Emergency response volunteers’ flood risk perception under climate change and flood hazard and risk maps acceptance behavior:

A comparative study between Baden-Württemberg, Germany, and Guangdong, China

Von der Fakultät Wirtschafts- und Sozialwissenschaften der

Universität Stuttgart

zur Erlangung der Würde eines Doktors der Wirtschafts- und

Sozialwissenschaften (Dr. rer. pol.) genehmigte Abhandlung

Vorgelegt von

Tong Wu

aus Shaanxi, China

Hauptberichter: Prof. Dr. Dr. h.c. Ortwin Renn

Mitberichter: Prof. Dr. Cordula Kropp

Tag der mündlichen Prüfung: 14. Juli 2022

Institut für Sozialwissenschaften der Universität Stuttgart

2022

Acknowledgements

First and foremost, I would like to express my deepest gratitude to my supervisor Professor Ortwin Renn for his guidance and insights. I would also like to thank Professor Cordula Kropp for her feedback and support.

In addition, many thanks to colleagues and friends at University of Stuttgart for their generous help.

Besides, special thanks to all the respondents who participated in the survey. I am very grateful for their time and efforts.

Last but not least, I want to address my thanks to my family for always supporting me.

Contents

List of Tables

List of Figures

Abbreviations

Selected Acronyms:

ENIT	Enthusiasm of New Information Technology
ERV	Emergency Response Volunteers
IQ	Information Quality
ISE	Internet Self-Efficacy
IU	Intention to Use
PECCMA	Perceived Effect of Climate Change Mitigation Actions
PEOU	Perceived Ease of Use
PICCFR	Perceived Impact of Climate Change on Flood Risk
PU	Perceived Usefulness
UCC	Uncertainty over Climate Change

Abstract

Emergency response volunteers (ERV) are considered as one of the most important groups in emergency management. With a combination of local experience as well as skills and knowledge from training regarding emergency response, ERV can rapidly respond to local emergencies by participating in rescue and relief work. Floods are among the most frequent natural hazards in both Germany and China, and ERV often face risk during their flood emergency response operations. The response of volunteers to flood risk is important for the safety of their lives and performance during flood emergency response operations.

In this thesis, based on an online survey of 580 respondents (including 382 from Germany and 198 from China) conducted among emergency response volunteers from Baden-Württemberg state in Germany and Guangdong province in China, three flood risk related topics are explored:

First, to answer the question "How different is flood risk perception among emergency response volunteers between Germany and China and what are the factors that significantly influence flood risk perception?", by using data collected from the survey, multiple regression and bootstrapping analysis were applied. The results show that direct experience with floods, physical location, trust in the authorities, and training are important factors affecting volunteers' risk perception. It is found that volunteers in Germany show a higher level of controllability of flood risk compared to China. Meanwhile, volunteers in China exhibit more worry about the adverse consequence of floods, including financial loss and personal injury.

The second topic investigates how the perceived impact of climate change on flood risk by ERV is influenced by previous flood experience and perceived flood risk, and how it is associated with climate change perceptions. By using multiple regression and mediation analysis, the results show that when ERV perceive higher local flood risk, they tend to believe that climate change will have a more significant effect on local flood risk. In addition, three aspects of climate change perceptions (perceived local vulnerability, uncertainty over climate change, and perceived effect of climate change mitigation

actions) are affected by physical location and the perceived impact of climate change on flood risk.

The third topic aims to detect the factors influencing the acceptance intention of online flood hazard and risk maps, which are useful risk communication tools for emergency planning and response. An extended Technology Acceptance Model incorporated four external constructs (Information quality, Trust in information, Internet self-efficacy, and Enthusiasm of new information technology) was applied to explain and predict the acceptance behavior intention. By using the Structural Equation Model - Artificial Neural Network approach for hypotheses testing, the main findings indicate that Perceived Usefulness and Trust in information are essential factors of the intention to accept flood maps in both countries.

As few studies focusing on emergency response volunteers regarding flood risk in both Germany and China were conducted, this thesis fills this gap and provides insights for future risk communication and management concerning flood hazards and climate change.

Zusammenfassung

Freiwillige Rettungskräfte zählen zu den wichtigsten Helfern im Katastrophenschutz. Aufgrund von lokalem Wissen und ihrer Ausbildung im Katastrophenschutz, können sie schnell auf lokale Katastrophen reagieren und dabei Rettungs- und Hilfsaufgaben übernehmen. Hochwasser gehören sowohl in Deutschland als auch in China zu den am Häufigsten vorkommenden Naturkatastrophen und setzen freiwillige Rettungskräfte während Ihres Einsatzes Risiken aus. Der Umgang der Rettungskräfte mit diesen Risiken ist für ihren Eigenschutz und ihre Leistungsfähigkeit sehr wichtig.

Im Rahmen dieser Arbeit wurden mit Hilfe einer Online-Befragung von freiwilligen Rettungskräften das Hochwasserrisiko betreffende Themen untersucht. An dieser Online-Befragung nahmen 580 Rettungskräften teil, 382 aus Baden-Württemberg in Deutschland und 198 aus der Provinz Guangdong in China. Dabei wurden die folgenden drei Themen untersucht:

Das erste Thema betrachtet die Frage: Wie unterscheidet sich die Risikowahrnehmung zwischen freiwilligen Rettungskräften in Deutschland und in China, und welche Faktoren beeinflussen diese Wahrnehmung signifikant? Hierzu wurden durch die Online-Befragung Daten gesammelt, welche mit multipler Regressionsanalyse und dem Bootstrapping-Verfahren ausgewertet wurden. Die Ergebnisse zeigen, dass selbst erlebte Hochwasserereignisse, der Wohnort, das Vertrauen in Autoritäten und die Ausbildung wichtige Einflussfaktoren auf die Risikowahrnehmung sind. Befragte in Deutschland schätzen die Beherrschbarkeit von Hochwasserkatastrophen höher ein, als Teilnehmer in China. Befragte in China äußerten dagegen eine größere Sorge vor Hochwasserfolgen, wie finanzielle Verluste und gesundheitliche Schäden.

Das zweite Thema untersucht, wie der von freiwilligen Rettungskräften wahrgenommene Einfluss von Klimawandel auf das Hochwasserrisiko von selbst erlebten Hochwasserereignissen, dem wahrgenommenen Hochwasserrisiko und der Wahrnehmung des Klimawandels beeinflusst wird. Als Methode für diese Analyse wird die multiple Regressionsanalyse verwendet. Die Ergebnisse zeigen, dass ein erhöht wahrgenommenes lokales Hochwasserrisiko mit einem größeren erwarteten Einfluss des Klimawandels auf das Hochwasserrisiko einhergeht. Darüber hinaus werden drei weitere

Aspekte der Wahrnehmung des Klimawandels (wahrgenommene lokale Gefährdung durch Klimawandel, die Unsicherheit bezüglich der Existenz des Klimawandels und die Einschätzung der Wirksamkeit von Klimaschutzmaßnahmen) vom Wohnort und dem wahrgenommenen Einfluss des Klimawandels auf das Hochwasserrisiko beeinflusst.

Das dritte Thema untersucht welche Faktoren beeinflussen, ob eine Online Hochwasserrisikokarte von freiwilligen Rettungskräften als Hilfsmittel für Rettungs- und Hilfsaufgaben angenommen wird. Hochwasserrisikokarten sind ein wirksames Instrument zur Bereitstellung von Informationen und zur Planung und Durchführung von Rettungs- und Hilfsaufgaben. Für diese Untersuchung wird ein erweitertes Technology Acceptance Model verwendet, welches zu diesem Zweck um die externen Faktoren Informationsqualität, Vertrauen in die Informationen, Selbstwirksamkeitserwartung im Umgang mit dem Internet und Begeisterung für neue Informationstechnologien ergänzt wird. Durch Nutzung der Structual Equation Model - Artificial Neural Network Methode in Verbindung mit der Multi-Group-Moderation-Analysis ergibt sich, dass in beiden Ländern die wahrgenommene Nützlichkeit und das Vertrauen in die Informationen wichtige Faktoren für die Bereitschaft zur Nutzung einer Online Hochwasserrisikokarte sind.

Aufgrund der geringen Anzahl an wissenschaftlichen Arbeiten, die sich mit freiwilligen Rettungskräften in China und Deutschland in Verbindung mit Hochwasserrisiko befassen, bestand eine Lücke, die durch die vorliegende Arbeit gefüllt wird. Die Ergebnisse bieten eine Hilfestellung für zukünftiges Risikomanagement und Risikokommunikation im Hinblick auf Hochwasserkatastrophen und Klimawandel. Die Ergebnisse können ebenfalls bei der Entwicklung und Verbesserung von Hochwasserrisikokarten helfen.

1. Introduction

Floods are one of the most severe and frequent natural hazards. They put the economy and the safety of many countries and regions under serious threat. According to Munich Re (2020), floods account for almost 40% of all natural disaster-related economic loss, with more than 1 trillion USD worldwide total loss since 1980. Between 1995 and 2015, floods had affected 2.3 billion people and caused 157,000 fatalities, as reported by UNISDR and CRED (2015). Both China and Germany are frequently affected by floods. In 2020, economic losses from flooding amounted to 56 billion USD globally, and floods loss in China accounts for 17 billion USD (Munich Re, 2020).

Due to a combined effect of climate change and vulnerability change resulting from population growth and spatial expansion in the progress of urbanization (Nirupama & Simonovic, 2007; Siegrist & Gutscher, 2006; Tanoue et al., 2016), in recent years, an increase in floods extremes has been observed in Europe (Alfieri et al., 2015; Hov et al., 2013) and China (Richerzhagen et al., 2008; Ying, 2000). Such changes in floods will lead to a more substantial impact on the environment, ecology, and other aspects of society.

To cope with the challenge of the changing flood risk, the flood management paradigm has shifted the focus from the physical defense and control infrastructure approach to a comprehensive approach that integrates non-structural measures. Under this shift, flooding is regarded as a natural existence, which is an object to be managed instead of controlled (Aven et al., 2010; Renn, 2008, pp. 173-184; Samuels et al., 2006). To minimize the adverse effects of flooding, non-structural measures in this approach aim to improve the resilience and risk reduction capacity of the public against flood hazards (Grothmann & Reusswig, 2006; Hartmann & Albrecht, 2014; Renn & Klinke, 2004). Therefore, this integrated approach calls for more active involvement of individuals to protect themselves from floods by improving flood preparedness and response (Botzen et al., 2009; Grothmann & Reusswig, 2006; Terpstra & Gutteling, 2008). Such shift is reflected in the EU Floods Directive (2007/60/EC) and China's Flood Control Law (CNNPC, 1997), where citizens at risk are encouraged to engage in the implementation of flood hazards mitigation measures actively (Kuhlicke et al., 2011, p. 806).

Individuals can participate in natural disaster risk management in various ways. Among them, participation in volunteering services is widely practiced. Volunteers are active in different stages of the disaster circle, including education and training, preparedness and early warning, emergency response, rescue and relief, and post-disaster building and economic reconstruction (UNV, 2011). The contribution of the volunteers is widely recognized by many political bodies, international organizations, and the public (e.g., IFRC, 2012, p. 3; UNISDR, 2005; UNV, 2011). They are crucial for the whole society with regards to resilience building and vulnerability reducing to disasters (Aminizade et al., 2017).

Among all the volunteers involved in different disaster management stages, volunteers who received specific emergency response training are one of the most important types. They are specifically engaged in the emergency response stage of disaster management. Their main responsibilities are evacuation, searching, rescues of the affected population, and disaster relief (IFRC, 2012, pp. 10-12; UNV, 2011). In this thesis, they are referred to as Emergency Response Volunteers (ERV). Their performance in emergency response vastly affects the safety of lives and properties of the affected population.

Due to the different organizational forms, the role that emergency response volunteers play varies by country (IFRC, 2012). In Germany, volunteers make up the majority of all emergency response personnel. They are the basis of civil protection and disaster management (BMI, 2019). In China, the whole emergency response system mainly relies on governmental responders. When facing major catastrophes, it requires a large amount of personnel in disaster response, which often exceeds the capacity of the governmental responders. Volunteer responders are therefore an essential complementary force to the governmental responders. Such support is especially crucial for rural and remote areas.

With a combination of local knowledge as well as professional skills and knowledge from training regarding emergency response, ERV can respond to local emergencies with rapid rescue and relief. In addition, they can also involve in local decision-making and planning regarding emergency response (UNV, 2011). In such a way, they function as an essential communication bridge to connect the general public and official risk managers.

Compared to Germany's well-developed volunteer emergency response system that integrates volunteers as an essential part of the emergency management system, China's ERV organizations and groups are still in their infancy stage. Particularly, after the severe Wenchuan earthquake in 2008, emergency rescue organizations are established and are growing into an important complementary force to official disaster response forces. Integrating private and non-governmental emergence response volunteer organizations into the disaster management system is still in progress.

Germany and China are both flood prone countries, and ERV in both countries are often at risk during their flood emergency response operation. To ensure the safety of volunteers and the effectiveness of the flood emergency response operations, ERV are required to have not only sufficient knowledge and skills but also a good understanding and estimate of the danger and risk they are facing. Hence, it is of importance to investigate how ERV respond to flood risk.

Risk perception is recognized by many studies as an important social aspect in risk management (e.g., Buchecker et al., 2013; Bradford et al., 2012). According to studies, perceptions of risk can influence the attitude and actual actions of the public for flood mitigation and preparedness behaviors, such as self-protection (Ge et al., 2011; Thistlethwaite et al., 2018). This is especially important for ERV as they are often exposed to risky and dangerous situations. Their understanding of risk is an essential part of self-protection from the disaster (Prati et al., 2013). Therefore, it is necessary to investigate the local flood risk perception of ERV.

As a result of climate change, a likely rise in frequency and impact severity of extreme floods in many regions of the world has been predicted by scientific studies (Stocker et al., 2014, pp. 159-250; Wetherald, 2002). Therefore, it is necessary to investigate how individuals perceive the impact of climate change on flood risk. Such perception can influence climate change perceptions of the public as well as the understanding of the current dynamic change of flood risk (O'Connor et al., 1999; van der Linden, 2014).

Aside from risk perception, risk communication is another important perspective to look at within social aspects of flood risk. It plays a vital role in risk management as it can affect the public's knowledge and assessment about risk and raise risk awareness. In this way, it is able to influence risk perception and their attitudes or behavior regarding preparedness and response to emergency cases (Lundgren & McMakin, 2013). Moreover, risk communication can help promote the confidence of the public in the responsible authorities and effective stakeholder involvement in risk issues (Renn, 2009; Gisela Wachinger et al., 2013).

Floods hazard and risk maps are very intuitive and commonly used communication tools regarding flood hazards. The importance of such tools for flood risk management is also reflected in the EU Flood Directive and China's ongoing national flood mapping projects (Xiang, 2017). By providing visualized flood risk information as well as hazard response and mitigation information, flood hazard and risk maps help not only enhance individuals' knowledge and awareness about flood risk but also support their flood response and risk reduction behaviors.

With more and more online flood risk and hazard maps available to the public and interested groups, an essential question for such risk communication tools is how they are viewed by potential user groups. In some regions, studies show that flood maps failed to convey information to the targeted groups as their content and design did not match the user groups' needs (Meyer et al., 2012). Consequently, it is necessary to investigate how ERV, who have a great demand for risk communication tools, will accept flood hazard and flood maps and apply them in their flood emergency response work.

Although professional emergency responders and emergency response volunteers usually cooperate and undertake similar tasks, and both are often exposed to risk during operations, this thesis selects only volunteers as the research target group in Germany and China for three main reasons:

Firstly, few studies have been conducted on this group in Germany and China, focusing on flood risk and climate change perceptions. While some existing studies target the volunteers involved in emergency response and civil protection, these studies often focus on generic volunteers' groups or study the motivation behind volunteering (e.g., Kragt et al., 2018; Shi et al., 2018). Little attention has been given to the risk perception of emergency response volunteers. This thesis aims to fill the gap in this area.

Secondly, volunteering in emergency response in China is newly developed and still a young field in the whole volunteering system compared to Germany, which has a long history in this field. Therefore, it is of interest to compare the volunteers to show the differences and similarities among emergency response volunteers between these two countries.

Thirdly, compared to professional responders, volunteers usually devote less time to the preparedness of emergency operations. Therefore, they require more efficient and effective information communication tools for obtaining hazard and risk information. Specific to flood maps, it demands the flood maps to be more intuitive and easier to use to be accepted by the volunteers. Thus, investigating flood maps acceptance behaviors among volunteers can help provide insights for improving flood map usability and being accepted by broader user groups.

To sum up, this thesis aims to investigate emergency response volunteers regarding flood risk in three main topics: flood risk perception, the perception of climate change's impact on flood risk, and acceptance intention of flood hazard and risk maps. Three research questions are raised：

1. How does flood risk perception differ between German and Chinese emergency response volunteers, and what are the main determining factors on flood risk perception?
2. How is climate change's impact on flood risk perceived differently by ERV between Germany and China? How is it related to climate change perceptions and flood experience of ERV?
3. Which factors determine the intention to accept flood risk and hazard maps among ERV? How do these factors work differently for German and Chinese EVR?

To answer the questions above, the thesis is arranged as below.

Chapter 2 introduces the flood hazard situation in the study areas of Germany and China. Besides, the current situation of emergency response volunteers in both countries is presented.

Chapter 3 first introduces the main approaches for risk perception measurement. Flood risk perception is measured by the psychometric paradigm approach (Fischhoff et al., 1978) in this thesis. Moreover, the main determining factors of flood risk perception are introduced based on a literature review. In addition, literature regarding the risk perception of emergency response personnel is reviewed.

Chapter 4 first introduces the current situation regarding the impact of climate change on flood risk in the study areas of Germany and China. Influential factors of climate change perceptions are then introduced based on a literature review.

Chapter 5 presents current online flood hazard and risk maps in Germany and China. Besides, three widely applied theories of information system adoption behaviors are introduced. The Technology Acceptance Model (TAM) (Davis, 1989) is chosen to investigate the intention to accept the flood maps. An extended TAM approach was developed based on previous studies, and the result is presented in chapter 8.

Chapter 6 first formulates all the hypotheses regarding the three questions raised in this thesis. It is followed by the introduction of the methodology of the research survey and the preliminary analysis result.

In chapter 7, to investigate the main determinants of flood risk perception among EVR, multiple regression and bootstrapping analysis are applied for data analysis. The results of direct, indirect, and mediation effects of flood experience, training, trust in the authorities, and demographic factors on flood risk perception are reported.

In chapter 8, path analysis is applied for data analysis to test the proposed hypotheses within flood experience, the perception of climate change's impact on flood risk, and climate change perceptions. The analysis results are then discussed.

In chapter 9, the proposed extended TAM is first tested using structural equation modeling (SEM). The testing results and the comparison results between the two countries are reported. The artificial neural network approach is then used to re-examine the results from the SEM model.

Chapter 10 discusses the main findings from previous chapters, the implication and limitations of the study are also included. Chapter 11 presents a brief conclusion of the whole thesis.

2. Situations of flood risk and emergency response volunteers in Germany and China

In this chapter, flood situations in study areas of Germany and China are introduced. Besides, the current situation of emergency response volunteer organizations in both countries is presented.

2.1 Current flood risk situation in Germany

Germany is frequently affected by floods, five main river catchments (the Elbe, upper Danube, Rhine, Weser, and Ems) were all affected by severe flooding in the last 20 years. In 2002, one of the most severe flood events due to continuous heavy rainfalls has caused 21 fatalities and 11,600 million Euro economic loss in Germany (AIR, 2012). This loss exceeded the historical records. In the following year, 2003, heavy precipitation in central Europe that heavily affected Germany resulted in a flood which led to 8 fatalities and 10,400 million Euro economic loss. In June 2013, a severe flooding disaster caused economic damage of 6 to 8 billion Euros (AIR, 2018). According to the record from Munich Re (2018), an average of 2.2 major hydrological events (including flood and mass movement) hit Germany between 2008-2018 (Figure 1).

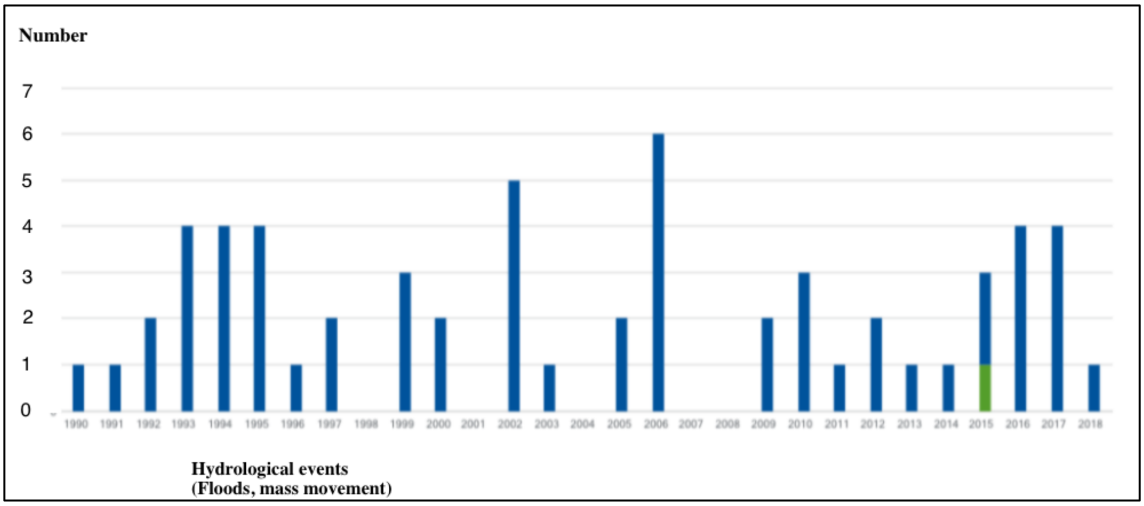

Figure 1. Frequency of hydrological events in Germany from 1990-2020

(Munich Re, 2018)

To mitigate and manage flood risks, the EU Floods Directive (2007/60/EC) entered into force in 2007. The directive required the member states to first assess and identify the flood risk by 2011, followed by the development of flood maps to demonstrate the risk and hazards information to the public by 2013. In the third stage, flood risk management plans were required to be established for flood risk prevention and preparedness by 2015. In Germany, the directive is transposed and implemented as the German Federal Water Act (CWA) (BMU, n.d.-b). Each state (Bundesland) is responsible for preparing programmes of measures and management plans required by the directive.

The study area, German federal state Baden-Wurttemberg (Figure 2), lies in Germany's southwest corner and shares borders with three European countries: France, Switzerland, and Austria. It is the third biggest German state with an area of around 35,000 square kilometers and a population of around 10.8 million. The highest mountain is 1,493 meters. Rhine, Neckar, and Danube are the biggest rives running through the state. Lake Constance in the south is the biggest lake in the state, with an area of 572 square kilometers (Staatsministerium Baden-Württemberg, n.d.). Baden-Württemberg is one of the leading economic regions in Germany and Europe, with a per-capita gross domestic product of 47,290 Euros in 2019 (OECD, 2021).

Along with the floods caused by extreme precipitation and snowmelt, the state faces the threat of riverine floods as part of the Rhine and the Danube river basins. To fulfill the requirements of the EU Floods Directive, floods maps were created, and risk management plans were established by the state authorities. The importance of the public's participation in flood risk management was stressed by the authorities in developing both the flood maps and the flood risk management plans (LUBW, n.d.).

Figure 2. Geographic map of Baden-Württemberg[1]

2.2 Current flood risk situation in China

Due to complex topography and climate conditions in China, floods are one of the most disastrous natural hazards and cause severe loss of life and economic damage every year. China suffers an average of more than 10 billion USD from floods every year. The spatial distribution of flood hazards shows that the eastern parts of China are more affected by flood hazards due to the relatively flat topography, high precipitation in the monsoon region, and a large number of lakes and rivers (Shi et al., 2020).

With the significant improvement in flood forecast and flood control facilities, the number of fatalities caused by floods has decreased significantly in the last several decades. The yearly average number of fatalities has dropped from more than 4,000 in 1960–1990 to approximately 1,000 since 2000. Meanwhile, the economic loss has significantly increased (Cheng, 2020; Wang et al., 2014).

As shown in Figure 3, the average value of the absolute direct economic loss (shown as the bar graph in figure 3) has decreased from around 100 billion CNY between 1994 and 1999 to around 100 billion CNY between 2000 and 2009. Such average value has risen to 250 billion between 2010 and 2016. Meanwhile, the average value of floods economic

[1] Source: http://ontheworldmap.com/germany/state/baden-wurttemberg/large-detailed-map-of-baden-wurttemberg.html

loss as a percentage of GDP (shown in the line chart in figure 3) has decreased from 2.26% between 1990 and 1999 to 0.47% between 2010 and 2016. This change is partly due to the rapid economic development after 2000 and the full completion of flood control projects of major rivers (Cheng, 2020).

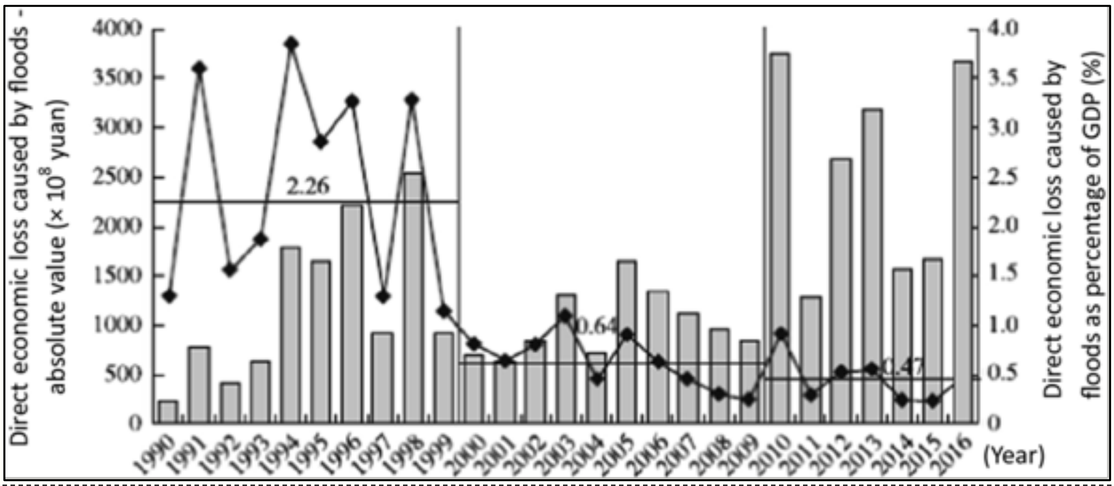

Figure 3. Direct economic loss caused by floods in China during 1990–2016 (Cheng, 2020)

With the fast economic development and urbanization process in China, three main aspects of flood risk challenges have been faced:

First, urban floods. Since the beginning of the twenty-first century, an unprecedented pace of urbanization has taken place in China. The percentage of China's total population living in urban areas increased from 19.4% in 1980 to 60.3% by the end of 2019 (World bank, 2020). During this change, flooding has become a common problem in many cities across the country due to lacking proper land planning for the current urbanization situation, inadequate draining system and infrastructure, and a high population density. Consequently, the victims of floods in China have shifted from rural areas to urban cities since 2010 (Kobayashi & Porter, 2012).

Second, floods in rural areas due to rural hollowing. In rural areas of China, the large-scale movement of young workers from rural areas to cities has caused labor shortages. Because of labor shortage, flood control works, such as dikes and dams, are poorly maintained, and flood preparedness and response forces are weakened during the flood season. As a result, floods caused the loss of production facilities and crops, which led to the affected area being under poverty and hard to recover (Kobayashi & Porter, 2012).

Moreover, flash floods and coastal floods. Flash floods typically occur in remote or mountainous areas, causing 70% of loss of life in all flood disasters (He et al., 2018). Coastal floods result from typhoons or other storms also frequently occur in China. On average, about four coastal floods occur annually, mostly in July to September, particularly in Fujian, Zhejiang, and Guangdong provinces (Chen et al., 2014).

To address these challenges, the authorities have developed several flood risk management policies in China. In 1997, the government of China passed the Flood Control Law (CNNPC, 1997). This law adopted the flood management approach that integrated both non-structural and structural measures in floods management. Furthermore, in 2005, the Ministry of Water Resources of China issued a national flood management strategy (Xiang, 2017). This strategy reconfirmed the integrated flood risk management paradigm. Despite the law and policies mentioned above, the flood control systems have not been fully adapted to the current changing flood risk situation (NDRCC&UNDP, 2017). The integration of climate change, urbanization, and land use management is still considered crucial for improving the effectiveness of flood risk management (He et al., 2018).

The study area Guangdong province (109°45′–117°20′ E and 20°09′–25°31′ N) is located in the southern part of China near the South China Sea (Figure 4). It covers an area of around 170,970 square kilometers and has a total coastline of 4,114 kilometers (State Council of PRC, 2015). Topographically, Guangdong province is high in the north and east, covered by mountains and hills, and is low in the south, mainly covered by plains and plateaus. Most of Guangdong province has a typical subtropical monsoons climate with a yearly average precipitation of 1,789 millimeters. The province has the highest number of typhoon landings among all the provinces in China, from July to September. The precipitation is mainly brought by typhoons (Zhang et al., 2011).

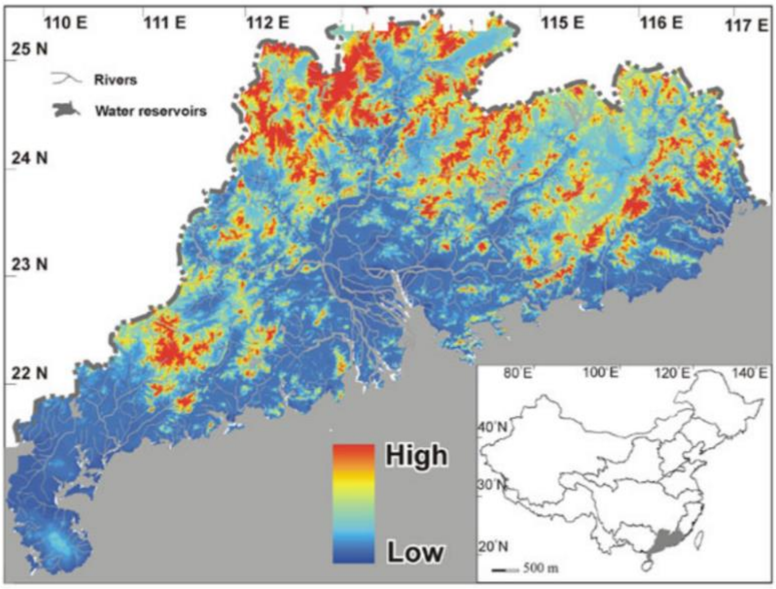

Figure 4. Location and topographical properties of Guangdong province [2](Zhang et al., 2011)

As one of the most economically developed regions in China, the province had the largest gross domestic product (GDP) since 1989. In 2020, the GDP of Guangdong province reached 1.7 trillion USD. The province also has the largest population in China, with 115 million residents in 2019. In 2019, per capita disposable income of residents reached 38,900 CNY (approximate 6,016 USD) (Guangdong Bureau of Statistics, 2019).

Due to more job opportunities and active economic events, Guangdong province attracts a large population from other provinces. The population has grown by around 8 million from 2015 to 2019 (National Bureau of Statistics of China, 2020). Moreover, the aging rate is relatively low in Guangdong compared to the rest of China. In 2019, the population over 65 years olds only made up 9% of the whole population, which is lower than the average rate of China (12.6%) (World Bank, 2019).

As a lowland in coastal regions coupled with a high population density and rapid land-use change, Guangdong is very prone to flood hazards, especially coastal floods, flash floods, as well as urban floods (Zhang et al., 2011).

[2] High and Low in the figure 4 refer to high and low altitude, respectively

2.3 Emergency response volunteers in Germany

In the cases of emergencies (e.g., flooding) in Germany, the federal states are legally responsible for civil protection, disaster control (natural and technical disasters), and relief. If necessary, the German Armed Forces, the German Federal Police, and the 16 state police forces can be deployed for disaster relief operations. A lot of official and non-official organizations are responsible for the execution of emergency response and relief tasks. Official organizations are Fire Brigades (Feuerwehren), Federal Technical Support Service (Technisches Hilfswerk/ THW), and Academy of Emergency Planning and Civil Defense (Akademie für Krisenmanagement, Notfallplanung und Zivilschutz). Examples for private organizations or Non-Governmental Organizations are German Red Cross (DRK), Arbeiter-Samariter-Bund Deutschland (ASB/Workers' Samaritan Association Germany), German Lifesaving Association (DGzRS/ Deutsche Gesellschaft zur Rettung Schiffbruchiger), St. John's Ambulance (JUH/ Johanniter-Unfall-Hilfe), Maltese-Relief-Organisation (MEID/ Malteser Hilfsdienst) (Kopschina & Stangl, 2008).

Among all the official and non-official organizations, more than 1.8 million volunteers function as an essential pillar of the civil protection system and disaster management, from preventing local threats to engaging in natural disasters relief (BMI, n.d.). For instance, inside Technisches Hilfswerk (THW/ Federal Agency for Technical Relief), volunteers make up 99% of all 79,543 members, according to the data in 2019 (Technisches Hilfswerk, 2019). Similarly, among the fire departments in Germany, 96.7% of members are volunteers (Deutscher Feuerwehr Verband, 2019).

Due to their ability to provide rapid response to the local emergency, fire departments are one of the most important organizations when facing emergencies. Besides the duties for fire prevention, rescue, and extinguish, the responsibilities of the fire departments have extended to multiple emergency responses, such as medical emergencies, water rescue and search, natural disaster, chemical, biological, and radioactive accident, pandemics, and natural disaster response.

In Germany, the fire protection system consists mainly of two kinds of fire departments: volunteer fire departments (Freiwillige Feuerwehr/FF) and professional fire departments (Berufsfeuerwehr). By the end of 2018, there were around 22,155 volunteer fire departments and 104 professional fire departments, with around 997,603 active volunteer firefighters and 33,549 professional firefighters in Germany. 98,493 female members account for 9,87% of active volunteer firefighters (Deutscher Feuerwehr Verband, 2019).

Professional fire departments and volunteer fire departments are organized differently depending on the administrative level. Large cities with a population of more than 80,000–100,000 people are required to organise a professional fire department which is operated entirely by professional firefighters. Professional firefighters are employees of the city and stay at the fire station during their duty. They support other fire departments in firefighting and fire prevention, training, as well as other emergency cases. Depending on their training and expertise, they are also deployed to repair and maintain the vehicles (Hegemann, 2020).

In addition to the professional fire departments, in big cities, there are typically also several volunteer fire departments assisting professional fire departments in firefighting and rescue, who are called upon in case of larger emergencies. Besides, volunteer fire departments are also engaged in organizing public firefighting activities, such as fire prevention publicity and education.

In medium-sized cities with a population under 50,000, fire departments are often partially staffed by professional firefighters and partially by volunteer firefighters. In most smaller cities and towns, the fire departments usually consist only of volunteer firefighters. In case of major incidents, several fire departments are usually alerted.

Volunteer firefighters work on a voluntary basis and usually also pursue a professional activity outside the fire brigade. They are alerted by means of a transmitter in case of an emergency. In order to perform emergency response, volunteers are required to acquire expertise and skills to perform emergency rescue tasks by receiving specific training. In Germany, the fire engine, protective clothing, equipment, as well as training between professional firefighters and volunteer firefighters are largely the same or very similar (Hegemann, 2020).

In addition to the fire departments, which are responsible for the emergency situations for the cities and towns, there are also the fire departments that belong to plants

(Werkfeuerwehr) and companies (Betriebsfeuerwehr). Usually, larger companies that work with chemicals or operate large production halls are obliged to set up their own plant fire departments. Plant fire departments function as professional fire departments in large cities (Hegemann, 2020). Plant fire departments are mainly active in preventive fire protection and taking the first action when facing fire accidents within a few minutes. Compared to plant fire departments, company fire departments are usually volunteer based, which means that the members are often employees of the company who perform this activity in addition to their actual job. In addition, company fire departments only operate on the company premises, while the plant fire department can also provide support to volunteer fire departments or professional fire departments (Feuerwehrverband BW, n.d.).

2.4 Emergency response volunteers in China

In China, emergency response and disaster reliefs mainly rely on official forces. The official emergency response forces consist of fire departments and a variety of other professional rescue forces. When facing major disasters, troops and Armed Police Force are also commonly deployed for disaster relief when it is necessary. They are coordinated and controlled by the authorities during disasters and emergencies. With the technical skills and training, as well as equipped with professional devices and apparatus, they are responsible not only for search, rescue, and evacuation during emergency response but also for maintaining the crucial infrastructure and constructions. For example, during floods disasters, official responders often undertake the tasks such as preventing dam failure, plugging the breaches, repairing important blocked roads, building emergency bridges, and delivering essential emergency supplies.

In addition to the official emergency response forces, the non-governmental volunteer organizations are also an irreplaceable part of the whole emergency response system in China. They function as the subsidiary to official response and relief forces. Compared to official responders, ERV are more flexible to deploy, and the services they provide are not only limited to essential emergency response tasks. For instance, they often undertake tasks such as delivering sandbags and performing disinfection in addition to evacuation, transferring, and rescue work during flood emergencies.

Since the Wenchuan earthquake in 2008 that caused 69,180 fatalities, emergency response volunteers have started to develop as a new field in volunteerism in China. Only several hours after the first wave of the earthquake in Wenchuan, there were already volunteer teams and individuals nearby heading to the affected area before the official rescue forces. There are in total more than 450 teams and organizations with more than 3 million volunteers from China and abroad who have participated in the rescue and relief work of the Wenchuan earthquake (State Council Information Office of PRC, 2009). This is the greatest emergency volunteering effort in China still today. Most of them have worked together with the official rescue forces, for example, digging out the victims trapped in debris, distributing supplies, transferring the wounded, burying the dead, as well as other auxiliary work. Their contributions to disaster rescue and relief work have received significant recognition from both the public and the authorities.

Influenced by the volunteering work during the Wenchuan earthquake in 2008, some volunteer organizations have decided to concentrate their work scope on disaster reliefs and emergency response. Before 2008, there were hardly any volunteer organizations focusing on disaster and emergency response and rescue. By the end of 2017, there were about 350 emergency response volunteer teams and organizations in China, and the number is growing (MCA China, 2017). Among them, two of the most well-known organizations are the Blue Sky Rescue and the One-Foundation Rescue Alliance.

Blue Sky Rescue (蓝天救援队) is a typical example of shifting the work scope from outdoors field search and rescue to disaster and emergency response after their participation in volunteering work during the Wenchuan earthquake. The organization registered in 2010 as the first emergency rescue volunteer organization in the country. The organization identifies itself as a complementary force for the official emergency response force. By 2020, the organization has 108 local branches with a total of more than 20,000 volunteers in different regions of China, including their special task teams, such as the technical rope rescue team and the rescue driver team (BLUE SKY RESCUE, n.d.).

Different from Blue Sky Rescue, which implements a unified management system with local branches, One-Foundation Rescue Alliance (壹基金救援联盟) is a platform to provide service for many independent rescue teams and organizations (One-Foundation, n.d.). The alliance, founded in 2009, not only works on rescue tasks on the local level but also coordinates the work across the provincial level. It is the largest alliance in the emergency response field covering 30 provinces and autonomous regions with around 300 rescue teams of nearly 5000 volunteers (One-Foundation,2020).

As a young field in volunteerism, several deficiencies have been experienced during the Wenchuan earthquake and other subsequent rescue activities, which can be categorized into five aspects. Firstly, emergency response volunteer organizations are not well integrated into the official emergency response system by the government. This leads to problems, such as lacking first-hand information and other supports. Secondly, it lacks a good coordination system among different organizations, resulting in difficulties in cooperating with other organizations. Thirdly, volunteers are not well covered by commercial insurance. Fourthly, well-developed systems for raising funding for the organization are still missing. Fifthly, there are not sufficient training and drills to improve the capacity and skills to ensure safety and personal protection. Besides, self-protection equipment and facilities are also often not provided to the volunteers (Wang, 2010; Xu, 2009).

3. Introduction of flood risk perception

When assessing risk, the difference between experts and the public has been observed in many domains (Slovic, 2016; Wright et al., 2002). Experts generally refer to ‘risk’ as objective risk, which is conventionally measured based on objective measurements, such as a product of probabilities and consequences (UNISDR, 2009), product of hazard, exposure, and vulnerability (Kron, 2005), or product of external risk (hazard), social vulnerability, and resilience (Birkmann et al., 2013).

Meanwhile, the public or lay people have their own subjective judgment of risk, which largely relies on their knowledge and experience from previous events and other factors (Botzen et al., 2009). Under the flood risk management approach that integrates social aspects, subjective risk measurement such as risk perception is gaining more and more importance. This view is also expressed by the International Risk Governance Council that emphasizes the need to integrate risk perception into risk governance as part of the societal context (Renn, 2009). The overlook of public risk perception when developing flood risk management plans can lead to the failures of risk communication between experts, policymakers, and the public (Bostrom, 1997; Brown & Damery, 2002; Rowe & Wright, 2001; Sjöberg, 2000). Thus, understanding public risk perception and its determinants are essential for improving risk communications and risk management.

Numbers of researches have suggested that risk perception is an important determinant of the risk reduction attitude and behavior, including distaste preparedness, response, resources allocation, and other preventive behaviors (Bubeck et al., 2012; Miceli et al., 2008; Zaalberg et al., 2009). In addition, risk perception can also affect how the public supports policies and strategies from authorities. In this way, it influences the effectiveness of flood risk management (Kousky et al., 2010; Lindell & Hwang, 2008; Lindell & Perry, 2012; Terpstra & Gutteling, 2008). Meanwhile, some researchers have argued that the risk perceptions, only by themselves, cannot significantly directly affect behaviors, such as preparedness and response to warning alarm. Instead, it is a mediator, which works closely with other factors, such as self-efficacy, and available resources, to affect risk reduction behaviors (Bubeck et al., 2012; Mulilis & Duval, 2003; Paton, 2003).

The majority of studies mainly focus on the risk perception of households living in flood-prone areas (Grothmann & Reusswig, 2006; Liu et al., 2018).

Studies about risk perception started in the 1940s in the United States when White (1945) pioneered research on the human adjustment to natural hazards. In the 1960s, numerous risk perception studies focused on the public's opinion about new technology, especially nuclear technology (Brilly & Polic, 2005). Up to today, risk perception studies have investigated a broad field of technology hazards, environmental (e.g., air pollution), and natural hazards (e.g., floods, landslides, and earthquakes), (Wachinger et al., 2010) and health-related issues (Brewer et al., 2007). Among them, flood risk research is one of the most extensively studied topics (Ho et al., 2008; Kellens et al., 2013; Lin et al., 2008).

3.1 Psychometric paradigm approach

Among the theories that dominate the risk perception research, the psychometric paradigm is one the most popular. Introduced in 1978 by Fischoff et al. (1978), the Psychometric Paradigm approach focuses on understanding flood risk perception through its perceived characteristics (Slovic, 1987). It assumed that the risk is multi-dimensionally based on different characteristics. Therefore, each dimension can be quantified via scale measurements in order to evaluate the hazard profile. The approach allows comparisons not only between different hazard types but also among different respondent groups, for example, across different countries and cultures (Boholm, 1998). Furthermore, it also enables the use of quantitative and statistical methods, such as factor analysis, to explore the interrelationship between different risk characteristics and external factors associated with risk perception, such as experience, age, and gender. Therefore, the psychometric paradigm approach is often used to emphasize the individual difference regarding risk perception characteristics (Slovic, 2016). Literature reviews show that plenty of cross countries and cultural studies have been conducted by using this approach (Boholm, 1998; Englander et al., 1986; Keown, 1989; Rohrmann, 2000; Teigen et al., 1988).

The initial psychometric paradigm model established the evaluation of perceived risk by using nine risk characteristics: voluntariness of risk, the immediacy of effect, knowledge about the risk by the person who is exposed to the potentially hazardous risk source, knowledge about the risk in science, control over the risk, newness, chronic/catastrophic, common/dread, and severity of consequences (Slovic, 1987). These factors can be classified into two main groups: “dread” of the risk (how uncontrollable, catastrophic, dangerous, and involuntary) and “knowledge” of the risk (how chronic, unknown, delayed, and new) that the exposed people have (Pidgeon, 1998). For natural hazards, dread is often characterized as worry. Knowledge of the risk is defined as awareness and control over the risk. The two factors can together be used as an indicator: the higher the hazard score for these two factors, the higher risk is perceived (Kraus & Slovic, 1988)

In this thesis, the psychometric paradigm approach is chosen to measure the flood risk perception of volunteers. This approach enables to compare quantified risk across countries as well as investigating determining factors of risk perception by using statistical methods such as regression, correlation, and factor analysis (Sjöberg, 2000).

3.2 Determining factors of flood risk perception

A large number of studies have identified the factors that cause the difference in risk perception among the public. According to Slovic, such heterogeneity can be influenced by psychological, social, cultural, as well as political factors (Slovic, 1987, 2016).

Wachinger et al. (2013) in their literature review research suggested a division of four groups of determining factors for natural hazards risk perception: **Risk factors**, which means the factors that are related to scientific characteristics of risk, such as perceived or experienced frequency of hazardous events; **Informational factors**, which are linked to indirect experience; **Personal factors**, including gender, age, education, personal knowledge, personal disaster experience, trust in authorities, trust in experts, confidence in different risk reduction measures, world views, and religiousness; **Contextual factors**, including economic factors, vulnerability indices, homeownership, family status, country, area of living, closeness to the waterfront, size of the community, age of the youngest child. According to the review, personal experience of a natural hazard and trust in authorities and experts have the most substantial influence on risk perception.

Specific to flood risk perceptions, the literature review from Kellens et al. (2013) also summarizes three groups of factors that are empirically proved to influence the flood risk perception: Physical Exposure and Previous Experiences; Knowledge, Trust, and Protection Responsibility; and Socio-Demographics.

In addition, in her literature review of flood risk perception factors, Lechowska (2018) also categorised the factors into six groups due to their nature: cognitive factors, behavioural factors, socio-economic and demographic factors, geographical (physical) factors, informational, and contextual (cultural, social, religious, political) factors. The factors of each group are summarized by Lechowska in Table 1.

Table 1. Classification of flood risk perception factors by their nature (Lechowska, 2018, p1358)

Nature of factors	Factors
Cognitive	Worry, direct experience
behavioural	Preparedness
socio-economic and demographical	Age, gender, incomes, education, household size (children), home ownership, cellar ownership
Geographical (physical)	Location (hazard), hazard proximity, type of building (living on ground floor), length of residence
Informational	Awareness (knowledge), indirect experience (media)
Contextual (cultural, social, religious, political)	Culture, religion, history, political system (government policy), social bonds (type of social capital), trust in government and public protection measures

In summary, the factors most common to affect risk perception based on previous literature reviews are objective risk characteristics, personal characteristics (personal disaster experience, trust in authorities and experts), social demographic characteristics (age, education, gender, income), and residence characteristics (distance to water, cellar ownership).

3.3 Studies of risk perception of emergency response personnel

While risk perception study often focuses on the private household and the general public, some risk-related groups are also the objects of empirical studies. For example, Becker et al. (2014) surveyed the flood risk perceptions of a group of German public officials responsible for municipal flood management along the Rhine.

In many countries, studies related to emergency response personnel are conducted. Among them, firefighters are one of the most frequently surveyed object groups. Many empirical studies have compared perceived risk differences between emergency situations, countries, career and volunteer firefighters.

Prati et al. (2013) compared the risk perception of firefighters between Germany and Italy with a sample of 1324 participants regarding different hazards, including fire, earthquake, and flood. The result indicated that German firefighters show a higher level of perceived flood risk than Italian firefighters. The Italian respondents perceived earthquakes as riskier than the German respondents. The findings from the study suggested that higher perceived risk was associated with training, practical experience, acute stress reactions, estimates of controllability, and job tenure.

Martínez-Fiestas et al. (2020) surveyed firefighters' risk perception among four Spanish-speaking countries by using the psychometric paradigm approach: Argentina, Chile, Ecuador, and Spain. The result showed that firefighters' perception of risk can be classified into three main dimensions: delay of consequences, personal vulnerability, as well as destructive potential. Professional firefighters tend to have a greater risk perception than the volunteers counterparts. Nationality does not significantly affect the perceived risk level.

Sadle et al. (2007) have investigated whether career and volunteer firefighters differ in their perception of the risk of a going fire compared to contained fire and whether the descriptions of fire as either going or contained affected perceptions of risk.

Besides firefighters, the risk perception of other emergency response personnel has also been investigated. For instance, Ahmed et al. (2020) have surveyed State Emergency Service personnel's risk perception and factors that influence the decision of driving through floodwater in Australia. The result showed that the location type, water depth, and water velocity were conditions that influenced more to the perception of risk when personnel drove through the floodwater.

From the literature review, it is found that empirical studies focusing on emergency response volunteers' risk perception regarding flood hazards in both China and Germany are still missing.

4. Climate change perceptions related to flood experience and risk perception

Among the potential negative impacts from climate change, the increasing risk of flooding in frequencies and impact magnitude is one of the most significant consequences (Dottori et al., 2018). This change is expected to become more pronounced in the future (Stocker et al., 2014, pp. 159-250). Such change could lead to unreliable flood risk assessment since the past flood records are not sufficient for a proper estimation of flood risk under the impact of climate change in the future. Therefore, to cope with this challenge, it is necessary for the authorities to incorporate the effect of climate change on flood risk into current flood protection measures and risk management strategies at the national and local levels (Haasnoot et al., 2013). For the general public, a good understanding of the relationships between climate change and flood risk is crucial to enhance their preparedness and response to flood hazards. In return, such understating could also influence the attitude and mitigation behaviours adoption of the public regarding climate change.

This chapter first introduces the impacts of climate change and the related policies in study areas of Germany and China. Besides, the main determining factors of climate change perception are introduced. The analysis of how climate change perceptions are affected by flood experience and flood risk perception will be presented in chapter 8.

4.1 Situation and policies of climate change in the study areas

In Germany, rising temperatures of the atmosphere and sea surfaces are influencing precipitation patterns. The study by Jongman et al. (2014) stated that cases of extreme damage by floods, which now occur once every 16 years, could shorten to once every 10 years. The current average losses of 4.9 billion Euros a year in the EU could reach 23.5 billion Euros by 2050, accounting for a rise of almost 380 percent. For Germany, the study also showed that total losses due to sea-level rise in Germany may reach 2.6 billion Euros per year by the 2080s without appropriate adaptation. Flood-related damage of currently about 500 million euro a year could multiply in the future (Hattermann et al., 2014).

The German government adopted the Climate Action Plan 2050 (BMU, n.d.-a), a long-term low greenhouse gas emission development strategy as required under the Paris Agreement. The Climate Action Plan maps out the process for achieving Germany's climate targets for different areas: energy supply, the building and transport sectors, industry and business, agriculture, and forestry. Germany's long-term goal is to become greenhouse-gas neutral by 2050, which means the net carbon emissions will be reduced to zero. The medium-term target is to cut greenhouse gas emissions (GHG emissions) in Germany by at least 55 percent by 2030 compared to 1990 levels. According to the Federal Environment Ministry, the greenhouse emission in 2019 has decreased by 35% compared to 1990 (Umweltbundesamt, 2021). Along with the Climate Action Plan 2050, Germany's first major national climate law has entered into force in 2019, and it was introduced as part of an extensive climate package to reach the 2030 climate targets. The package forms the foundation of the country's long-term climate policy.

According to the study by KIT’s South German Climate Office (Süddeutsches Klimabüro am KIT, 2016), in Baden-Württemberg, one of the warmest regions in Germany, climate change impacts such as heatwaves, extreme rains, and fine dust are already perceptible. The state has also adopted measures to address climate change. Currently, the contribution of Baden-Württemberg to worldwide greenhouse emissions is approximately 0.3 percent. According to the Act Governing the Mitigation of Climate Change in Baden-Württemberg that came into force in 2013, the greenhouse gas emissions for the state are planned to be reduced by at least 25% by 2020 and by 90% by 2050 compared to the 1990 level. Under this action plan, several campaigns have been conducted to increase energy efficiency. The behavioural support from the public of the state is considered an integral part of the implementation.

International and national evidence have shown that climate change in China has a similar trend as global climate change (Bi et al., 2014; Richerzhagen et al., 2008). Adverse impacts of climate change have been shown in agriculture production, environment, water resources, human health, and sea-level rise (Hong et al., 2019; Kan, 2011; Xie et al., 2020). In terms of changes in water resources, the office of the National Coordination Committee on Climate Change predicted that annual runoff will increase in the south and decrease in the north of the country, as the average annual precipitation in the country will increase in the next 50 years and may increase by 5% to 7% by 2050 (Ying, 2000). This change will lead to the frequent occurrence of extreme hydrological events such as droughts in the north and floods in the south. Besides, there will also be more intense storms and higher coastal storm surges due to climate change (Zhao, 2020).

As the urbanization and industrialization process continues to accelerate, the level of energy consumption is still rising in China. The country is facing serious challenges in addressing the climate change issue. China is the world's largest energy consumer as well as a major emitter of greenhouse gases (Piao et al., 2010). In 2017, China accounted for 28.3% of the global total CO_2 emissions (Shan et al., 2020), partially due to the high reliance on coal burning. As an important obligation to fulfil the UNFCCC, China issued its National Strategy for Climate Change Adaptation and set goals for improving adaptation regarding climate change in 2013 (SCIO, 2011). China has committed to reducing its carbon emissions intensity by 60-65% by 2050 in the Paris Agreement. In 2018, the Chinese government announced that China has met its 2020 emissions reduction targets set out in the Copenhagen Accord, including reducing carbon emissions intensity by 40-45% and increasing the proportion of non-fossil energy to 15% (State Council Information Office of PRC, 2019).

The geographical location and industry structure make Guangdong a vulnerable region to the adverse impacts of climate change. Consistent with global warming trends, the climate is also becoming warmer year by year in Guangdong province. The temperature warming rate of the province in the past 50 years has been 0.21℃/10 years (Zhang et al., 2011). Several main aspects about the potential impacts of climate change will threaten the province. The frequency of extreme weather events will increase, including greater intensity of tropical cyclones and the extent and occurrence of storm surge. In addition, floods will be more frequent due to the increasing precipitation. Moreover, sea-level rise has exacerbated and endangered the economic development and ecological environment of coastal areas, resulting in urban flooding and coastal erosion (OECD, 2010).

4.2 The role of flood experience and risk perception in climate change perceptions

Public support or opposition to climate policies, decisions, and implementation is greatly influenced by the perception of the risk and dangers of climate change (Leiserowitz, 2006). The studies regarding climate change can provide valuable insights for the scientific community, policymakers, and risk communicators to better understand attitudes and actions towards climate change mitigation among the public. Therefore, it is important to evaluate the public's subjective judgment and belief of climate change as well as to investigate the factors that influence climate change perceptions.

4.2.1 Climate change perceptions of the public in Germany and China

In order to understand how the public perceives climate change and global warming, numerous polls and surveys have been conducted at the regional, national, and global levels. In general, these surveys and polls with regard to climate change perception usually look into three aspects: perceived threat and risk of climate change, skepticism and uncertainty about climate change, and the attitudes towards climate change mitigation policy and behaviours (Wang& Zhou,2020).

Concern and perceived threat of climate change

As the adverse impact caused by climate change in the past decades becomes more visible, concern and worry about climate change have also been raised among the public. According to the global survey by GlobalScan in 2015 (GlobalScan,2015), for the question "How serious is the climate change or global warming, due to the greenhouse effect?" the result shows that 44% of the Chinese respondents perceived that climate change is "somewhat serious," and 33% perceived it "very serious." Meanwhile, 43% of the German respondents considered it "somewhat very serious" and 42% of the German respondents considered it "very serious". The result from this survey shows that both in Germany and China, the perceived seriousness of climate change is relatively high.

In addition, the survey results from Special Eurobarometer 2019 show that the percentage of German respondents considering climate change as "the single most serious problem facing the world as a whole" has increased from 14% in 2017 to 30% in 2019, above the European average of 27%. Besides, 81% of respondents in Germany regarded climate change as a "very serious problem", slightly higher than the EU average of 79%. (European Commission, 2022, pp. 6-22). For the public in China, according to a national survey conducted by the China Center for Climate Change Communication (China 4C) in 2017 among 4025 respondents, 79.8% of respondents were either very or somewhat worried about the impacts of climate change. 75% of the respondents believed that they had already experienced the impacts of climate change (China Center for Climate Change Communication, 2017).

To summarize, the results from surveys and polls show that the public in both Germany and China perceive climate change as a major threat and show strong concern about the adverse consequences of climate change.

Perceived uncertainty over climate change

The belief of uncertainty and skepticism regarding the reality and seriousness of climate change of the public is always seen as a challenge to climate change risk management (Poortinga et al., 2011; Zehr, 2000). Several studies have suggested that public uncertainty over climate change impairs the effectiveness of climate change adaption policy and strategy implementation. It affects the public's corresponding action and behavior of climate change mitigation on the individual level (Lorenzoni et al., 2007; Stoll-Kleemann et al., 2001; Whitmarsh, 2011). From the international poll by Yougov (2019), 2% of the German respondents and 1% of the Chinese respondents denied the existence of climate change. Besides, 2% of Chinese and 5% of German respondents believed that climate change is happening, but human activities are not responsible at all. Another survey shows that, in Germany, 7% of the respondents believed that the earth is not warming, and climate change is not happening, 5% believed that climate change will not have significant negative impacts (Brzoska & Fröhlich, 2016; Engels et al., 2013). Data from a 2017 national survey in China indicated that 94.4% of the 4,250 Chinese respondents think that climate change is happening and that 55% think it is mostly caused by humans, while 38% think it is mostly caused by nature itself (China Climate Change Communication Centre, 2017). In total, the results from previous surveys indicate that the percentage of climate change skeptics is very low in both Germany and China. The public in both countries acknowledges the existence of climate change.

Attitude towards climate change mitigation policy and behaviours

Regarding the attitude towards climate change mitigation policy, the results from Special Eurobarometer in 2019 show that eight out of ten Germans agreed that more public financial support should be provided for the transition to clean energy sources, even if this meant reducing subsidies for fossil fuels. About nine out of ten German and EU citizens overall agreed that the EU economy should be climate neutral by 2050 (European Commission, 2022, pp. 28-36). Besides, results from the 2015 Pew Research Centre survey show that 71% of the Chinese and 87% of the German respondents strongly support the effort of the government to limit greenhouse gas emissions from the burning of coal, natural gas, and petroleum (Pew Research Centre, 2015).

With respect to adjusting to a climate-friendly lifestyle, the result from the 2015 Pew Research Centre survey show that 58% of the Chinese respondents considered "lifestyle changes are necessary to reduce effects of climate change," rather than solely relying on technology to "solve the problem". The result among German respondents is 75%.

Even though many surveys have surveyed climate change perceptions, most of them chose the general public as the target group. Climate change perceptions among emergency response personnel are rarely surveyed. As emergency response volunteers are more frequently exposed to flood hazards during disaster relief tasks, the impact of climate change on flood risk is more pronounced for them. To improve their preparedness, response, and safety during flood emergency response, the study of the perception of climate change and the impact on flood risk among ERV is necessary.

4.2.2 Determining factors of climate change perceptions for emergency response volunteers

Theoretical background

Previous research findings suggest that risk perception is influenced not only by analytical reasoning and rational choice but also by psychological and social factors, including previous experience, affect, political preference, worldview, and trust (Slovic, 2000). Such findings are supported by researchers in the fields of climate change risk perception (e.g., Leiserowitz, 2006; Myers et al., 2013).

Among the theories to explain the factors that influence climate change perception, the "psychological distance" is proposed as a construct that affects concern, perceived uncertainty, and actions intention with regard to climate change (Liberman, Trope, & Stephan, 2007; Lorenzoni & Pidgeon, 2006; Weber, 2010). Psychological distance refers to the extent that an object is distanced from the self in different dimensions. Four core dimensions are specified in the Construal Level Theory: spatial, social, temporal, and hypothetical (Liberman, Trope, & Stephan, 2007).

According to the Construal Level Theory, the psychological distance is associated with how individuals perceive and understand objects and events (Trope & Liberman, 2010). When an object is considered to be psychologically close to the self, the individual tends to perceive more concrete and pay attention to the details of the object. Meanwhile, when an object is considered to be removed from the self, the object tends to be perceived more abstractly and focuses more on the broad view. In such a way, the difference in psychological distance can further affect the behaviours and attitudes towards the object.

Direct experience

Climate is a concept that indicates a long-time effect that requires scientific measurement and modelling (Kollmuss & Agyeman, 2002; Ungar, 2000). It cannot be easily directly experienced by most people in the variability of every day's weather (Swim et al., 2011). Under the frame of Construal Level Theory, previous experience related to climate change, such as extreme weather and water shortage, will result in a closer phycological distance by influencing all four core dimensions: spatial, social, temporal, and hypothetical. In this way, the public will perceive climate change as more concrete and relevant to daily life. Such close psychological distance will impact not only the concern and the acceptance of climate change but also the behavior intention regarding climate change mitigation and adaption (McDonald et al., 2015).

Empirically, many studies highlighted that weather and climate change-related events, and abnormal phenomenon experiences have an effect on individuals' concern and acceptance of climate change and mitigation action, especially when climate change-related extreme weather and hazards have affected health or caused economic loss (Joireman et al., 2010; Lorenzoni & Pidgeon, 2006; Reser et al., 2012, pp. 26-44). This could be attributed to higher exposure to climate change-related natural hazards. Similarly, studies have found that lacking knowledge is the reason that people neglect or overlook the risk of climate change because they have not experienced the impact of climate change themselves (Lawrence et al., 2014; Spence et al., 2011b). A review of previous empirical studies regarding relationships between climate change perceptions, mitigation behaviours, and direct experience of climate change-related events is summarised in Table 2. The climate change-related events in the table include temperature anomaly, floods, hurricanes, water shortage, air pollution, and others.

Table 2. Studies of climate change perceptions influenced by related direct experience

Climate change related event	**Main Findings**
Temperature change or heat	Respondents who perceived warmer weather than usual believed more in and had greater concern about global warming and were more willing to make a donation to a global-warming charity (Li et al., 2011) Outdoor heat-related experience has been found to increase belief in climate change (Joireman et al., 2010) The fraction of respondents to national polls who express "belief in" or "worry about" climate change is found to be significantly correlated to U.S. mean temperature anomalies over the previous 3–12 months (Donner, 2011)
Flood	Respondents from the UK who report the experience of flooding express more concern and less uncertainty over climate change and feel more confident that their actions will have an effect on climate change.

	Besides, the flood experience is also related to a greater willingness to save energy to mitigate climate change (Spence et al, 2011) Direct flooding experience leads to an overall increased salience of climate change, pronounced emotional responses, and greater perceived personal vulnerability and risk perceptions. In addition, it also leads to a rise of behavioural intentions beyond individual sustainability actions, including support for mitigation policies and personal climate adaptation (Demski et al., 2017). Having personal experience of damage affect the respondents' concern towards climate change (Lujala et al., 2015).
Air pollution	Experience of air pollution significantly affects the perceptions of and behavioral responses to climate change. The relationship between air pollution experience and responses to climate change may be indirect and mediated by environmental values (Whitmarsh, 2008).
Hurricanes	Experiences of hurricanes were associated with a change from negative to positive implicit attitudes toward a “green” politician (Rudman et al., 2013)
Water availability	Farmers who perceived greater changes in water availability reported a greater belief in and concern about global climate change and were more willing to engage in both mitigation and adaptation behaviours (Haden et al., 2012).
Other climate change related experience	The perceived exposure to climate change impacts is associated with an increased belief in, and distress about climate change (Reser et al., 2012) The perceived personal experience of global warming (changes in seasons, weather, lake levels, animals and plants, and snowfall) appears to increase people's perception of the risks (Akerlof et al., 2013). “Personal experience with extreme weather is best conceptualized as a predictor of climate change risk perception and, in turn. risk perception and affect reciprocally influence each other in a stable feedback system” (van der Linden, 2014)

	The relationship between actual and perceived risk is driven by specific types of physical conditions and experiences(Brody et al., 2008). Beliefs about whether global warming are related to relevant personal experiences (with the weather) and formation source (scientists) (Krosnick et al., 2006)

The table above summarises the studies which support the relationship between climate change-related experience and climate change perceptions. Meanwhile, some findings also suggested that experience is not always a factor in climate change perceptions. For instance, a meta-analysis by van Valkengoed & Steg (2019) found that knowledge and experience, which are often assumed to be key barriers to climate change adaptation, were relatively weakly related to adaptation behaviours. Besides, Haden et al. (2012) also suggested that there is no significant relationship between willingness to engage in climate change mitigation behaviours and experience of temperature change among farmers. In addition, the study by Whitmarsh (2008) also found that respondents in England who had experienced a flood were no more likely to be knowledgeable, concerned, or engage in undertaking behavioural responses to climate change than those who have not experienced floods.

Similar to perceived concern and risk of climate change, uncertainty over climate change is also found to be related to experience and knowledge from previous climate change-related events (Whitmarsh, 2011). Besides, perception factors, perceived risk, perceived benefit and negative effects, as well as ideology also play moderating role on individuals' scepticism (Wang & Kim, 2018).

Locations

The physical risk level is directly related to the vulnerability and the risk of the objective hazards. For example, people who reside near coastal regions are at higher risk of sea-level rise and coastal hazards than people who live in inner land regions. The geographic distance to the climate change is an important dimension that measures the psychological distance (Liberman et al., 2007). Studies showed that the relationship between actual and perceived risk is driven by specific types of physical conditions and experiences (Brody et al., 2008). Carlton & Jacobson (2013) have also suggested that focusing on physical environment risks may be more salient to audiences than communications about general climate change risk adaptation. In addition, the location's effect on the perceived uncertainty over climate change were also stressed by several other studies (Upham et al., 2009, pp. 23-36; Wang & Kim, 2018; Whitmarsh, 2011). Therefore, due to the differences in physical risk regarding climate changes in China and Germany, it is necessary to consider the location as a variable when investigating climate change perceptions.

Perceived flood risk

Previous studies have suggested that higher perceived exposure to climate change impacts and higher risk estimates are associated with increased belief in and concern about climate change, as well as more active climate change behaviors (Reser et al., 2012). A Study from Kwon et al. (Kwon et al., 2019) also suggested that perceived risks and benefits, trust, and knowledge increased action on climate change mitigation. These findings supported a closer look at the relationship between perceived flood risk and climate change perceptions.

Demographic factors

Demographic factors such as age, gender, and education are often investigated as influential factors in studies of climate change perceptions. For example, Schubert and Soane (2008) found that people over 65 years old and men appear to be the most skeptical of climate change. The effect of demographic factors on climate change perceptions is supported by Upham et al (2009, pp. 23-36). and Whitmarsh et al. (Whitmarsh, 2011).

To summarise, previous climate change-related experience, location, perceived impact risk from climate change, and demographic factors have been suggested by previous studies as determinants of climate change perceptions.

5. Flood hazard and risk maps and Technology Acceptance Model

With the development of the Internet and information technology, such as Geographic Information System (GIS) Technology, the interactive online hazard and risk maps show several advantages for risk management (Hagemeier-Klose & Wagner, 2009). Firstly, online hazard and risk maps provide broader access to risk information for the general public. Secondly, interactive maps can provide different views by presenting different simulation scenarios and customized content, supporting the communication among users. Moreover, together with other media (such as video, pictures), online maps can provide more information and past historical events data and documents. This helps the users to understand the risk more comprehensively and intuitively. Particularly together with social media, the advantages can be enhanced by gathering information from the public, for example, crowdsourcing hazards maps during disasters (WMO&GWP,2017). Therefore, Human-centered GIS platforms and maps have been recognized as important tools for emergency management (ESRI, n.d.; Gunes & Kovel, 2000; Hassanzadeh et al., 2013; Johnson, 1995; Rauschert et al., 2002).

Flood hazard and risk maps are effective risk communication tools for providing and presenting flood hazard and risk information. By visualizing the extent and depth of inundation from various flood simulation scenarios, flood maps help the general public, planners, and risk managers to understand the flood hazards and risk (Paine et al., 2013). Therefore, flood maps serve as a basis for spatial planning, local hazard assessment, and technical protection measures (EXCIMAP, 2007). For emergency response, flood maps with risk and hazards information can help detect the risk spot as well as support risk communication and planning for emergency response personnel.

This chapter first introduces the current development of flood hazard and risk maps. It is followed by introducing the theories to understand technology and information system adoption behaviours. The application of the Technology Acceptance Model (TAM) in the emergency response field is then reviewed. In addition, the application of the TAM to flood hazard and risk maps acceptance intention analysis will be presented in chapter 9.

5.1 A review of current flood hazard and risk maps in the study areas

Recognizing the importance of flood map as a useful communication tool (Spachinger et al., 2008), many public flood maps have been developed by governments. A review of flood maps in Europe, the USA, and Japan is introduced in the report from EXCIMAP (EXCIMAP, 2007).

In some countries, flood mapping is directly linked to land-use regulations, building codes, and insurances. For example, in the United States, flood insurance is connected to flood mapping. The National Flood Insurance Program (NFIP) [3] in the USA, administered by the Federal Emergency Management Agency (FEMA), makes flood insurance available to community residents and businesses of communities (FEMA, 2013). The map used in this program help adopt floodplain regulations and promote hazard identification and floodplain management at the municipal level. It covers nearly 25,000 communities.

In Europe, the EU Floods Directive (2007/60/EC) requires member states to prepare detailed and extensive flood maps by 2013 as a measure to reduce adverse impacts of flood damage at the level of the river basin district or unit of management. The directive requires that these information tools available to the general public. These maps form a prerequisite for flood risk management plans.

Two types of flood maps are required by the directive: flood hazard map and flood risk map. According to the directive, flood hazard maps should contain extensions of floods with different probabilities, water depths, and flow velocities. In the majority of cases, the 100-year flood is used as the basis and is assigned as a medium flood event. Flood risk maps should show the adverse impact of specific flood scenarios, e.g., economic loss and the number of people affected. Besides, population, economic activities and the environment at potential risk from flooding, and other helpful information are also suggested to be presented on the map.

By the end of 2013, all EU countries have created flood hazard maps and risk maps at the country or regional levels. For example, at the international level, the International

[3] https://www.fema.gov/flood-insurance

Commission for the Protection of the Rhine published the Rhine-Atlas that is available to the public[4].

Some studies have reviewed the EU flood maps by comparing and assessing the implementation process on rivers in selected European countries, focusing on the different structures, methodologies, and data conditions used for flood risk assessment and flood hazard mapping (Nones, 2015, 2017). Similar comparisons and overview are also presented in the EU's report (European Commission, 2016).

In Germany, all federal states have completed flood maps as a basis for flood management plans. The maps are available on Internet platforms. Details of procedures and mapping techniques vary from state to state due to local concerns (e.g., data availability, vulnerability, public funds). An overview of different approaches for maps in several states was published (LAWA, 2006).

In the study area Baden-Württemberg, the flood hazard map and risk map have been created by Baden-Württemberg State Institute for the Environment, Survey and Nature Conservation (LUBW) and are available on their Environment Data and Maps (UDO) Platform (UDO, 2013).

These flood maps provide information regarding potential flood impact to the public and stakeholders and help preparedness and response towards flood hazards. The public and business communities are specifically referred to as target groups for such instruments (LUBW, n.d.).

The flood hazards map (HWGK) was created for all relevant bodies of water in the state. The map provides specific information about the possible extent and depth of a flood with a 10-year, 50-year, 100-year extreme flood scenario. A guideline that explains the contents of the flood hazard maps and shows how it is used in the various areas of activity is presented on the website of LUBW[5] (LUBW, n.d.)

Based on the flood hazard map, the interactive flood risk map (HWRK) was created later and has been accessible to the public since the end of 2013. The interactive flood risk

[4] https://geoportal.bafg.de/mapapps/resources/apps/ICPR_EN/index.html?lang=en
[5] https://www.hochwasser.baden-wuerttemberg.de/hochwassergefahrenkarten

map shows the danger of flooding throughout the state. In addition, with the flood risk management query, it is possible to display the flood depths at certain spots for different flood scenarios and all available information for flood risk management and planning (see in Figures 5 and 6).

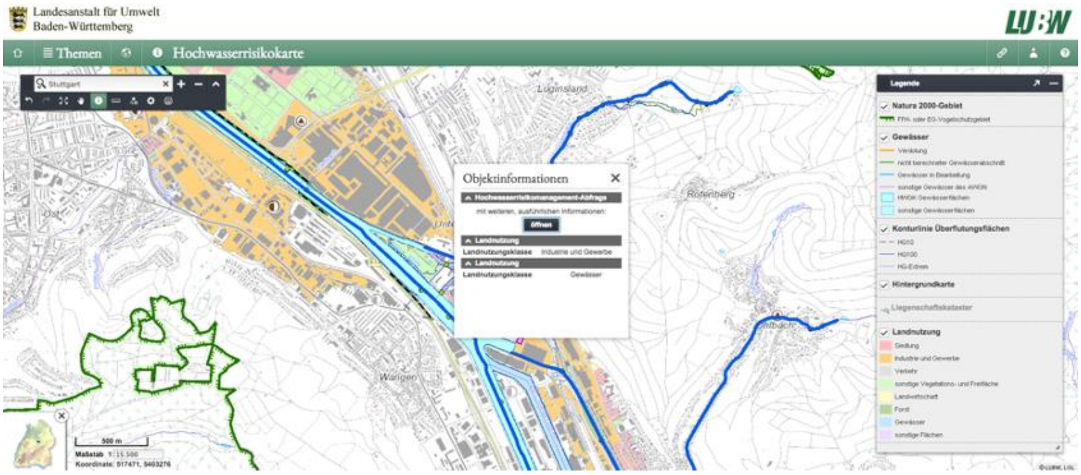

Figure 5. Flood risk map of Baden-Württemberg

Figure 6. Flood risk query result on flood risk map of Baden Württemberg

In China, the Ministry of Water Resources has started to deploy the project *Development of National Flood Risk Maps* in all provinces, municipalities, and major rivers and lakes since 2008. The project aims for flood risk reduction, flood disaster emergency planning, and land planning (Ministry of Water Resources of PRC, 2017; Xiang, 2017).

By the time of June 2020, according to the Chinese Ministry of Water Resources, several provinces and river basins have finished the development of the flood maps, and many other regions are at the end stage of the work. For example, Henan province has finished its flood map[6].

[6] http://www.ysy.com.cn/gongchengyeji/shuiliguihua/2019-10-12/2683.html

According to the plan, the flood risk map will be only available to public officials who are involved in flood hazard management at the current stage. The access for the public is planned to be available in the future stage (Xiang, 2017). Therefore, in this thesis, the risk map from the authorities will not be used.

In addition to public flood maps provided by the authorities, several commercial insurance companies also provide flood hazard and risk and map service to the general public or exclusively to their clients at regional, national, or global scales. These maps usually present the flood extent probability on damage potential. They fill the gaps for the regions and countries where there are no available maps. The maps can be used as a basis for both the general users to check the possibilities of their properties threatened by floods and the insurance companies to assess the actual flood risk.

The insurance company FM Global has developed a natural hazard toolkit and maps toolkit. The maps toolkit provides a flood map globally, an earthquake map for China, and a hail hazards map for the USA[7] (FM Global, n.d.). The flood map by FM Global shows the exposure level of flood and helps users understand the global and regional flood risk, particularly the regions where local or regional flood maps are inconsistent or unavailable.

The flood map by FM Global is based on physical hydrology and the hydraulic model. The map identifies areas exposed to moderate or high-hazard flooding via a 90 x 90-meter grid. Moderate hazard areas are covered by yellow color and show a 500-year flood zone, which has at least a 0.2 percent chance of experiencing a flood each year. The pink color marks the “high hazard” area, which is a 100-year flood zone. The “high hazard” areas have at least one percent chance of experiencing a flood each year.

[7] https://www.fmglobal.com/research-and-resources/nathaz-toolkit/flood-map

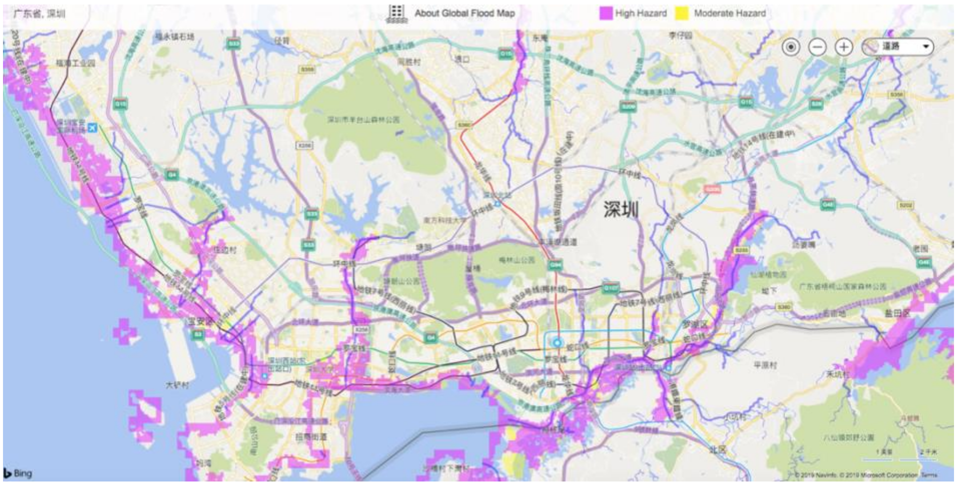

Figure 7. FM Global flood hazard map of city Shenzhen, Guangdong

In addition to the flood map from FM global, another global-scale flood map is the Global Flood Zone Map from Swiss Re (Swiss Re, 2018). Currently, it is on its third version. The map is available on the company's CatNet Web Map Services platform (Swiss Re, n.d.). The platform provides natural hazards information, including earthquakes, hails, and hurricanes. Regarding flood hazards, it presents river flood and coastal flood information for its clients. On the flood map, different zones based on flood exposure assessment results are displayed. The map provides the flood with a return period of 50, 100, 250, and 500 years.

As flood map by FM Global provides flood hazard information for China, due to the lack of such a flood map from public maps, it functions as a valuable information tool for checking local flood information in China. Moreover, the users do not need to create an account on the company website to access the flood map, which means it is open for users worldwide. Therefore, it is chosen as an alternative to the official map from the government for the study area in China. According to the survey presented in chapter 6, users in the mainland of China can connect to this map webpage on a computer. For the mobile end-users, some reported that a disconnection could frequently happen when opening the web link on smartphones, especially via the built-in browser from WeChat App.

5.2 The acceptance of flood hazard and risk maps by the target groups

As an information tool, the usability of flood maps to suit the user groups' needs is essential for effective risk communication. This requires the maps to have easily understandable content and an easy-to-use interface (Hagemeier-Klose & Wagner, 2009). With the current flood maps, it is suggested by some studies that while risk managers and other types of experts are able to decode and interpret map content, the general public very often finds it more challenging to understand the maps (Dransch et al., 2010; Hagemeier-Klose & Wagner, 2009).

Previous research has identified several barriers to flood hazard maps as tools used in flood risk communication.

Meyer et al. (2012) have pointed out that the flood risk maps in the EU countries often fail to integrate local stocks of knowledge. They cannot meet the need of end-users and are not easily understood by residents or public authorities in risk management.

Bavaria hazard zone map has been indicated as failing to function as public information tools between the local populations and responsible authorities (Hagemeier-Klose & Wagner, 2009). It is suggested that flood maps should illustrate not only the hazard (such as inundation areas and water depths) and possible consequences but also the information that could be helpful in case of a flood, such as evacuation routes, disaster management centers, hospitals, fire brigades.

In the German state of Baden-Württemberg, a study by Kjellgren (2013) identified four barriers to the risk manager at the local level to use the flood hazard map: perceived disinterest/sufficient awareness on behalf of the population at risk; unwillingness to cause worry or distress; lack of skills and resources; and insufficient support.

Different from neither risk managers nor the public, emergency response personnel have their own requirements for flood maps. Therefore, it is necessary to examine the emergency response volunteers' attitude and acceptance intention towards the flood maps.

5.3 Theories of information system acceptance behaviors

Adoption and utilization of information systems (IS) have been identified as one of the most critical issues by IS developers and researchers. A large number of studies have provided valuable theoretical frameworks for this topic. Three of the most popular models in this field are TRA, TPB, and TAM.

Theory of Reasoned Action (TRA)

Fishbein and Ajzen (Fishbein & Ajzen, 1974, 1975) developed the causal framework of beliefs, attitudes, intentions, and behaviors (as shown in Figure 8) to predict human behavior. According to the model, the individual is more likely to perform a particular behavior if this individual has a higher degree of intention. This means that an individual's behavior is decided by the intention regarding the behavior. In the model, the intention to perform a particular behavior is jointly influenced by the attitude and the subjective norm. Attitude is defined as the individual's positive or negative feelings regarding a particular behavior. The subjective norm was defined as an individual's perception of the importance of the behavior that should be performed. The norm is affected by the normative beliefs regarding that particular behavior.

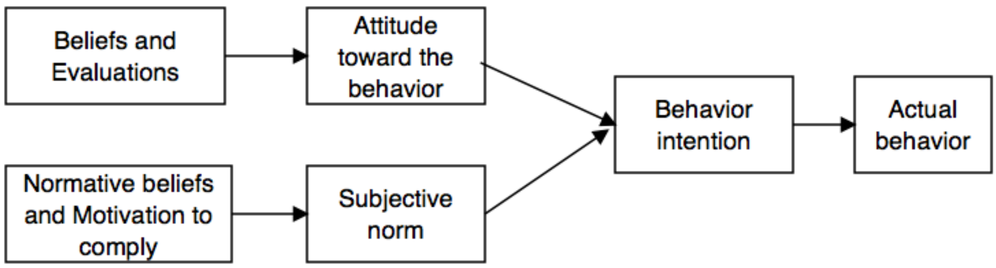

Figure 8. Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975)

The TRA is widely adopted to explain and predict human behavior in various situations. Empirical literature reviews conducted by Hale et al. (Hale et al., 2012) and Sheppard et al. (Sheppard et al., 1988) found that the TRA has been successfully applied in studies regarding consumer behavior and health behaviors. Researchers suggested that the model applied in TRA was only limited to the volitional controlled behaviors. However, there are many possibilities that the behavior is not voluntary or out of the individual's control

(Ajzen, 1985; Sheppard et al., 1988). For example, the behavior could be performed unconsciously or out of habit, and some behaviors might require skills that the individual doesn't have (Fishbein & Ajzen, 2011, pp20-21).

Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TPB) was proposed by Ajzen (Ajzen, 1991) to address the volitional issue towards the behavior. The TPB proposed perceived behavioral control as an additional determinant of an individual's behavioral intention as well as actual behavior. Perceived behavioral control refers to how much a person has control over his/her own behavior, usually including the effort and resources required to perform a behavior. Therefore, the TPB assumed that an individual's behavior is determined by the intention to the behavior and perceived behavioral control. The intention is jointly affected by the individual's attitude and subjective norm toward the behaviors as well as perceived behavioral control (see Figure 9).

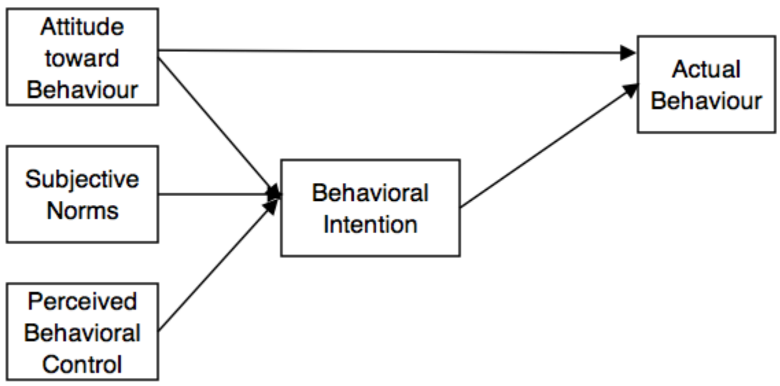

Figure 9. Original Theory of Planned Behavior (TPB) (Ajzen, 1991)

The TPB has been considered one of the most popular theories to explain the individual's beliefs towards the behaviors. Several meta-analysis studies (Armitage & Conner, 2001; Hausenblas et al., 1997) were conducted about TPB-based studies and concluded that the constructs of TPB provide the power to explain and predict human behaviors.

Technology Acceptance model (TAM)

Based on the Theory of Reasoned Action (TRA), Davis (Davis, 1989) proposed the Technology Acceptance Model (TAM). In the TAM, the individual's acceptance and adoption behaviour is determined by the intention to use the system. The intention is jointly determined by Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). PU is defined by Davis as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p320), and PEOU is defined as "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p320). Additionally, Perceived Ease of Use was also hypothesized to have a direct impact on Perceived Usefulness. Several measures have been used for factors in the TAM (Davis, 1989; Galib et al., 2018; Legris et al., 2003; Venkatesh & Davis, 2000). The measures of perceived usefulness include performance increase, productivity increase, effectiveness, overall usefulness, time savings, and increased job performance. Correspondingly, measures for the perceived ease of use include ease of learning, ease of control, ease of understanding, ease of use, clarity, and flexibility of use.

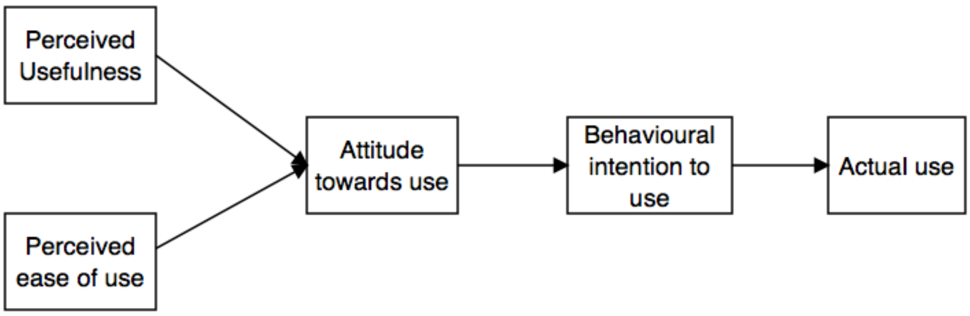

Figure 10. Original Technology Acceptance Model (TAM) (Davis, 1989)

Partly due to its understandability and simplicity, it is probably the most widely used framework for explaining and predicting users' intentions and acceptance behaviors of information technologies (Galib et al., 2018; Venkatesh, 2000), especially for Internet-based technologies (Lederer et al., 2000; Shih, 2004).

5.4 Extending Technology Acceptance Model with external factors

Due to the factors contributing to the adoption of new technology are likely to vary with specific technology context and users, the original TAM has often been criticized too general to predict intention in some fields. This results in low variance explanations of behaviour, such as in the field of mobile internet applications (Dishaw & Strong, 1999; Moon & Kim, 2001). To address this problem, Davis (1989, p988) suggested that future technology acceptance studies address how external variables affect perceived usefulness, perceived ease of use, and use intention with three types of variables: individual differences, situational constraints, and managerially controllable interventions. Other researchers have also suggested taking into account social, cultural, specific influences of technology and usage context for extending TAM (Dishaw & Strong, 1999; Legris et al., 2003; Marangunić & Granić, 2015; Schepers & Wetzels, 2007). Such proposed external factors are summarised in meta-analyses by Marangunić & Granić (2015) and King and He (2006). In total, researchers have proposed more than 70 various external variables for PU and PEOU (Yousafzai et al., 2007).

Among all the proposed factors, two main categories of external variables, namely individual differences and system characteristics, are most commonly identified. (Hong et al, 2001).

According to Davis (Davis, 1989), system characteristics have the potential to directly affect both perceived ease of use and perceived usefulness of IS (Davis, 1989). Previous researches on TAM support this argument by showing that system characteristics can significantly affect the intention to use IS via perceived usefulness and perceived ease of use (Igbaria et al., 1995; Torkzadeh et al., 2006; Venkatesh & Davis, 2000).

Information quality

The output quality is the first external variable added to TAM and is one of the most essential variables among all system characteristics (Davis et al., 1992). Several studies have shown that information quality has a positive impact on perceived ease of use and perceived usefulness. The output information quality assessment usually includes the perception of output data's accuracy, completeness, format, timeliness, relevance, clear practicability, reliability, relevance, and objectivity (Chen et al., 2000; Moores, 2012; Wixom & Todd, 2005).

Individual characteristics

Individual differences are an important external factor for TAM in IS suggested by Davis (Davis,1989). Such suggestion has been empirical valid in many studies from different fields (Chen et al., 2000; Torkzadeh et al., 2006).

Two factors are considered to be closely connected to online information systems: self-efficacy and Enthusiasm of new information technology (ENIT).

Internet self-efficacy

Self-efficacy reflects the individuals' belief in their ability to use a specific system effectively. Bandura (1978) found that individuals' beliefs and behaviors are influenced by self-efficacy. Researchers also suggested that the effective usage of an information system is influenced by not only system design features but also the user's ability to use the system effectively (Legris et al., 2003; Torkzadeh et al., 2006). Studies proposed that self-efficacy measures should be tailored to the targeted domain context, such as computer self-efficacy and Internet self-efficacy (Lee et al., 2003; Torkzadeh & van Dyke, 2002). Computer self-efficacy is found to have a direct effect on perceived ease of use and actual use in some studies (Chau, 2001; Venkatesh & Davis, 2000). Some studies also incorporate Internet self-efficacy as an external factor to improve the capacity of TAM. For example, Ma et al. (Ma & Liu, 2005) incorporated Internet self-efficacy into TAM and found it is a significant predictor of perceived ease of use.

Enthusiasm of new information technology (ENIT)

The Enthusiasm of new information technology (ENIT) describes how much an individual is willing to try new technology(Agarwal & Prasad, 1997). Studies found that it can affect PU and PEOU in TAM in the context of Internet and mobile information technology adoption (Asadi et al., 2019; Leong et al., 2013). Agarwal & Prasad (Agarwal & Prasad, 1997) also found that the enthusiasm towards information and technology can closely influence the intention to adopt new technology.

Trust

Gefen (2003) and Pavlou (2003) introduced and tested the original TAM by incorporating trust in an e-commercial context. The result showed that users' trust in the party behind the technology has positive impacts on the perceived usefulness of the technology. Several other studies confirm this relationship in different domains, such as a location sharing application (Beldad & Citra Kusumadewi, 2015), online social network website (Wu, Huang, & Hsu, 2014), and online shopping (Chircu et al., 2000). Besides, it is found that trust in the information provided by the system also plays an essential role in the acceptance of the information system since incorrect information is associated with risks and uncertainties to the system (Lewis & Wyatt, 2014; Wu et al., 2011). As an information tool, the flood information provided by the flood map is essential for its application. Therefore, trust in information from the flood map will be used as an external factor to extend TAM in chapter 6.

To summarize, the factors proposed in the extended Technology Acceptance Model consist of internal and external factors. Internal factors are from the original TAM, including Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Attitude towards Use, and Intention to Use (IU). External factors are generally divided into two categories: individual differences and system characteristics. Individual differences usually include the factors such as trust in the new application and technology, Internet self-efficacy (ISE), and Enthusiasm of New Information Technology (ENIT). For system characteristics, the quality of an information system is considered an essential factor and has commonly been integrated into the extended TAM. In empirical studies, moderating factors are employed in multi-group studies. For example, country or culture is used as moderating factor when conducting cross-national or cross-cultural comparative studies.

5.5 Application of Technology Acceptance Model in emergency response field

Compared to the TRA and the TPB, which are the more generalized theories for explaining human behavior, TAM is specifically formulated to explain acceptance and adoption behaviors of information systems and technology tools (Davis,1989). TAM is widely applied in various information systems and proves its capability to explain technology acceptance behaviors (Legris et al., 2003; Lee et al., 2003), such as communication systems, general-purpose systems, office systems, and specialized business systems.

Flood hazard and risk maps are typical web Geoinformation System-based risk communication tools. Therefore, similar to other studies in the field of information system acceptance behavior (Galib et al., 2018; Venkatesh, 2000), TAM is chosen as the theoretical model in this thesis for predicting and explaining the intention to accept flood maps.

In terms of emergency response, TAM has been used in a series of studies to explore end users' acceptance of information systems for supporting response in emergencies.

Wirz (2010) applied the TAM framework with the external factors of desired system deployment vector and privacy considerations on the sensor-enabled mobile system. The system aims to assist organizers and participants of public events in emergencies and evacuation situations using human computing principles.

Haataja(2011) uses the refined version of TAM with external factors of perceived trust and perceived financial cost to investigate the acceptance of emergency alerting systems in a university and community context

Wu (2009) used TAM driven mixed-method research to explore the acceptance of a SMS-based emergency alert systems among university contexts in the USA. Results of this research show that the concept of usefulness has an influence on intended users, and the ease of use is closely related to the users' ability to control the system behaviour.

Lindsay et al. (2011) applied a revised TAM model to evaluate the implementation of police mobile data terminals within one of the UK police force branches.

Specific to the flood maps field, only one study on the acceptance of flood hazard maps has been conducted. Opella and Hernandez (2019) applied the extended Technology Acceptance Model through a survey among different users in the Philippines. Results of the study show an affirmative acceptance of flood risk and hazard mapping systems.

In total, few studies have investigated the acceptance and adoption behavior of flood hazards and risk maps in. Therefore, this research aims to fill this gap with a comparison study of Germany and China.

6. Hypotheses and Methodology

In this chapter, the hypotheses regarding the three topics explored in this thesis are formulated firstly, the methodology and the preliminary results of the survey are then presented.

6.1 Hypotheses formulation

6.1.1 Hypotheses of relationships between flood risk perception and determining factors

In this part, hypotheses with regard to the relationships between determining factors and flood risk perception are postulated.

As introduced in chapter 3, the psychometric paradigm approach is applied to measure flood risk perception. Based on the previous studies (Ho et al., 2008; Kellens et al., 2011), five flood risk characteristics are measured: perceived likelihood, worry about financial loss, worry about the threat to life, perceived able to control loss from floods, and knowledge of mitigation actions.

Based on the literature review in chapter 3.3 (Kellens et al., 2013; Lechowska, 2018; Wachinger et al., 2013), three groups of variables are chosen as determining factors of flood risk perception characteristics for emergency response volunteers. The first groups are demographic and residence characteristics of volunteers, including Location, age (AGE), education level (EDU), whether children in the household (CHILD), ownership of property (OP), distance to water sources (DISTANCE). The second groups are factors about training and previous flood-related experiences: the number of times of practical experience regarding flood emergency response (Exp_Pra), economic loss from previous floods (Exp_Loss), recency of the last flood (Exp_Rec), and received training about flood emergency response (TRAINING). The third group is trust in the authorities (TRUST).

6.1.1.1 Hypotheses of direct effects of flood risk perception relationship with determining factors

The detailed hypotheses are summarised in Table 3 to show the direct effect of determining factors on the individual flood risk perception characteristic.

Table 3. Hypotheses of direct relationships between determining factors and flood risk perception characteristics

IV / DV	Location (H1)	Exp_ Pra (H2)	Exp_ Loss (H3)	Exp_ Rec (H4)	TRUST (H20)	TRAINING (H19)	AGE (H7)	EDU (H8)	Children (H9)	OP (H10)	Distance (H11)
1. perceived likelihood	-	+	+	+	-	+	+	+	+	+	+
2. worry about financial loss	-	+	+	+	-	-	+	-	+	+	+
3. worry about threat to life	-	+	+	+	-	-	+	-	+	+	+
4. able to control loss	+	-	-	-	+	+	-	+	-	-	-
5. mitigation knowledge	-	+	+	+	+	+	+	+	+	+	+

Note: Location is encoded as dummy variable: Germany =1, China. = 0. "+" = positive relationship, "-" = negative relation. For example, Greater loss from previous flood will be related to higher perceived likelihood, more worry about financial loss, more worry about threaten to life, lower able to control loss, and greater knowledge of mitigation actions.

6.1.1.2 Hypotheses of mediation and moderation effects

Mediation effects hypotheses

As proposed in the study by Kellens et al. (Kellens et al., 2011), direct flood experience mediates the relationship between location and perceived flood risk. In this study, such mediation effects will also be tested.

H21: three experience-related variables (Exp_Pra, Exp_Loss, and Exp_Rec) mediate the relationships between physical location (LOCATION) and each risk perception characteristic.

Moderation effects

In order to test how location influences the relationships between independent factors and each risk perception item, the following hypotheses are proposed: Location moderates the effect of AGE(H15), EDU(H16), OP(H17), Distance(H18), TRAINING(H19), and TRUST(H20) on each risk perception characteristic.

6.1.2 Hypotheses of relationships between climate change perception and determining factors

In this chapter, two models are postulated to explore the relationships within flood experience, perceived climate change's impact on flood risk, and climate change perceptions.

6.1.2.1 Hypotheses of Model 2.1

Based on findings from previous studies (Demski et al., 2017; Spence et al., 2011; Whitmarsh, 2008), location, demographic factors, flood experience and perceived climate change related-hazards risk, e.g., perceived flood risk, are related to the concern about climate change impact. Therefore, model 2.1 formulates the relationships of previous flood experience on the perceived impact of climate change on floods risk (**PICCFR**). The flood experience includes practical experience and economic loss. Besides, the model also proposes the relationship between perceived flood risk (**PFR**) and the perceived impact of climate change on flood risk. The hypothesized Model 2.1 is presented in Figure 11, and all hypotheses are listed in Table 4.

Table 4. Proposed hypotheses of Model 2.1

Dependent Variable	Hypothesis
Perceived impact of climate change on flood risk (**PICCFR)**	H1: Volunteers from China (**Location**) will perceive a stronger impact of climate change on flood risk than Germany
	H2: **Exp_Loss** has a positive influence on **PICCFR**
	H3: **Exp_Pra** has a positive influence on **PICCFR**
	H4: **Perceived Flood risk** has a positive influence on **PICCFR**
	H5: **Age** has a positive influence on **PICCFR**
Flood risk perception index (**PFR**)	H31: **Exp_Pra** has a positive influence on **Perceived Flood Risk**
	H32: **Exp_Loss** has a positive influence on **Perceived Flood Risk**

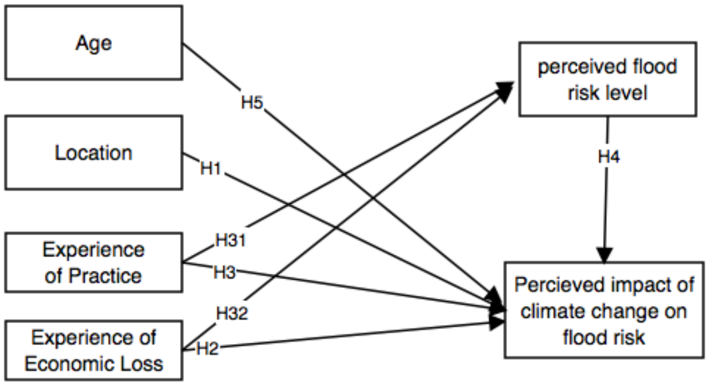

Figure 11. Summary of research model 2.1

6.1.2.2 Hypotheses of Model 2.2

Based on the literature review in chapter 4.2, model 2.2 is formulated to investigate the influential factors of climate change perception. The predictors used in the model are age, location, flood practical experience, economic loss from flood, perceived flood risk, and perceived impact of climate change on flood risk. Three climate change perception variables are Perceived Local Vulnerability (PLV), Uncertainty about Climate Change (UCC), and Perceived Effect of Climate Change Mitigation Actions (PECCMA).

The perceived local vulnerability to climate change is chosen for the model instead of the perceived global vulnerability in this study. Compared to the global level of worry about climate change, studies have found that local risks are more important than global risks in terms of climate change risk perception (Demski et al., 2017; Hinchliffe, 1996). Perceived local vulnerability is found to be closely related to willingness to adaptation behaviours in several studies (Demski et al., 2017; Stoll-Kleemann et al., 2001). Model 2.2 is presented in Figure 12, and all hypotheses are listed in Table 5.

Table 5. Proposed hypotheses of Model 2.2

Dependent Variable	Hypothesis
	H6: Volunteers from China (**LOCATION**) will show more PLV than Germany.

Perceived local vulnerability (**PLV**)	H7: Perceived impact of climate change on flood risk (**PICCFR**) has a positive influence on Perceived local vulnerability (**PLV**).
	H8: **Exp_Pra** has a positive influence on PLV.
	H9: **Exp_Pra** has a positive influence on PLV.
	H10: **Perceived Flood Risk** has a positive influence on PLV
	H11: **Uncertainty over climate change (UCC)** has a negative influence on PLV
	H12: **Age** has a positive influence on PLV.
Uncertainty over Climate change (**UCC**)	H13: Volunteers from Germany (**Location**) will show a higher UCC than China.
	H14: **PICCFR** has a negative influence on UCC.
	H15: **Perceived Flood Risk** has a negative influence on UCC
	H16: **Exp_Pra** has a negative influence on UCC
	H17: **Exp_Loss** has a negative influence on UCC
	H18: **Age** has a negative influence on UCC
Perceived Effect of Climate Change Mitigation Actions (**PECCMA**)	H19: Volunteers from Germany (**LOCATION**) exhibit higher **PECCMA** towards climate change mitigation.
	H20: **UCC** has a negative influence on **PECCMA**.
	H21: **PLV** has a negative influence on **PECCMA**.
	H22: **PICCFR** has a positive influence on **PECCMA**.
	H23: **Exp_Pra** has a positive influence on **PECCMA**.
	H24: **Exp_Loss** has a positive influence on **PECCMA.**
	H25: **Age** has a positive influence on **PECCMA.**

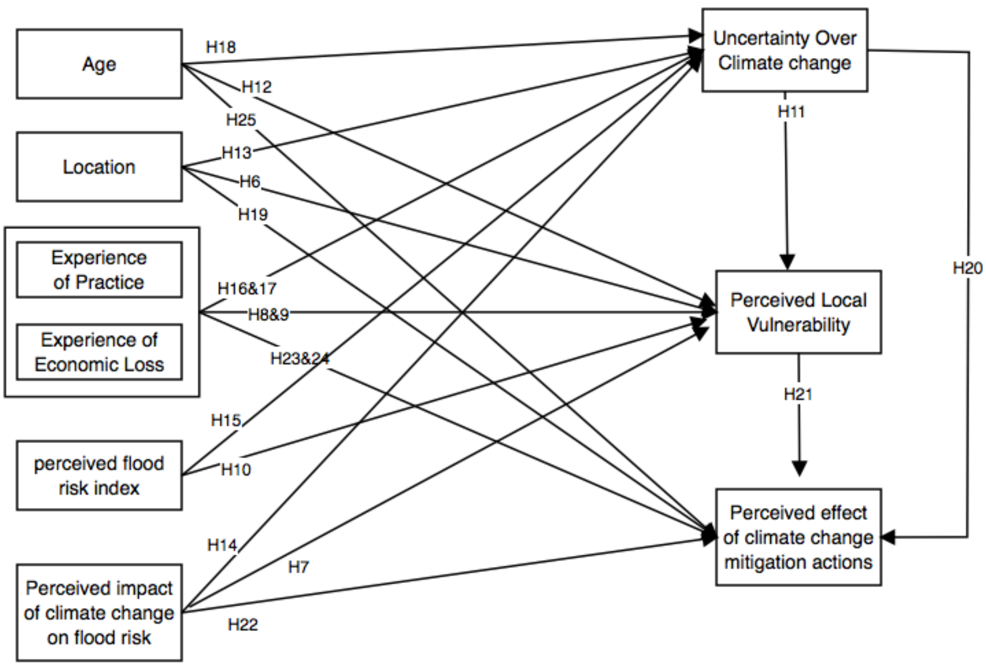

Figure 12. Summary of research model 2.2

6.1.3 Hypotheses of flood map acceptance intention model

An extended TAM model is developed to explore the intention to accept flood hazard and risk maps as risk communication tools among emergency response volunteers in Germany and China.

To improve the explanatory power of TAM for predicting acceptance intention and make TAM more adaptive in flood hazard and risk maps field, based on the literature review in section 5.4, the original TAM is incorporated with four external factors: Information quality of flood maps, Trust in information from flood map, Internet self-efficacy, Enthusiasm of new information technology.

According to literature in chapter 5, when users believe the flood maps are useful, they tend to be more willing to adopt the flood maps for their emergency response and planning work. An easy-to-operate system, which allows users to easily find interesting information, makes users more likely to accept the flood maps. Furthermore, when users consider the information is high quality, they may view flood maps are more useful and easier to use. Moreover, if users have trust in the information provided by flood maps, they will perceive the maps are useful and accept the maps as an information tool. In addition, when users have high confidence that they are able to acquire information from the Internet easily, they tend to believe that it does not require extra effort to operate an online map platform and understand the information on the maps. Besides, users with more interest in trying new information and technology products tend to believe that the flood map as a new information tool is useful and easy to use. To summarize, all proposed hypotheses of the Extended Technology Acceptance Model are presented in Figure 13.

H1: Perceived usefulness (PU) has a direct positive effect on the Intention to Use (IU).
H2: Perceived ease of use (PEOU) has a direct positive effect on Intention to Use (IU).
H3: Perceived ease of use (PEOU) has a positive effect on Perceived usefulness (PU).
H4: Information quality (IQ) has a positive effect on the Perceived usefulness (PU).
H5: Information quality (IQ) has a positive effect on PEOU.

H6: Trust in the online flood map information (Trust) has a positive effect on Intention to Use (IU).

H7: Trust in the online flood map information (Trust) has a positive effect on Perceived usefulness (PU).

H8: Internet self-efficacy (ISE) has a positive effect on Perceived ease of use (PEOU).

H9: Enthusiasm of new information technology (ENIT) has a positive effect on Perceived usefulness (PU).

H10: Enthusiasm of new information technology (ENIT) has a positive effect on Perceived ease of use (PEOU).

H11: Country has a moderation effect on each path.

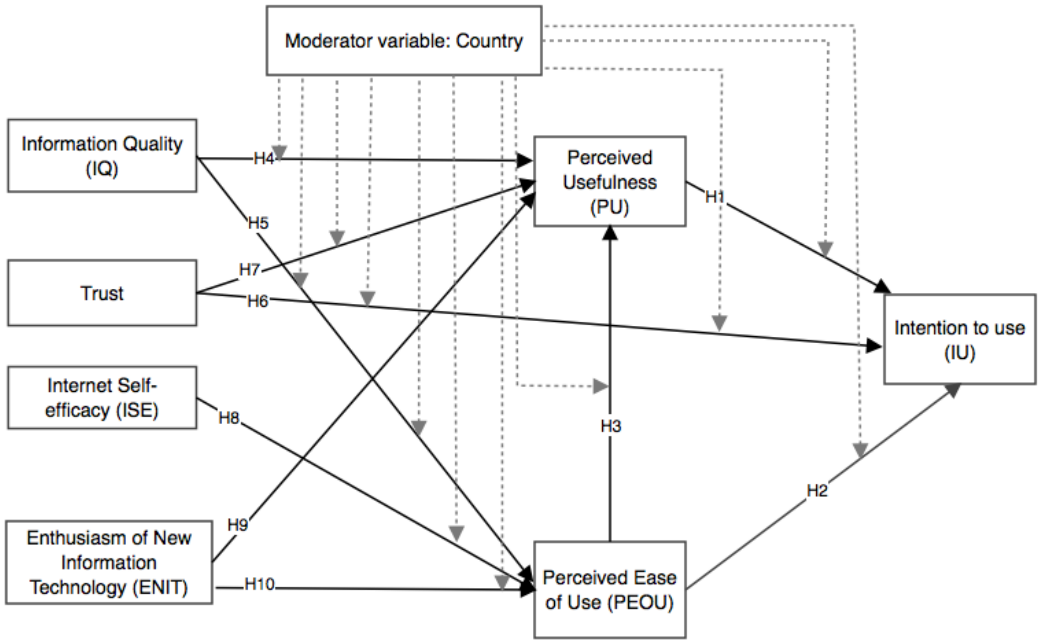

Figure 13. Proposed extended Technology acceptance model

6.2 Methodology

A survey questionnaire has been developed for data collection in this thesis. The questionnaire, including 44 questions, consists of four sections: flood risk perception, climate change perceptions, flood maps acceptance, and demographic questions (see Appendix). The questionnaire was translated into German and Chinese and was pre-tested by around 20 people from University of Stuttgart.

From August 2019 to January 2020, online surveys were conducted in Baden-Württemberg, Germany, and Guangdong province, China, with emergency response volunteers as the target group. In total, 580 valid cases were collected, 382 from Germany and 198 from China.

In China, volunteer organizations and teams with the work scope of emergency response in Guangdong were contacted and asked to distribute the questionnaire in their communication platforms and groups. Data from the responders were collected from August 2019 to November 2019. The responded organizations include Shenzhen Rescue Volunteers Federation（深圳市公益救援志愿者联合会/SRVF)(http://www.srvf.cn/), Zhuhai Min'an Rescue Service Team (珠海民安应急救援)，Foshan Boluo Rescue Service Center (佛山市菠萝救援服务中心) and others. The survey was mostly spread on the WeChat and the QQ chatting App platforms，which are two of the most popular chatting apps in China. The survey was published in Chinese on the Tencent Survey platform (https://wj.qq.com/) and the WenJuanXing survey platform (https://www.wjx.cn/).

For the survey conducted in Germany, data from the responders were collected from November 2019 to January 2020. The questionnaire was published on SurveyMonkey (https://www.surveymonkey.com/). The questionnaire link was shared in an email list of the Volunteer Firefighter Association of Baden-Württemberg as well as promoted on the website（http://www.feuerwehr.de/). Since the questionnaire link was disseminated via online chatting groups, email lists as well as websites, the number of recipients could not be estimated, and thus the response rate is unknown. Statistic software SPSS 25 is used for data analysis. The demographic profile is presented in Table 6.

Table 6. Demographic profile of respondents

Variables	**Response options**	**Germany**	**China**
Gender	Female	2 (0.8%)	91 (46.2%)
	Male	243 (99.2%)	106 (53.8%)
	Sum	245	197

Highest education level	Bachler degree or higher	173 (70.4%)	117 (59.70%)
	others	73 (29.6%)	79 (40.30%)
	Sum	246	196
Ownership of property	Yes	202 (81.46%)	97 (50.3%)
	No	46 (18.5%)	96 (49.7%)
	Sum	248	193
Children in household	Yes	118 (51.3%)	121(65.1%)
	No	112 (48.7%)	64 (34.4%)
	Sum	230	185
Length of residence	less than 1 year	0	8 (4.1%)
	1 year to 5 year	13 (5.2%)	55 (28.1%)
	6 year to 10 year	15 (6%)	41 (20.9%)
	11 year to 15 year	10 (4%)	27 (13.8%)
	more than 15 year	210 (84.7%)	65 (33.2%)
	Sum	248	196

Age

The average age for Chinese sample group is 35.83 (N=192, SD=8, range= 21- 65). 72% of respondents are younger than 40 years old. The respondents from Germany have an average age of 42.14 (N=245, SD =10.73, range=20-70), and 48.6% are younger than 40 years old. Chinese respondents have younger age than German respondents (Mann-Whitney U =15449, p<0.001).

Residence Length

For residence length, 88.7% of German respondents (N = 248) and 47% of Chinese respondents (N = 196) reported that they have lived in their current location for more than ten years.

Gender

46.2% (N= 196) of respondents are female among Chinese respondents, showing a high participation rate of female volunteers. However, for the German sample group, there are only two respondents are female. Female respondents are under-representative among German respondents.

Education

Given that there are certain differences in the education system between Germany and China, to compare the education level between two groups, the education level is only divided into two tiers: university degree or higher and others. 40.3% (N = 196) of Chinese respondents hold a university degree or higher, while the rate is 29.7% (N = 247) for the German samples.

Children in the household

Regarding whether there are children under 18 years old in the household, 122 respondents out of 186 (65%) answered yes in Chinese cases, the average number of children is 1.06 (SD= 0.99, range=1 to 5). For German respondents, 118 out of 230 (51%) respondents answered there is under 18 years old in the household with an average number of 0.87 (SD=0.62, range = 1 to 4).

Ownership of property

The proportion of respondents owning property in German respondents is higher with 81.45% (N = 248) than in China sample group with 43% (N =193). Part of the reason could be due to the older age and the longer residence period of German respondents.

Income

For the income of the two groups, the German samples' average income is 3,385EURO (SD= 1143), and for Chinese samples is 11,828 CNY (SD=6352). By using Purchasing Power Parity with OECD data in 2018 (OECD, 2008), the result shows that the average value of Purchasing Power Parity level of German respondents is 4,573USD (SD = 1544) and the value for Chinese respondents is 4,275USD (SD = 1789).

Distance to the water area

For the question about how far they live near the water area, 56.7% (N = 247) of German respondents and 30.9% (N=193) of Chinese respondents answered that they live less than 1 km distance to a river, a lake, or the sea.

7. Models and results of the flood risk perception analysis

In this chapter, based on the formulated hypotheses in chapter 6.1, multiple linear regression analysis is applied to test the direct relationships of the hypotheses, bootstrapping is used to examine the indirect and mediation effects. The analysis results are then presented.

7.1 Preliminary result of flood risk perception

7.1.1 Characteristics as emergency response volunteers

In the questionnaire code sheet (see Appendix), v1 asks how long respondents have been enrolled as volunteers in the current emergency response volunteer organization. The result is shown in Figure 14. 12. 39% of Chinese respondents (N = 197) have enrolled for less than six months, 26% in 1 to 3 years. In total, more than 73% of the volunteers have enrolled shorter than three years. Meanwhile, 94.7% of German respondents (N = 380) have enrolled for more than five years. As introduced in chapter 2, volunteer organizations of emergency response in China don't have a long history. Most of them were established less than ten years. Therefore, the noticeable difference between the two sample groups could be attributed to the different development stages of the volunteer system between the two counties.

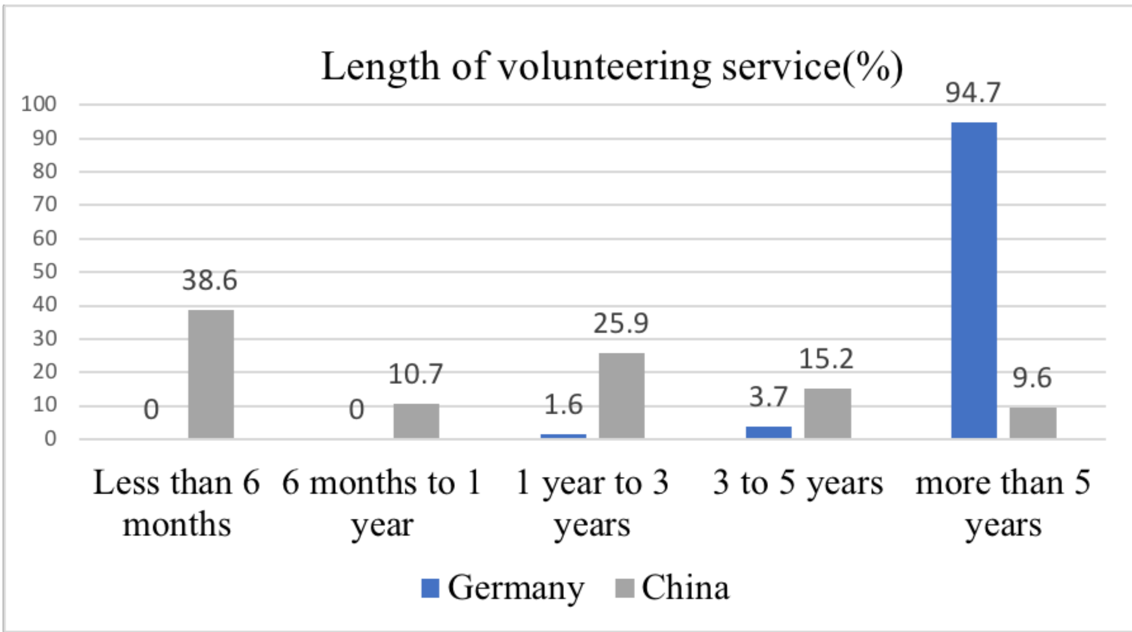

Figure 14. Volunteering length of time

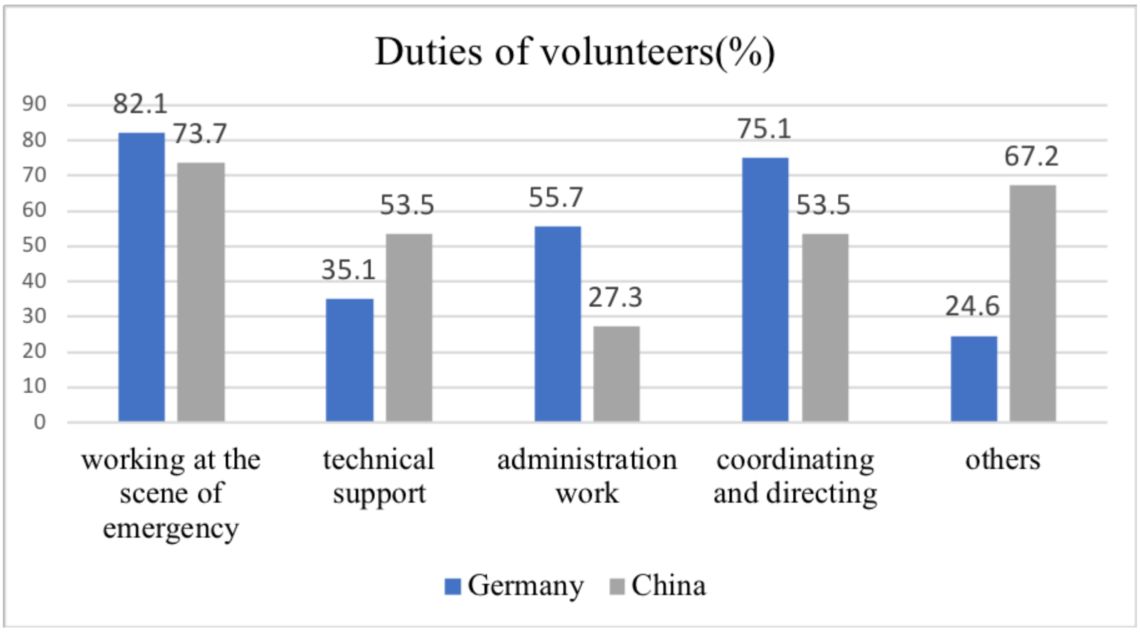

Figure 15. Tasks conducted by volunteers

In regard to the main duty undertaken by respondents in their volunteering service, 82.1% of German respondents (N = 278) and 73.7% (N=198) Chinese respondents reported their main task contains working at the scene of emergencies. The results are in Figure 15.

For received training of flood emergency response, 64.2% of Chinese respondents (N =193) and 69.8% (N=378) of German respondents have received at least one training (see Table 7). There is no significant difference between the number of times of received training between two groups (Mann-Whitney U = 34005.5, p=0.171).

Table 7. Results of received training frequency(%)

		1 = not at all	2 = 1 time	3 = 2-3 times	4 = 4-6 times	5 = More than 6 times	Mean (SD)
Training (TRAINING) "How much training you have received	GER	30.2	17.5	30.7	10.8	10.8	2.55 (1.31)

concerning flood rescue after you enrolled as a volunteer firefighter?”	CHN	35.8	22.8	19.2	7.3	15	2.43 (1.42)

7.1.2 Flood experience characteristics

The results of practical flood response experience (v8), previous economic loss (v5) and injury (v6) from floods, and last experience recency (v4) are shown in Table 8.

Table 8. Results of flood experience

Variable and item	sample size	1= none	2 = 1-2 times	3 = 3-4 times	4 = 5-6 times	5 = more than 6 times	Mean (SD)
Practical experience (Exp_Pra) “How many times you have participated in flood emergency response(rescue)?”	GER N = 380	3.90%	13.20%	19.50%	15.3%	48.2%	3.91 (1.24)
	CHN N = 196	44.90 %	37.80%	7.10%	3.60%	6.60 %	1.89 (1.12)
		1 = no loss	2 = slight loss	3= mediu m loss	4= severe loss	5= very severe loss	Mean (SD)
Economic loss from floods (Exp_Loss) “What is the most severe financial loss the flood event has caused you and your family?”	GER N = 371	73.90 %	15.90%	6.50%	3.00%	0.80%	1.41 (0.80)
	CHN N = 191	36.10 %	42.40%	14.70%	5.20%	1.60%	1.94 (0.92)
		1= no injury	2= slightly injury	3= mediu m injuries	4 = severe injuries	5 = loss of life in your family	Mean (SD)

Injury from floods "What is the most severe injury that flood event has caused you and your family?"	GER N = 377	95.50 %	3.70%	0.50%	0.00%	0.30%	1.06 (0.31)
	CHN N = 191	71.20 %	19.40%	5.80%	2.10%	1.60%	1.43 (0.82)
		No experience (Score = -99)	2 = Less than 6 months	3 = Six months to 1 year	4 = 1-3 years	5 = More than 3 years	Mean (SD)
Last experience recency (Exp_Rec) "When was the last time you experienced a flood in your region?"	GER N = 379	4.00%	5.00%	23.50%	47.7%	19.8%	3.72 (0.96)
	CHN N = 197	30.50 %	21.30%	22.80%	13.7%	11.7%	2.58 (1.35)
		Riverine flood	Flash flood	Dyke breach	Costal flood	Others	
Flood type (multiple choice)	GER N = 229	62.3%	35.1%	0.018%	0	49%	
	CHN N = 108	27%	61%	11.00%	11%	10%	

For practice experience, 3.90% of German respondents (N =380) and 44.90% of Chinese respondents (N = 196) reported never participating in any flood emergency response operation. 48.2% of German respondents and 6.60% of Chinese respondents have participated more than six times in flood-related emergency responses. A significantly higher frequency of practice experience in the German sample group is observed compared to the Chinese sample group (Mann-Whitney U= 9967, p <0.001).

73.9% (N =371) of German respondents reported that they have not experienced any economic loss from the flood. This rate for Chinese respondents (N =191) is 36.1% (Mann-Whitney U =22665, p <0.001). For the personal injury by flood, 71.2% (N = 191) of Chinese respondents haven't experienced any injure, and 19.3% reported slight injury. For German respondents, 95.49% (N = 377) have never had an injury, and only 3.71% have a slight injury. This indicates that the Chinese respondents have experienced more severe consequences from the flood than German respondents.

In addition, riverine floods and flash floods are the most frequent flood type for both sample groups. 62.3% of German respondents have experienced riverine floods, and 61% of Chinese respondents experienced flash floods. Coastal flood is also an important flood type in the Chinese sample, for which 11% of respondents have experienced.

To sum up, it can be seen from the data that German respondents have more practical experience and less economic loss and injury from previous floods than Chinese respondents.

Trust and responsibility

The result (see in Table 9) shows that almost 43.4% (N = 376) of German respondents have great trust in the government's strategy and policy regarding flood mitigation, and 5.9% have total trust in the authorities. Meanwhile, only 7.9% (N = 170) of Chinese respondents show "very much trust" in authorities, and 2.9% have "total trust". The trust level in the German sample group (Mean = 3.32) is significantly higher than in the Chinese sample group (Mean = 2.31, Mann-Whitney U test, p<0.001).

For trust in experts' flood hazards forecast and warning ability, it shows that 49.5% (N = 378) have relatively high trust in experts, and 9% have the total trust of experts in German respondents. In comparison, only 5.9% (N = 169) of Chinese respondents have relatively high trust in experts and 2.29% have total trust. The German samples (mean = 3.6) also show higher trust in experts than Chinese samples (mean = 2.29) (Mann-Whitney U test, p<0.001). In total, German respondents have higher trust in both authorities and experts for flood mitigation policy and hazard warning capability than Chinese respondents.

Table 9. Results of trust in authorities and experts (%)

item		1 = not at all	2 = not very much	3 = medium	4 = very much	5 = total	Mean (SD)	Difference between groups. P value of Mann-Whitney test
Trust in authorities "How much do you trust in the current flood prevention strategy conducted by your local authority?"	GER N=376	3.7	15.7	31.4	43.4	5.9	3.32 (0.935)	P <0.001
	CHN N=170	16.5	50.0	22.9	7.9	2.9	2.31 (0.936)	
Trust in experts "How much do you trust the capability of experts to give flood warnings?"	GER N=378	1.6	9.3	30.7	49.5	9.0	3.6 (0.842)	P <0.001
	CHN N=169	17.2	47.3	27.2	5.9	2.4	2.29 (0.902)	

Responsibility

The participants were asked how much they think the authorities and citizens themselves should be responsible for flood risk reduction, respectively. The results are in Table 10:

Table 10. Results of responsibility for flood risk reduction (%)

item	sample size	1 = not at all	2 = not very much	3 = somewhat	4 = very much	5 = total	Mean (SD)
Responsibility on authorities	GER N =376	0.8	3.46	25	59.04	11.7	3.77 (0.72)

	CHN N = 168	2.4	6	18.5	58.3	14.9	3.78 (0.86)
Responsibility on citizens	GER N = 375	1.6	6.1	25.9	57.9	8.5	3.66 (0.78)
	CHN N =167	4.2	25.7	41.9	22.2	6	3.00 (0.74)

To the question of how much authorities are responsible for flood risk reduction, similar results are shown between two groups. 59.04% (N = 376) in the German sample group and 58.3% (N = 168) in the Chinese sample group take the authorities for "main of responsibly". 11.7% in the German sample and 14.9 % in the Chinese sample take the authorities for "total responsibility".

For the question of how much responsibility a citizen him/herself should take, 57.9% of German samples believe that citizens should be mainly responsible, and this rate in Chinese samples is only 22.2%.

7.1.3 Flood risk perception characteristics

Five characteristics are selected to measure the perception of flood risk. The result is presented in Table 11. Five-point scale is used, "not true at all" = 1, "totally true" = 5, and "somewhat true" = 3.

Table 11. Flood risk perception measurement results

Variable	Item	Mean value (SD) Germany	Mean value (SD) China	Difference between groups (P value of Mann-Whitney test)
1. Perceived likelihood	I think it's very likely in the next 5 years that a flood will occur in the municipality which I live in.	4.07 (1.08)	3.04 (1.22)	$p<0.001$

2. Worry about the financial loss	I am worried about that a flood causes financial loss to me and my family.	2.76 (1.17)	3.97 (1.09)	p<0.001
3. Worry about threat to life	I am very worried about that a flood causes fatal consequences to me and my family.	2.94 (1.21)	3.96 (1.15)	p<0.001
4. Able to control loss	I believe that I am totally capable of controlling a loss due to a flood event.	3.72 (0.93)	2.56 (1.20)	p <0.001
5. knowledge of mitigation actions	I know very clearly what mitigation actions I can adopt during flood event.	3.87 (0.84)	3.52 (1.02)	p <0.001

Note: German samples N =376, Chinese samples N = 196.

The correlation results within the five risk perception characteristic items are shown in Table 12 for German samples and Table 13 for Chinese samples.

Table 12. Correlation coefficients within risk characteristics of German sample

	1	2	3	4	5
1 perceived likelihood		.244**	.373**	.109*	.225**
2 worry about financial loss			.379**	-0.012	.105*
3 worry about threat to life				-0.013	.129*
4 perceived able to control loss					.537**
5 knowledge of mitigation actions					

Note: Value of Spearman’s rho is used as Correlation coefficients.
* p<0.05
** p <0.01
*** p <0.001

Table 13. Correlation coefficients within risk characteristics of Chinese sample

	1	2	3	4	5
1 perceived likelihood		0.111	0.069	.226**	.290**
2 worry about financial loss			.798***	-0.108	.192**
3 worry about threat to life				-0.019	0.13
4 perceived able to control loss					.354**
5 knowledge of mitigation actions					

Note: Value of Spearman's rho is used as Correlation coefficients.
* p<0.05
** p <0.01
*** p <0.001

The correlations result shows that in both sample groups, worry about financial loss from floods are closely correlated to worry about the threat to life, indicating a latent construct as "**worry about the adverse impact from floods**". Such correlation is higher in samples from China (ρ=0.798***) than Germany (ρ = 0.379**). Perceived able to control loss from floods is closely related to knowledge of mitigation actions for both sample groups from Germany (ρ = 0.354**) and China (ρ =0.537**), indicating a latent construct as "**perceived controllability over floods risk**". Such findings are consistent with Ho's (2008) study. Perceived likelihood of flood is correlated to worry about financial loss (ρ =0.244**) and worry about the threat to life (ρ =0.373**) in China, while in Germany, it is not significantly correlated to neither of these two items. Instead, it is correlated to perceived able to control loss (ρ =0.226**) and knowledge of mitigation actions (ρ =0.290**).

7.2 Regression analysis

7.2.1 Hypothesized regression models

Model 1.1

To investigate the direct effects of demographic and residence characteristics on flood risk perception as well as the moderation effect of location, Model 1.1 is proposed and tested by applying a two-level hierarchical regression model.

In level one, variables of Location (LOCATION), Age, Education (EDU), Children, Ownership of Property (OP), Distance to Water Source (Distance) is added to the model. In level two, four interaction terms for testing moderation effects are added: Location* Age (_X Age), Location * Education (_X Edu), Location*OP (_X OP) and Location*Distance (_X Distance)

Model 1.2

To test whether flood experience mediates the effect of location on risk perception characteristics, model 1.2 is proposed. The model consists of four independent variables: Exp_Pra, Exp_Loss, Exp_Rec, and LOCATION.

Model 1.3

To test the role of training on risk perception, a regression model is applied with three independent variables: Location, Training, and the interaction term Location* TRAINING.

Model 1.4

To test the impact of trust in authorities on flood risk perception, a regression model is formulated with three independent variables: Location, TRUST and the interaction term LOCATION*TRUST.

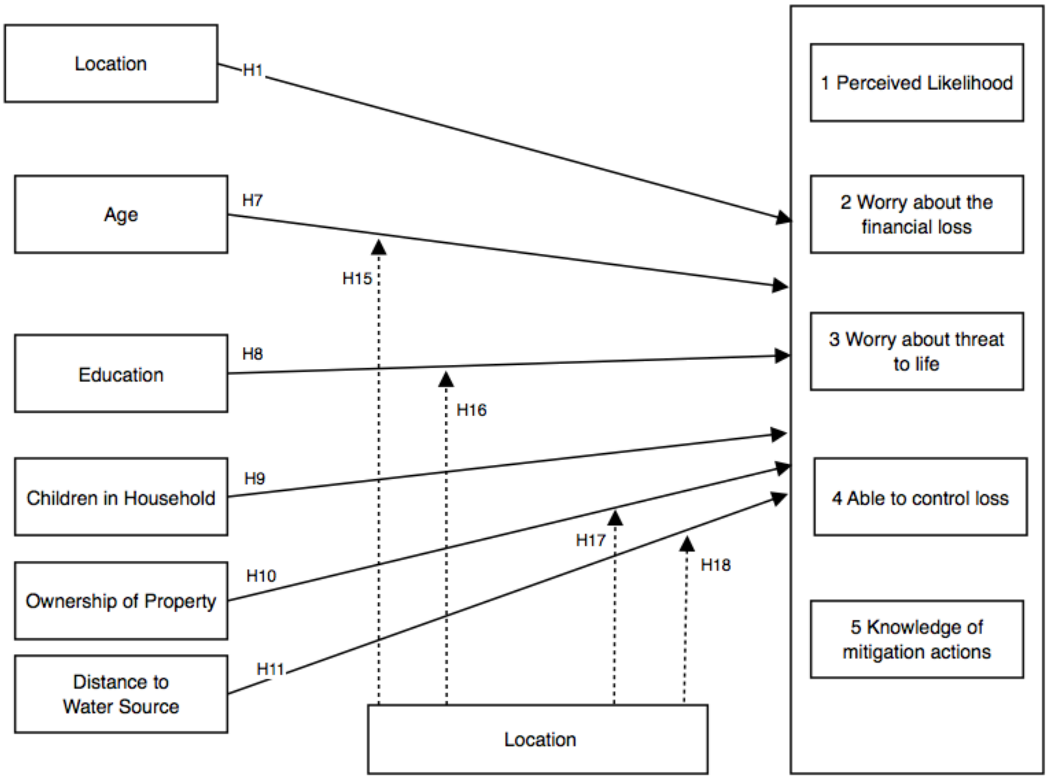

Figure 16. Proposed regression Model 1.1

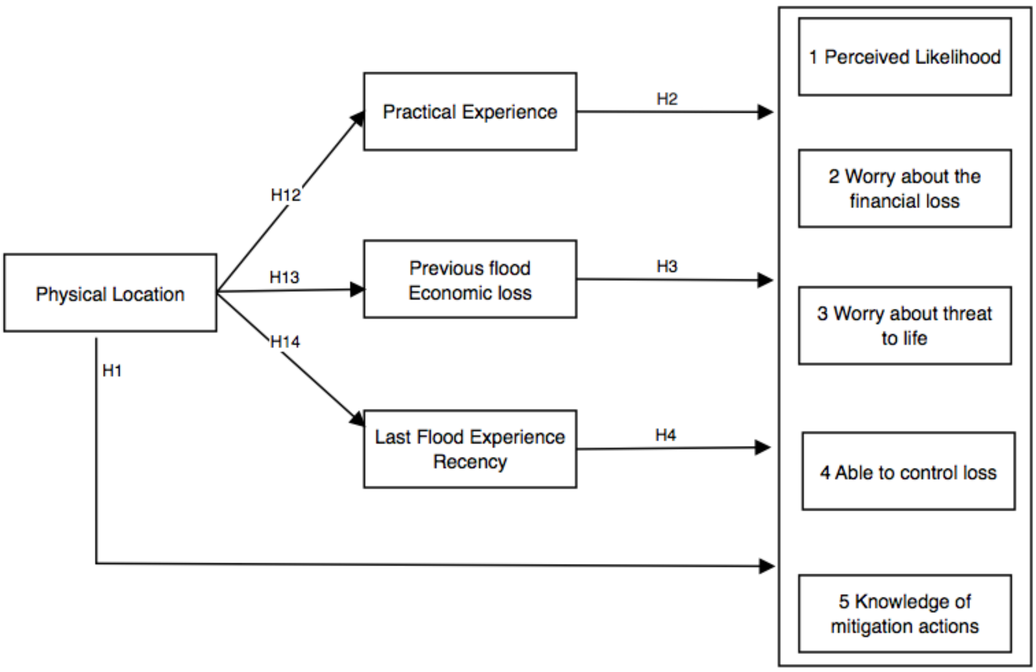

Figure 17. Hypothesized model of experience and risk perception (model 1.2)

7.2.2 Results of regression model analysis

Summary of regression models results

A summary of the regression model 1.1 shows that demographic and residence factors have a slightly higher ability to explain the variance of three risk perception characteristics: likelihood (adjusted R^2 =0.22, SE = 1.10, p<0.001, df1 = 10, df2 = 390), worry about economic loss (adjusted R^2 =0.24, SE =1.13, p<0.001), and able to control loss (adjusted R^2 =0.24, SE =1.05, p<0.001).

The model accounts for a lower variance of two risk characteristics: **worry about threats to life (**adjusted R^2 =0.15, SE =1.12, p<0.001**), knowledge of mitigation actions (**adjusted R^2 =0.045, SE =0.92, p<0.001). In total, all adjusted R^2 values from the models have a low effect size (adjusted R^2 <0.3).

Direct relationships testing results of model 1.1

Results of coefficients from regression models 1.1 are presented in Table 14. The highest VIF in all regression models is 4.125. As it is lower than 5, it shows no multicollinear problem exists.

Table 14. Result of significant standardized coefficients (Beta) of regression model 1.1

Risk perception item	LOCATION	AGE	EDU	DISTANCE	OP	CHILD	X_AGE	X_EDU	X_OP	X_DISTANCE
perceived likelihood	0.476***					0.094*				
	0.448***									
worry about financial loss	-0.484***									
	-0.499***									-0.177*
worry about threat to life	-0.402***									
	-0.377**		-0.138*							
able to control loss	0.468***									
	0.562***			0.193**						0.193*
knowledge of mitigation actions	0.18**									
	0.269*					0.101*				

Note: coefficients with p value>0.05 are excluded. "X_AGE" = LOCATION*AGE, "X_EDU" = LOCATION*EDU.

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Result of model 1.2

In order to test the significance of indirect effect between location and risk perception characteristics via experience factors, bootstrapping method is applied to produce bias-corrected confidence interval and path coefficient estimates (MacKinnon et al., 2004; Preacher & Hayes, 2004). Bootstrapping is a method commonly used to produce a large number of subsamples (e.g., 5000) from the original sample with replacement to obtain standard errors and perform the student's t-test to measure the significance of path model relationships (Efron & Tibshirani, 1993; Kushary et al., 2000). In this study, bootstrapping is conducted using PROCESS Macro (Hayes, 2013) in SPSS. The 95% confidence interval of the indirect effects was obtained from 5000 bootstrap resamples. If zero falls between the lower and upper bounds of the confidence interval, the indirect effect is not significant. Otherwise, the indirect effect is considered significant.

With the results from indirect effect testing, the mediation effect is then examined by following the technique proposed by Zhao et al (X. Zhao et al., 2010). This method could be briefly summarized: If the indirect effect between the Independent variable (IV) to the Dependent variable (DV) via mediation variables (M) is not significant, the mediation effect does not exist. If the indirect effect is significant and the coefficient of IV to DV is also significant in regression model "IV +M -> DV", a partial mediation effect exists. Otherwise, a full mediation is found.

In this thesis, the effects of three experience variables as the mediator between location and each risk perception characteristic are tested. The result of the direct effect of experience factors on risk perception characteristics is shown in Table 15. Results of the indirect and mediation effects analysis are in Table 16.

Table 15. Results of standardized coefficients (Beta) of model 1.2

Risk perception item	Factor	Beta value	p value	Summary of model
1 Perceived likelihood	Location	.395	.0003	R squared = 0.25, F = 47.28, P value <0.001
	Exp_pra	.365	.0000	
	Exp_loss	.086	.0288	
	Exp_Rec	-.017	.6841	
2 worry about financial loss	Location	-.846	.0000	R squared = 0.26, F =48.24, P value <0.001
	Exp_pra	- .048	.3134	
	Exp_loss	.201	.0000	
	Exp_Rec	.086	.0390	
3 worry about threat to life	Location	-.809	.0000	R squared = 0.18, F = 31.27, P value <0.001
	Exp_pra	.123	.0146	
	Exp_loss	.140	.0007	
	Exp_Rec	.090	.0388	
4 able to control loss	Location	.765	.0000	R squared = 0.23, F = 40.87, P value <0.001
	Exp_pra	.166	.0007	
	Exp_loss	.046	.2472	
	Exp_Rec	.037	.3811	
5 knowledge of mitigation actions	Location	.124	.2977	R squared = 0.11, F = 17.69, P value <0.001
	Exp_pra	.382	.0000	
	Exp_loss	-.002	.9653	
	Exp_Rec	.038	.4074	

Table 16. Indirect and mediation effects results of model 1.2

DV	mediator	partially Indirect standard coefficients	SE	95% CI	Indirect effect support	IV to DV supported	Mediation Effect support
1 perceived likelihood	Exp_pra	0.49	0.08	(0.34, 0.63)	yes	yes	partial
	Exp_loss	0.05	0.03	(0.01. 0.10	yes		partial
	Exp_Rec	-0.01	0.04	(-0.01, 0.07)	no		no
2 worry about financial loss	Exp_pra	-0.09	0.07	(-0.22, 0.04)	no	yes	no
	Exp_loss	0.13	0.03	(0.007, 0.18)	yes		partial
	Exp_Rec	0.08	0.01	(0.04, 0.16)	yes		partial
	Exp_pra	0.16	0.08	(0.007,	yes	yes	partial

3 worry about threat to life				0.30)			
	Exp_loss	0.09	0.03	(0.03, 0.14)	yes		partial
	Exp_Rec	0.08	0.043	(0.00, 0.17)	yes		partial
4 able to control loss	Exp_pra	0.13	0.06	(0.00, 0.25)	yes	yes	partial
	Exp_loss	-0.03	0.03	(-0.08, 0.01)	no		no
	Exp_Rec	0.03	0.041	(-0.05, 0.11)	no		no
5 knowledge of mitigation actions	Exp_pra	0.31	0.08	(0.16, 0.46)	yes	no	full
	Exp_loss	-0.01	0.03	(-0.07, 0.05)	no		no
	Exp_Rec	0.03	0.04	(-0.05, 0.12)	no		no

Note: IV = Location, SE = standard error, 95% CI = 95% confidence interval

Results of model 1.3

The impact of TRAINING on flood risk perception characteristics is also tested with a regression model. The results are listed in Table 17.

Table 17. The analysis results of model 1.3

	Location		Training		Location *TRAINING		Summary of the model. (Adjusted R squared)
	Beta	P value	Beta	P value	Beta	P value	
1perceived likelihood	0.387	<0.001	0.176	0.006	-0.077	0.221	0.166 (p<0.001)
2 worry about financial loss	-0.45	<0.001	-0.019	0.758	0.056	0.365	0.20 (p<0.001)
3 worry about threat to life	-0.376	<0.001	0.079	0.217	-0.012	0.855	0.14 (p<0.001)
4 perceived able to control loss	0.468	<0.001	0.093	0.122	0.066	0.272	0.24 (p<0.001)

5 knowledge of mitigation actions	0.155	<0.001	0.265	<0.001	0.085	0.184	0.14 (p<0.001)

Results of model 1.4

The impact of trust in the authorities (TRUST) on flood risk perception is tested in the regression model. The results are presented in Table 18.

Table 18. The analysis results of model 1.4

	Location		TRUST		TRUST *location		Summary of the model. (Adjusted R squared)
	Beta	P value	Beta	P value	Beta	P value	
1perceived likelihood	0.364	<0.001	-0.233	0.001	0.13	0.064	0.173 (p<0.001)
2 worry about financial loss	-0.451	<0.001	-0.024	0.731	-0.085	0.218	0.201 (p<0.001)
3 worry about threat to life	-0.366	<0.001	0.018	0.802	-0.137	0.057	0.14 (p<0.001)
4 perceived able to control loss	0.441	<0.001	-0.091	0.189	-0.182	0.008	0.208 (p<0.001)
5 knowledge of mitigation actions	0.188	<0.001	0.143	0.063	0.031	0.686	0.048 (p<0.001)

7.3 Summary of flood risk perception analysis results

Perceived likelihood

Volunteers from Germany (Beta = 0.476, $p < 0.001$), those who with lower trust in the authorities (Beta = -0.233, $p = 0.001$), more practical experience with flood emergency response (Beta = 0.365, $p < 0.001$), with children in household (Beta = 0.094, $p = 0.036$), and received more training (Beta = 0.176, $p = 0.006$) show higher perceived likelihood of flood. The influence of location on perceived likelihood is partially mediated by volunteers' practical experience (95% confidence interval (0.341,0.632)).

Worry about financial loss

Volunteers from China (Beta = -0.484, $p < 0.001$) and those who with severer economic loss from the previous flood (Beta = 0.200, $p < 0.001$) show greater worry about financial loss by flood in the future. The influence of location on worry about financial loss is partially mediated by previous experience of economic loss from the flood (indirect effect 95% confidence interval (0.007, 0.18)). The relationships of age, education, trust, and training on worry about financial loss don't significantly differ between Germany and China.

Worry about threat to life

Volunteers from China (Beta = -0.402, $p < 0.001$) and those with severer losses from the previous flood (Beta =0.141, $p < 0.001$) show higher worry about the threat to life by floods. The indirect effect of location on worry about the threat to life is partially mediated by practical experience (indirect effect 95% confidence interval (0.007, 0.30)) and partially mediated by previous economic loss from floods (indirect effect 95% confidence interval (0.03, 0.14)).

Able to control loss

Volunteers from Germany (Beta = 0.468, $p < 0.001$) and those who have more practical experience (Beta =0.166, $p < 0.001$) show a higher perceived able to control loss from floods. The relationship between location and perceived able to control is not mediated by practical flood experience (indirect effect 95% confidence interval (0.001, 0.25)). The influence of trust in authorities on perceived able to control in Germany is stronger than in China (Beta =0.182, p =0.08).

Knowledge of mitigation actions

Volunteers from Germany (Beta =0.180, p<0.001) and those who received more training (Beta =0.265, p<0.001) have more practical experience (Beta =0.383, p<0.001) believe they know more about flood mitigation actions. The relationship between location and mitigation knowledge is fully mediated by practical experience (95% confidence interval (0.163,0.460)). The relationships of age, education, trust, and training on mitigation knowledge don't have a significant difference between Germany and China.

8. Models and results of climate change perception analysis.

In this chapter, models 2.1 and model 2.2 postulated in chapter 6 are tested to explore the relationships among flood experience, perceived impact of climate change on flood risk, and climate change perceptions. With the data collected from the survey, the hypothesized direct, indirect, and mediation effects are tested with multiple linear regression and bootstrapping.

8.1 Preliminary survey results of climate change perception

Perceived impact of climate change on flood risk (PICCFR)

Four items are used (see Table 19) to measure the construct "perceived impact of climate change on flood risk (PICCFR)". The result shows that both sample groups have a relatively high level of worry about climate change's impact on flood risk. Specifically, respondents from China believe that climate change will have a stronger overall impact on flood risk level (Mann–Whitney test, $p < 0.001$). They show more worry about climate change leads to higher flood risk (Mann–Whitney U test, $p = 0.003$) and more severe flood consequence result caused by climate change (Mann–Whitney U test, $p < 0.001$) compared to German respondents. Meanwhile, respondents from Germany show more worry that climate change will lead to more frequent extreme rainfall in their regions than respondents from China (Mann–Whitney U, $p < 0.001$).

Table 19. Result of perceived impact of climate change on flood risk (% within countries).

	sample size	1 = not true at all	2 = hardly true	3= partially true	4 = quite true	5= totally true	Mean	Mann–Whitney p value (two tails)
V9a: overall impact on flood risk level from climate change	GER N = 377	5.30	12.50	25.20	35.80	21.20	3.55	0.00
	CHN N= 197	1.00	6.60	15.70	39.60	37.10	4.05	

V9b: Worry about climate change leads to a higher risk	GER N=377	5.30	13.00	23.60	38.20	19.90	3.54	0.03
	CHN N=197	2.00	7.60	23.40	38.10	28.90	3.84	
V9c: severe consequence result caused by climate change	GER N=375	17.90	37.10	20.80	17.90	6.40	2.58	0.00
	CHN N=196	2.60	11.20	30.10	33.20	23.00	3.63	
V9d: more frequent extreme rainfall happens by climate change	GER N=377	1.60	6.40	12.20	41.90	37.90	4.08	0.00
	CHN N=197	1.00	11.70	27.90	33.00	26.40	3.72	

Cronbach alpha of the four items is 0.587, showing a poor internal consistency. After excluding item v9c, the alpha has changed to 0.847. Therefore, by applying principal component factor analysis on v9a, v9b, and v9d, the result shows there is only one component with eigenvalue 2.298 and explains 76.61% of the variance. Kaiser-Meyer-Olkin Measure of Sampling Adequacy value is 0.678 and Bartlett's Test of Sphericity p <0.001. The Factor Scores are used as an index variable for each case by calculating an optimally weighted linear combination of the items. The range of factor scores is from -1.33 to 3.085. A higher value indicates a higher level of perceived impact of climate change on flood risk.

Climate change perceptions

Perceived local vulnerability, Uncertainty over climate change, and the Perceived effect of climate change mitigation actions (PECCMA) are measured as below (see Table 20).

Table 20. Results of climate change perceptions variables (%).

Variable and question	sample size	1 = not true at all	2= hardly true	3= partially true	4= quite true	5= total true	mean (SD)	Difference between sample groups P value
Perceived local vulnerability (**PLV**) "My local area will be affected by climate change".	GER N =366	2.5	6.0	30.9	37.4	23.2	3.73 (0.97)	.002
	CHN N = 197	0.5	4.1	23.9	39.1	32.5	4.00 (0.88)	
Uncertainty over Climate change **(UCC)** "I am uncertain that climate change, sometimes referred to as 'global warming', is really happening."	GER N =366	38.8	17.5	21.3	15.3	7.10	2.34 (1.30)	0.00
	CHN N = 196	15.7	21.3	27.4	19.8	15.70	2.98 (1.29)	
Perceived effect of climate change mitigation actions (**PECCMA**) "I can personally help to reduce climate change by changing my behavior."	GER N=369	13.3	14.6	32.2	28.5	11.4	3.10 (1.12)	.000
	CHN N = 197	2.0	5.1	18.9	36.7	37.2	4.01 (0.98)	

The samples from China (Mean = 4.00, SD = 0.97) have a slightly higher Perceived local vulnerability than Germany (Mean = 3.73, SD =0.88). Both sample groups show a relatively high level of worry about climate change. For the uncertainty over climate change, Chinese samples (mean = 2.98) show a significantly higher doubt over climate change than German samples (mean = 2.34). For the Perceived effect of climate change mitigation actions, respondents from China (mean = 4.01) are more positive that their behaviour can actually contribute to climate change mitigation than German respondents (mean = 3.10).

Other variables

A summary of the rest of the predictors proposed in study models 2.1 and 2.2 can be seen in Table 21, including age, location, flood experience, perceived flood risk.

Table 21. Statistical results of the factors in models 2.1 and 2.2

Variable	item	Options and scores	Mean value (SD) Germany	Mean value (SD) China
Location		Germany = 1, China = 0		
Practical experience (Exp_Pra)	How many times you have participated in flood emergency response(rescue)?	Five-point score, None = 1, more than 6 times = 5	3.91 (1.24)	1.89 (1.12)
Economic loss (Exp_Loss)	What is the most severe financial loss the flood event has caused you and your family?	Five-point score No financial loss= 1, very severe financial loss = 5	1.41 (0.80)	1.94 (0.92)
Perceived flood risk index	(Perceived likelihood*worry about financial loss)/5 *(calculated from flood risk characteristic variables)*	Score from 1 to 5 1 = very low risk, 5 = very high risk	3.69 (0.99)	3.72 (0.98)
Age (AGE)	What is your age?		42.14 (10.73)	35.83 (8.00)

8.2 Results of climate change perception models analysis

Multiple linear regressions and bootstrapping analysis are applied to analyse the causal relationships for both model 2.1 and model 2.2, including direct, indirect, and mediation effects.

8.2.1 Summary of models

Model 2.1 has a low ability to explain the PICCFR variance (adjusted $R^2 = 0.151$, p =0.001, df1 =5, df2 = 535). Model 2.2 accounts for 27.3% (adjusted R2 = 0.273, p <0.001, df1 = 6, df2 = 531) of the variance of perceived local vulnerability and 25.9% (adjusted R2 = 0.259, p <0.001, df1 =5, df2 =532) of the variance of perceived effect of climate change mitigation actions. Model 2.2 has a relatively low ability to explain the perceived uncertainty over climate change (adjusted R2 = 0.109, p <0.001, df1 = 5, df2 = 531).

8.2.2 Direct relationships testing results

The results of direct causal relationships are presented in Table 22 for both model 2.1 and model 2.2. A summary of the direct effect results is shown in Figure 18 for model 2.1 and Figure 19 for model 2.2.

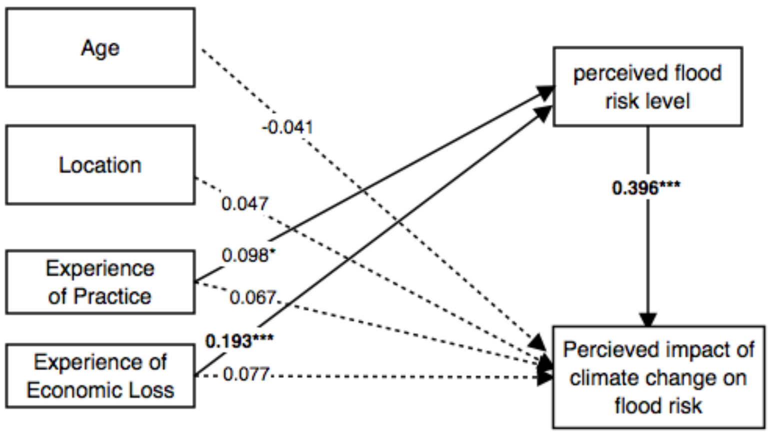

Figure 18. Results of direct relationships in model 2.1

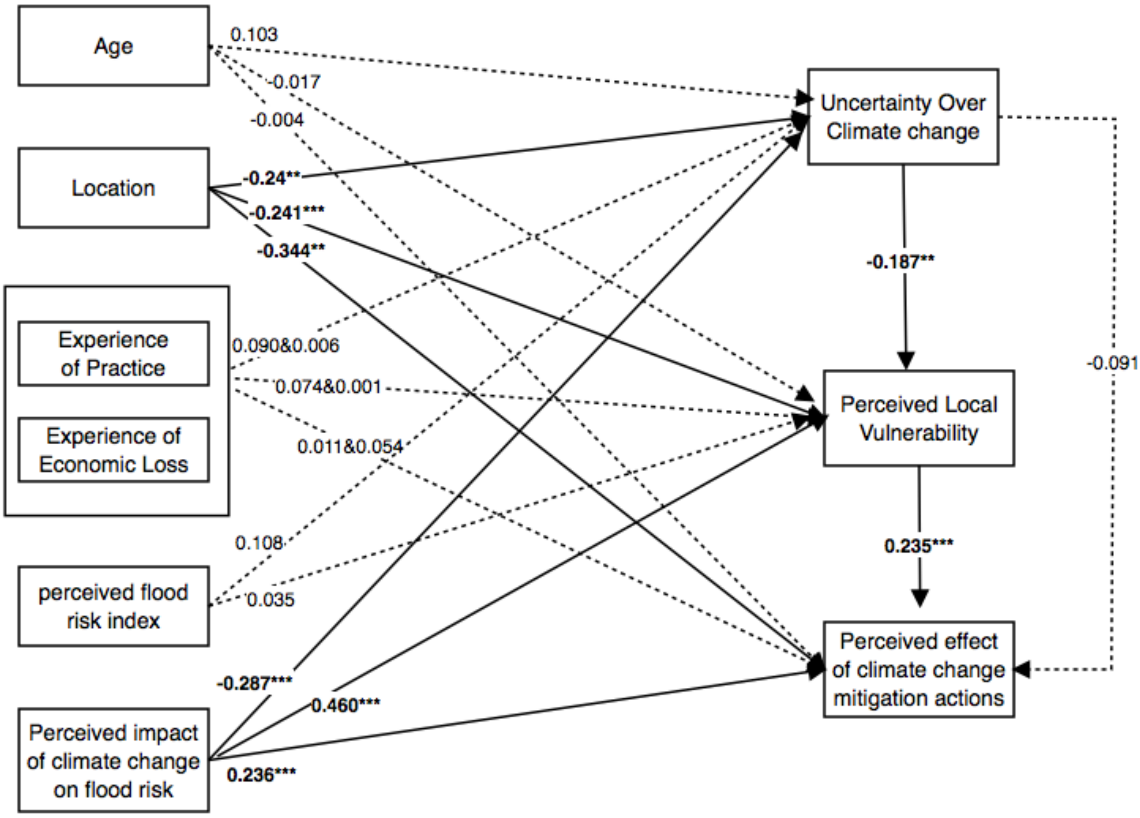

Figure 19. Results of direct relationships in model 2.2

Table 22. Direct path results (standardized coefficients)

DV / IV	Perceived local vulnerability (**PLV**)	Uncertainty of Climate change (**UCC**)	Perceived effect of climate change mitigation actions (**PECCMA**)	perceived impact of climate change on flood risk (**PICCFR**)	Perceived flood risk index (**PFR**)
Location	-0.241***	-0.24**	-0.344***	-0.047	
Exp_Pra	-0.074	0.090	0.011	0.067	0.0975*
Exp_Loss	0.001	0.006	0.054	-0.077	0.193***
PICCFR	0.46***	-0.287***	0.236***		
Perceived flood risk index	0.035	-0.108		0.396***	
Age	-0.017	-0.103	-0.004	-0.041	
PLV			0.235***		
UCC	-0.187**		-0.091		

Note: IV = independent variable, DV= dependent variable. Perceived effect of climate change mitigation actions (PECCMA)

The perceived impact of climate change on flood risk (PICCFR) is significantly influenced by perceived flood risk (Beta =0.396, p <0.001). Neither of the two flood experience variables directly significantly affect PICCFR. Respondents from Germany and China do not show a significant difference in how they perceive the impact of climate change on flood risk.

Respondents from China (Beta = -0.241, p <0.001) and those who perceived greater climate change's impact on floods (Beta =0.461, p < 0.001), less uncertainty over climate change (Beta = -0.187, p = 0.001) show higher perceived local vulnerability (PLV). Flood experience does not have a significant direct influence on PLV.

Respondents from China (Beta = -0.243, p =0.003) and those who perceive the weaker impact of climate change on flood risk (PICCFR) (Beta = -0.287, p <0.001) show higher uncertainty over climate change. Flood experience and perceived flood risk don't have a significant direct influence on uncertainty over climate change.

Respondents from China (Beta = -0.344, p<0.001) and those who perceived greater climate change's impact on flood (Beta = 0.236, p<0.001) as well as greater perceived local vulnerability (Beta = 0.235, p < 0.001) perceive higher effects of climate change mitigation actions. Flood Experience and uncertainty over climate change don't have a significant influence on perceived climate change mitigation actions effect.

8.2.3 Results of indirect effects and mediation effects

Similar to chapter 6, bootstrapping is used to test the indirect effect. By using the indirect effect result, the mediation effect is also examined by Zhao's (2010) technique. A summary of the results is presented in Table 23.

Table 23. Results of significant indirect effect and mediation effect of model 2.1 and model 2.2

Indirect path	Estimate	S.E	P Value	LL CI	UL CI	IV->DV	Mediation effect
Exp_Loss -> Perceived flood risk -> PLV	0.076	0.021	0.000	0.03	0.12	no	full
PICCFR -> PLV -> PECCMA	0.109	0.038	0.004	0.04	0.20	yes	partial

Location -> PLV -> PECCMA	-0.057	0.023	0.013	-0.17	-0.02	yes	partial
UCC -> PLV -> PECCMA	-0.044	0.017	0.009	-0.09	-0.02	no	full
PICCFR -> UCC -> PLV	0.054	0.021	0.013	0.02	0.11	yes	partial
Location -> UCC -> PLV	-0.045	0.020	0.025	-0.09	-0.02	yes	partial

Note: IV = independent variable, DV= dependent variable. UCC = Uncertainty over climate change. PLV = Perceived local vulnerability. PICCFR = Perceived Impact of Climate Change on Flood Risk. PECCMA = Perceived Effect of Climate Change Mitigation Actions

The results show that PLV partially mediates the relationship between PICCFR and PECCMA (indirect effect 95% confidence interval (0.048,0.198)). PLV also mediates the relationships between Location and PECCMA (indirect effect 95% confidence interval (-0.016, -0.022)) and UCC to PECCMA (indirect effect 95% confidence interval (-0.084, -0.017)).

8.2.4 Results of total effects

The results of the total effect of predictors on dependent variables are presented in Table 24.

Table 24. Result of total effect estimates

DV / IV	Perceived local vulnerability (**PLV**)	Uncertainty over climate change (**UCC**)	Perceived climate change mitigation actions effect **(PECCMA)**	Perceived climate change's impact on flood risk (**PICCFR**)	Perceived flood risk
Location	-0.197**	-0.235**	-0.369***	-0.046	
Exp_Pra	0.091	0.09	-0.019	0.028	0.098*
Exp_Loss	0.001	0．006	0.053	0.153**	0.193***
Perceived impact of climate change on Flood risk (PICCFR)	0.514***	-0.287***	0.384***		
Perceived flood risk	0.015	-0.108	0.008	0.397***	
Age	0.003	0.103	0.007	0.042	
PLV			0.235***		
UCC	-0.187**		-0.134*		

Note: * p<0.05.
** p<0.01.

*** $p<0.001$.

With the total effect analyses by using bootstrapping, two main results are found:

PICCFR is the strongest factor influencing all three climate change perception variables: Perceived local vulnerability (estimate = 0.514, p <0.001, 95% confidence interval (0.390, 0.627)), uncertainty over climate change (estimate = -0.287, p <0.001, 95% confidence interval (-0.411, -0.163)), and Perceived climate change mitigation actions effect (estimate = 0.384, p<0.001,95% confidence interval (0.282, 0.481)).

Location is another factor that influences climate change perceptions: Perceived local vulnerability (Estimate =-0.197, p =0.001, 95% confidence interval (-0.315, -0.073)), uncertainty over climate change (Estimate =-0.235, p= 0.003, 95% confidence interval -0.399, -0.084) and Perceived climate change mitigation actions effect (Estimate =-0.369, p <0.001, 95% confidence interval (-0.498, -0.240)). Flood experience does not show a significant total effect on any of climate change perception variables.

8.3 Summary of the analysis results

To sum up, perceived flood risk level influences the degree that volunteers believe climate change will affect flood risk. In addition, instead of flood experience, the factors that have an important influence on climate change perceptions are volunteers' physical location and how strongly volunteers believe their local flood risk will be affected by climate change.

Compared to respondents from China, respondents from Germany perceive a higher local vulnerability to climate change, show a higher uncertainty over climate change, and perceive a greater effect of climate change mitigation actions.

Moreover, when respondents believe that the local flood risk is more significantly influenced by climate change, they tend to perceive a higher local vulnerability to climate change, show a lower uncertainty over climate change, and perceive a greater effect of climate change mitigation actions.

9. Model and results of flood hazard and risk maps acceptance intention analysis

In this chapter, the SEM-ANN approach is applied to test the proposed extended TAM model in chapter 6.

As one of the most prevalent data analysis methods, linear regression and modeling methods developed based on linear regression are frequently applied to explain the linear relationships between independent and dependent variables. Nevertheless, linear regression faces some limitations, such as oversimplifying the complexity of reality. Besides, it has requirements for the distribution of the data. To gain a better data modeling performance and overcome these limitations, researchers often recommend integrating a nonlinear data analysis method with linear regression into a hybrid approach.

As a popular nonlinear analysis method, Artificial Neural Network (ANN) is often preferred by researchers for this purpose. Compared to linear regression, it can achieve better accuracy for data modeling (Morris et al., 2004). In addition, it does not require the distribution of the data (Chiang et al., 2006; Leong et al., 2013). However, using ANN cannot provide insights into the structure of the function based on the approximation given by the neural network. Due to this shortcoming, ANN is more commonly used for predicting modeling instead of explaining the causal relationships in the model.

This chapter employs an integrated two-staged SEM-ANN method to conduct the data analysis as suggested by previous studies (e.g., Asadi et al., 2019; Leong et al., 2013). Such an integrated method is more comprehensive than a plain linear regression method or ANN. It combines the advantage of the two approaches and can better explain the determinants of the intention for flood maps acceptance in the extended Technology Acceptance Model.

In this integrated approach, a method developed based on linear regression called SEM is first applied to detect the significant determining factors of the intention to adopt flood maps. These significant determining factors are then used as input variables in the proposed ANN models and retest the causal relationships indicated by the SEM approach.

By using multigroup analysis, country is used as a moderator variable to show the difference of causal paths in the model between German and Chinese sample groups.

9.1 Preliminary survey results of flood maps acceptance intention analysis

Regarding the experience with flood maps, German participants were asked how often they have applied specifically the flood risk map from LUBW, Baden-Württemberg [8] (Hochwasserrisikobewertungskarte Baden-Württemberg) in their emergency response work. Participants from China were asked if they had applied the FM flood map or the maps similar to it. The results (Table 25) show that around 50% of respondents have never used online flood maps in both sample groups.

Table 25. Experience of previous use of flood maps (%)

	sample size	never	seldom	Sometimes	often	always
Use experience ‘How often do you or your colleagues use the flood risk map in the link below in your work for flood rescue?’	Germany N = 263	48.6	22.4	13.1	10	5.8
	China N=191	53.7	20.7	14.9	9.6	1.1

After being asked to visit the flood map websites and find the flood risk information in their region, participants from Germany were asked about how much they can understand the terms used on the flood map to indicate the flood risk level. The result shows that 18.1% answered they totally understand all the terms, 41.2% answered they knew most of the terms, 23.5% reported they knew some of the terms,11.5% knew a little of terms, and the rest 5.6% did not understand the terms at all.

[8] https://udo.lubw.baden-wuerttemberg.de/public/pages/map/default/index.xhtml?mapId=4e5c40da-4791-456f-b745-a25bf79afbad&overviewMapCollapsed=false&mapSrs=EPSG%3A25832&mapExtent=446323.4259480754%2C5350418.49642647%2C598394.4266880892%2C5436412.628703346

Participants were then asked their understanding of one of the most frequently used terms when describing flood risk by media: “100-year flood”. It is defined by experts as “a flood of that magnitude has a one percent chance of occurring in any given year” or “extreme hydrologic event as a flood having a 100-year recurrence interval(USGS, n.d.). This term is expressed as “HQ100” for German participants, which is also used for the flood risk map. For Chinese participants, the corresponding word for “100-year flood” is “百年一遇洪水” in Chinese.

For Chinese cases, 105 participants answered this open question, while 40 answers described this term roughly as “severe flood which will lead very bad consequence”. 12 respondents described it as “the biggest flood in past one hundred years”, which is not correctly understand the term meaning. 9 respondents answered as “a flood event that rarely or very low chance will happen”. 6 respondents answered as “will happen once 100 years” and the rest answers are not related to the real meaning of the term. This result shows that the majority of Chinese respondents lack understanding of this term.

9.2 Analysis of extended TAM by using SEM approach

The partial least squares structural equation model (PLS-SEM) is applied to test the hypotheses proposed in the model by using the statistical software SmartPLS.

A structural equation model (SEM) is a system of linear equations among several unobservable variables (constructs) and observed variables (Duncan, 2014). It is used to evaluate the measurement of latent variables as well as test relationships between latent variables (Babin et al., 2008). Therefore, SEM is a combination of multiple linear regression for examining dependence relationships and factor analysis to evaluate the measurement of latent variables.

The covariance-based SEM (CB-SEM) that aimed to minimize the difference between theoretical and estimated covariance matrix is the most popular applied one among all SEM approaches (Rigdon et al., 2017). This approach has several requirements for the data. For example, it requires multivariate normality of data and has a strict demand for the minimum sample size (e.g., Diamantopoulos and Siguaw, 2000). When the requirement is not met, Partial Least Squares Approach (PLS-SEM) is often applied as an alternative approach as it does not assume the data distribution (Hair et al., 2012; Hair & Sarstedt, 2014). PLS-SEM is an approach aimed at maximizing the explained variance of the dependent latent constructs. While far less prevalent than CB-SEM, PLS-SEM has been increasingly applied in marketing and business disciplines and social science fields (Hair & Sarstedt, 2014; Henseler et al., 2009).

Due to the size (less than 300 data samples) and the non-normal distribution of the collected data sample for this study, the PLS-SEM is applied for testing the model.

The assessment of the model result consists of the inner model assessment and the outer model assessment. The inner model, or structural model, shows the relationships between the constructs. The outer models, also known as the measurement models, link the constructs to observed measurements (Duncan, 2014).

9.2.1 Outer model assessment

When evaluating the outer models, it requires first to distinguish between reflective and formative constructs (Hair & Sarstedt, 2014; Ringle & Sarstedt, 2016) as they use different evaluation methods. In this study, the items for measuring constructs are designed as reflective constructs, which are highly correlated and capable of being eliminated without changing the meaning of the construct (Diamantopoulos & Winklhofer, 2001). The reflective constructs need to be assessed of both reliability and validity of the outer model first.

The reliability assessment includes two parts: Internal consistency reliability and Indicator reliability assessment. Internal consistency reliability is measured by Composite Reliability instead of Cronbach's alpha (Bagozzi & Yi, 1988; Hair & Sarstedt, 2014). For the PLS-SEM approach, the value should be higher than 0.7. Indicator reliability is measured by Indicator loadings, which also should be higher than 0.70. If it is an exploratory study, 0.4 or higher is acceptable.

Validity assessment of reflective measurement models also consists of two parts: Convergent validity and Discriminant validity. Convergent validity is measured by Average Variance Extracted (AVE). An AVE value of 0.50 and higher indicates a sufficient degree of convergent validity, meaning that the constructs explain more than half of its indicators' variance (Hair & Sarstedt, 2014). For the assessment of discriminant validity, two measures are most commonly applied: Fornell-Larcker criterion and cross loadings.

For Fornell-Larcker criterion, the AVE of each latent construct should be greater than the latent construct's highest squared correlation with any other latent construct (among the latent variables) (Fornell & Larcker, 1981). For the cross loadings approach, an indicator's loading with its associated latent construct should be higher than its loadings with all the rest constructs (Wong, 2013).

Table 26. Results of construct reliability and convergent validity assessment

Constructs and items	Indicator	Factor Loadings		composite reliability		Average Variance Extracted (AVE)	
		GER	CHN	GER	CHN	GER	CHN
IU							
"I intend to use the map in future for flood related events."	IU_1	0.894	0.917	0.912	0.916	0.839	0.846
"Using this online map enables me to acquire flood risk information more quickly."	IU_2	0.937	0.923				
PU							
"Generally, I find this risk map to be useful when dealing with flood events."	PU_1	0.941	0.946	0.937	0.943	0.881	0.892
"Using this online map enables me to acquire flood risk information more quickly."	PU_2	0.937	0.943				
PEOU							

"This flood risk map is easy to operate in order to find the information that I am interested in. "	PEOU_1	0.944	0.923	0.946	0.926	0.897	0.862
"This online flood risk map is clear and understandable to me."	PEOU_2	0.950	0.934				
Information quality (IQ)							
"I think the information on the map is accurate enough for my work when dealing with floods emergency."	IQ_1	0.858	0.886	0.874	0.902	0.776	0.822
"I think the risk map is intuitive enough to read and understand."	IQ_2	0.903	0.927				
Trust							
"When dealing with the emergency rescue, I trust my experience to make decisions more than this risk map."							
Internet self-efficacy (ISE)							
"I feel confident to access knowledge and information via Internet."	ISE_1	0.919	0.926	0.925	0.955	0.861	0.914
"I feel confident to access information from web maps (e.g., Google maps)"	ISE_2	0.937	0.950				
Enthusiasm of new information technology (ENIT)							

"I inform myself about online information resources and tools (such as Apps, disaster risk map, warning systems, videos, articles) for hazards preparedness and responding."							

Table 27. Results of discriminate validity using Fornell-Larcker Criterion of German samples

	UI	PU	PEOU	IQ	TRUST	ISE	ENIT
UI	0.916	0.729	0.445	0.578	0.522	0.154	0.225
PU		0.939	0.549	0.602		0.110	0.198
PEOU			0.947	0.656		0.154	0.153
IQ				0.881			0.160
TRUST		0.548	0.426	0.630	1.000	0.019	0.190
ISE				0.104		0.928	0.448
ENRT							1.000

Table 28. Results of discriminate validity using Fornell-Larcker Criterion of Chinese samples

	UI	PU	PEOU	IQ	TRUST	ISE	ENIT
UI	0.920	0.777	0.585	0.655	0.535	0.412	0.355
PU		0.945	0.627	0.594		0.440	0.367
PEOU			0.928	0.532		0.538	0.439
IQ				0.907			0.407
TRUST		0.477	0.579	0.643	1.000	0.589	0.419
ISE				0.505		0.956	0.618
ENRT							1.000

As seen from Table 26, all composite reliability, factor loading, and AVE values are higher than 0.85, showing good reliability and convergent validity. With the results from Table 27 for German cases and Table 28 for Chinese cases, the squared root of AVE in each latent variable is larger than other correlation values among the latent variables, showing a good discriminant validity in both sample groups according to Fornell-Larcker Criterion.

9.2.2 Inner model assessment

Before assessing the inner model, multicollinearity needs to be detected to avoid biases if constructs are highly correlated (Hair et al., 2014). The result of the multicollinearity detection shows that VIF values are not larger than 2.16 in both sample groups, indicating a low probability of the existence of the multicollinearity problem.

Evaluation of the Structural Model

For PLS-SEM, the assessment of the inner model is based on its ability to explain the latent constructs. The primary evaluation criteria for the inner model are the coefficient of determination measure and the level of the path coefficients (Hair et al., 2011; Henseler et al., 2009).

Similar to chapters 7 and 8, nonparametric bootstrapping is also applied in PLS-SEM as the data are not presumed normally distributed (Efron & Tibshirani, 1993; Kushary et al., 2000). After running the PLS model, estimated path coefficients are provided to test their significance (Wong, 2013). It can be interpreted as standardized beta coefficients of ordinary least squares regressions. In addition, a standard error is obtained using bootstrapping for testing significance (Helm et al., 2009).

Moderation effect in multi-groups

To test whether there is a significant difference exists between two groups of samples for each inner relationship, the following formula is used to calculate the t value according to Chin (2000).

$$t = \frac{Path_{sample\_1} - Path_{sample\_2}}{\left[\sqrt{\frac{(m-1)^2}{(m+n-2)} * S.E._{sample1}^2 + \frac{(n-1)^2}{(m+n-2)} * S.E._{sample2}^2}\right] * \left[\sqrt{\frac{1}{m} + \frac{1}{n}}\right]}$$

9.2.3 Results of inner model assessment

Adjusted R squared values of IU in Germany (Adjusted $R^2 = 0.547$, $p<0.001$, df1 =3, df2 = 256) and China (Adjusted $R^2 = 0.635$, $p<0.001$, df1 =3, df2 = 175) show moderated level ability to predict the variance of Intention to use the flood maps (in Table 29).

Besides, the model could also explain 44.2% (p <0.001, df1=4, df2 = 255) of the variance of PU in the Chinese sample group and 47.6% in the German sample group (p <0.001, df1 = 4, df2 =174), also showing a moderated level of explanatory power in both sample groups.

Table 29. Summary of inner model

	R Squared		R Squared Adjusted	
	Germany	China	Germany	China
IU	0.554	0.641	0.547	0.635
PU	0.454	0.489	0.442	0.476
PEOU	0.437	0.382	0.432	0.370

Table 30. Direct path coefficients and moderation effect results

Path		Path coefficient	S.E	P Values	p value for difference (2-tailed)	Difference between groups
H1. PU -> UI	GER	0.621	0.066	0.000***	0.886	No
	CHN	0.641	0.078	0.000***		
H2. PEOU -> UI	GER	0.033	0.058	0.563	0.954	No
	CHN	0.076	0.075	0.285		
H3. PEOU -> PU	GER	0.256	0.074	0.000***	0.350	No
	CHN	0.431	0.086	0.000***		
H4.IQ -> PU	GER	0.254	0.092	0.006**	0.619	No
	CHN	0.370	0.093	0.008**		
H5.IQ -> PEOU	GER	0.647	0.046	0.000***	0.003	Yes
	CHN	0.355	0.095	0.000***		
H6. TRUST -> UI	GER	0.169	0.061	0.005**	0.202	No
	CHN	0.183	0.071	0.008**		
H7. TRUST -> PU	GER	0.264	0.064	0.000***	0.127	No
	CHN	-0.029	0.096	0.812		
H8. ISE -> PEOU	GER	0.090	0.060	0.146	0.019	Yes
	CHN	0.356	0.112	0.001***		
H9. ENIT -> PU	GER	-0.035	0.054	0.504	0.521	No
	CHN	0.040	0.070	0.563		
H10. ENIT -> PEOU	GER	0.095	0.056	0.112	0.449	No
	CHN	0.019	0.089	0.915		

Note: S.E = Standard Error.

Based on the estimated path coefficients in Table 30, the intention to use a flood map (IU) is primarily influenced by Perceived Usefulness (PU) (Germany: Beta = 0.621, $p<0.001$; China: Beta =0.644, $p<0.001$) and TRUST (Germany Beta= 0.169, p = 0.005; China Beta = 0.183, p =0.008) in both groups. PEOU does not show significant influence on IU in either sample group.

PU is directly affected by PEOU (Germany: Beta = 0.256, $p<0.001$; China Beta = 0.431, $p<0.001$) and IQ (Germany: Beta = 0.254, p=0.006; China Beta =0.370, $p<0.001$). TRUST (Beta= 0.264, $p < 0.001$)) has a significant positive influence on PU in the German sample group. Such a relationship is not significant in the Chinese group. The Enthusiasm of New Information Technology (ENIT) does not have a significant influence on PU in neither group.

PEOU is directly influenced by information quality (IQ) in Germany (Beta = 0.647, $p<0.001$) and China (Beta = 0.355, $p<0.001$). Internet self-efficacy (ISE) has a significant influence in the Chinese group (Beta= 0.356, p=0.001). This relationship is not supported in Germany.

Multi-groups moderation analysis result

For the results of examining the country as a moderator between two groups, PEOU is significantly stronger influenced by information quality (IQ) in Germany (Beta = 0.647, $p<0.001$) than in China (Beta = 0.355, $p<0.001$). Internet self-efficacy (ISE) has a significantly stronger influence on PEOU in the Chinese sample group (Beta= 0.356, p=0.001) than in the Germany sample group (Beta =0.090, p = 0.146). The results are shown in Figure 20 for the German sample group and Figure 21 for the Chinese sample group.

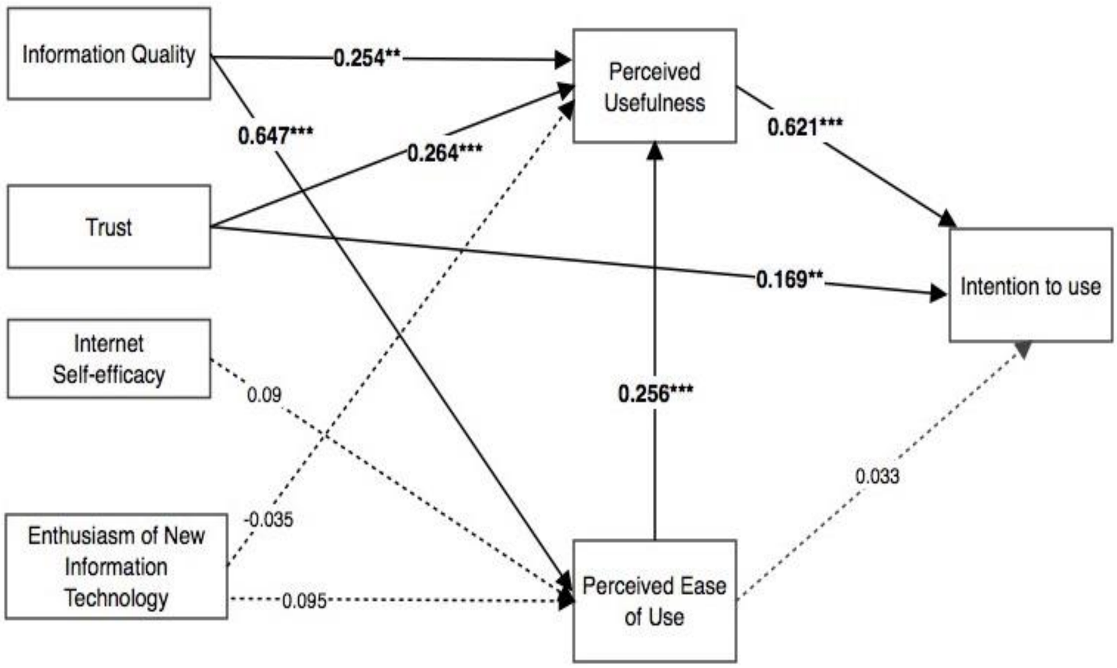

Figure 20. Results of SEM analysis for Germany sample group

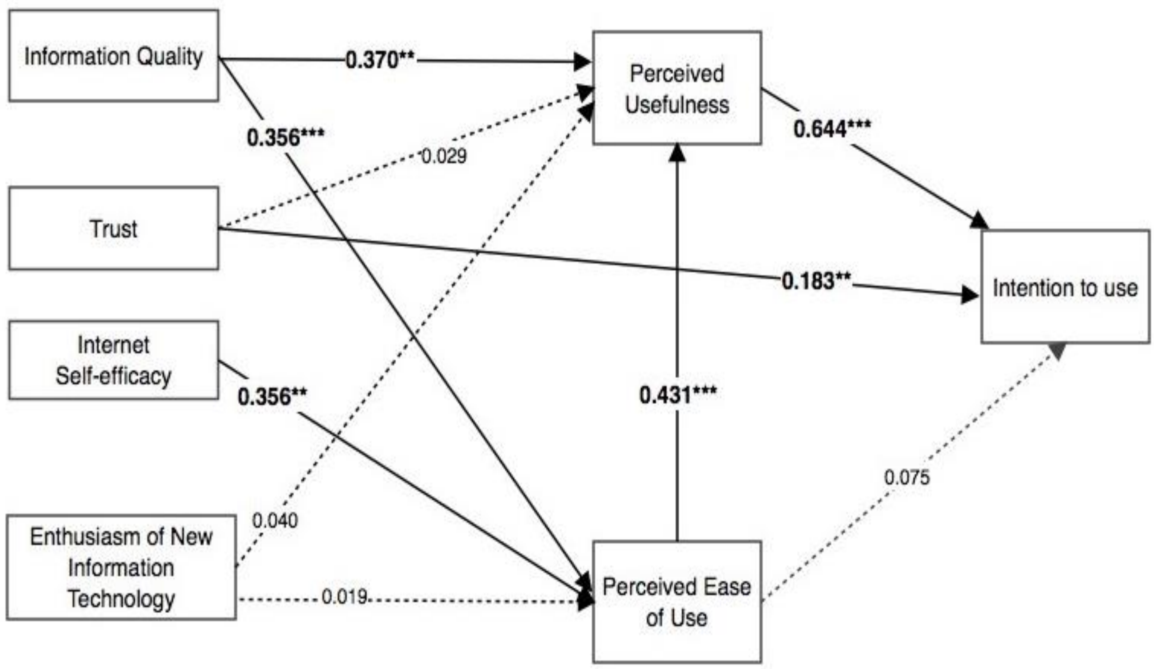

Figure 21. Results of SEM analysis for Chinese sample group

Indirect and mediation effects analysis

The results of all indirect effects and mediation effects are listed in Table 31. The results show that PU fully mediates the relationship between PEOU and IU in both groups. PU has a partial mediation effect between TRUST and IU in the German sample group. PEOU partially mediates the relationship between IQ and PU in both sample groups.

Table 31. Results of indirect and mediation effect analysis

Path		Estimates	S.E.	P Values	Indirect effect	IV->DV support	Mediation Effect
PEOU -> PU -> IU	GER	0.158	0.047	0.001***	Yes	No	Full
	CHN	0.277	0.061	0.000***	Yes	No	Full
IQ -> PU -> IU	GER	0.159	0.062	0.012*	Yes	-	-
	CHN	0.240	0.072	0.001**	Yes	-	-
IQ -> PEOU -> IU	GER	0.022	0.038	0.562	No	-	No
	CHN	0.030	0.029	0.384	No	-	No
IQ -> PEOU -> PU	GER	0.165	0.051	0.001***	Yes	Yes	partial
	CHN	0.153	0.050	0.003**	Yes	Yes	partial
TRUST -> PU -> IU	GER	0.164	0.046	0.000**	Yes	Yes	partial
	CHN	-0.018	0.062	0.813	No	-	No
ISE -> PEOU -> UI	GER	0.003	0.007	0.656	No	-	No
	CHN	0.023	0.025	0.265	No	-	No
ISE -> PEOU -> PU	GER	0.022	0.017	0.188	No	-	No
	CHN	0.154	0.060	0.010*	Yes	-	partial
ENIT -> PU -> IU	GER	0.043	0.034	0.224	No	-	No
	CHN	0.026	.045	0.569	No	-	No
ENIT -> PEOU -> IU	GER	-0.022	0.034	0.506	No	-	No
	CHN	0.018	0.058	0.694	No	-	No

Note: GER = Germany, CHN = China. PU = Perceived Usefulness. *** $p<0.001$. ** $p<0.01$. * $p<0.05$

To sum up, IU is influenced by PU and Trust in both groups. PEOU does not have a direct influence on IU in neither sample group. PU is influenced by PEOU, IQ, and Trust in the German sample group. For the Chinese sample group, PU is only influenced by PEOU and IQ. PEOU is only influenced by IQ in the German sample group. For the Chinese sample group, PEOU is influenced by both IQ and ISE. Country moderates the effects of IQ on PEOU and ISE on PEOU.

9.3 Testing Extended TAM via artificial neural network approach

9.3.1 Proposed ANN models

Based on the results from the SEM method, the artificial neural network (ANN) retests the relationships with a non-linear approach. Four ANN models for Germany and China sample groups are formulated (see Figure 22-25), and the hypotheses are listed below. Each ANN model contains three layers: input layer, hidden layer, and output layer. The hidden layer is chosen with five nodes. MPU, MPEOU, MIQ, MISE are mean values of PU, PEOU, IQ, ISE. They are used as input and output data in the models. The Sigmoid function is used both for the hidden layer and the output layer as an activation function. Data are divided into the training set and test set with a ratio of 70/30.

H4.1: IU is influenced by PU and Trust (Germany and China)
H4.2: PU is influenced by PEOU, IQ and Trust (Germany)
H4.3: PU is influenced by PEOU and IQ (China)
H4.4: PEOU is influenced by IQ and ISE (China)

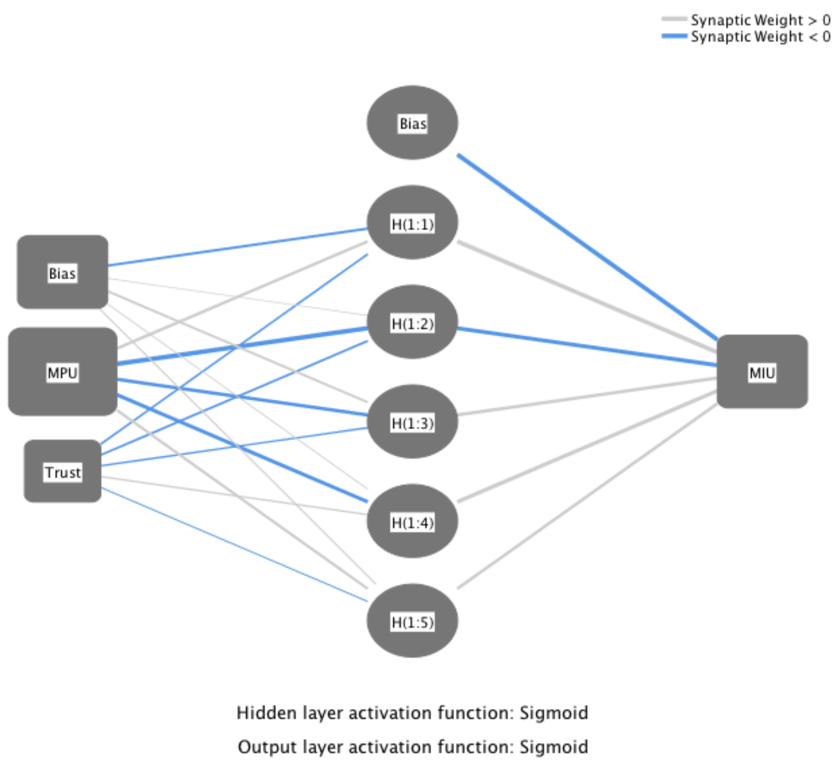

Figure 22. Model 4.1- IU is influenced by PU and Trust (Germany and China)

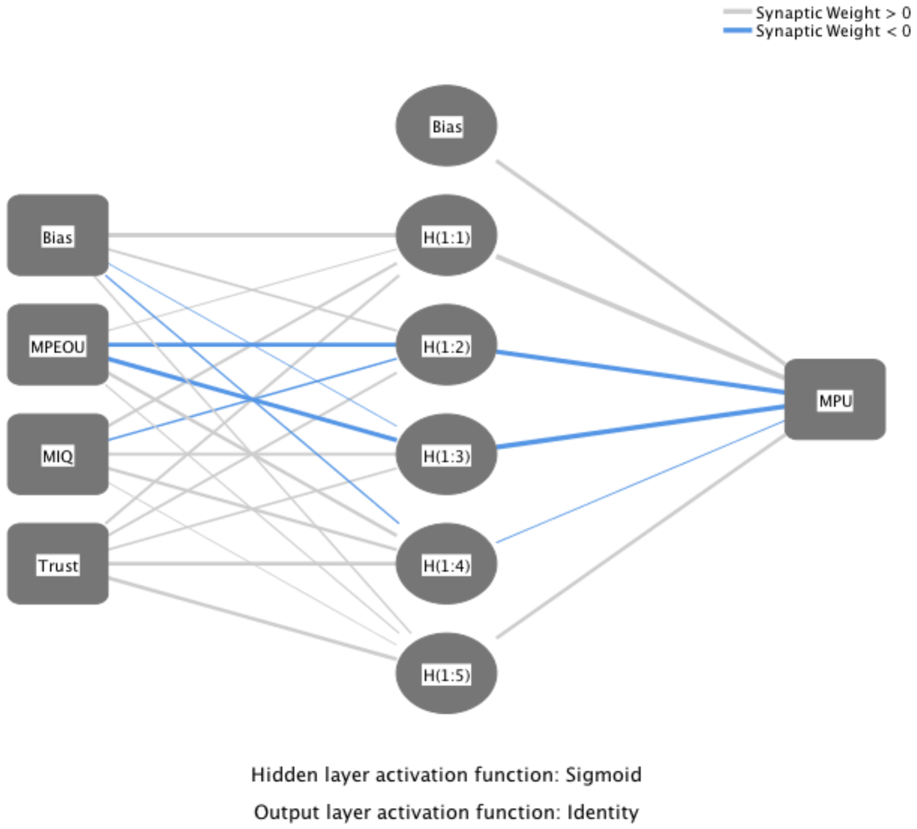

Figure 23. Model 4.2- PU is influenced by PEOU, IQ and Trust (Germany)

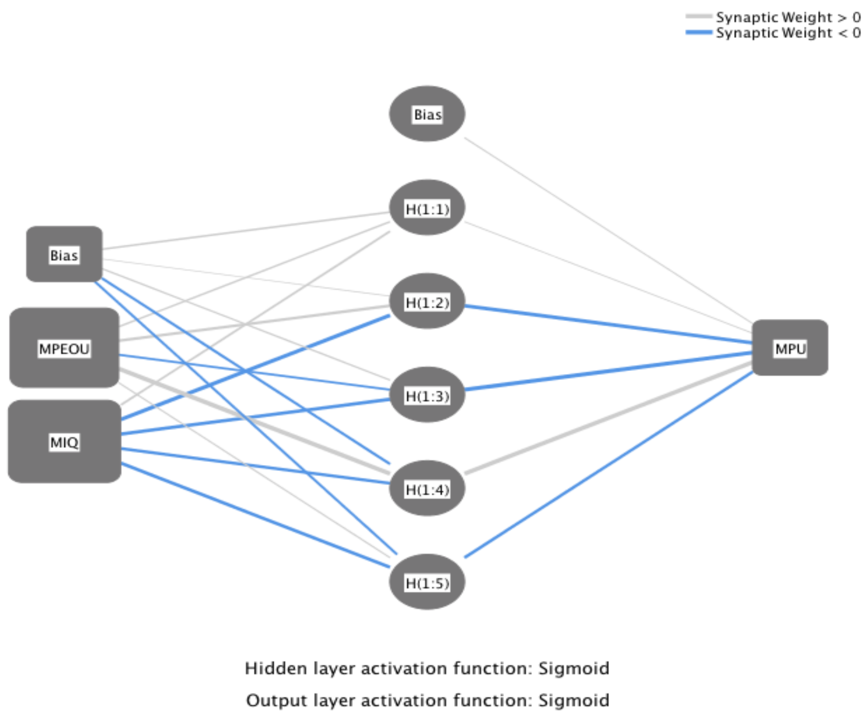

Figure 24. Model 4.3 - PU is influenced by PEOU and IQ(China)

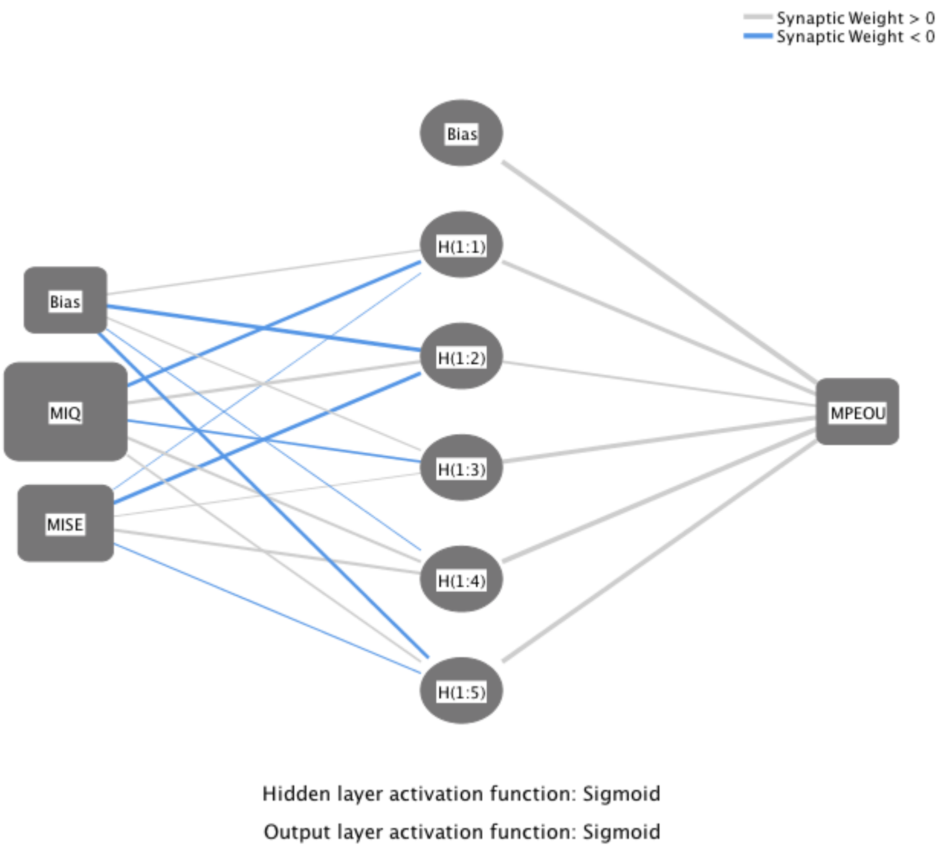

Figure 25. Model 4.4 – PEOU is influenced by IQ and ISE (China)

9.3.2 ANN analysis results

Root Mean Square Error (RMSE) from 10 networks was used to examine the accuracy of the model. For model 4.1 and model 4.2, the mean value of RMSE values for the training set is 0.086 and 0.0716, respectively, and the test set is 0.0174 and 0.0391 (Table 32). The result indicates both model 4.1 and model 4.2 are reliable. In the sensitivity analysis, the normalized importance of each input is used for displaying how strongly each input affects the output unit. The results confirm the results from SEM for the German samples (Table 33).

Similarly, ANN model 4.1, model 4.3, and model 4.4 were applied to the data from the Chinese sample group. The mean value of ten networks RMSE of each model in the training set ranges from 0.0620 to 0.1339, and in the test set ranges from 0.0123 to 0.1356 (Table 34), indicating all models for the Chinese sample group are reliable. The sensitive analysis results confirm the results from SEM for the Chinese sample group as well (Table 35).

Table 32. RMSE values of ANN for German sample group

Network	model 4.1 input units: **PU** and **TRUST**; output units: **IU**			model 4.2 Input units: **PEOU**, **IQ, TRUST**; output units: **PU**	
	Training	test		Training	test
1	0.0925	0.0243		0.0635	0.1191
2	0.0830	0.0650		0.0885	0.0451
3	0.0875	0.0682		0.0584	0.1083
4	0.0823	0.0728		0.0918	0.0589
5	0.0830	0.0606		0.0724	0.0617
6	0.0866	0.0300		0.0461	0.1347
7	0.0846	0.0650		0.0754	0.0586
8	0.0766	0.0534		0.0848	0.0572
9	0.0847	0.0503		0.0571	0.1021
10	0.0995	0.0836		0.0773	0.0079
Mean	0.0860	0.0574		0.0716	0.0753
Standard deviation	0.0062	0.0174		0.0150	0.0391

Table 33. Sensitivity analysis: normalized importance of German sample

Network	model 4.1 Importance (%)			model 4.2 Importance (%)		
	PU	Trust		PEOU	IQ	TRUST
1	0.622	0.378		0.862	0.0645	0.072
2	0.658	0.342		0.818	0.152	0.030
3	0.729	0.271		0.759	0.172	0.069
4	0.647	0.353		0.526	0.454	0.019
5	0.703	0.297		0.620	0.275	0.104
6	0.655	0.345		0.731	0.140	0.128
7	0.587	0.413		0.697	0.174	0.129
8	0.556	0.444		0.795	0.180	0.024
9	0.639	0.361		0.739	0.184	0.076
10	0.896	0.104		0.785	0.157	0.058
Average importance (%)	66.9	33.1		0.733	0.196	0.071
normalized importance (%)	100	49.4		100	26.739	9.686

Table 34. RMSE values of ANN for Chinese sample group

Network	model 4.1: input units: PU and trust; output units: IU			model 4.3: Input units: PEOU, IQ; Output: PU			model 4.4: Input units: IQ and ISE Output: PEOU	
	training	test		training	test		training	test
1	0.110	0.0828		0.1402	0.1205		0.0629	0.0140
2	0.119	0.1103		0.1245	0.1469		0.0646	0.0160
3	0.108	0.1202		0.1486	0.1404		0.0627	0.0101
4	0.120	0.0800		0.1531	0.1407		0.0640	0.0127
5	0.112	0.1094		0.1554	0.1523		0.0628	0.0153
6	0.114	0.1061		0.1533	0.1520		0.0625	0.0119
7	0.108	0.1176		0.1291	0.1203		0.0593	0.0106
8	0.121	0.1010		0.1307	0.1252		0.0576	0.0105
9	0.118	0.1000		0.1261	0.1230		0.0661	0.0107
10	0.107	0.1184		0.1192	0.1348		0.0615	0.0115
Mean	0.113	0.1046		0.1380	0.1356		0.0620	0.0123
Standard deviation	0.005	0.0140		0.0137	0.0127		0.0024	0.0021

Table 35. Sensitivity analysis: normalized importance of Chinese sample group

Network		model 1 Importance (%)			model 2 Importance (%)			model 3 Importance (%)	
		PU	Trust		PEOU	IQ		IQ	ISE
1		0.896	0.104		0.515	0.485		0.588	0.412
2		0.936	0.064		0.518	0.482		0.561	0.439
3		0.915	0.085		0.532	0.468		0.504	0.496
4		0.888	0.112		0.533	0.467		0.540	0.460
5		0.887	0.113		0.574	0.462		0.551	0.449
6		0.943	0.057		0.505	0.495		0.799	0.201
7		0.929	0.071		0.489	0.511		0.502	0.498
8		0.958	0.042		0.612	0.388		0.587	0.413
9		0.891	0.109		0.554	0.446		0.517	0.483
10		0.936	0.064		0.459	0.541		0.752	0.248
Mean		0.917	0.082		0.5291	0.474		0.590	0.409
normalized importance		100	8.9		100	89.7		100	69.5

10. Discussion

In this chapter, the main findings from previous chapters are discussed, corresponding implications from the results are also presented.

10.1 Flood risk perception

10.1.1 Results of flood risk perception analysis

In model 1.1, the findings suggest a significant difference regarding flood risk perception between Germany and China among emergency response volunteers. Specifically, German volunteers perceive a higher likelihood and greater ability to control the adverse consequence and have more knowledge of mitigation actions than volunteers from China. Meanwhile, Chinese volunteers show more significant worry about floods, including financial loss and threat to life caused by floods in the future. Such difference between the two counties shows that objective flood risk (location) has an influence on flood risk perception, which is consistent with previous studies (Botzen et al., 2009; Kellens et al., 2011). As introduced in chapter 2, the study area of Guangdong province, China, has higher physical exposure to flood hazards caused by typhoons, coastal floods, and urban floods than Baden-Württemberg, Germany. Such differences in objective flood risk can also be viewed on FM global flood map. The map displays that Guangdong province is more widely marked as moderate to a high level of flood hazard. Meanwhile, in Baden-Württemberg, most areas are covered with low-level exposure to flood hazards. Only regions near rivers and lakes are covered with high and moderate hazard levels.

Among demographic factors and residence factors, only one demographic factor is found to have an influence on flood risk perception. Volunteers with children in households perceive a greater likelihood that floods will happen in their areas in the future.

Using multiple regression analysis, the result of model 1.2 shows that two previous experience variables affect flood risk perception. Practical experience, as the most important experience variable, shows a strong positive effect on perceived likelihood, able to control loss, and a weak positive influence on knowledge of mitigation actions. This is due to that more previous operations in flood emergency response could enhance volunteers' knowledge and skills in dealing with flood situations. This result is in line with the study of Prati et al. (2013), which suggested that the practical experience is an important factor of risk perception among firefighters. Previous economic loss from floods has a positive influence on worry about floods, including both financial loss and threat to life. This finding is empirically supported by several studies (Barnett & Breakwell, 2001; Grothmann & Reusswig, 2006). With bootstrapping technique, it is found that practical experience partially mediates the effect of location on perceived likelihood, worry about the threat to life, and perceived control of loss. Besides, practical experience fully mediates the effect of location on knowledge about flood mitigation actions, showing the importance of the operational experience for emergency response volunteers.

The result of model 1.3 suggests that training is positively related to the perceived likelihood of flood and knowledge about mitigation actions of volunteers. This finding indicates that high-quality and sufficient training help to improve the perceived self-efficacy of the volunteers in the flood response operation. This is in line with the previous studies (Neal & Griffin, 2009; Prati et al., 2013), which indicate that training is part of psychological safety climate. The moderation effects testing result shows that the relationships of training and each risk perception characteristic are not significantly different between the two sample groups.

Findings from model 1.4 indicate that higher trust in the government's strategies of mitigating flood risk can lead to a lower perceived likelihood that flood will occur in the future. This finding is aligned with studies that proposed trust in governments affects flood risk perception (Bradford et al., 2012; Heitz et al., 2009; Wachinger et al., 2013).

10.1.2 Implication from flood risk perception analysis

Data analysis results show that previous flood experience, training, and trust in the authorities are the most important factors influencing flood risk perception among emergency response volunteers. Therefore, sufficient training and drills are necessary to protect the volunteers from harm and improve their operational capacity during emergency response. Activities to promote practical experience sharing among the volunteers are also recommended as they could help improve volunteers' understanding of the local flood risk. In addition, as trust in the authorities also plays a role in affecting perceived flood risk, the authorities are suggested to perform proper communication with the public about their strategies and plans regarding flood protection and mitigation. Such suggestion is especially for Guangdong province as the trust in government shows lower level than in Baden-Württemberg, Germany.

10.2 Climate change perceptions and flood risk perception

10.2.1 Results of climate change perceptions related to flood experience and risk perception

Proposed models 2.1 and 2.2 were tested in this study to examine the hypotheses of the relationships among flood experience, perceived impact of climate change on flood risk, and climate change perceptions.

By using multiple regression and bootstrapping methods, the results from model 2.1 show that a higher level of perceived flood risk leads to a stronger belief that climate change impacts flood risk. In addition, economic loss from previous flooding has a significant indirect effect on the perceived impact of climate change on flood risk, and the relationship is fully mediated by perceived flood risk. These findings confirm previous studies that when individuals perceive risk change of a specific climate change-related hazards (e.g., flood, hurricane), they will associate such change with climate change (Kwon et al., 2019; Reser et al., 2012).

With the results from model 2.2, differences are found regarding climate change perceptions between the two countries. Respondents from China reported greater perceived local vulnerability impact, higher uncertainty over climate change, and perceived a stronger effect of their own actions on climate change mitigation. Such difference is partially due to that Guangdong province is a coastal province that is stronger affected by climate change, such as sea-level rise, storm surge, and typhoon, compared to Baden-Württemberg. Therefore, in line with previous studies (Upham et al., 2009, pp. 23-36; Wang & Kim, 2018), the difference in perceived local vulnerability is strongly influenced by local geographic and environmental factors.

The perceived impact of climate change on flood risk is an essential determinant of all three aspects of climate change perceptions. This indicates that the perceived impact of climate change on floods is closely related to the perception of the overall climate change effect in both study areas. Among all the climate change-related events, e.g., heat waves, tropical cyclones, air pollution, the impact on flood are among the most common hazards that are familiar to the public in both study areas. The understating of the impact of climate change on flood risk could help to improve the salience of climate change among the public.

Direct flood experience is found not to have a significant direct or indirect effect on climate change perceptions. While it is inconsistent with many studies, this finding is supported by several other studies (van Valkengoed & Steg, 2019). In addition, age does not have a significant influence on climate change perceptions.

Among climate change perceptions, higher perceived uncertainty of climate change leads to lower perceived local vulnerability. Greater perceived local vulnerability leads to a higher belief that an individual's action can contribute to climate change mitigation. Perceived local vulnerability mediates the indirect effect between uncertainty over climate change on the perceived effect of climate change mitigation action.

Model 2.2 shows a low ability to explain the variance of the three climate change perceptions. It accounts for 10.9% of the variance of uncertainty over climate change, 27.3% of the variance of perceived local vulnerability, and 25.9% of the variance of the perceived effect of climate change mitigation actions. Two reasons could be attributed to this result.

Firstly, in this study, as the primary goal focuses only on the impact of climate change on flood risk, other climate change-related events, such as temperature anomalies, air quality, and typhoons, are not included in the model to predict climate change perceptions.

Secondly, many studies have suggested that several individual characteristics, which are not included in the research model in this study, are important determinants of climate change beliefs. These factors are environmental value (Corbett & Durfee, 2004), political view (Dunlap & McCright, 2008; Whitmarsh, 2011), world view (Hulme, 2009, pp. 109–

141; Kahan et al., 2011), and others. Besides, studies also proposed that media is an influential factor in the perception of climate change risk as it affects the information source related to climate change. This impact is especially stressed on perceived uncertainty over climate change (Antilla, 2005; Poortinga et al., 2011; Whitmarsh, 2011).

10.2.2 Implication from climate change perception analysis

This study extends the empirical climate change research by exploring the relationship between flood risk perception and climate change perceptions in Germany and China.

As the perceived impact of climate change on flood risk is closely related to the perceived local vulnerability, strategies of climate change risk communication with the public are recommended to highlight the specific effects caused by climate change to enhance awareness at the local level. Besides, flood risk communication with the public is also suggested to integrate the impact of climate change on flood risk.

10.3 Flood hazard and risk maps acceptance

10.3.1 Results of flood maps acceptance intention analysis

A proposed extended Technology Acceptance Model (TAM) is tested with the SEM-ANN approach to investigate the flood maps acceptance behaviors. Besides, multigroup analysis is conducted to investigate the moderation effect of the country. The external constructs for the TAM are information quality, trust in information, Internet self-efficacy, and Enthusiasm of new information technology.

The proposed TAM model accounts for 54.7% of the variance of Intention to Use (IU) for the German sample group and 63.5% of the variance for the Chinese sample group, showing a strong ability to predict the acceptance intention.

The findings show that Perceived Usefulness (PU) is an essential predictor of Intention to use flood maps in both sample groups. This is proposed by the origin TAM and has been empirically tested in different fields (Davis, 1989; Venkatesh, 2000; Venkatesh & Davis, 2000). This relationship in the German sample group is stronger than in the Chinese sample group. Meanwhile, Perceived Ease to Use (PEOU) is found to affect

Perceived Usefulness strongly. It is also found that PEOU only has an indirect effect on Intention to Use, and such indirect effect is fully mediated by Perceived Usefulness. This is in line with studies that also show PEOU has a slight effect on the intention to adopt new technology (Venkatesh, 2000; Venkatesh & Davis, 2000). Compared to other technology, online maps mainly function as an information tool to provide intuitive visualized hazard and risk information, which usually do not require complex operations from users. Perceived usefulness hence plays a more critical role than perceived ease of use on intention to use maps.

Information quality (IQ) is found to be a significant predictor of PU and PEOU in both sample groups. Such findings are also supported by previous studies (Moores, 2012; Wixom & Todd, 2005). As an information tool that aims to visualize and present information, the quality of information is undoubtedly critical for users when perceiving the usefulness of maps. It suggests that more accurate and intuitive information will help to improve the acceptance of flood maps for users.

Besides, higher trust in information also leads to greater perceived usefulness in Germany. This relationship is not supported in China. One explanation of the difference between the two groups is partially due to that the map is provided by an institute under state authorities in Germany. Meanwhile, the map used in China was created by a commercial insurance company for this study.

Internet self-efficacy (ISE) is found to be an antecedent factor of perceived ease of use in the sample group from China but not from Germany. Moreover, ISE has an indirect effect on Perceived usefulness in the Chinese sample group, and such effect is partially mediated by PEOU. In addition, Enthusiasm of new information technology (ENIT) does not have a significant influence on perceived usefulness in neither country.

10.3.2 Implication from flood maps acceptance analysis

As mentioned in chapter 5, currently, there is still a lack of user-centered studies about acceptance of flood hazard and risk maps in both Germany and China, particularly with a quantitative method. This study narrows this gap by applying extended TAM with cross-nation studies.

Theoretical Implication

This study improves the capacities of original TAM in predicting adoption behavior intention by incorporating four external factors: Trust in information, Information Quality, Internet-Efficacy and Enthusiasm of new information technology. Although focusing on flood maps adoption, the findings from this study could also benefit other similar hazard and risk maps adoption research. Therefore, this study also extends the TAM application in the field of hazard and risk maps.

Practical implication

This thesis provides several suggestions for developers to improve the acceptance of hazard and risk maps by potential users.

As perceived usefulness is confirmed as the most important factor in predicting the acceptance behavior in this study, this emphasizes the integration of various user groups' requirements when developing hazard and risk maps. The effect of perceived ease of use on adoption intention is mediated by Perceived Usefulness, indicating the necessity to keep the maps easy to operate for finding targeted information for users.

Trust in the information provided on maps also plays an important role in predicting both Use Intention and Perceived Usefulness. In order to increase trust in information, the mechanism and data source for assessing hazard and risk levels needs to be clearly explained on the online map platform.

Attention should also be given to Information Quality, as it affects both Perceived Usefulness and Perceived Ease of Use of the maps. The information presented in the map needs to be easy to understand and with high accuracy. Especially when certain scientific terms are used to describe the risk level in the map, users' interpretation and understanding of these terms should be taken into account.

Besides, the collected data shows that more than 60% of Chinese respondents visited the flood map from mobile devices. Some connection and map rendering problems are reported by respondents. Therefore, an improvement for a more mobile user-friendly interactive interface of the map is suggested for map developers.

10.4 Limitation and outlook of the study

Several limitations of this study need to be acknowledged.

The representativeness of the samples used for data analysis in this study is limited in three aspects.

Firstly, the study areas only cover the state of Baden-Württemberg for Germany and Guangdong province for China. Due to the spatial variation of geographic and social-economic conditions within both countries, the samples should not be regarded as representative of the whole population of emergency response volunteers in both countries.

Secondly, the respondents are not fully representative of a wide range of volunteers organizations in both countries. In Germany, only volunteer firefighters were invited to participate in the survey. In Guangdong province, among all the organizations that have been contacted, only a part of them have distributed the questionnaire among their members.

Thirdly, the percentage of female participants of the German respondents is lower than the rate of female volunteer firefighters in Baden-Württemberg. Therefore, future work is suggested to sample volunteers from more regions and various organizations, such as Technisches Hilfswerk (THW) and Red Cross in both countries.

For the climate change topic in this study, the climate change adoption and mitigation behaviors are not included in the research model. Therefore, a future study is suggested to examine the relationship between the intention of climate change mitigation behaviors and perceived flood risk.

For the topic of flood map adoption intention, flood maps used for the two sample groups are provided by different types of developers. Certain differences exist in the mechanism for flood risk and hazard assessment. As a result, the inherent differences within the two flood maps also affect the relationships in the research model. Therefore, the comparison between the two sample groups should be more analyzed in a future similar study.

10.5 Summary of implications for policymaking and flood risk management

In order to improve the operational performance of emergency response, the volunteers are recommended to engage in sufficient training and drills. Besides, as practical experience is a critical factor influencing the flood risk perception, it is suggested to share the experience of flood emergency response among the volunteers via various platforms and activities. Additionally, the authorities are suggested to improve flood risk communication with the public for a better understanding of the flood risk reduction strategy and policies.

Based on the analysis results from flood risk perception and climate change perceptions among the emergency response volunteers, an emphasis on climate change's impacts on local flood risk could be an important topic to address in climate change risk communication for both Germany and China.

In addition, several suggestions are provided to promote the acceptance of flood hazard and risk maps. The flood maps developers should take the user requirements as an essential element in developing the maps. Besides, the mechanism and data source for assessing hazard and risk levels should be clearly explained to users to increase trust in information. Furthermore, to improve the understanding of flood and risk maps, the information presented in the map needs to be easy to understand and with high accuracy.

11. Conclusion

Emergency response volunteers play an indispensable role in emergency rescue and relief work. However, few studies on perceived risks of emergency response volunteers have been conducted. This study provides insights to ERV regarding flood risk in three different aspects: flood risk perception, perception of climate change impacts on flood risk, and intention to accept flood hazard and risk maps.

Firstly, flood risk perception analysis results show the difference between the two countries. German volunteers perceive a higher likelihood of flood and a greater ability to control loss as well as more mitigation knowledge. Chinese volunteers show greater worry about the adverse consequence of the flood. Moreover, both practical experience and previous financial loss are important predictors of the risk perception of volunteers. In addition, received training regarding flood emergency response and trust in authorities also influence flood risk perception. The results suggest that sufficient training and drills and experience-sharing of previous emergency operations among volunteers can help to improve their understandings of flood risk.

Secondly, the perceived impact of climate change on flood risk is influenced by perceived flood risk among volunteers. In addition, the perceived flood risk level fully mediates the indirect effect between economic loss from previous floods and the perceived impact of climate change on flood risk.

In terms of climate change perceptions, Chinese volunteers perceived more significant local vulnerability to climate change, higher uncertainty over climate change, and stronger effect of climate change mitigation actions. These three aspects of climate change perceptions are influenced by the perceived impact of climate change on flood risk. Results from the findings suggest that stressing the impact of climate change on flood risk could help to enhance climate change awareness of the public in both Germany and China.

Lastly, the intention to accept flood hazard and risk maps was examined by applying an extended technology acceptance model. The extended TAM model can explain 64% of the variance of the intention to accept flood maps in Germany and 55% in China. The findings indicate that the perceived usefulness is the key factor of intention to accept flood maps in both countries. The relationship between perceived ease of use and intention to accept maps is fully mediated by perceived usefulness. Besides, among the external factors proposed in the model, information quality is an important factor affecting both perceived usefulness and perceived ease of use. Furthermore, trust in information provided on the flood maps also affects the intention to accept flood maps in both Germany and China. Trust in information also affects the perceived usefulness in Germany. In addition, higher Internet self-efficacy is found to lead to greater perceived ease of use in China.

In order to improve the flood maps acceptance intention by users, suggestions are made for flood maps developers to integrate various user groups' requirements for developing maps. Besides, it is necessary to keep the maps easy to operate, and the terms used on the maps to describe the hazard and risk information should be easy for users to understand. To increase users' trust in information, the mechanism and data source for assessing hazard and risk level should be clearly explained.

Bibliography

Agarwal, R., & Prasad, J. (1997). The role of innovation characteristics and perceived voluntariness in the acceptance of information technologies. *Decision Sciences*, *28*(3), 557–582. https://doi.org/10.1111/j.1540-5915.1997.tb01322.x

Ahmed, M. A., Haynes, K., Tofa, M., Hope, G., & Taylor, M. (2020). Duty or safety? Exploring emergency service personnel's perceptions of risk and decision-making when driving through floodwater. *Progress in Disaster Science*, *5*, 100068. https://doi.org/10.1016/j.pdisas.2020.100068

AIR. (2012, August 23). *Ten Years after the Elbe Floods: Putting Lessons Learned Toward the Development of a Detailed Flood Model*. Retrieved January 01, 2021, from https://www.air-worldwide.com/publications/air-currents/2012/Ten-Years-after-the-Elbe-Floods--Putting-Lessons-Learned-Toward-the-Development-of-a-Detailed-Flood-Model/

AIR. (2018, July 9). *Why the Central European Floods of 2013 Were So Devastating*. Retrieved January 01, 2021, from https://www.air-worldwide.com/blog/posts/2018/7/why-the-central-european-floods-of-2013-were-so-devastating/

Ajzen, I. (1985). From Intentions to Actions: A Theory of Planned Behavior. In *Action control* (pp. 11-39). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69746-3_2

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Akerlof, K., Maibach, E. W., Fitzgerald, D., Cedeno, A. Y., & Neuman, A. (2013). Do people "personally experience" global warming, and if so how, and does it matter? *Global Environmental Change*, *23*(1), 81–91. https://doi.org/10.1016/j.gloenvcha.2012.07.006

Alfieri, L., Burek, P., Feyen, L., & Forzieri, G. (2015). Global warming increases the frequency of river floods in Europe. *Hydrol. Earth Syst. Sci*, *19*, 2247–2260. https://doi.org/10.5194/hess-19-2247-2015

Aminizade, M., Nekouei Moghaddam, M., Birami Jam, M., Shamsi, M., Majidi, N., Amanat, N., & Hoseini, S. H. (2017). The Role of Volunteer Citizens in Response to Accidents and Disasters. *Health in Emergencies and Disasters Quarterly*, *2*(3), 107–124. https://doi.org/10.18869/nrip.hdq.2.3.107

Antilla, L. (2005). Climate of scepticism: US newspaper coverage of the science of climate change. *Global Environmental Change*, *15*(4), 338–352. https://doi.org/10.1016/j.gloenvcha.2005.08.003

Armitage, C. J., & Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta-analytic review. *British Journal of Social Psychology*, *40*(4), 471–499. https://doi.org/10.1348/014466601164939

Asadi, S., Abdullah, R., Safaei, M., & Nazir, S. (2019). An Integrated SEM-Neural Network Approach for Predicting Determinants of Adoption of Wearable Healthcare Devices. *Mobile Information Systems, 2019.* https://doi.org/10.1155/2019/8026042

Aven, T., Renn, O., Aven, T., & Renn, O. (2010). Introduction: Concept of Risk. In *Risk Management and Governance* (pp. 1–15). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-13926-0_1

Babin, B. J., Hair, J. F., & Boles, J. S. (2008). Publishing research in marketing journals using structural equation modeling. *Journal of Marketing Theory and Practice*, *16*(4), 279–286. https://doi.org/10.2753/MTP1069-6679160401

Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the Academy of Marketing Science*, *16*(1), 74–94. https://doi.org/10.1007/BF02723327

Bandura, A. (1978). Self-efficacy: Toward a unifying theory of behavioral change. *Advances in Behaviour Research and Therapy*, *1*(4), 139–161. https://doi.org/10.1016/0146-6402(78)90002-4

Barnett, J., & Breakwell, G. M. (2001). Risk Perception and Experience: Hazard Personality Profiles and Individual Differences. *Risk Analysis*, *21*(1), 171–178. https://doi.org/10.1111/0272-4332.211099

Becker, G., Aerts, J. C. J. H., & Huitema, D. (2014). Influence of flood risk perception and other factors on risk-reducing behaviour: a survey of municipalities along the Rhine. *Journal of Flood Risk Management*, *7*(1), 16–30. https://doi.org/10.1111/jfr3.12025

Beldad, A., & Citra Kusumadewi, M. (2015). Here's my location, for your information: The impact of trust, benefits, and social influence on location sharing application use among Indonesian university students. *Computers in Human Behavior*, *49*, 102–110. https://doi.org/10.1016/j.chb.2015.02.047

Bi, J., Young, O. R., Costanza, R., Liu, L., Kasperson, R., Qi, Y., Guttman, D., Jiang, K., Mazmanian, D., Zhang, S., Zhang, J., Osherenko, G., Percival, R., Zhang, B., Wang, H., He, P., & Liu, M. (2014). Same dream, different beds: Can America and China take effective steps to solve the climate problem? *Global Environmental Change, 24*, 2-4. https://doi.org/10.1016/j.gloenvcha.2013.11.015

Birkmann, J., Cardona, O. D., Carreño, M. L., Barbat, A. H., Pelling, M., Schneiderbauer, S., Kienberger, S., Keiler, M., Alexander, D., Zeil, P., & Welle, T. (2013). Framing vulnerability, risk and societal responses: The MOVE framework. *Natural Hazards*, *67*(2), 193–211. https://doi.org/10.1007/s11069-013-0558-5

BLUE SKY RESCUE. (n.d.). *BLUE SKY RESCUE 蓝天救援队官网.* Retrieved March 01, 2021, from http://www.bsr.net.cn/

BMI. (n.d.). *BMI - Volunteering in civil protection*. Retrieved March 11, 2021, from https://www.bmi.bund.de/EN/topics/civil-protection/volunteering/volunteering-node.html

BMU. (n.d.-a). *Climate Action Plan 2050 – Germany's long-term low greenhouse gas emission development strategy*. Retrieved February 18, 2021, from https://www.bmuv.de/en/topics/climate-adaptation/climate-protection/national-climate-policy/climate-action-plan-2050-germanys-long-term-low-greenhouse-gas-emission-development-strategy

BMU. (n.d.-b). *Water protection policy in Germany*. Retrieved March 13, 2021, from https://www.bmuv.de/en/topics/water-resources-waste/water-management/policy-goals-and-instruments/water-protection-policy-in-germany

Boholm, Å. (1998). Comparative studies of risk perception: A review of twenty years of research. *Journal of Risk Research*, *1*(2), 135–163. https://doi.org/10.1080/136698798377231

Bostrom, A. (1997). Risk Perception: "Experts" vs. "Lay People." *Duke Environmental Law & Policy Forum*, *8*(1). https://scholarship.law.duke.edu/delpf/vol8/iss1/8

Botzen, W. J. W., Aerts, J. C. J. H., & van den Bergh, J. C. J. M. (2009). Dependence of flood risk perceptions on socioeconomic and objective risk factors. *Water Resources Research*, *45*(10), 10440. https://doi.org/10.1029/2009WR007743

Bradford, R. A., O'Sullivan, J. J., van der Craats, I. M., Krywkow, J., Rotko, P., Aaltonen, J., Bonaiuto, M., de Dominicis, S., Waylen, K., & Schelfaut, K. (2012). Risk perception - Issues for flood management in Europe. *Natural Hazards and Earth System Science*, *12*(7), 2299–2309. https://doi.org/10.5194/nhess-12-2299-2012

Brewer, N. T., Chapman, G. B., Gibbons, F. X., Gerrard, M., McCaul, K. D., & Weinstein, N. D. (2007). Meta-analysis of the relationship between risk perception and health behavior: The example of vaccination. *Health Psychology*, *26*(2), 136–145. https://doi.org/10.1037/0278-6133.26.2.136

Brilly, M., & Polic, M. (2005). Public perception of flood risks, flood forecasting and mitigation. *Natural Hazards and Earth System Science*, *5*(3), 345–355. https://doi.org/10.5194/nhess-5-345-2005

Brody, S. D., Zahran, S., Vedlitz, A., & Grover, H. (2008). Examining the Relationship Between Physical Vulnerability and Public Perceptions of Global Climate Change in the United States. *Environment and Behavior*, *40*(1), 72–95. https://doi.org/10.1177/0013916506298800

Brown, J. D., & Damery, S. L. (2002). Managing flood risk in the UK: towards an integration of social and technical perspectives. *Transactions of the Institute of British Geographers*, *27*(4), 412–426. https://doi.org/10.1111/1475-5661.00063

Brzoska, M., & Fröhlich, C. (2016). Climate change, migration and violent conflict: vulnerabilities, pathways and adaptation strategies. *Migration and Development*, *5*(2), 190–210. https://doi.org/10.1080/21632324.2015.1022973

Bubeck, P., Botzen, W. J. W., & Aerts, J. C. J. H. (2012). A Review of Risk Perceptions and Other Factors that Influence Flood Mitigation Behavior. *Risk Analysis*, *32*(9), 1481–1495. https://doi.org/10.1111/j.1539-6924.2011.01783.x

Buchecker, M., Salvini, G., di Baldassarre, G., Semenzin, E., Maidl, E., & Marcomini, A. (2013). The role of risk perception in making flood risk management more effective. *Natural Hazards and Earth System Sciences*. https://doi.org/10.5194/nhess-13-3013-2013

Carlton, S. J., & Jacobson, S. K. (2013). Climate change and coastal environmental risk perceptions in Florida. *Journal of Environmental Management*, *130*, 32–39. https://doi.org/10.1016/j.jenvman.2013.08.038

Chau, P. Y. K. (2001). Influence of computer attitude and self-efficacy on IT usage behavior. *Journal of End User Computing*, *13*(1), 26–33. https://doi.org/10.4018/joeuc.2001010103

Chen, C., Czerwinski, M., & Macredie, R. (2000). Individual differences in virtual environments? Introduction and overview. *Journal of the American Society for Information Science*, *51*(6), 499–507. https://doi.org/10.1002/(SICI)1097-4571(2000)51:6<499::AID-ASI2>3.0.CO;2-K

Cheng, X. (2020). *Flood Risk and Flood Management Policies in China* (pp. 49–65). Springer, Singapore. https://doi.org/10.1007/978-981-13-9660-1_6

Chiang, W. Y. K., Zhang, D., & Zhou, L. (2006). Predicting and explaining patronage behavior toward web and traditional stores using neural networks: a comparative analysis with logistic regression. *Decision Support Systems, 41*(2), 514-531. https://doi.org/10.1016/j.dss.2004.08.016

Chin, W. W. (2000). *Partial Least Squares for Researchers: An overview and presentation of recent advances using the PLS approach*. https://pdfs.semanticscholar.org/8e84/bce5ea24612e985742402779c438d11b6439.pdf

China Center for Climate Change Communication. (2017). *Climate Change in the Chinese Mind Survey Report 2017.* https://www.efchina.org/Attachments/Report/report-comms-20171108/Climate_Change_in_the_Chinese_Mind_2017.pdf

Chircu, A., Davis, G., & Kauffman, R. (2000). Trust, Expertise, and E-Commerce Intermediary Adoption. *AMCIS 2000 Proceedings*. 405. https://aisel.aisnet.org/amcis2000/405

CNNPC. (1997). *Flood Control Law of the People's Republic of China*. http://www.npc.gov.cn/zgrdw/englishnpc/Law/2007-12/11/content_1383581.htm

Corbett, J. B., & Durfee, J. L. (2004). Testing Public (Un)Certainty of Science. *Science Communication*, *26*(2), 129–151. https://doi.org/10.1177/1075547004270234

CRED&UNDRR. (2015). *The human cost of weather-related disasters 1995-2015*. https://www.preventionweb.net/publication/human-cost-weather-related-disasters-1995-2015

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly: Management Information Systems*, *13*(3), 319–339. https://doi.org/10.2307/249008

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1992). Extrinsic and Intrinsic Motivation to Use Computers in the Workplace. *Journal of Applied Social Psychology*, *22*(14), 1111–1132. https://doi.org/10.1111/j.1559-1816.1992.tb00945.x

Demski, C., Capstick, S., Pidgeon, N., Sposato, R. G., & Spence, A. (2017). Experience of extreme weather affects climate change mitigation and adaptation responses. *Climatic Change*, *140*(2), 149–164. https://doi.org/10.1007/s10584-016-1837-4

DeutscherFeuerwehrVerband. (2019). *Statistik - Feuerwehrverband*. https://www.feuerwehrverband.de/presse/statistik/

Diamantopoulos, A., & Winklhofer, H. M. (2001). Index Construction with Formative Indicators: An Alternative to Scale Development. *Journal of Marketing Research*, *38*(2), 269–277. https://doi.org/10.1509/jmkr.38.2.269.18845

Dishaw, M. T., & Strong, D. M. (1999). Extending the technology acceptance model with task-technology fit constructs. *Information and Management*, *36*(1), 9–21. https://doi.org/10.1016/S0378-7206(98)00101-3

Donner, S. D. (2011). An evaluation of the effect of recent temperature variability on the prediction of coral bleaching events. *Ecological Applications*, *21*(5), 1718–1730. https://doi.org/10.1890/10-0107.1

Dottori, F., Szewczyk, W., Ciscar, J. C., Zhao, F., Alfieri, L., Hirabayashi, Y., Bianchi, A., Mongelli, I., Frieler, K., Betts, R. A., & Feyen, L. (2018). Increased human and economic losses from river flooding with anthropogenic warming. *Nature Climate Change, 8*(9), 781-786. https://doi.org/10.1038/s41558-018-0257-z

Dransch, D., Rotzoll, H., & Poser, K. (2010). The contribution of maps to the challenges of risk communication to the public. *International Journal of Digital Earth, 3*(3), 292-311. https://doi.org/10.1080/17538941003774668

Duncan, O. D. (2014). *Introduction to structural equation models.* Elsevier.

Dunlap, R. E., & McCright, A. M. (2008). A widening gap republican and democratic views on climate change. *Environment*, *50*(5), 26–35. https://doi.org/10.3200/ENVT.50.5.26-35

Efron, B., & Tibshirani, R. J. (1993). An Introduction to the Bootstrap. In *An Introduction to the Bootstrap*. Springer US. https://doi.org/10.1007/978-1-4899-4541-9

Engels, A., Hüther, O., Schäfer, M., & Held, H. (2013). Public climate-change skepticism, energy preferences and political participation. *Global Environmental Change*, *23*(5), 1018–1027. https://doi.org/10.1016/j.gloenvcha.2013.05.008

Englander, T., Farago, K., Slavic, P., & Fischhoff, B. (1986). A comparative analysis of risk perception in Hungary and the United States. *Social Behaviour, 1*(1), 55–66.

ESRI. (n.d.). *GIS in Emergency Management Operations*. Retrieved March 13, 2021, from https://www.esri.com/en-us/industries/emergency-management/overview

EU Floods Directive (2007). Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks. *Official Journal of the European Union*. L 288/27, 6.11.2007.

European Commission, Directorate-General for Climate Action. (2022). *Climate change: report,* Publications Office of the European Union. https://data.europa.eu/doi/10.2834/00469

European Commission, Directorate-General for Environment, Nixon, S. (2016). *EU overview of methodologies used in preparation of flood hazard and flood risk maps: final report,* Publications Office. https://data.europa.eu/doi/10.2779/204606

EXCIMAP. (2007). *Atlas of Flood Maps Examples from 19 European countries, USA and Japan*. https://puc.overheid.nl/rijkswaterstaat/doc/PUC_132557_31/

FEMA. (2013). *Flood Insurance*. Retrieved May 13, 2021, from https://www.fema.gov/flood-insurance

Feuerwehr Verband BW (n.d.). *Werkfeuerwehren.* Retrieved July 13, 2021, from https://www.fwvbw.de/werkfeuerwehren,65.html

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., & Combs, B. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy Sciences*, *9*(2), 127–152. https://doi.org/10.1007/BF00143739

Fishbein, M., & Ajzen, I. (1974). Attitudes towards objects as predictors of single and multiple behavioral criteria. *Psychological Review*, *81*(1), 59–74. https://doi.org/10.1037/h0035872

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behaviour: An introduction to theory and research*. Reading, MA: Addison-Wesley.

Fishbein, M., & Ajzen, I. (2011). *Predicting and changing behavior: The reasoned action approach.* Psychology press.

FM Global. (n.d.). *FM Global Natural Hazards Map*. Retrieved March 13, 2021, from https://www.fmglobal.com/research-and-resources/nathaz-toolkit/flood-map

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, *18*(1), 39–50. https://doi.org/10.1177/002224378101800104

Galib, M. H., Hammou, K. A., & Steiger, J. (2018). Predicting Consumer Behavior: An Extension of Technology Acceptance Model. *International Journal of Marketing Studies*, *10*(3), 73. https://doi.org/10.5539/ijms.v10n3p73

Ge, Y., Xu, W., Gu, Z. H., Zhang, Y. C., & Chen, L. (2011). Risk perception and hazard mitigation in the Yangtze River Delta region, China. *Natural Hazards*, *56*(3), 633–648. https://doi.org/10.1007/s11069-010-9579-5

Gefen, D., Karahanna, E., & Straub, D. W. (2003). Trust and TAM in online shopping: An integrated model. *MIS Quarterly: Management Information Systems*, *27*(1), 51–90. https://doi.org/10.2307/30036519

Globescan. (2015, November 27). *Wealthy Countries Less Concerned about Climate Change: Global Poll*. Retrieved May 03, 2021, from https://globescan.com/wealthy-countries-less-concerned-about-climate-change-global-poll/

Grothmann, T., & Reusswig, F. (2006). People at Risk of Flooding: Why Some Residents Take Precautionary Action While Others do not. *Natural hazards*, *38*(1–2), 101–120. https://doi.org/10.1007/s11069-005-8604-6

Guangdong Bureau of Statistics. (2019). *Guangdong Statistical Yearbook 2019*. http://stats.gd.gov.cn/gdtjnj/content/post_2639622.html

Gunes, A. E., & Kovel, J. P. (2000). Using GIS in Emergency Management Operations. *Journal of Urban Planning and Development*, *126*(3), 136–149. https://doi.org/10.1061/(ASCE)0733-9488(2000)126:3(136)

Haasnoot, M., Kwakkel, J. H., Walker, W. E., & Ter Maat, J. (2013). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. *Global Environmental Change*, *23*(2), 485–498. https://doi.org/10.1016/j.gloenvcha.2012.12.006

Haden, V. R., Niles, M. T., Lubell, M., Perlman, J., & Jackson, L. E. (2012). Global and Local Concerns: What Attitudes and Beliefs Motivate Farmers to Mitigate and Adapt to Climate Change? *PLoS ONE*, *7*(12). https://doi.org/10.1371/journal.pone.0052882

Hagemeier-Klose, M., & Wagner, K. (2009). Evaluation of flood hazard maps in print and web mapping services as information tools in flood risk communication. *Natural Hazards and Earth System Science*, *9*(2), 563–574. https://doi.org/10.5194/nhess-9-563-2009

Hair, J. F., Sarstedt, M., Ringle, C. M., & Mena, J. A. (2012). An assessment of the use of partial least squares structural equation modeling in marketing research. *Journal of the Academy of Marketing Science*, *40*(3), 414–433. https://doi.org/10.1007/s11747-011-0261-6

Hair, J., & Sarstedt, M. (2014). Partial Least Squares Structural Equation Modeling (PLS-SEM): An Emerging Tool in Business Research. *European business review, 26*(2)*, 106-121.* https://doi.org/10.1108/EBR-10-2013-0128

Hale, J. L., Householder, B. J., & Greene, K. L. (2012). The Theory of Reasoned Action. In *The Persuasion Handbook: Developments in Theory and Practice* (pp. 259–286). SAGE Publications, Inc. https://doi.org/10.4135/9781412976046.n14

Hartmann, T., & Albrecht, J. (2014). From flood protection to flood risk management: Condition-based and performance-based regulations in German Water Law. *Journal of Environmental Law*, *26*(2), 243–268. https://doi.org/10.1093/jel/equ015

Hassanzadeh, R., Nedović- Budić, Z., Alavi Razavi, A., Norouzzadeh, M., & Hodhodkian, H. (2013). Interactive approach for GIS-based earthquake scenario development and resource estimation (Karmania hazard model). *Computers and Geosciences, 51*, 324-338. https://doi.org/10.1016/j.cageo.2012.08.016

Hattermann, F. F., Huang, S., Burghoff, O., Willems, W., Österle, H., Büchner, M., & Kundzewicz, Z. (2014). Modelling flood damages under climate change conditions-a case study for Germany. *Natural Hazards and Earth System Sciences, 14*(12), 3151-3168. https://doi.org/10.5194/nhess-14-3151-2014

Hausenblas, H. A., Carron, A. v., & Mack, D. E. (1997). Application of the theories of reasoned action and planned behavior to exercise behavior: A meta-analysis. *Journal of Sport and Exercise Psychology*, *19*(1), 36–51. https://doi.org/10.1123/jsep.19.1.36

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach.* Guilford publications.

He, B., Huang, X., Ma, M., Chang, Q., Tu, Y., Li, Q., Zhang, K., & Hong, Y. (2018). Analysis of flash flood disaster characteristics in China from 2011 to 2015. *Natural Hazards*, *90*(1), 407–420. https://doi.org/10.1007/s11069-017-3052-7

Hegemann, J. (2020, March 11). *So funktioniert Feuerwehr in Deutschland.* Retrieved July 13, 2021, from https://www.feuerwehrmagazin.de/wissen/so-funktioniert-feuerwehr-in-deutschland-77805

Heitz, C., Spaeter, S., Auzet, A. V., & Glatron, S. (2009). Local stakeholders' perception of muddy flood risk and implications for management approaches: A case study in Alsace (France). *Land Use Policy*, *26*(2), 443–451. https://doi.org/10.1016/j.landusepol.2008.05.008

Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009). The use of partial least squares path modeling in international marketing. *Advances in International Marketing*, *20*, 277–319. https://doi.org/10.1108/S1474-7979(2009)0000020014

Hinchliffe, S. (1996). Helping the earth begins at home. The social construction of socio-environmental responsibilities. *Global Environmental Change*, *6*(1), 53–62. https://doi.org/10.1016/0959-3780(95)00113-1

Ho, M. C., Shaw, D., Lin, S., & Chiu, Y. C. (2008). How do disaster characteristics influence risk perception? *Risk Analysis*, *28*(3), 635–643. https://doi.org/10.1111/j.1539-6924.2008.01040.x

Hong, C., Zhang, Q., Zhang, Y., Davis, S. J., Tong, D., Zheng, Y., Liu, Z., Guan, D., He, K., & Schellnhuber, H. J. (2019). Impacts of climate change on future air quality and human health in China. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(35), 17193–17200. https://doi.org/10.1073/pnas.1812881116

Hov, Ø., Cubasch, U., Fischer, E., Höppe, P., Iversen, T., Gunnar Kvamstø, N., Kundzewicz, Z. W., Rezacova, D., Rios, D., Duarte Santos, F., Schädler, B., Veisz, O., Zerefos, C., Benestad, R., Murlis, J., Donat, M., Leckebusch, G. C., & Ulbrich, U. (2013). *Extreme Weather Events in Europe: preparing for climate change adaptation*. Norwegian Meteorological Institute. http://real.mtak.hu/8366/

Hulme, M. (2009). *Why We Disagree About Climate Change: Understanding Controversy, Inaction and Opportunity*. Cambridge: Cambridge University Press. https://doi.org/10.1017/cbo9780511841200

IFRC. (2012). *Volunteering in emergencies Practical guidelines for Red Cross and Red Crescent Societies managing volunteers in emergency situations*. https://volunteeringredcross.org/wp-content/uploads/2019/02/Volunteering-in-emergencies-LR.pdf

Igbaria, M., Guimaraes, T., & Davis, G. B. (1995). Testing the Determinants of Microcomputer Usage via a Structural Equation Model. *Journal of Management Information Systems*, *11*(4), 87–114. https://doi.org/10.1080/07421222.1995.11518061

Johnson, G. O. (1995). *GIS Applications in Emergency Management* (pp. 133–142). Springer, Dordrecht. https://doi.org/10.1007/978-94-011-0245-2_8

Joireman, J., Barnes Truelove, H., & Duell, B. (2010). Effect of outdoor temperature, heat primes and anchoring on belief in global warming. *Journal of Environmental Psychology*, *30*(4), 358–367. https://doi.org/10.1016/j.jenvp.2010.03.004

Jongman, B., Hochrainer-Stigler, S., Feyen, L., Aerts, J. C. J. H., Mechler, R., Botzen, W. J. W., Bouwer, L. M., Pflug, G., Rojas, R., & Ward, P. J. (2014). Increasing stress on disaster-risk finance due to large floods. *Nature Climate Change*, *4*(4), 264–268. https://doi.org/10.1038/nclimate2124

Kahan, D. M., Jenkins-Smith, H., & Braman, D. (2011). Cultural cognition of scientific consensus. *Journal of Risk Research*, *14*(2), 147–174. https://doi.org/10.1080/13669877.2010.511246

Kan, H. (2011). Climate change and human health in China. *Environmental Health Perspectives*, *119*(2), A60. https://doi.org/10.1289/ehp.1003354

Kellens, W., Terpstra, T., & de Maeyer, P. (2013). Perception and Communication of Flood Risks: A Systematic Review of Empirical Research. *Risk Analysis*, *33*(1), 24–49. https://doi.org/10.1111/j.1539-6924.2012.01844.x

Kellens, W., Zaalberg, R., Neutens, T., Vanneuville, W., & de Maeyer, P. (2011). An Analysis of the Public Perception of Flood Risk on the Belgian Coast. *Risk Analysis*, *31*(7), 1055–1068. https://doi.org/10.1111/j.1539-6924.2010.01571.x

Keown, C. F. (1989). Risk Perceptions of Hong Kongese vs. Americans. *Risk Analysis*, *9*(3), 401–405. https://doi.org/10.1111/j.1539-6924.1989.tb01005.x

King, W. R., & He, J. (2006). A meta-analysis of the technology acceptance model. *Information and Management*, *43*(6), 740–755. https://doi.org/10.1016/j.im.2006.05.003

Kjellgren, S. (2013). Exploring local risk managers' use of flood hazard maps for risk communication purposes in Baden-Württemberg. *Natural Hazards and Earth System Sciences*, *13*(7), 1857–1872. https://doi.org/10.5194/nhess-13-1857-2013

Kobayashi, Y., & Porter, J. W. (2012). *Flood Risk Management in the People's Republic of China: Learning to Live with Flood Risk*. The Asian Development Bank (ADB). http://hdl.handle.net/11540/911

Kollmuss, A., & Agyeman, J. (2002). Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, *8*(3), 239–260. https://doi.org/10.1080/13504620220145401

Kopschina, C., & Stangl, R. (2008). Schulungskonzept präklinisches traumamanagement: Integration von notarzt und rettungsdienst. *Unfallchirurg*, *111*(8), 641–644. https://doi.org/10.1007/s00113-008-1481-1

Kousky, C., Kousky, & Carolyn. (2010). Learning from Extreme Events: Risk Perceptions after the Flood. *Land Economics*, *86*(3). https://EconPapers.repec.org/RePEc:uwp:landec:v:86:y:2010:iii:1:p395-422

Kragt, D., Dunlop, P., Gagne, M., Holtrop, D., & Luksyte, A. (2018). When joining is not enough: Emergency services volunteers and the intention to remain. *Australian Journal of Emergency Management, 33*(4), 35-40.

Kraus, N. N., & Slovic, P. (1988). Taxonomic Analysis of Perceived Risk: Modeling Individual and Group Perceptions Within Homogeneous Hazard Domains. *Risk Analysis*, *8*(3), 435–455. https://doi.org/10.1111/j.1539-6924.1988.tb00508.x

Kron, W. (2005). Flood risk = hazard • values • vulnerability. *Water International*, *30*(1), 58–68. https://doi.org/10.1080/02508060508691837

Krosnick, J. A., Holbrook, A. L., Lowe, L., & Visser, P. S. (2006). The origins and consequences of democratic citizens' policy agendas: A study of popular concern about global warming. *Climatic Change*, *77*(1–2), 7–43. https://doi.org/10.1007/s10584-006-9068-8

Kushary, D., Davison, A. C., & Hinkley, D. v. (2000). Bootstrap Methods and Their Application. *Technometrics*, *42*(2), 216. https://doi.org/10.2307/1271471

Kwon, S. A., Kim, S., & Lee, J. E. (2019). Analyzing the determinants of individual action on climate change by specifying the roles of six values in South Korea. *Sustainability*, *11*(7), 1834. https://doi.org/10.3390/su11071834

LAWA. (2006). *Flood hazard map guidelines of the German Working Group of the Federal States on Water Issues*. Bund/Länder-Arbeitsgemeinschaft Wasser. https://www.lawa.de/documents/flood-hazard-map-guidelines_1552307459.pdf

Lawrence, J., Quade, D., & Becker, J. (2014). Integrating the effects of flood experience on risk perception with responses to changing climate risk. *Natural Hazards*, *74*(3), 1773–1794. https://doi.org/10.1007/s11069-014-1288-z

Lechowska, E. (2018). What determines flood risk perception? A review of factors of flood risk perception and relations between its basic elements. *Natural Hazards*, *94*(3), 1341–1366. https://doi.org/10.1007/s11069-018-3480-z

Lederer, A. L., Maupin, D. J., Sena, M. P., & Zhuang, Y. (2000). Technology acceptance model and the World Wide Web. *Decision Support Systems*, *29*(3), 269–282. https://doi.org/10.1016/S0167-9236(00)00076-2

Lee, Y., Kozar, K. A., & Larsen, K. R. T. (2003). The Technology Acceptance Model: Past, Present, and Future. *Communications of the Association for Information Systems*, *12*(1), 752–780. https://doi.org/10.17705/1cais.01250

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information and Management*, *40*(3), 191–204. https://doi.org/10.1016/S0378-7206(01)00143-4

Leiserowitz, A. (2006). Climate change risk perception and policy preferences: The role of affect, imagery, and values. *Climatic change, 77*(1), 45-72. https://doi.org/10.1007/s10584-006-9059-9

Leong, L., Hew, T., Tan, G. W., & Ooi, K. (2013). Predicting the determinants of the NFC-enabled mobile credit card acceptance: A neural networks approach. *Expert Systems with Applications, 40*(14), 5604–5620. https://doi.org/10.1016/j.eswa.2013.04.018

Lewis, T. L., & Wyatt, J. C. (2014). mHealth and mobile medical apps: A framework to assess risk and promote safer use. *Journal of Medical Internet Research, 16*(9), e210. https://doi.org/10.2196/jmir.3133

Li, Y., Johnson, E. J., & Zaval, L. (2011). Local warming: Daily temperature change influences belief in global warming. *Psychological Science*, *22*(4), 454–459. https://doi.org/10.1177/0956797611400913

Liberman, N., Trope, Y., & Stephan, E. (2007). Psychological distance. *Social psychology: Handbook of basic principles, 2,* 353-383.

Lin, S., Shaw, D., & Ho, M. C. (2008). Why are flood and landslide victims less willing to take mitigation measures than the public? *Natural Hazards*, *44*(2), 305–314. https://doi.org/10.1007/s11069-007-9136-z

Lindell, M. K., & Hwang, S. N. (2008). Households' perceived personal risk and responses in a multihazard environment. *Risk Analysis*, *28*(2), 539–556. https://doi.org/10.1111/j.1539-6924.2008.01032.x

Lindell, M. K., & Perry, R. W. (2012). The Protective Action Decision Model: Theoretical Modifications and Additional Evidence. *Risk Analysis*, *32*(4), 616–632. https://doi.org/10.1111/j.1539-6924.2011.01647.x

Lindsay, R., Jackson, T. W., Cooke, L., Lindsay, R., Jackson, T. W., & Cooke, L. (2011). Adapted technology acceptance model for mobile policing Adapted technology acceptance model for mobile policing. *Journal of Systems and Information Technology, 13*(4), 389-407. https://doi.org/10.1108/13287261111183988

Liu, D., Li, Y., Shen, X., Xie, Y., & Zhang, Y. (2018). Flood risk perception of rural households in western mountainous regions of Henan Province, China. *International Journal of Disaster Risk Reduction*, *27*, 155–160. https://doi.org/10.1016/j.ijdrr.2017.09.051

Lorenzoni, I., Nicholson-Cole, S., & Whitmarsh, L. (2007). Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global Environmental Change*, *17*(3–4), 445–459. https://doi.org/10.1016/j.gloenvcha.2007.01.004

Lorenzoni, I., & Pidgeon, N. F. (2006). Public views on climate change: European and USA perspectives. *Climatic Change*, *77*(1–2), 73–95. https://doi.org/10.1007/s10584-006-9072-z

LUBW. (n.d.). *Landesanstalt für Umwelt Baden-Württemberg. Hochwassergefahrenkarten - Hochwasser Baden-Württemberg*. Retrieved March 13, 2021, from https://www.hochwasser.baden-wuerttemberg.de/hochwassergefahrenkarten

Lujala, P., Lein, H., & Rød, J. K. (2015). Climate change, natural hazards, and risk perception: the role of proximity and personal experience. *Local Environment*, *20*(4), 489–509. https://doi.org/10.1080/13549839.2014.887666

Lundgren, R. E., & McMakin, A. H. (2013). Risk communication: A handbook for communicating environmental, safety, and health risks: Fifth Edition. In *Risk Communication: A Handbook for Communicating Environmental, Safety, and Health Risks: Fifth Edition*. Wiley-IEEE Press. https://doi.org/10.1002/9781118645734

Ma, Q., & Liu, L. (2005). The role of internet self-efficacy in the acceptance of web-based electronic medical records. *Journal of Organizational and End User Computing*, *17*(1), 38–57. https://doi.org/10.4018/joeuc.2005010103

MacKinnon, D. P., Lockwood, C. M., & Williams, J. (2004). Confidence limits for the indirect effect: Distribution of the product and resampling methods. *Multivariate Behavioral Research*, *39*(1), 99–128. https://doi.org/10.1207/s15327906mbr3901_4

Marangunić, N., & Granić, A. (2015). Technology acceptance model: a literature review from 1986 to 2013. *Universal Access in the Information Society*, *14*(1), 81–95. https://doi.org/10.1007/s10209-014-0348-1

Martínez-Fiestas, M., Rodríguez-Garzón, I., & Delgado-Padial, A. (2020). Firefighter perception of risk: A multinational analysis. *Safety Science*, *123*, 104545. https://doi.org/10.1016/j.ssci.2019.104545

Matti Haataja, M. H. S. (2011). Understanding user acceptance of mobile alerting systems. *Proceedings of the 8th International ISCRAM Conference*.

McDonald, R. I., Chai, H. Y., & Newell, B. R. (2015). Personal experience and the ‘psychological distance’ of climate change: An integrative review. *Journal of Environmental Psychology, 44,* 109-118. https://doi.org/10.1016/J.JENVP.2015.10.003

Meyer, V., Kuhlicke, C., Luther, J., Fuchs, S., Priest, S., Dorner, W., Serrhini, K., Pardoe, J., McCarthy, S., Seidel, J., Palka, G., Unnerstall, H., Viavattene, C., & Scheuer, S. (2012). Recommendations for the user-specific enhancement of flood maps. *Natural Hazards and Earth System Science*, *12*(5), 1701–1716. https://doi.org/10.5194/nhess-12-1701-2012

Miceli, R., Sotgiu, I., & Settanni, M. (2008). Disaster preparedness and perception of flood risk: A study in an alpine valley in Italy. *Journal of Environmental Psychology*, *28*(2), 164–173. https://doi.org/10.1016/j.jenvp.2007.10.006

Ministry of Water Resources of PRC. (2017). *Guidelines for preparation of flood risk maps 洪水风险图编制导则*. http://std.samr.gov.cn/hb/search/stdHBDetailed?id=8B1827F24E11BB19E05397BE0A0AB44A

Moon, J. W., & Kim, Y. G. (2001). Extending the TAM for a World-Wide-Web context. *Information and Management*, *38*(4), 217–230. https://doi.org/10.1016/S0378-7206(00)00061-6

Moores, T. T. (2012). Towards an integrated model of IT acceptance in healthcare. *Decision Support Systems*, *53*(3), 507–516. https://doi.org/10.1016/j.dss.2012.04.014

Morris, S. A., Greer, T. H., Hughes, C., & Clark, W. J. (2004). Prediction of CASE adoption: a neural network approach. *Industrial Management & Data Systems, 104*(2), 129–135. https://doi.org/10.1108/02635570410522099

Mulilis, J. P., & Duval, T. S. (2003). Activating Effects of Resources Relative to Threat and Responsibility in Person-Relative-to-Event Theory of Coping with Threat: An

Educational Application. *Journal of Applied Social Psychology*, *33*(7), 1437–1456. https://doi.org/10.1111/j.1559-1816.2003.tb01957.x

Munich Re. (2018). *NatCatSERVICE | Munich Re*. Retrieved May 10, 2021, from https://www.munichre.com/en/solutions/for-industry-clients/natcatservice.html

Munich Re. (2020). *Flood risk: Underestimated natural hazards | Munich Re*. Retrieved May 10, 2021, from https://www.munichre.com/en/risks/natural-disasters-losses-are-trending-upwards/floods-and-flash-floods-underestimated-natural-hazards.html#-24989000

Myers, T. A., Maibach, E. W., Roser-Renouf, C., Akerlof, K., & Leiserowitz, A. (2013). The relationship between personal experience and belief in the reality of global warming. *Nature climate change, 3*(4), 343-347. https://doi.org/10.1038/NCLIMATE1754

National Bureau of Statistics of China. (2020). *Statistical Communique of the People's Republic of China on the 2019 National Economic and Social Development*. http://www.stats.gov.cn/english/PressRelease/202002/t20200228_1728917.html

NDRCC&UNDP. (2017). *Research Report on Urban Flood Risk Management Capacity*. https://www.cn.undp.org/content/china/en/home/library/crisis_prevention_and_recovery/environmental-risk-identification-and-obviation-in-post-earthqua1.html

Neal, A., & Griffin, M. A. (2009). Safety climate and safety at work. In *The psychology of workplace safety.* (pp. 15–34). American Psychological Association. https://doi.org/10.1037/10662-002

Nirupama, N., & Simonovic, S. P. (2007). Increase of flood risk due to urbanisation: A Canadian example. *Natural Hazards*, *40*(1), 25–41. https://doi.org/10.1007/s11069-006-0003-0

Nones, M. (2015). Implementation of the floods directive in selected EU member states. *Water and Environment Journal*, *29*(3), 412–418. https://doi.org/10.1111/wej.12129

Nones, M. (2017). Flood hazard maps in the European context. *Water International*, *42*(3), 324–332. https://doi.org/10.1080/02508060.2016.1269282

O'Connor, R. E., Bord, R. J., & Fisher, A. (1999). Risk perceptions, general environmental beliefs, and willingness to address climate change. *Risk Analysis*, *19*(3), 461–471. https://doi.org/10.1023/A:1007004813446

OECD. (2008). *Purchasing power parities (PPP) - OECD Data*. Retrieved January 13, 2020, from https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm

OECD. (2010). *Environmental and climate change challenges in Guangdong* (pp. 191–215). https://doi.org/10.1787/9789264090088-7-en

OECD. (2021, March 9). *OECD (2021), Gross domestic product (GDP) (indicator).* OECD. Retrieved January 01, 2021, from https://doi.org/10.1787/34bfd999-en

One-Foundation. (n.d.). *One-Foundation Rescue Alliance 壹基金救援联盟*. Retrieved March 13, 2021, from http://www.onefoundation.cn/lianhejiuzai/index.html

Opella, J. M. A., & Hernandez, A. A. (2019). User acceptance of flood risk and hazard mapping system: A field survey in the Philippines. *2019 IEEE 9th International Conference on System Engineering and Technology, ICSET 2019 - Proceeding*, 374–379. https://doi.org/10.1109/ICSEngT.2019.8906438

Paine, J. D., Watt, W. E., Painel, J. D., & Wattl, W. E. (1992). FLOOD RISK MAPPING IN CANADA: 2. COMPATIBLE MAPPING. *Canadian Water Resources Journal*, *17*(2), 139–148. https://doi.org/10.4296/cwrj1702139

Paton, D. (2003). Disaster preparedness: A social-cognitive perspective. *Disaster Prevention and Management: An International Journal*, *12*(3), 210–216. https://doi.org/10.1108/09653560310480686

Pavlou, P. A. (2003). Consumer acceptance of electronic commerce: Integrating trust and risk with the technology acceptance model. *International Journal of Electronic Commerce*, *7*(3), 101–134. https://doi.org/10.1080/10864415.2003.11044275

Pew Research Center. (2015, November 5). *Public Support for Action on Climate Change.* Retrieved May 03, 2020, from https://www.pewresearch.org/global/2015/11/05/2-public-support-for-action-on-climate-change/

Piao, S., Ciais, P., Huang, Y., Shen, Z., Peng, S., Li, J., Zhou, L., Liu, H., Ma, Y., Ding, Y., Friedlingstein, P., Liu, C., Tan, K., Yu, Y., Zhang, T., & Fang, J. (2010). The impacts of climate change on water resources and agriculture in China. *Nature, 467*(7311), 43-51. https://doi.org/10.1038/nature09364

Pidgeon, N. (1998). Risk assessment, risk values and the social science programme: Why we do need risk perception research. *Reliability Engineering and System Safety*, *59*(1), 5–15. https://doi.org/10.1016/S0951-8320(97)00114-2

Poortinga, W., Spence, A., Whitmarsh, L., Capstick, S., & Pidgeon, N. F. (2011). Uncertain climate: An investigation into public scepticism about anthropogenic climate change. *Global Environmental Change*, *21*(3), 1015–1024. https://doi.org/10.1016/j.gloenvcha.2011.03.001

Prati, G., Pietrantoni, L., Saccinto, E., Kehl, D., Knuth, D., & Schmidt, S. (2013). Risk perception of different emergencies in a sample of European firefighters. *Work*, *45*(1), 87–96. https://doi.org/10.3233/WOR-121543

Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, and Computers*, *36*(4), 717–731. https://doi.org/10.3758/BF03206553

Rauschert, I., Agrawal, P., Sharma, R., Fuhrmann, S., Brewer, I., & MacEachren, A. (2002). Designing a human-centered, multimodal GIS interface to support emergency management. *Proceedings of the Tenth ACM International Symposium on Advances in Geographic Information Systems*, 119-124. https://doi.org/10.1145/585147.585172

Renn, O. (2008). *Risk Governance: Coping with Uncertainty in a Complex World*. Earthscan. https://doi.org/10.1007/978-1-4020-6799-0

Renn, O. (2009). *White Paper on risk governance: Towards and integrative approach*. International Risk Governance Council (IRGC).

Renn, O., & Klinke, A. (2004). Systemic risks: a new challenge for risk management. *EMBO reports, 5*(S1), S41-S46. https://doi.org/10.1038/sj.embor.7400227

Reser, J. P., Bradley, G. L., Glendon, A. I., Ellul, M. C., & Callaghan, R. (2012). *Public risk perceptions, understandings, and responses to climate change and natural disasters in Australia, 2010 and 2011 Final Report*. Gold Coast: National Climate Change Adaptation Research Facility. https://nccarf.edu.au/public-risk-perceptions-understandings-and-responses-climate-change-and-natural-disaster-0/

Richerzhagen, C., Scholz, I., Richerzhagen, C., & Scholz, I. (2008). China's capacities for Mitigating Climate Change. *World Development*, *36*(2), 308–324. https://EconPapers.repec.org/RePEc:eee:wdevel:v:36:y:2008:i:2:p:308-324

Rigdon, E. E., Sarstedt, M., & Ringle, C. M. (2017). On Comparing Results from CB-SEM and PLS-SEM: Five Perspectives and Five Recommendations. *Marketing ZFP*, *39*(3), 4–16. https://doi.org/10.15358/0344-1369-2017-3-4

Ringle, C. M., & Sarstedt, M. (2016). Gain more insight from your PLS-SEM results the importance-performance map analysis. *Industrial Management and Data Systems*, *116*(9), 1865–1886. https://doi.org/10.1108/IMDS-10-2015-0449

Rohrmann, B. (2000). Cross-Cultural Studies on the Perception and Evaluation of Hazards. In *Cross-Cultural Risk Perception* (pp. 103–143). Springer US. https://doi.org/10.1007/978-1-4757-4891-8_3

Rowe, G., & Wright, G. (2001). *Expert Opinions in Forecasting: The Role of the Delphi Technique* (pp. 125–144). Springer, Boston, MA. https://doi.org/10.1007/978-0-306-47630-3_7

Rudman, L. A., McLean, M. C., & Bunzl, M. (2013). When Truth Is Personally Inconvenient, Attitudes Change: The Impact of Extreme Weather on Implicit Support for Green Politicians and Explicit Climate-Change Beliefs. *Psychological Science*, *24*(11), 2290–2296. https://doi.org/10.1177/0956797613492775

Sadler, P., Holgate, A., & Clancy, D. (2007). Is a contained fire less risky than a going fire? Career and volunteer firefighters' perception of risk. *Australian Journal of Emergency Management, 22*(2), 44-48.

Samuels, P., Klijn, F., & Dijkman, J. (2006). An analysis of the current practice of policies on river flood risk management in different countries. *Irrigation and Drainage*, *55*(S1), S141–S150. https://doi.org/10.1002/ird.257

Schepers, J., & Wetzels, M. (2007). A meta-analysis of the technology acceptance model: Investigating subjective norm and moderation effects. *Information and Management*, *44*(1), 90–103. https://doi.org/10.1016/j.im.2006.10.007

Schubert, I., & Soane, E. (2008). Report of a pilot study of uncertainty, decision-making and communication of information about climate change and food safety. Kingston Business School, Kingston University.

SCIO. (2011). *China's Policies and Actions for Addressing Climate Change*. The State Council Information Office of the People's Republic of China. Retrieved July 06, 2020, from http://www.scio.gov.cn/zfbps/ndhf/2011/Document/1052718/1052718.htm

Shan, Y., Huang, Q., Guan, D., & Hubacek, K. (2020). China CO2 emission accounts 2016–2017. *Scientific Data*, *7*(1), 1–9. https://doi.org/10.1038/s41597-020-0393-y

Sheppard, B. H., Hartwick, J., & Warshaw, P. R. (1988). The Theory of Reasoned Action: A Meta-Analysis of Past Research with Recommendations for Modifications and Future Research. *Journal of Consumer Research*, *15*(3), 325-343. https://doi.org/10.1086/209170

Shi, J., Cui, L., & Tian, Z. (2020). Spatial and temporal distribution and trend in flood and drought disasters in East China. *Environmental Research*, *185*, 109406. https://doi.org/10.1016/j.envres.2020.109406

Shi, M., Xu, W., Gao, L., Kang, Z., Ning, N., Liu, C., ... & Wu, Q. (2018). Emergency volunteering willingness and participation: a cross-sectional survey of residents in northern China. BMJ open, 8(7), e020218.

Shih, H. P. (2004). Extended technology acceptance model of Internet utilization behavior. *Information and Management*, *41*(6), 719–729. https://doi.org/10.1016/j.im.2003.08.009

Siegrist, M., & Gutscher, H. (2006). Flooding risks: A comparison of lay people's perceptions and expert's assessments in Switzerland. *Risk Analysis*, *26*(4), 971–979. https://doi.org/10.1111/j.1539-6924.2006.00792.x

Sjöberg, L. (2000). Factors in Risk Perception. *Risk Analysis*, *20*(1), 1–12. https://doi.org/10.1111/0272-4332.00001

Slovic, P. (1987). Perception of risk. *Science*, *236*(4799), 280–285. https://doi.org/10.1126/science.3563507

Slovic, P. (2000). The Perception of Risk. Earthscan, London.

Slovic, P. (2016). Understanding perceived risk: 1978-2015. *Environment*, *58*(1), 25–29. https://doi.org/10.1080/00139157.2016.1112169

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1980). Facts and Fears: Understanding Perceived Risk. In *Societal Risk Assessment* (pp. 181–216). Springer US. https://doi.org/10.1007/978-1-4899-0445-4_9

Spachinger, K., Dorner, W., Metzka, R., Serrhini, K., & Fuchs, S. (2008). Flood Risk and Flood hazard maps – Visualisation of hydrological risks. *IOP Conference Series: Earth and Environmental Science*, *4*, 012043. https://doi.org/10.1088/1755-1307/4/1/012043

Spence, A., Poortinga, W., Butler, C., & Pidgeon, N. F. (2011). Perceptions of climate change and willingness to save energy related to flood experience. *Nature Climate Change*, *1*(1), 46–49. https://doi.org/10.1038/nclimate1059

Staatsministerium Baden-Württemberg. (n.d.). *Geografie: Baden-Württemberg.de*. Retrieved March 01, 2021, from https://www.baden-wuerttemberg.de/de/unser-land/land-und-leute/geografie/

State Council Information Office of PRC. (2009). *China's Actions for Disaster Prevention and Reduction《中国减灾行动》白皮书.* http://www.scio.gov.cn/zfbps/ndhf/2009/Document/847130/847130_7.htm

State Council of PRC. (2015). *Guangdong Province*. Retrieved May 01, 2021, from http://www.gov.cn/guoqing/2018-01/17/content_5257350.htm

Stocker, T., Qin, D., Plattner, G., Tignor, M. M. B., Allen, S. K., Boschung, J., … Wuebbles, D. (2014). *Climate change 2013. The physical science basis. Working Group I contribution to the Fifth assessment report of the Intergovernmental Panel on Climate Change* (Report No. INIS-FR-14-0250). Cambridge university press. https://www.osti.gov/etdeweb/biblio/22221318

Stoll-Kleemann, S., O'Riordan, T., & Jaeger, C. C. (2001). The psychology of denial concerning climate mitigation measures: Evidence from Swiss focus groups. *Global Environmental Change*, *11*(2), 107–117. https://doi.org/10.1016/S0959-3780(00)00061-3

Süddeutsches Klimabüro am KIT. (2016). *Klimawandelanpassung in Städten : Klimasimulationen für Baden-Württemberg* (Report No. urn:nbn:de:swb:90-539712). Karlsruher Institut für Technologie (KIT). https://www.sueddeutsches-klimabuero.de/downloads/Broschuere_Klimabuero_Klimawandelanpassung_2017_Ensemble.pdf

Swim, J. K., Stern, P. C., Doherty, T. J., Reser, J. P., Weber, E. U., Gifford, R., & Howard, G. S. (2011). Psychology's Contributions to Understanding and Addressing Global Climate Change. *American psychologist, 66*(4), 241-250. https://doi.org/10.1037/a0023220

Swiss Re. (n.d.). *CatNet® Sample Data Sets of 10 Natural Perils*. Retrieved March 13, 2021, from https://swissre.maps.arcgis.com/apps/MapSeries/index.html?appid=627cf4f854294d2d9777a0e835a85b89

Swiss Re. (2018, November 20). *Enhanced risk models with Global Flood Zones | Swiss Re*. Retrieved March 01, 2021, from https://www.swissre.com/institute/research/topics-and-risk-dialogues/climate-and-natural-catastrophe-risk/enhanced-risk-models-with-global-flood-zones-tool.html

Tanoue, M., Hirabayashi, Y., & Ikeuchi, H. (2016). Global-scale river flood vulnerability in the last 50 years. *Scientific Reports*, *6*(1), 1–9. https://doi.org/10.1038/srep36021

Technisches Hilfswerk. (2019). *Jahresbericht Annual Report 2019.* Retrieved July 13, 2021, from https://www.thw.de/SharedDocs/Downloads/DE/Hintergrund/Jahresberichte/jahresbericht_2019.pdf?__blob=publicationFile.

Teigen, K. H., Brun, W., & Slovic, P. (1988). Societal risks as seen by a Norwegian public. *Journal of Behavioral Decision Making*, *1*(2), 111–130. https://doi.org/10.1002/bdm.3960010205

Terpstra, T., & Gutteling, J. M. (2008). Households' perceived responsibilities in flood risk management in the Netherlands. *International Journal of Water Resources Development*, *24*(4), 555–565. https://doi.org/10.1080/07900620801923385

Thistlethwaite, J., Henstra, D., Brown, C., & Scott, D. (2018). How Flood Experience and Risk Perception Influences Protective Actions and Behaviours among

Canadian Homeowners. *Environmental Management*, *61*(2), 197–208. https://doi.org/10.1007/s00267-017-0969-2

Torkzadeh, G., Chang, J. C. J., & Demirhan, D. (2006). A contingency model of computer and Internet self-efficacy. *Information and Management*, *43*(4), 541–550. https://doi.org/10.1016/j.im.2006.02.001

Trope, Y., & Liberman, N. (2010). Construal-level theory of psychological distance. *Psychological review, 117*(2), 440-463. https://doi.org/10.1037/a0018963

UDO. (2013). *Überflutungsflächen Daten und Kartendienst der LUBW*. Retrieved March 01, 2021, from https://udo.lubw.baden-wuerttemberg.de/public/

Umweltbundesamt. (2021, January 18). *Indicator: Greenhouse gas emissions* . Retrieved March 01, 2021, from https://www.umweltbundesamt.de/en/indicator-greenhouse-gas-emissions#assessing-the-development

Ungar, S. (2000). Knowledge, ignorance and the popular culture: Climate change versus the ozone hole. *Public Understanding of Science*, *9*(3), 297–312. https://doi.org/10.1088/0963-6625/9/3/306

UNISDR. (2005). *Building the Resilience of Nations and Communities to Disasters*. Retrieved March 01, 2021, from www.unisdr.org/wcdr

UNISDR. (2009). *2009 UNISDR terminology on disaster risk reduction*. Retrieved March 01, 2021, from https://www.undrr.org/publication/2009-unisdr-terminology-disaster-risk-reduction

UNV. (2011). *Volunteerism and Disasters: An extract from the 2011 State of the World's Volunteerism Report*. https://www.preventionweb.net/files/33033_33033bookletswvrvolunteerismanddisa.pdf

Upham, P., Whitmarsh, L., Poortinga, W., Purdam, K., & Devine-Wright, P. (2009). *Public Attitudes to Environmental Change: a selective review of theory and practice, report for ESRC/LWEC*. Economic and Social Research Council.

USGS. (n.d.). *The 100-Year Flood*. Retrieved March 14, 2021, from https://www.usgs.gov/special-topic/water-science-school/science/100-year-flood?qt-science_center_objects=0#qt-science_center_objects

van der Linden, S. (2014). On the relationship between personal experience, affect and risk perception: The case of climate change. *European Journal of Social Psychology*, *44*(5), 430–440. https://doi.org/10.1002/ejsp.2008

van Valkengoed, A. M., & Steg, L. (2019). Meta-analyses of factors motivating climate change adaptation behaviour. *Nature Climate Change*, *9*(2), 158–163. https://doi.org/10.1038/s41558-018-0371-y

Venkatesh, V. (2000). Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model. *Information Systems Research*, *11*(4), 342–365. https://doi.org/10.1287/isre.11.4.342.11872

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the Technology Acceptance Model: Four longitudinal field studies. *Management Science*, *46*(2), 186–204. https://doi.org/10.1287/mnsc.46.2.186.11926

Wachinger, G, Renn, O., Bianchizza, C., & Coates, T. (2010). *Risk perception of natural hazards*. http://caphaz-net.org/outcomes-results

Wachinger, Gisela, Renn, O., Begg, C., & Kuhlicke, C. (2013). The risk perception paradox-implications for governance and communication of natural hazards. *Risk Analysis*, *33*(6), 1049–1065. https://doi.org/10.1111/j.1539-6924.2012.01942.x

Wang, B., & Zhou, Q. (2020). Climate change in the Chinese mind: An overview of public perceptions at macro and micro levels. *Wiley Interdisciplinary Reviews: Climate Change, 11*(3), e639. https://doi.org/10.1002/wcc.639

Wang, J., & Kim, S. (2018). Analysis of the Impact of Values and Perception on Climate Change Skepticism and Its Implication for Public Policy. *Climate*, *6*(4), 99. https://doi.org/10.3390/cli6040099

Wang, X. (2010). Role Assessment of Disaster Social Work: Theoretical dimension of “three stages” and practical prospect. *Journal of Beijing Normal University (Social Sciences)*, *04*, 129–137.

Wang, Y. J., Gao, C., Zhai, J. Q., Li, X. C., Su, B. da, & Hartmann, H. (2014). Spatio-temporal changes of exposure and vulnerability to floods in China. *Advances in Climate Change Research*, *5*(4), 197–205. https://doi.org/10.1016/j.accre.2015.03.002

Weber, E. U. (2010). What shapes perceptions of climate change? *Wiley Interdisciplinary Reviews: Climate Change, 1*(3), 332-342. https://doi.org/10.1002/wcc.41

Wetherald, R. T., Manabe, S. (2002). Simulation of hydrologic changes associated with global warming. *Journal of Geophysical Research*, *107*(D19), ACL-7. https://doi.org/10.1029/2001JD001195

White, G. F. (1942). *Human adjustment to floods: a geographical approach to the flood problem in the United States* [Doctoral dissertation, The University of Chicago].

Whitmarsh, L. (2008). Are flood victims more concerned about climate change than other people? the role of direct experience in risk perception and behavioural response. *Journal of Risk Research*, *11*(3), 351–374. https://doi.org/10.1080/13669870701552235

Whitmarsh, L. (2011). Scepticism and uncertainty about climate change: Dimensions, determinants and change over time. *Global Environmental Change*, *21*(2), 690–700. https://doi.org/10.1016/j.gloenvcha.2011.01.016

Wirz, M., Roggen, D., & Tröster, G. (2010). User acceptance study of a mobile system for assistance during emergency situations at large-scale events. In *2010 3rd International Conference on Human-Centric Computing* (pp. 1-6). IEEE. https://doi.org/10.1109/HUMANCOM.2010.5563347

Wixom, B. H., & Todd, P. A. (2005). A theoretical integration of user satisfaction and technology acceptance. *Information Systems Research*, *16*(1), 85–102. https://doi.org/10.1287/isre.1050.0042

Wong, K. K. K. (2013). Partial Least Squares Structural Equation Modeling (PLS-SEM) Techniques Using SmartPLS. *Marketing Bulletin, 24*(1), 1-32.

World Bank. (2019). Population ages 65 and above (% of total population) | Data. Retrieved May 01, 2021, from https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS

Wright, G., Bolger, F., & Rowe, G. (2002). An Empirical Test of the Relative Validity of Expert and Lay Judgments of Risk. *Risk Analysis*, *22*(6), 1107–1122. https://doi.org/10.1111/1539-6924.00276

Wu, K., Zhao, Y., Zhu, Q., Tan, X., & Zheng, H. (2011). A meta-analysis of the impact of trust on technology acceptance model: Investigation of moderating influence of subject and context type. *International Journal of Information Management*, *31*(6), 572–581. https://doi.org/10.1016/j.ijinfomgt.2011.03.004

Wu, P. F. (2009). User Acceptance of Emergency Alert Technology: A Case Study. *In Proceedings of the 6th International ISCRAM Conference* (pp. 1-9).

Xiang, L. (2017). A brief introduction on drawing and application of flood risk map. *China Water Resources*, *5*, 9–13.

Xie, W., Huang, J., Wang, J., Cui, Q., Robertson, R., & Chen, K. (2020). Climate change impacts on China's agriculture: The responses from market and trade. *China Economic Review*, *62*, 101256. https://doi.org/10.1016/j.chieco.2018.11.007

Xu, D. (2009). Emergency relief inspiration of the Wenchuan earthquake. *Engineering Sciences*, *11*(6), 100–106.

Ying, A. (2000). Impact of global climate change on China's water resources. *Environmental Monitoring and Assessment*, *61*(1), 187–191. https://doi.org/10.1023/A:1006351126446

Yougov. (2019, September 15). *International poll: most expect to feel impact of climate change, many think it will make us extinct.* Retrieved January 01, 2021, from https://yougov.co.uk/topics/science/articles-reports/2019/09/15/international-poll-most-expect-feel-impact-climate

Yousafzai, S. Y., Foxall, G. R., & Pallister, J. G. (2007). Technology acceptance: a meta-analysis of the TAM: Part 2. *Journal of Modelling in Management 2*(3), 281–304. https://doi.org/10.1108/17465660710834462

Zaalberg, R., Midden, C., Meijnders, A., & McCalley, T. (2009). Prevention, Adaptation, and Threat Denial: Flooding Experiences in the Netherlands. *Risk Analysis*, *29*(12), 1759–1778. https://doi.org/10.1111/j.1539-6924.2009.01316.x

Zehr, S. C. (2000). Public representations of scientific uncertainty about global climate change. *Public Understanding of Science*, *9*(2), 85–103. https://doi.org/10.1088/0963-6625/9/2/301

Zhang, Q., Zhang, W., Chen, Y. D., & Jiang, T. (2011). Flood, drought and typhoon disasters during the last half-century in the Guangdong province, China. *Natural Hazards*, *57*(2), 267–278. https://doi.org/10.1007/s11069-010-9611-9

Zhao, W. (2020). Extreme weather and climate events in China under changing climate. *National Science Review*, *7*(5), 938–943. https://doi.org/10.1093/nsr/nwaa069

Zhao, X., Lynch, J. G., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and truths about mediation analysis. *Journal of Consumer Research*, *37*(2), 197–206. https://doi.org/10.1086/651257

Appendix

Questionnaire Coding sheet

Section I Flood risk perception

V1. How long have you enrolled as a volunteer firefighter?

1	Less than 6 months	2	6 months to 1 year	3	1 year to 3 year	4	3 to 5 years	5	more than 5 years

V2. Your work in the fire brigade is mainly about? (multiply choices possible)

❑administrative work ❑ working at the scene of emergency ❑technique support
❑coordinate and command ❑others

V3. How many flood events you have experienced so far?

code	1	2	3	4	5
option	None	1- 2 times	3-4 times	5- 6 times	more than 6 times

V4. When was the last time you experienced a flood in your region?

code	1		2		3		4		-99
option	more than 3 years		1 year to 3 year				Less than 6 months		Never

V5. Please choose flood types you have experienced in your region so far. (multiple choices possible)
❑No experience of flood so far ❑Riverine flood ❑Flash flood ❑Urbane Flooding
❑Dyke breach ❑coastal flood ❑Other ❑not clear

V6a. What is the most severe financial loss the flood event has caused you and your family?

1	no financial loss	2	slight financial loss	3	medium financial loss	4	severe financial loss	5	very severe financial loss

V6b. What is the most severe injury that flood event has caused you and your family?

1	no personal injuries	2	slight injuries	3	medium injuries	4	severe injuries	5	loss of life in your family

V7. How many times you have participated in flood rescue?

1	None	2	1- 2 times	3	3 – 4 times	4	5-6 times	5	more than 6 times

V8. Below are some questions about flood risk. Please choose the one which fits your opinion.

Code		1=is absolutely true	2=is quite true	3=is partially true	4=is hardly true	5=is not true at all
V8a.	I think it's very likely in the next 5 years that a flood will occur in the municipality which I live in.					
V8b.	I know very clearly what mitigation actions I can adopt during flood event.					
V8c	I believe that I am totally capable of controlling a loss due to a flood event.					
V8d	I am very worried about that a flood causes fatal consequences to me and my family.					
V8e.	I am worried about that a flood causes financial loss to me and my family.					

V9. Below are some questions about climate change's impact on flood risk. Please choose the one which fits your opinion.

Code		1= not true at all	2= hardly true	3= partially true	4= quite true	5= absolutely true

V9a.	I think climate change could strongly affect flood risk in my region.					
V9b.	I am very worried that climate change could lead to higher flood risk level in my region.					
V9c.	I think that the damage caused by floods will be severer under the impact of climate change in my region.					
V9d.	Climate change could lead to higher frequency of extreme precipitation in my region.					

V10. Besides your service for the fire brigade, have you ever participated in civil defence activities against flood events?

1	Yes	0	No

V11. How much training you have received concerning flood rescue after you enrolled as a volunteer firefighter?

1	not at all	2	1 time	3	2-3 times	4	4-6times	5	More than 6 times

V12. How well do you think your local authority protects the citizens with regard to flood risk?

1	very good	2	good	3	barely acceptable	4	poor	5	very poor

V13. Please choose the one which fits your opinion.

Code		1=not trust at all	2=a little	3=partial trust	4= much	5=very trust
V13a.	How much do you trust in the current flood prevention strategy					

	conducted by your local authority?					
V13b.	How much do you trust the capability of experts to give flood warnings?					

V14. Please choose the one which fits your opinion.

Code		1 = not at all	2= some	3=moderate	4=most	5= total
V14a.	How much the authorities should be responsible for flood risk reduction?					
V14b.	How much citizens themselves should be responsible for flood risk reduction?					

V15. Below are some statements about climate change. Please choose the one which fits your opinion.

Code		1= strongly disagree	2= somewhat disagree	3= undecided	4= somewaht agree	5= strongly agree
V15a.	I am uncertain that climate change, sometimes referred to as ‘global warming’, is really happening.					
V15b.	My local area is likely to be affected by climate change.					
V15c.	I can personally help to reduce climate change by changing my behavior.					

Section II Acceptance of flood risk map

V20. Please click this link of Flood Risk Map in Baden-Württemberg (https://udo.lubw.baden-wuerttemberg.de/public/pages/map/default/index.xhtml), and try to find the flood risk information about your region(similar as the pictures below).

Have you ever seen the flood risk map in Baden-Württemberg before your service in the fire department?

1	Yes	0	No

V21. How often do you or your colleagues use the flood risk map in Baden-Württemberg in your work for flood rescue?

1	Never	2	Seldom	3	Sometimes	4	Frequently	5	Always

V22. Do you find it is easy to understand the terms on the map?

1	I don't know the terms at all	2	I understand only severl terms, but not all.	3	I understand many of the terms.
4	I understand most all the terms	5	I understand all the terms		

V23. Please complete in the blank your understanding of HQ 100. ________________

Please choose the one which fits your opinion.

Code		1= not true at all	2= hardly true	3= partially true	4= quite true	5= absolutely true	99=don't know
V24 a.	This flood risk map is easy to operate in order to find the information that I am interested in.						
V24b.	This online flood risk map is clear and understandable to me						
V25 a.	Generally, I find this risk map to be useful when dealing with flood events.						
V25 b.	Using this online map enables me to acquire						

	flood risk information more quickly.						
V26 a.	I intend to use the map in future for flood related events.						
V26 b.	I would like to recommend the risk map to my colleagues and other people or organizations I work with in the future.						

Please choose the one which fits your opinion.

Code		1= not true at all	2= hardly true	3= partially true	4= quite true	5= absolutely true	99=don't know
V27a.	I find the risk information showed on the map is similar with my own experience regarding to flood emergency.						
V27b.	When dealing with the emergency rescue, I trust my experience to make decisions more than this risk map.						
V28 a.	I think the information on the map is **accurate** enough for my work when dealing with floods emergency.						
V28 b.	I think the risk map is **intuitive** enough to read and understand.						

Please choose the one which fits your situation.

Code		1= not true at all	2= hardly true	3= partially true	4= quite true	5= absolutely true	99=don't know
V29 a.	I inform myself about online information resources and tools (such as Apps, disaster risk map, warning systems, videos, articles) for hazards preparedness and responding.						
V29 b.	I hope more online resources and information tools(such as Apps, disaster risk maps, warning systems) could be introduced my work as volunteer firefighter.						
V30 a.	I feel confident to access knowledge and information via Internet.						
V30 b.	I feel confident to access information from web maps(e.g., google maps)						

V31. How many hours you usually spend on Internet every day?

1	less than 1 hour	2	1-2 hours	3	3-4 hours	4	5-6 hours	5	more than 6 hours

V32. How often does your work require you to use STEM (Science, Technology, Engineer, Mathematics) knowledges and skills?

1	not at all	2	only a little	3	to some extend	4	often	5	very often

V33. I think I am interested in science and technology.

1	very often	2	often	3	sometimes	4	rarely	5	never

V35. Do you consider yourself as an optimistic or sceptics about the new scientific discoveries and inventions?

1	Very sceptics	2	Somewhat sceptics.	3	Neutral	4	Somewhat optimistic	5	Very optimistic

V36. The public should be informed and involved in decisions about science.

1	absolutely true	2	quite true	3	partially true	4	hardly true	5	not true at all

Section V About you

V37. What's your age?_____

V38. You are:
○ Female
○Male

V39. What is the highest degree or level of school you have completed? If currently enrolled, please mark the previous grade or highest degree you have received.

V40. How many people under 18 are living in your household?

V41. Home ownership. Please choose

1	I own a house or apartment	0	I am a tenant

V42. Area: Please fill in the first 3 numbers of your zip code, so we could have an idea of your living region. __________

V43. For which region of fire brigade in state Baden-Württemberg you serve now? Please indicate the first three zip code __________

V44a. How far away do you live from the river or lake?

1	less than 1 km	0	1 km or more

V44b. How long have you lived in your current municipality?

1	less than 1 year	2	1 - 5 years	3	6 - 10 years	4	11- 15 years	5	more than 15 years

Declaration of Authorship

I, Tong Wu, hereby declare that I wrote this doctoral dissertation independently and did not make use of any support or sources other than those acknowledged in the paper.

Signature: ____________________

Date: ______________________