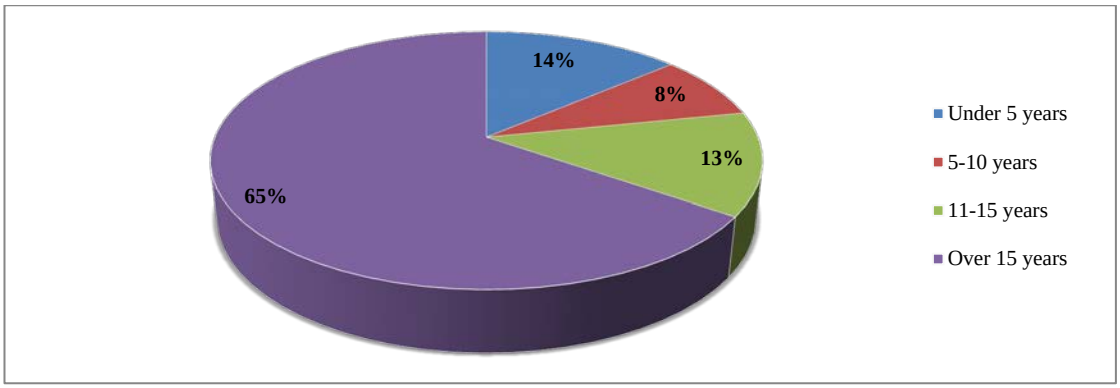

Figure 7: Distribution of residence length of respondents, public survey sample (N=516)

Figure 7 reveals that 4.5 percent of the interviewee had lived under 5 years in their residence (23 respondents), 17.4 percent had lived 5-10 years (90 respondents), 13.6 percent had lived 11-15 years (70 respondents), and 64.5 percent had lived more than 15 years in their residence (333 respondents). Due to the influences of flood experience on public perception of climate change is an essential in this study and the long-term residents may provide more accuracy and experienced information than short-term residents.

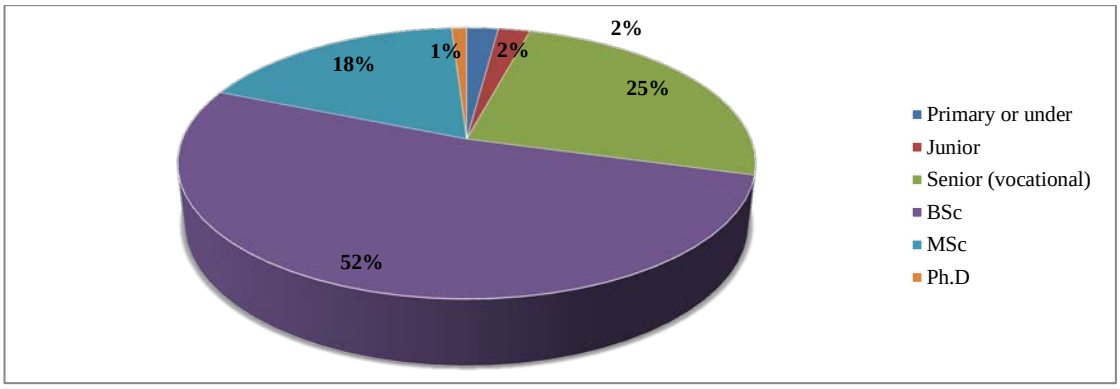

Figure 8: Highest educational qualifications of respondents, public survey sample (N=516)

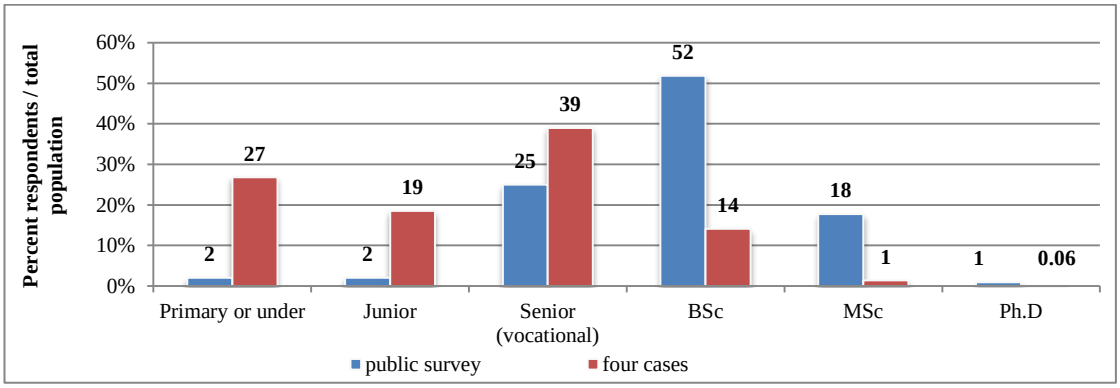

Figure 9: Highest educational qualifications (%) of respondents and four townships residents (2013 estimates, N=221,706)

Figure 8 shows that the educational degree of the respondents as follows: primary or under (2.1%, 11 respondents), junior (2.1%, 11 respondents), senior and vocational (25%, 129 respondents), BSc (51.9%, 268 respondents), MSc (17.8%, 92 respondents), and Ph.D (1%, 5 respondents). The composition of educational degree in the four townships is senior (vocational), junior, and primary or under, but the percent of BSc is the highest group in the public survey (Figure 9). The major cause is the complicated questionnaire and novel issue to Taiwan public, so that the willingness to complete, response rate, and effective response rate of high-educational degree is higher than low-educational degree.

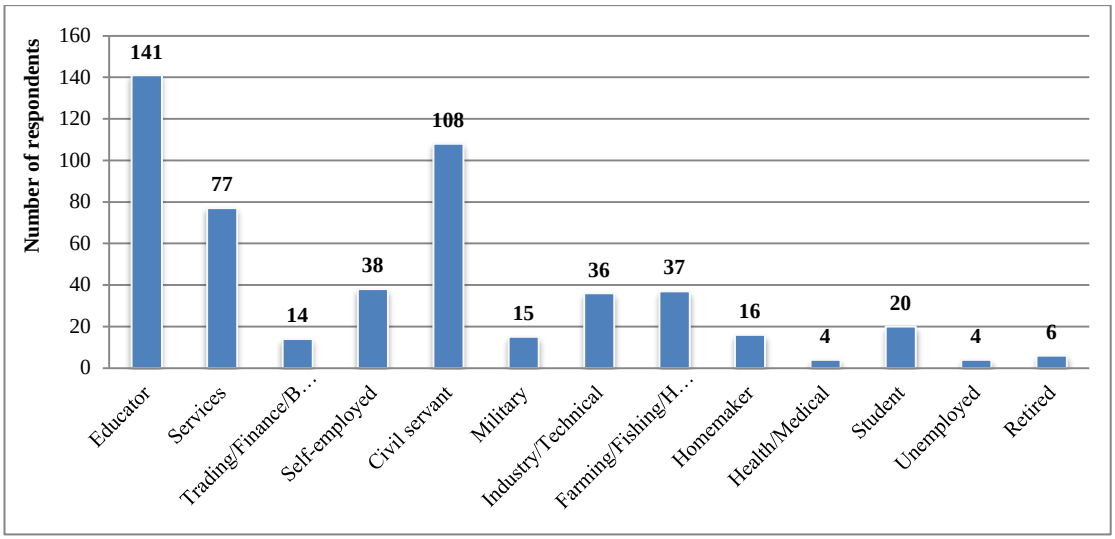

Figure 10 Occupation profile of respondents, public survey sample (N=516)

The employment status of the respondents was follows (Figure 10): educator group with 141 respondents (27.3%), services group with 77 respondents (14.9%), trading/finance/banking group with 14 respondents (2.7%), self-employed group with 38 respondents (7.4%), civil servant group with 108 respondents (20.9%), military group with 15 respondents (2.9%), industry/technical group with 36 respondents (7.0%), farming/fishing/husbandry group with 37 respondents (7.2%), homemaker group with 16 respondents (3.1%), health/medical group with 4 respondents (0.8%), student group with 20 respondents (3.9%), unemployed group with 4 respondents (0.8%), and retired group with 6 respondents (1.2%). According to the disposition of respondents, it reveals that the educator and civil servant amount to almost a half of the respondents. It is because the educator and civil servant were better educated in Taiwan. The two groups of respondent have higher willingness to and able to complete the face to face questionnaire.

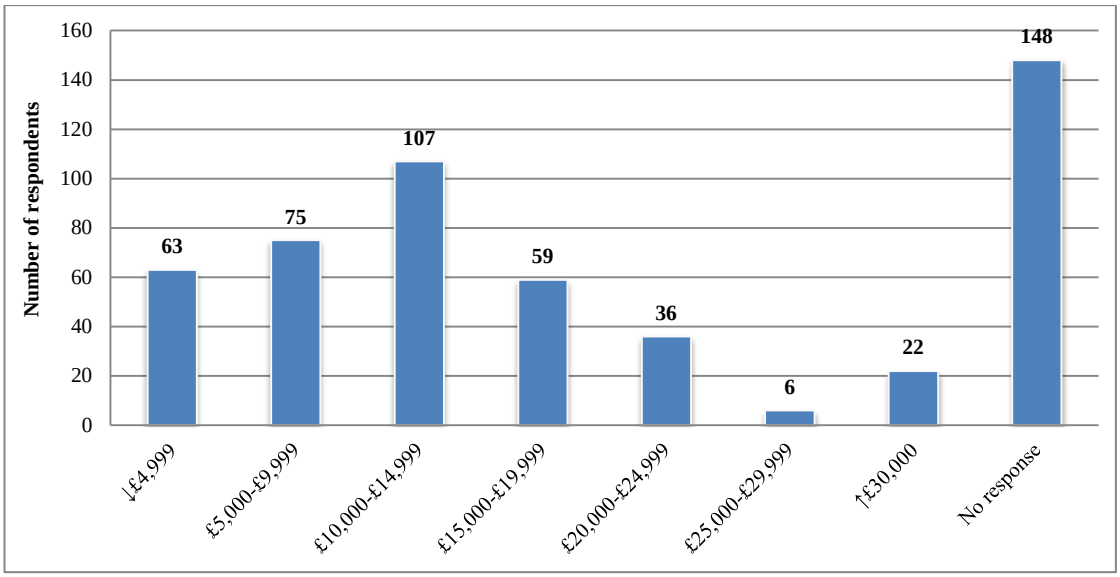

Figure 11 Annual household income of respondents, public survey sample (N=516)

Annual income of household profile was as follows (Figure 11): ↓£4,999 group with 63 respondents (12.2%), £5,000-£9,999 group with 75 respondents (14.5%), £10,000-£14,999 group with 107 respondents (20.7%), £15,000-£19,999 group with 59 respondents (11.4%), £20,000-£24,999 group with 36 respondents (7.0%), £25,000-£29,999 group with 6 respondents (1.2%), ↑£30,000 group with 22 respondents (4.3%), and no response group with 148 respondents (28.7%). Due to the financial state is a very private question in Taiwan, and therefore a one third respondents were unwilling to answer it. Significantly, the distribution of annual household income of respondents includes low-income, medium-income, and high income respondents.

APPENDIX H. SURVEY TOP LINE RESULTS

This Appendix contains the raw data tables from the public questionnaire. It shows frequencies of responses, unless otherwise stated.

Q8: Please tick the following statements apply to your flood experience?

		Frequency	Percent (%)
Properties loss	Yes	290	56.2
	No	217	42.1
	Don't know	9	1.7
Physical effect	Yes	256	49.6
	No	254	49.2
	Don't know	6	1.2
Effect upon your surroundings	Yes	402	77.9
	No	91	17.6
	Don't know	23	4.5

Q9: Can you estimate your maximum financial loss in a single flood event?

	Frequency	Percent (%)
No loss	175	33.9
↓£4,999	112	21.7
£5,000-£9,999	34	6.6
£10,000-£14,999	16	3.1
£15,000-£19,999	8	1.6
↑£20,000	34	6.6
No response	39	7.6
I don't know	98	19.0

Q10: Based on your knowledge and experience, please tick the factors that you think are the most relevant causes of flood in your home district. (tick up to 3)

	Frequency	Percent (%)
Sea level rise	97	6.0
Extreme rainfall	203	12.6
Natural environment degradation	85	5.3
Storm surge	40	2.5
Land subsidence	303	18.8
River sedimentation	126	7.8
Typhoon	243	15.1
Seawater encroachment	150	9.3
Inadequate drainage system	299	18.5
Inadequate height of embankment	48	3.0
Other (specify)	8	0.5
None	6	0.4
I don't know	4	0.2

Others: river dike-break, incompetent institution, the function of flood pumping station is failure, dike is damaged

Q11: How intense this flood will be in your home district? Please tick the boxes that reflect your opinion about the changes of frequency and intensity of flood by 2025, 2050, and 2100.

		not sure	fewer	slight fewer	same	slight more	much more
Frequency by 2025	Frequency	110	21	23	38	194	130
	Percent (%)	21.3	4.1	4.5	7.4	37.6	25.2
Frequency by 2050	Frequency	121	19	13	19	161	183
	Percent (%)	23.4	3.7	2.5	3.7	31.2	35.5
Frequency by 2100	Frequency	135	23	7	15	102	234
	Percent (%)	26.2	4.5	1.4	2.9	19.8	45.3
Intensity by 2025	Frequency	115	8	19	50	190	134
	Percent (%)	22.3	1.6	3.7	9.7	36.8	26.0
Intensity by 2050	Frequency	123	13	7	25	173	175
	Percent (%)	23.8	2.5	1.4	4.8	33.5	33.9
Intensity by 2100	Frequency	138	13	9	22	101	233
	Percent (%)	26.7	2.5	1.7	4.3	19.6	45.2

	More	Same	Fewer	Not sure
Flood victim				
Frequency of flood by 2025	63.3%	7.3%	8.9%	20.5%
Frequency of flood by 2050	67.3%	2.8%	6.4%	23.5%
Frequency of flood by 2100	65.6%	2.4%	5.9%	26.1%
Intensity of flood by 2025	63.3%	9.2%	5.9%	21.6%
Intensity of flood by 2050	68.5%	3.3%	4.5%	23.8%
Intensity of flood by 2100	65.6%	2.8%	4.7%	26.8%
Non-flood victim				
Frequency of flood by 2025	60.2%	8.0%	6.8%	25.0%
Frequency of flood by 2050	63.6%	8.0%	5.7%	22.7%
Frequency of flood by 2100	62.5%	5.7%	5.7%	26.1%
Intensity of flood by 2025	60.2%	12.5%	2.3%	25.0%
Intensity of flood by 2050	67.4%	4.9%	3.9%	23.9%
Intensity of flood by 2100	60.2%	11.4%	2.3%	26.1%

Q12: Using your flood experience or known information about flood to answer this section. To what extent do you agree with the following statements?

		strongly agree	tend to agree	neutral	tend to disagree	strongly disagree
Flood experience makes me think that the climate is changing (N=513)	Frequency	247	205	52	5	4
	Percent (%)	48.1	40.0	10.1	1.0	0.8
Flood experience makes me concern about climate change than before (N=506)	Frequency	286	156	51	7	6
	Percent (%)	56.52	30.83	10.08	1.38	1.19
Flood experience makes me want to know more information about climate change (N=514)	Frequency	184	229	87	12	2
	Percent (%)	35.8	44.6	16.9	2.3	0.4
Flood experience makes me think that climate change is inevitable (N=512)	Frequency	137	210	78	64	23
	Percent (%)	26.8	41.0	15.2	12.5	4.5
Flood experience makes me think climate change is a disastrous consequence (N=509)	Frequency	147	225	76	56	5
	Percent (%)	28.9	44.2	14.9	11.0	1.0
Flood experience makes me think that it is impossible to tackle climate change (N=505)	Frequency	50	118	115	161	61
	Percent (%)	9.9	23.4	22.8	31.9	12.1
Flood experience makes me to take actions to response to climate change (N=512)	Frequency	112	228	144	18	10
	Percent (%)	21.9	44.5	28.1	3.5	2.0
Flood experience makes me think it is too late to take any action (N=513)	Frequency	38	84	105	193	93
	Percent (%)	7.4%	16.4	20.5	37.6	18.1
Flood experience makes me think that current measures and actions are insufficient and limited efficacy (N=509)	Frequency	118	212	104	57	18
	Percent (%)	23.2	41.7	20.4	11.2	3.5
The scale ranges from 1 (strongly disagree) to 5 (strongly agree)						

	Mean	SD	SE
Flood experience makes me think that the climate is changing	4.34	0.76	0.03
Flood experience makes me concern about climate change than before	4.40	0.82	0.36
Flood experience makes me want to know more information about climate change	4.13	0.80	0.35
Flood experience makes me think that climate change is inevitable	3.73	.12	0.49
Flood experience makes me think climate change is a disastrous consequence	3.89	0.98	0.04
Flood experience makes me think that it is impossible to tackle climate change	2.87	1.19	0.05
Flood experience makes me to take actions to response to climate change	3.81	0.88	0.04
Flood experience makes me think it is too late to take any action	2.57	1.18	0.05
Flood experience makes me think that current measures and actions are insufficient and limited efficacy	3.70	1.05	0.05
The scale ranges from 1 (strongly disagree) to 5 (strongly agree)			

Q13: Are you concerned about any of the following issues in your home district?

	Frequency	Percent (%)
Economic development	266	17.3
Pollution	293	19.1
Political issues	48	3.1
Social issues	60	3.9
Climate change	216	14.1
Environmental protection	295	19.2
Traditional culture	80	5.2
Natural disasters	273	17.8
None	3	0.2
No comment	3	0.2

Q14: To what extent are you concerned about climate change?

	Frequency	Percent (%)
Very concerned	143	27.7
Fairly concerned	255	49.4
Neutral	109	21.1
Not very concerned	5	1.0
Not at all concerned	4	0.8

Q15: Do you think which one is the best description of the cause of climate change?

	Frequency	Percent
Completely by natural process	13	2.5
Principally by natural process	23	4.5
Completely by human activity	50	9.7
Principally by human activity	124	24.0
Caused by natural process and human activity	299	57.9
I don’ t know	7	1.4
No, climate is not changing	0	0
Other (specify)	0	0

Q16: Which sources of information about climate change would you trust?

	Frequency	Percent (%)
Newspaper/magazine	172	13.0
Environmental group/NGO	199	15.0
Academic publication	47	3.5
TV/radio	293	22.1
Friends/family	29	2.2
School/university	32	2.4
Scientists	129	9.7
Local government	28	2.1
Governmental agency	41	3.1
International organizations	123	9.3
Libraries	13	1.0
By experiencing it myself	49	3.7
Internet	163	12.3
None	7	0.5

Q17: When will you expect to experience the impacts of climate change?

	Frequency	Percent (%)
Already experience it	405	78.5
10 years from now	57	11.0
50 years from now	18	3.5
100 years or longer from now	0	0
Never	2	0.4
I don’t know	14	6.6

Responses to Q18: Please tick the phenomena that you have observed, had affected you, and you most concerned with based on your personal experience.

	Observed		Affected		Concerned	
	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)
Sea level rise	289	11.7	187	8.8	124	7.4
Seasonal cycle change	263	10.7	233	10.9	53	3.2
Extreme rainfall	267	10.8	291	13.6	179	10.6
Heat wave	230	9.3	184	8.6	84	5.0
Flood	327	13.3	382	17.9	382	22.7
Storm surge	214	8.7	132	6.2	132	7.8
Super typhoon	227	9.2	184	8.6	184	10.9
Temperature change	241	9.8	266	12.4	266	15.8
Droughts	220	8.9	166	7.8	166	9.9
Ocean acidification	186	7.5	111	5.2	111	6.6
Other (specify)	1	0	1	0	1	0.1
Others: Chilling injure						

Q19: Please tick the main influences of climate change that you are most concerned with. (tick up to 5)

	Frequency	Percent (%)
Private property loss	231	10.1
Business profit loss	34	1.5
Pollution	252	11.0
Water/food shortage	290	12.7
Mental impacts	148	6.5
Lose your job	54	2.4
Insurance premiums	8	0.3
Residence loss	204	8.9
Health & wellbeing damage	212	9.3
Infrastructure loss	70	3.1
Tourism reduction	9	0.4
Livelihood	108	4.7
Security and safety	322	14.1
Ecosystem degradation	206	9.0
Wildlife habitat destruction	108	4.7
House prices decrease	31	1.4
None	1	0

Q20: When should people have to take actions to tackle climate change?

	Frequency	Percent (%)
Need to take now	473	92.8
10 years from now	13	2.5
50 years from now	3	0.6
100 years or longer from now	1	0.2
We don't need to act	3	0.6
I don't know	17	3.3

Q21: Over the past week, have you taken any of the following actions?

	Frequency	Percent (%)
Recycling	371	25.8
Walk or cycle to work	117	8.1
Use public transport	95	6.6
Bring your own bags or self-prepared tableware	218	15.1
Use energy-conserving facilities	221	15.3
Participate in environment protection action	45	3.1
Be a vegetarian	53	3.7
Turn off unwanted lights	319	22.2
Other(specify)	1	0.1
Others: driving electric car		

Q22: What are the key motivations that encourage you to take the above actions?

	Frequency	Percent (%)
Save money	219	16.8
Exercise	90	6.9
Climate change	105	8.1
Protect environment	360	27.6
Comply with policies	29	2.2
Health	104	8.0
Sustainable develop	168	12.9
My habit	226	17.3
Other (specify)	3	0.2
Others: Obey School Rules, Increase Family Income		

Q23: Do you know what types of actions or measures are being implemented to cope with climate change in your home district?

	Frequency	Percent (%)
No actions and measures have been taken	150	21.7
Monitoring and investigating the changes and influences of climatic events only	136	19.7
Preparing for response the impacts of climate change in the near future	105	15.2
Taking action now to deal with existing and future impacts of climate change	125	18.1
I don't know	170	24.6
Other (specify)	5	0.7
Others: The Project of The Photovoltaic Farming to Reserve Water, Improve Hydro-system, Improve Drainage System, Elevate Road		

Q24: What factors of institutional arrangement would encourage you to participate with local climate change adaptation?

	Frequency	Percent (%)
Understandable information and guidance	293	22.5
Clear responsibilities and roles	91	7.0
Salient information for specific communities	174	13.4
Dependable information sources	263	20.2
Accessible decision-making process	177	13.6
Trustworthy policymakers	132	10.2
Appropriate incentives for communities	149	11.5
None, I don't want engage with local climate change adaptation	20	1.5
Other (specify)	1	0.1
Others: Economic assistance		

Q25: Please indicate what extent do you agree with these following response actions would be effective to tackle with climate change in Taiwan.

		strongly agree	tend to agree	neutral	tend to disagree	strongly disagree
More defences /improvements in current infrastructures (N=512)	Frequency	189	212	91	15	5
	Percent (%)	36.91	41.41	17.77	2.93	0.98
Removing the artificial buildings and facilities from natural environment and habitat (N=506)	Frequency	72	162	179	69	24
	Percent (%)	14.23	32.02	35.38	13.64	4.74
Planting more trees (N=513)	Frequency	255	209	48	1	0
	Percent (%)	49.71	40.74	9.36	0.19	0.00
Purchasing natural disaster insurance (N=511)	Frequency	99	213	170	24	5
	Percent (%)	19.37	41.68	33.27	4.70	0.98
Developing prediction, emergency and warning systems (N=515)	Frequency	254	206	49	4	2
	Percent (%)	49.32	40.00	9.51	0.78	0.39
Relocating residents and towns (N=507)	Frequency	91	154	176	65	21
	Percent (%)	17.95	30.37	34.71	12.82	4.14
Educating people so that they are aware the risk of climate change (N=514)	Frequency	277	182	50	4	1
	Percent (%)	53.89	35.41	9.73	0.78	0.19
Compensation and disaster relief actions (N=512)	Frequency	186	204	103	14	5
	Percent (%)	36.33	39.84	20.12	2.73	0.98
Increasing the flexibility of house and city design (N=510)	Frequency	171	224	101	12	2
	Percent (%)	33.53	43.92	19.80	2.35	0.39
Limiting the greenhouse gas emission (N=512)	Frequency	219	189	96	8	0
	Percent (%)	42.77	36.91	18.75	1.56	0.00
Developing renewable energy (N=514)	Frequency	300	155	51	7	1
	Percent (%)	58.37	30.16	9.92	1.36	0.19
Saving the earth's resources (N=513)	Frequency	319	155	35	3	1
	Percent (%)	62.18	30.21	6.82	0.58	0.19
Carbon tax (N=509)	Frequency	155	150	152	31	21
	Percent (%)	30.45	29.47	29.86	6.09	4.13
Industrial restructuring and industrial transformation (N=510)	Frequency	173	199	123	13	2
	Percent (%)	33.92	39.02	24.12	2.55	0.39
No action can tackle with the climate change (N=498)	Frequency	12	27	71	115	273
	Percent (%)	2.41	5.42	14.26	23.09	54.82

The scale ranges from 1 (strongly disagree) to 5 (strongly agree)

Q26: The question will ask about your general perception of appropriate implement timing in each specific response action. Please tick when you think these actions should be implemented as indicated in the table below.

		Short-term	Medium-term & Long-term	ineffective
More defence /improvement of current infrastructure (N=491)	Frequency	319	160	12
	Percent (%)	8.04	6.01	4.38
Removing artificial buildings and facilities from natural environments (N=473)	Frequency	175	233	65
	Percent (%)	4.41	8.76	23.72
Planting more trees (N=504)	Frequency	330	173	1
	Percent (%)	8.31	6.5	0.36
Purchasing natural disaster insurance (N=484)	Frequency	289	149	46
	Percent (%)	7.28	5.6	16.79
Developing prediction, emergency and warning systems (N=504)	Frequency	351	150	3
	Percent (%)	8.84	5.64	1.09
Relocating residents and towns (N=480)	Frequency	157	276	47
	Percent (%)	3.95	10.37	17.15
Educating people so that they are aware of the risk of climate change (N=504)	Frequency	375	120	9
	Percent (%)	9.45	4.51	3.28
Compensation and disaster relief actions (N=495)	Frequency	351	122	22
	Percent (%)	8.84	4.58	8.03
Increasing the flexibility of house and city design (N=495)	Frequency	225	261	9
	Percent (%)	5.67	9.81	3.28
Reducing greenhouse gas emissions (N=499)	Frequency	295	194	10
	Percent (%)	7.43	7.29	3.65
Developing renewable energy (N=505)	Frequency	295	209	1
	Percent (%)	7.43	7.85	0.36
Saving the earth’s resources (N=506)	Frequency	340	162	4
	Percent (%)	8.56	6.09	1.46
Carbon tax (N=482)	Frequency	253	194	35
	Percent (%)	6.37	7.29	12.77
Industrial restructuring and industrial transformation (N=483)	Frequency	215	258	10
	Percent (%)	5.42	9.7	3.65

Q27: This section investigated public knowledge, awareness and attitude about climate change may influence public engagement with local climate change adaptation. To what extent do you agree with these following statements?

		strongly agree	tend to agree	neutral	tend to disagree	strongly disagree
I think climate is changing (N=515)	Frequency	290	196	26	1	2
	Percent (%)	56.3	38.1	5.0	0.2	0.4
I think human activity affects climate (N=513)	Frequency	262	200	38	11	2
	Percent (%)	51.1	39.0	7.4	2.1	0.4
Climate change will have significant impact on human society (N=514)	Frequency	311	170	31	1	1
	Percent (%)	60.5	33.1	6.0	0.2	0.2
Climate change will have significant impact on natural environment (N=513)	Frequency	325	163	22	3	3
	Percent (%)	63.4	31.8	4.3	0.6	0.6
Climate change has serious consequences for me and my family (N=507)	Frequency	209	195	87	12	4
	Percent (%)	41.2	38.5	17.2	2.4	0.8
Climate change are unpredictable (N=514)	Frequency	158	168	86	76	26
	Percent (%)	30.7	32.7	16.7	14.8	5.1
Climate change is disastrous, especially to vulnerable groups (e.g. poverty) (N=508)	Frequency	188	210	72	25	13
	Percent (%)	37.0	41.3	14.2	4.9	2.6
Climate change has benefits to some specific communities (N=489)	Frequency	79	118	118	118	56
	Percent (%)	16.2	24.1	24.1	24.1	11.5
The impacts of climate change are inevitable (N=507)	Frequency	111	194	85	79	38
	Percent (%)	21.9	38.3	16.8	15.6	7.5
The impacts of climate change are unrecoverable (N=508)	Frequency	69	114	97	155	73
	Percent (%)	13.6	22.4	19.1	30.5	14.4
Climate change is human responsibility (N=513)	Frequency	280	155	45	28	5
	Percent (%)	54.6	30.2	8.8	5.5	1.0
I am able to do a lot about climate change (N=508)	Frequency	127	222	143	11	5
	Percent (%)	25.0	43.7	28.1	2.2	1.0
I tend to sustainable development (N=510)	Frequency	282	179	43	5	1
	Percent (%)	55.3	35.1	8.4	1.0	0.2
It is necessary to take action to adapt to the impacts of climate change (N=512)	Frequency	288	177	44	0	3
	Percent (%)	56.3	34.6	8.6	0.0	0.6

The scale ranges from 1 (strongly disagree) to 5 (strongly agree)

Q28: This section explored public concern, feeling, skepticism and trust about the issue of climate change may influence public engagement with local climate change adaptation. To what extent do you agree with these following statements?

		strongly agree	tend to agree	neutral	tend to disagree	strongly disagree
I am concerned about the issue of climate change (N=515)	Frequency	184	247	83	0	1
	Percent (%)	35.70	48.00	16.10	0.00	0.20
I am concerned about the impacts of climate change on me personally (N=514)	Frequency	171	248	86	6	3
	Percent (%)	33.30	48.20	16.70	1.20	0.60
I am concerned about the impacts of climate change on human society (N=515)	Frequency	197	241	73	4	0
	Percent (%)	38.30	46.80	14.20	0.80	0.00
I am concerned about the impacts of climate change on wildlife and the natural environment (N=515)	Frequency	201	239	70	4	1
	Percent (%)	39.00	46.40	13.60	0.80	0.20
Climate change and its impacts frighten me (N=514)	Frequency	182	238	81	10	3
	Percent (%)	35.40	46.30	15.80	1.90	0.60
I have direct experience of impacts (N=509)	Frequency	152	156	163	34	4
	Percent (%)	29.90	30.60	32.00	6.70	0.80
I am affected by the relevant reports in the media (N=514)	Frequency	135	249	106	21	3
	Percent (%)	26.30	48.40	20.60	4.10	0.60
The information about climate change is reality (N=509)	Frequency	120	227	140	20	2
	Percent (%)	23.60	44.60	27.50	3.90	0.40
I think climate change is a real problem (N=515)	Frequency	235	219	51	8	2
	Percent (%)	45.60	42.50	9.90	1.60	0.40
The impacts or seriousness of climate change are **not** overstated (N=505)	Frequency	156	180	110	48	11
	Percent (%)	30.90	35.60	21.80	9.50	2.20
The science of climate change is certain (N=507)	Frequency	131	200	142	31	3
	Percent (%)	25.60	39.60	28.00	6.10	0.60
I trust the scientific evidences about climate change (N=507)	Frequency	152	215	119	19	2
	Percent (%)	30.00	42.40	23.50	3.70	0.40
I trust the government will protect people from the impacts of climate change (N=507)	Frequency	65	100	176	110	56
	Percent (%)	12.80	19.70	34.70	21.70	11.00
I believe these actions will have effect on climate change (N=501)	Frequency	116	199	148	27	11
	Percent (%)	23.20	39.70	29.50	5.40	2.20
The scale ranges from 1 (strongly disagree) to 5 (strongly agree)						

Responses to Q29: This section investigated what factor can be a motivation or a barrier to limit public engagement with local climate change adaptation. To what extent do you agree with these following statements?

		strongly agree	tend to agree	neutral	tend to disagree	strongly disagree
I think that I have already done enough (N=501)	Frequency	15	33	179	184	90
	Percent (%)	3.0	6.6	35.7	36.7	18.0
It is **impossible** to have strong economic development and tackle climate change at the same time (N=505)	Frequency	31	122	132	155	65
	Percent (%)	6.1	24.2	26.1	30.7	12.9
I think that adaptation action is irrelevant to me (N=513)	Frequency	14	32	55	210	202
	Percent (%)	2.7	6.2	10.7	40.9	39.4
I have more important priorities than climate change adaptation actions (N=504)	Frequency	24	96	148	151	85
	Percent (%)	4.8	19.0	29.4	30.0	16.9
The actions that I take are unrelated to tackle with climate change (N=505)	Frequency	16	41	111	226	111
	Percent (%)	3.2	8.1	22.0	44.8	22.0
I am **not** well informed about climate change adaptation actions (N=511)	Frequency	37	131	152	137	54
	Percent (%)	7.2	25.6	29.7	26.8	10.6
I **don't** understand climate change adaptation actions (N=511)	Frequency	22	48	117	199	125
	Percent (%)	4.3	9.4	22.9	38.9	24.5
I **don't** know what actions I can take (N=508)	Frequency	32	75	136	186	79
	Percent (%)	6.3	14.8	26.8	36.6	15.6
I **don't** have time (N=506)	Frequency	21	61	127	193	104
	Percent (%)	4.2	12.1	25.1	38.1	20.6
I think these actions are too costly (N=498)	Frequency	26	98	127	160	87
	Percent (%)	5.2	19.7	25.5	32.1	17.5
I **don't** want change my habit or way of life (N=514)	Frequency	32	60	122	182	118
	Percent (%)	6.2	11.7	23.7	35.4	23.0
I think that the majority of people are not doing enough (N=508)	Frequency	129	184	108	58	29
	Percent (%)	25.4	36.2	21.3	11.4	5.7
Engage with these actions make my life more inconvenient (N=503)	Frequency	27	58	158	173	87
	Percent (%)	5.4	11.5	31.4	34.4	17.3
It is too late to undertake any actions (N=505)	Frequency	30	38	79	176	182
	Percent (%)	5.9	7.5	15.6	34.9	36.0
The scale ranges from 1 (strongly disagree) to 5 (strongly agree)						

APPENDIX I. SUMMARISED NOTES OF THE EXPERT WORKSHOP

Profile of participant in the workshop

Participants	Organisation	Position
Wen-Hong, Liu	National Kaohsiung Marine University	Professor
Meng-Tsung, Li	National Kaohsiung Marine University	Assistant Professor
Yueh-Ting, Lin	National Kaohsiung Marine University	Lecturer
Yung-Ming, Chen	The Group of Disaster Assessment and Adaptation Strategy of Extreme Weather, National Science and Technology Central for Disaster Reduction	Associate Researcher/Director
Tzu-Wei, Chen	Urban Development Bureau, Kaohsiung City Government	Officer
Yu-Hsu, Chen	Disaster Prevention Research Central National Cheng Kung University	Associate Researcher

I. EXPERTS' VIEWS ON FURTURE TRENDS OF FLOOD

1.1 The questionnaire analysis shows that most respondents thought that the frequency and intensity of flood will increase in the future. Do you think that current local adaptation actions can effectively reduce flood in the near future? Please specify.

Comment: Yes, the frequency of flood will be effectively reduced. The central government has provided NT$ 60 billion for a period of six years to promote a watershed management scheme after the Comprehensive River Basin Governance Regulation was passed (central government and academic). In addition, climatic scientific data has been able to predict rainfall in for the near future. However, disasters were caused by extreme weather (extreme rainfall) and it is hard to implement prevention measure as extreme weather is unpredictable (central government).

II. EXPERTS' VIEWS ON COMMUNITY ENGAGEMENT WITH THE LOCAL ADAPTATION FRAMEWORK

2.1 Do you know whether any communities participated in the formulation process of

local adaptation actions? Whether there are any opportunities or barriers to engage the community with this process? Please specify.

Comment: Most Taiwanese do not understand the real meaning of climate change adaptation. Most people think that the actions of carbon emission reduction, recycling, energy conservation are climate change adaptation. However, the meaning of adaptation is a combination of strength from government and public to reduce the impacts of climate change. It is difficult to encourage the community to participate in climate change adaptation actions if they do not understand the significance of adaptation (central government, local government).

The public already knows the importance of disaster prevention and response after suffering from the influences and impacts of disasters. Therefore, the concept of disaster prevention and response is well known in Taiwan but long-term adaptation actions, for example: land use re-planning and immigration are not(central government, local government).

Therefore, the general orientation of climate change adaptation policy needs to be changed to assist the public in understanding the notion of adaptation and participation in the local adaptation actions (central government). In addition, education programmes (long-term education planning) can emphasise the importance of climate change adaptation and impacts of climate change to the local communities (academic).

2.2 If the local adaptation action is without community engagement, what are the possible consequences on the local adaptation actions? Please specify.

Comment: the adaptation actions may be inconsistent with the needs of the local community (central government, local government).

The adaptation action may be ineffective or not executable due to community's unwillingness to co-operate (central government, local government, academic).

III. LOCAL ADAPTATION FRAMEWORK

The critical issues for local planning in adapting to climate change at the coast. Please specify and draw out these issues by PESTLE as follows:

3.1 Political Perspective

- Would you identify what you think are the critical factors for local planning actions in adapting to climate change which have led to the adaptation framework? Please specify. e.g.: drive from Central government: top-down (Adaptation Strategy to Climate Change in Taiwan; A Guide for Local Climate Change Adaptation Planning); drive occurring locally: bottom-up (Adaptation Plan to Climate Change in Pingtung County); inter-departmental cooperation and coordination.

  Comment:

  These above principles are very important (central government, local government, academic), but top-down policy framework is prevalent and the central government dominates the climate change adaptation policy framework in Taiwan (central government, local government). The local adaptation actions and policy framework all follow the national adaptation strategy for climate change (Academic).

- Do you think the identification of roles and responsibilities among sectors of local governments are clear in coastal adaptation to climate change? Could you please describe briefly how to clearly identify the roles and responsibilities of different departments?

  Comment:

  The roles and responsibilities of different departments in local government are clear in coastal adaptation to climate change and the sectors are distinguished by function. Take Kaohsiung City for example, the Marine Bureau is responsible for ocean affairs and protection of embankments is undertaken by the Water Resource Bureau. The main issue is interdepartmental coordination (local government).

  In the Central government, the Environmental Protection Administration is the central competent authority responsible for climate change issues. However, though the EPA administers the mitigation measures, adaptation actions are not. The Adaptation Strategy to Climate Change in Taiwan was developed by the National Development Council to correlate with different departments on the issue of climate change adaptation. (central government).

  Generally, in Taiwan, the administration of local coastal adaptation actions is based on the classification of Adaptation Strategy to Climate Change in

Taiwan. However, different local governments put emphasis on different issues, and the primary agencies for climate change adaptation are dissimilar in different local governments. For example, the Environmental Protection Bureau is the primary agency in Kaohsiung City, but the Urban and Rural Development Department is responsible for climate change adaptation in Yunlin and Pingtung Counties (central government, local government)

- Do you know any mechanism for inter-departmental and cross-jurisdictional coordination in local coastal adaptation action to climate change? Could you please describe briefly how to establish a practical mechanism or improve existing measures? Please specify.

  Comment: Administrative duties have been designated in local governments according to the issues and function (local government, academic). However, inter-departmental and cross-jurisdictional cooperation is very difficult because coastal adaptation is a complicated issue in Taiwan as it includes land subsidence, coastal retrograding, coastal erosion, and storm surge (central government, local government).

  Because local governments establish their administrations according to the principle of service attributes, it is difficult to coordinate between various administrations that are responsible for the implementation of the local adaptation actions. In the future, local governments could designate the roles of the administrations bases on the prevailing problem (central government, local government). For instance, the Water Resource Bureau could be coordinating administration in Pingtung and Yunlin County because flood is the main problem in the two counties. As carbon emission reduction is the key objective in Kaohsiung, the Environmental Protection Bureau is competent authority to coordinate it (academic).

  Inter-departmental and cross-jurisdictional coordination should be enforced by the central government because local governments are incompetent (local government, academic). So far, the River Basin Management Committee[1] is

[1] The River Basin Management Committee was instituted on Tamsui River Watershed and Kaoping River Watershed. The aim of the committee is to establish the watershed management, communication and coordination mechanism before administrative authority establishing. The membership includes center government (Environmental Protection Agency, Council of Agriculture, Water Resources Agency, Construction and Planning Agency), local governments within the watershed, experts, and scholars.

the only organisation responsible for cross-jurisdictional river basin management, but there is no similar organisation to manage coastal areas (central government, local government). Due to the financial issue and institutional structure, the central government and local governments are unlikely to establish inter-department or cross-jurisdictional organisations (central government, local government, academic).

Alternatively, the way of legislation can be used to advance the coordination and cooperation between departments. The coercive force of legislative decree can divide explicitly the specific responsibilities of different administrations and establish a coordination platform for the existing administrative structure. It is more effective than establishing a new inter-department organisation, due to the limitation of budget and human resources (central government, academic).

3.2 Economic Perspective

- Would you identify what you think are the critical factors for local planning actions in adapting to climate change? Please specify. e.g.: economic incentive; financial planning; cost-effectiveness.

  Comment: economic incentives and financial support are the critical factors because the budget and revenue of local governments are insufficient to implement integrated adaptation actions (local government and central government). For example, as many heavy industry areas are located in Kaohsiung City, the Environmental Protection Bureau is actively devoting legislation to impose a carbon emission tax in Kaohsiung. The local government will obtain revenue to support local adaptation actions (local government and academic). The academic participators focus on formulation of adaptation actions which are low cost and effective. They think that the cost-effectiveness of adaptation action is the critical factor.

- Do you think that funds are sufficient for adapting to climate change in coastal areas? Could you please describe briefly any current financial support?

  Comment: generally, the major budget of local governments comes from the

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Web: Kaoshung & Pingtung River Management. http://www.kpriver.com.tw/ (2014/11/17)
Web: Tamsui River Basin Management. http://ivy2.epa.gov.tw/TamShuiRiver/default.htm (2014/11/17).

central government, but the budget is irregular and limited because the central government does not prepare an annual budget for the climate change adaptation (local government).

The budgets of local governments are insufficient and cannot provide adequate funds to climate change adaptation. The budgets are composed by special grants from the central government and matched by funds from local governments (central government and local government).

- Do you know any potential financing sources? Could you please describe briefly how to obtain it?

  Comment: Adaptation funds can be raised through international or regional cooperation. In the near future, the government should consider imposing a carbon tax to make it the major source to establish the national adaptation fund (central government).

3.3 Social Perspective

- Would you identify what you think are the critical measures in local planning actions in adapting to climate change? Please specify. e.g.: education on climate change; information platform.

  Comment: promote climate change adaptation education and activities to enhance public awareness on climate change adaptation (central government and local government and academic).

- Do you think public participation is conducive to local coastal adaptation to climate change? Could you please describe briefly how to improve public participation in climate change adaptation?

  Comment: Yes, public participation is beneficial to climate change adaptation, but the public only have consciousness of disaster and prevention without the notion of adaptation (central government and academic).

  Government can create low-risk communities to climate change through land-use change and community deliberations to condense the differences in common consensus (central government and local government).

- Do you know of any incentive programmes that have been conducted to encourage community engage in local coastal adaptation to climate change? Could you please

describe briefly how to establish or improve these programmes?

Comment: No programmes have been conducted to encourage community engage in adaptation action (central government, local government, academic).

Now, central government focuses on the issue of disaster prevention. The government implemented disaster resistant community plans and drafted disaster prevention maps to inspire awareness on disaster prevention and improve organisational functions in local communities. The notion of adaptation can be introduced to the public after the implementation of disaster prevention awareness programmes (central government and local government).

- Do you think the public have fully understood and received the relevant information about climate change? Could you please describe briefly how to improve information and communication?

Comment: most of the public have a good understanding of disaster prevention, but relevant information on climate change and adaptation are not fully understood yet (central government and local government).

We need an information communication platform, for example, encourage the public to participate in climate change adaptation workshops, make available literature about climate change and promote activities in communities (local government and academic).

3.4 Technological perspective

- Would you identify what you think are the critical factors for local planning actions in adapting to climate change? Please specify. e.g.: interdisciplinary research, expertise, facilities.

Comment: The expertise and research infrastructures are sufficient for research on climate change in Taiwan, but the key points are the reliability of the data and how to use these scientific data (central government).

The policymakers and researchers will be able to formulate long-term and sound policy and measures when they can clearly understand the meaning of the relevant scientific data (central government and academic).

- Do you think that existing defensive infrastructure and facilities are sufficient to

protect the local communities? Could you please describe briefly how to improve it?

Comment: No, especially in western coastal areas. Previous coastal defensive infrastructure was unable to resist the existing impacts because the planning was done for medium term and only for 25 years (academic).

In the future, the protective standard of coastal defensive infrastructure should be formulated under long-term planning of at least 50 years (academic and central government).

- Do you think the scientific data of climate change is creditable to the public? Could you please describe briefly how to increase the public's confidence on the available information?

  Comment: They do not believe the information entirely, as the understanding of the general public on climatic information is limited and difficult to apply because their scientific knowledge on the subject is limited. In addition, the disadvantaged groups find it harder to use or access the relevant climatic information (e.g.: electronic information) (central government, academic)

  Many people misunderstand the concept of climate change, as they think that inter-annual variations (El Niño Phenomenon, Arctic Oscillation) are the so-called climate change. However, existing climate change research focuses on the long-term climatic change (academic).

  Education maybe the best way to create awareness, for example, network information and brochures on climate change, climate change education programmes (from primary school to university), and courses in general education. It may be difficult to enhance public confidence in scientific data on climate change, but more and more people will accept the notion of adaptation after experiencing the frequent and serious consequences of climate change (central government, local government, academic).

- Do you think the early warning systems, emergency preparedness, and response procedures are carried out effectively? Could you please describe briefly how to improve such systems?

  Comment: Yes, these systems are carried out effectively (central government,

local government, academic). Ministry of Science and Technology has developed three cross-disciplinary research programmes: 1. Climatic Development Model: forecasting weather and climate patterns in the future; 2. Taiwan Climate Change Projection and Information Platform: providing all climate change relevant information to researchers; 3. Taiwan integrated research program on Climate Change Adaptation Technology: adaptation technology and assessment in the future (central government).

In addition, many relevant systems have been established. For example, the Hydrological Information System, Taiwan Disaster Response Information Platform, the Disaster Map, the Disaster Prevention Information Service Network, Flood Monitoring System, the Coastal Hydrologic Information System and the Disaster Warning Information Platform. The key point is how to assist public on how to look for these available information (central government, local government, academic).

These facilities and measures should be improved to respond to the most serious potential impacts according to the simulation results of scientific data. Therefore, scenario projection can be used to understand the future situation and then select practicable and cost-effective adaptation actions (central government and local government).

3.5 Legal Perspective

- Would you identify what you think are critical factors for local planning actions in adapting to climate change? Please specify. e.g.: identification of roles and responsibilities among authorities, integrated and exclusive legal regime, specific administrations.

  Comment: lack of an exclusive law and an administration (central government, local government, academic).

- Do you think the land use and development regulations and coastal laws can effectively reduce coastal vulnerability to climate change? Could you please describe briefly how to accelerate the legislative procedure for such regulations?

  Comment: yes, these relevant regulations and laws of land use and coastal management can effectively reduce the vulnerability of coastal areas (e.g.: National Land Planning Act, National Land Restoration Law, Coastal Act).

For example, the Urban Planning Law can be used to comprehensively review the land use of coastal low-lying areas and flood-prone areas (local government). The key point is that these relevant regulations of national land management have not been legislated because they may lead to property and livelihood loss of local communities in coastal or susceptive areas. Therefore, the government should communicate with the public during the process of legislation to minimise the negative effects on local communities. (central government and academic).

In the case of the National Land Planning Act and the Coastal Act, they have not been passed, and national land planning was implemented under the Regional Planning Act. However, the planning is incomprehensive (central government, local government).

- Do you think that integrating the adaptation notion into coastal zone management plans can respond effectively to the impacts of climate change in near future? Could you please describe briefly how to make it practical?

  Comment: yes, and that is why the concept of climate change adaptation has been incorporated into the National Land Planning Act[2] (draft) and the Coastal Act [3](draft) (central government, local government and academic).

3.6 Environmental Perspective

- Would you identify what you think are the critical factors for local planning actions in adapting to climate change? Please specify. e.g.: uncertainty of impacts, basic datasets.

  Comment: the key point is that we must take account of the disaster

[2] Article 6: The basic principle of national land planning includes: land planning shall consider the impact of climate change that enable disaster prevention and response capacity.
Article 9: Land plan prepared by central competent authorities shall specify the strategy of disaster prevention and climate change adaption.
Article 10: Land plan prepared by county (city) competent authorities shall specify the strategy of disaster prevention and climate change adaption.
Ministry of the Interior. 2012. National Land Planning Act (draft)
http://moodle.ncku.edu.tw/file.php/55443/%E5%9C%8B%E5%9C%9F%E8%A8%88%E7%95%AB%E6%B3%95_%E8%8D%89%E6%A1%88_.pdf (Access: 2014/11/18)

[3] Article 7: For land protection, conservation, using and management on coastal area, the central competent authority shall draft an overall coastal management plan, it includes sustainable and climate change adaptation policy.
Executive Yuan. 2014. Coastal Act (draft).
http://www.ey.gov.tw/Upload/RelFile/2016/713660/cd201108-647b-46a9-b457-f3fed6755421.pdf
(Access: 2014/11/18)

prevention and environmental protection in developing adaptation actions (central government and local government, academic).

- Most respondents think that coastal protection engineering is the best way to defend coastal areas. Do you think that natural environment protection measures are more effective to respond to climate change than artificial defensive infrastructures?

  Comment: actually, the natural beach provides the best protection. In the past few decades, traditionally coastal protection measures have been to erect hard structures to protect beaches against erosion, in Taiwan. As such, a submerged breakwater was built on the west coast, and armoured blocks and bank revetments were the major protection structures on the east coast (academic).

  In fact, there is no absolute good or bad construction method. Consideration has to be given for compatibility. So, artificial protection constructions need to satisfy two conditions: conformance with the requirements of local communities and geographical characteristics of the areas (academic and local government).

- Could you please describe briefly how to construct artificial infrastructures that take into account life and property protection and environmental friendliness?

  Comment:

  The objective of adaptation measure focuses on public safety protection and disaster prevention rather than environmental and ecological protection. Consequently, there are hard structures (riverbank, embankment, dike, seawall) on the coasts in Taiwan. There is no protection engineering method that can be used to effectively protect both the people and the natural environments. Ecological engineering method and environmental constructions may be the best way to achieve this objective. Examples of such include green belts, flood detention pools and beach nourishment (academic).

APPENDIX J. SUMMARISED RESULT OF FOLLOW-UP QUESTIONNAIRE

Profile of representatives of follow-up questionnaire

	Name	**Organisation**	**Experience**	**Education Degree**	**Specialty**
No. 1	Yi-Syuan, He	Pingtung County Government	↓5 years	BSc	Water Conservancy Engineering
No. 2	Guo-Fong, Jiang	Pingtung County Government	↑ 20 years	MSc	Civil Engineering
No. 3	Fong-Jhih, Guo	Pingtung County Government	↑ 20 years	MSc	Climate Change, Water Conservancy Engineering, Disaster Prevention
No. 4	Chia-Hung, Chang	Pingtung County Government	10-14 years	MSc	Constructional Engineering
No. 5	Sheng-Hsin, Hsieh	Pingtung County Government	↑ 20 years	MSc	Water Conservancy Engineering
No. 6	Chiao-Wei, Chang	Yunlin County Government	10-14 years	MSc	Climate Change Adaptation; Marine Environmnetal Conservation
No. 7	Tung-Hsuan, Li	Yunlin County Government	↓5 years	MSc	Climate Change Adaptation
No. 8	Tung-Min, Tseng	Yunlin County Government	5-9 years	BSc	Environmental Conservation

I. Governmental actions

1.1 Local adaptation actions and community engagement

- Existing phase of the three main adaptation actions.

Q1	Formulating	Implementing	Completed
Protection Technology	25%	75%	0%
Retreat Technology	50%	50%	0%
Accommodation Technology	25%	75%	0%

- Three types of adaptation actions that involved community engagement.

Q1	Explicit Engagement	Implicit Engagement	Without Engagement
Protection Technology	0%	80%	20%
Retreat Technology	20%	80%	0%
Accommodation Technology	0%	40%	60%

1.2 Public awareness and understanding of local adaptation actions

- Concern level of public unawareness of local adaptation actions.

	very concerned	fairly concerned	neutral	not very concerned	not at all concerned
Q2. Concern Level	38%	38%	25%	0%	0%

- The potential reasons why local communities are unaware and unfamiliar with these planned adaptation actions.

No.1: *insufficient publicity for information about climate change and adaptation.*

No.2: *lack of effective communication and information sharing.*

No.3: *public understanding of relevant issue is limited, lack of adequate information platforms.*

No.4: *news coverage focuses on social phenomena, not governmental actions.*

No.5: *no direct impacts, less concern. Only a few members of environmental groups concern about this issue.*

No.7: *the understanding of the general public on the purpose and meaning of adaptation is limited.*

Comment Box 1

- Suggestions to increase local communities' awareness and understanding of the local adaptation framework and actions.

No.1: *dissemination of information via the internet and the TV media.*

No.2: *the government should actively spread and communicate relevant policies with the public through appropriate communication channesl.*

No.3: *short-term: simplifying and exploring the issues, providing simple and understandable information to the general public by mass media in order to increase the public understanding and concerns. Long-term: Primary education is used to increase the public understanding and perception of public issues (e.g.: Japan, Germany). Therefore, coordinating with educational departments to provide information and improve interest in relevant issues to children is the best way.*

No.4: *extensive coverage of governmental actions and international news.*

No.5: *community education, such as the basic education of rural rejuvenation, environmental education.*

No.7: *using public enlightenment and mass media to express the information in terms that are readily understood.*

Comment Box 2

II. Institutional arrangements

2.1 Community engagement with local adaptation framework and actions

- Existing Adaptation actions have increased community awareness and understanding.

	strong agree	tend to agree	neither agree or disagree	tend to disagree	strongly disagree
Q3. actions have increased community awareness and understanding	0%	38%	50%	13%	0%

No.1: *the availability and understanding of relevant information is difficult for general public.*

No.2: *climate change adaptation is comprehensive, and therefore it is need the cooperation between the central government, local governments, and NGOs to increase the public understanding.*

Comment Box 3

- The difficulties or challenges associated with community engagement on adaptation actions.

No.1: *communities have no time to engage in adaptation actions, and most people do not know these actions because they have limited information.*

No.2: *relevant information is difficult to access for the general public and the public's understanding is insufficient.*

No.3: *limited public understanding of the adaptation actions and most people are only concerned about personal interests, which leads to low willingness to participate in these actions. In addition, most local communities have no time to engage in these actions.*

No.4: *people do not perceive adaptation actions, do not know what action they can engage with, or cannot implement these actions.*

No.5: *People think the issue of climate change is irrelevant to them. So, it is only communities in disaster-prone areas and students who may have a higher will to engage with adaptation actions.*

Comment Box 4

- Further plans (actions) to engage with the communities in future decision-making activities related to adaptation actions.

No.1: *providing incentive allowances and accessible information on the internet, to encourage community engagement,*

No.3: *making programmes and actions such as the issues of water management, disaster prevention, infrastructure, and industrial transformation highly related to local communities' life a priority.*

No.4: *reasonably adjusting the utilisation rate of fuel, water, and electricity.*

No.5: *provide emergency notification and evacuation actions.*

Comment Box 5

- Further comments/suggestions in relation to community engagement with local adaptation actions.

No.1: *provision of understandable information.*

No.2: *the government should actively spread and communicate policies with public through appropriate communication channels in order to increase public participation.*

No.3: *it is inappropriate to adapt the idea of a single method of action The primary issue of public concern is a top priority and the related issues are different in different areas, and therefore flexible approaches are more effective.*

No.4: *spreading information on the global views and the importance of climate change adaptation via news coverage.*

No.5: *The central government should administrate the national issue and coordinate with local governments to develop and implement the relevant policies. Sharing the information of climate change through mass media and educational systems to encourage community participation from bottom-up*

Comment Box 6

III. The potential problems in local adaptation frameworks from the PESTEL perspectives

3.1 Political Perspective

- Is the idea of **interdepartmental coordination** used in the local adaptation frameworks?

	Yes	No
Q5.2 Is the idea of **interdepartmental coordination** used in the local adaptation frameworks?	75%	25%

No.2: *Pingtung County Government has established an interdepartmental green energy promotion office.*

No.3: *the information platform of disaster prevention incorporates the department of water resources, police, fire, and social welfare to evaluate the*

comprehensive performance of township offices.

No.4: *some programmes and actions need interdepartmental coordination.*

No.5: *integrated policies and measures are being planned in Pingtung County Government*

Comment Box 7

- To what extent do you agree/disagree that **<u>interdepartmental coordination</u>** is effective to respond to climate change in your county?

	strong agree	tend to agree	neither agree or disagree	tend to disagree	strongly disagree
Q5.3 this idea is effective	38%	50%	13%	0%	0%

No.3: *government's resources are limited.*

No.4: *interdepartmental coordination is important because climate change causes compound disasters.*

No.5: *for example, the Fire Bureau is responsible for emergency notification; the Engineering Department and the Water Resources Agency are in charge of rehabilitation after a natural disaster; the Department of Indigenous Peoples, the Urban and Rural Development Department and the Civil Administration Department are responsible for evacuation and resettlement.*

Comment Box 8

- Are the **<u>roles and responsibilities of different departments clear</u>** in the local adaptation framework?

	Yes	No
Q5.4 roles and responsibilities among sectors of local government	63%	38%

No.3: *the roles and responsibilities have been roughly divided through the process of departmental integration.*

No.5: *the roles and responsibilities of different departments are clear for natural disaster, such as floods.*

Comment Box 9

- To what extent do you agree/disagree that **clear roles and responsibilities** in the local adaptation framework is effective to respond to climate change.

	strong agree	tend to agree	neither agree or disagree	tend to disagree	strongly disagree
Q5.5 the idea is effective	13%	75%	13%	0%	0%

No.3: yes, but each department still needs to strengthen their response capacity.

No.4: yes, and increasing budget is necessary to develop specific adaptation actions.

No.5: *the roles and responsibilities of departments are clear for flood, but not for other natural disasters.*

Comment Box 10

3.2 Economic Perspective

- Is the **financial support and budget** sufficient in the local adaptation framework?

	Yes	No
Q6.2 sufficient financial support	0%	100%

No.3: *reasonable distribution of financial support and budget according to the objective of adaptation framework is important. However, the actual budget is a drop in the bucket.*

No.5: *the finance from the local governments is insufficient to support the existing actions and plans, and the financial support from the central government is necessary.*

Comment Box 11

- To what extent do you agree/disagree that **sufficient financial source and budget** is necessary to respond to climate change.

	strong agree	tend to agree	neither agree or disagree	tend to disagree	strongly disagree
Q6.3 this idea is necessary	25%	75%	0%	0%	0%

No.3: *sufficient financial support is important and integration of resources and manpower to enforce the adaptation actions is another requisite for success.*

No.4: *stable financial support can effectively support the implementation of adaptation actions.*

Comment Box 12

- Are any **international or regional cooperation funds or carbon tax** used in the local adaptation frameworks?

	Yes	No
Q6.4 international or regional cooperation funds and carbon tax	0%	100%

- To what extent do you agree/disagree that **funding sources** such as the above would be effective to respond to climate change in your county?

	strong agree	tend to agree	neither agree or disagree	tend to disagree	strongly disagree
Q6.5 the idea is effective	13%	75%	13%	0%	0%

No.3: *user pay would be productive. Additional, sufficient finance can support adaptation actions, and practicable and effective supporting measures are key requirements for success.*

No.4: *sufficient finance can support long-term actions and increase the adaptive capacity*.

No.5: *other environmental taxes such as the tax of air pollution can be used for specified purposes only.*.

Comment Box 13

3.3 Social Perspective

- Is the idea of **increasing the public awareness** used in the local adaptation

frameworks?

	Yes	No
Q7.2 used in local adaptation framework	63%	38%

No.3: *integrated adaptation frameworks have not involved the general public. Decisions made by individual department such as* flood prevention, disaster prevention without the involvement of the general public.

Comment Box 14

- To what extent do you agree/disagree that **increasing the public awareness** is effective to respond to climate change in your county?

	strong agree	tend to agree	neither agree or disagree	tend to disagree	strongly disagree
Q7.3 this idea is effective	75%	13%	13%	0%	0%

No.4: *the ignorance of the public may increase the impacts of climate change.*

Comment Box 15

- Is any **communication programme** used in the local adaptation framework to communicate with the public?

	Yes	No
Q7.4 programmes encouraging better communication	75%	25%

No.3: *public hearings and consultative council for water control programme.*

Comment Box 16

- To what extent do you agree/disagree that such **programmes** are effective to respond to climate change in your county?

	strong agree	tend to agree	neither agree or disagree	tend to disagree	strongly disagree
Q7.5 the idea is effective	63%	38%	0%	0%	0%

No.3: *communication channels and platforms have been established, but low public participation on public issues. So, the communication is a mere process.*

Comment Box 17

3.4 Technological Perspective

- Is any **scientific data and database** used in the local adaptation frameworks?

	Yes	No
Q8.2 used in local adaptation framework	88%	13%

No.2: *GIS integrated database, biodiversity database and monitoring system are used.*

No.3: *Water level monitoring system, water pump GPS, and the data of river drainage and depth are used.*

No.5: *Monitoring systems in important sites of Pingtung County are used and the local community can watch the CCTV on the internet when disasters occurred.*

Comment Box 18

- To what extent do you agree/disagree that **scientific data and databases** are effective to respond to climate change in your county?

	strong agree	tend to agree	neither agree or disagree	tend to disagree	strongly disagree
Q8.3 this idea is effective	38%	63%	0%	0%	0%

No.3: *not only is the scientific data necessary, but also the interpretation of experts is important. However, frequent change of personnel may influence the effectiveness of scientific data.*

No.4: *that is not debated.*

Comment Box 19

- Are the approaches of **defensive infrastructures and facilities, as well as preventive actions and emergency preparedness** addressed in the local adaptation frameworks?

	Yes	No
Q8.4 defensive, preventive, emergency	100%	0%

No.2: *impact assessment systems of roads' and bridges' safety, reinforcement of existing building, and strengthening the response capacity of local government*

are incorporated.

No.3: *these actions are being undertaken.*

No.4: *the monitoring system of rainfall and water levels and community-based flood risk management programmes are incorporated.*

No.5: *overall maintenance of river drainage system (river dike, pumping station), monitorin systems in disaster-prone sites, and emergency evacuation plans and exercises in disaster-prone areas are incorporated.*

Comment Box 20

- To what extent do you agree/disagree that these **approaches** are effective in your county?

	strong agree	tend to agree	neither agree or disagree	tend to disagree	strongly disagree
Q8.5 the idea is effective	63%	38%	0%	0%	0%

No.3: *if we can completely implement these planning actions, it can effectively protect local communities.*

No.4: *the disaster emergency operation center has effectively increased response capacity when hazards occur.*

Comment Box 21

3.5 Legal Perspective

- Is the idea of **specific laws and administrations** used in the local adaptation frameworks?

	Yes	No
Q9.2 used in local adaptation framework	25%	75%

No.3: *I doubt whether the legal and administrative personnel in county governments are qualified to legislate on climate change issues.*

No.5: *we do not have specific laws and administrative departments for this, in Pingtung County.*

Comment Box 22

- To what extent do you agree/disagree that **specific laws and administrations** would be effective to respond to climate change in your county?

	strong agree	tend to agree	neither agree or disagree	tend to disagree	strongly disagree
Q9.3 this idea is effective	0%	75%	13%	0%	13%

No.3: *specific administrations would be unable to respond to climate change.*

No.4: *I think that developing specific laws for implementing adaptation actions by individual departments is better than establishing specific administrations. Specific administrations are useless.*

Comment Box 23

- Is the idea of **integrating adaptation into management plans and projects** used in the local adaptation frameworks?

	Yes	No
Q9.4 integrating adaptation into management plans and projects	63%	38%

No.2: *it is, in evaluating environmental capacity of urban areas, developing water retention facilities in urban areas, integrating flood prevention design of urban areas.*

No.3: *incorporating the idea of adaptation into management plans needs a legal basis.*

No.4: *defining the adaptation actions and responsibilities of each department, and processing the performance are essential.*

Comment Box 24

- To what extent do you agree/disagree that **integrating adaptation into management plans** is effective to respond to climate change in your county?

	strong agree	tend to agree	neither agree or disagree	tend to disagree	strongly disagree
Q9.5 the idea is effective	38%	25%	38%	0%	0%

No.3: *adaptation framework is just a beginning, and not all of these actions will*

effectively respond to climate change.

No.4: *the key factor is "concrete implementation of these adaptation actions."*

No.5: *the implementation of adaptation actions will be easier with clear and definite directions and steps.*

Comment Box 25

3.6 Environmental Perspective

- Is the idea of **disaster prevention and environmental protection** used in the local adaptation frameworks?

	Yes	No
Q10.2 used in local adaptation framework	88%	13%

o.2: *used in integrating national land monitoring and early-warning system, dispersing the risk of disaster, coastal land monitoring, and environmental conservation.*

No.3: *disaster reduction and prevention is used in the local adaptation framework.*

No.5: *used in establishing reporting systems, enforcing comprehensive watershed management, encouraging forestation and forest reservation.*

Comment Box 26

- To what extent do you agree/disagree that **disaster prevention and environmental protection** is effective to respond to climate change in your county?

	strong agree	tend to agree	neither agree or disagree	tend to disagree	strongly disagree
Q10.3 this idea is effective	50%	38%	13%	0%	0%

No.4: *human activity is a partial factor for significant natural disasters.*

No.5: *these measures of environmental conservation can increase the effectiveness of climate change adaptation.*

Comment Box 27

- Do artificial infrastructures involve the idea of **environmental protection and be**

environmental friendly in the local adaptation frameworks?

	Yes	No
Q10.4 protection and be environmental friendly	75%	25%

No.3*: local governments are incompetent to develop comprehensive measures from a top-down perspective. Local governments only consider costs.*

No.4: *developing preventive constructions have to consider the different individual scenarios, and not all of these areas need artificial structures.*

Comment Box 28

- To what extent do you agree/disagree that constructing artificial infrastructures being **environment protection and be environmental friendly** is effective to respond to climate change in your county?

	strong agree	tend to agree	neither agree or disagree	tend to disagree	strongly disagree
Q10.5 the idea is effective	63%	38%	0%	0%	0%

No.5: *comprehensive climate change adaptation programmes can have multiple effects*

Comment Box 29