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Environmental Risk Communication and Management Based on Stakeholders' Quantitative Risk Assessment:
A Case of Maptaphut Industrial Development Area, Thailand

(利害関係者の定量的リスク評価に基づく環境リスクのコミュニケーションとマネジメント：
タイ国マタプット工業地帯を例として)

Piyapong Janmaimool

Graduate School of Engineering
Kochi University of Technology

A dissertation submitted to Kochi University of Technology in partial fulfillment
of the requirement for the degree of Doctor of Philosophy in
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Abstract

Failures in multi-stakeholders' cooperative environmental risk management are contributed by (1) the immense gap in risk judgment and perception among relevant stakeholders (2) fragile trust between stakeholders which effects their involvement in risk management processes. The goal of this study is to develop risk communication strategies that potentially bridge the gap in risk perception and increase trust among relevant parties. Maptaphut industrial estate development area in Rayong province, Thailand was selected as a case study due to the seriousness of environmental contamination and the need for the improvement of risk communication. The study was divided into two parts.

In the first part, understanding the difference in the risk judgment of stakeholders and lay people living in industrial communities potentially provides insight regarding how to develop risk communication strategies; therefore, the study aims at exploring stakeholders' fundamental understanding of risk-related judgments and identifying factors contributing to perceived risks. An exploratory model was generated in order to investigate stakeholders' qualitative risk assessment. In this model, the relationship between stakeholder's perceived risks and three potential predictive factors such as factors related to socio-demographic characteristic of residents (gender, age, income, and education), factors related to the physical nature of risks (such as perceived probability of environmental contaminations, probability of receiving impacts, and severity of catastrophic consequences), and psychological and cognitive factors (as ability to control the risk, concern about family members, experiences with air pollution, perceived benefits from industrial development and social trust) were examined. The analysis consists of two sections.

1: the qualitative analysis of risk perception exhibited by NGOs, environmental protection agencies, academia, and public health service had been conducted based on the results of in-depth interviews. The significant factors determining a degree of risk perception were also identified. The results demonstrated that stakeholders exhibited different degrees of risk perception, and their risk perception had been determined by different factors related to the nature of risks. This phenomenon caused the gap in risk perception among stakeholders.

2: risk perception held by lay people was thoroughly investigated, and relationship between risk perception and potential predictor factors, including socio demographic factors, factors related to the nature of risks, and psychological and cognitive factors, were analyzed by means of multiple regression analysis. In addition, how the relationship between these factors differs among people facing a different level of hazardous gas contamination was also investigated. The study conducted a questionnaire survey by distributing questionnaire sheets to 181 residents who currently live in communities experiencing different levels of hazardous gas contamination. The results showed that the factors related the physical nature of risk were more influential to predict risk perception hold by lay people from high-risk and moderate-risk communities. Moreover, different from findings of previous studies, environmental risk perception held by lay people in high-risk community has a positive relationship with perceived benefits. Lay people in high-risk community, actually, realized the fact that higher benefits are always associated with higher risk taking. The results suggest that communication platform for fostering mutual information sharing between stakeholders should be established because laypeople are actually knowledgeable, and their possessed information should be communicated to other stakeholders as well. The goal of communication should go beyond the mere conveying information from experts to non-experts. In addition, stakeholders' qualitative risk assessment should be included in a mandatory environmental risk management.

In the second part, the study aims to investigate roles of uncertainty communication in building trust in industrial agencies and public authorities. The study first investigates whether lay people have capability to conceptualize uncertainty associated with risk management and uncertainty related to potential impacts. Then, relationship between lay people's understanding of uncertainties and levels of trust in risk management operated by public authorities and industrial agencies were examined. Finally, (1) roles of uncertainty communication in building trust and (2) the strategic way to communicate information related to uncertainty were discussed based on empirical studies and literature reviews.

In conclusion, the study proposed risk communication strategies which contain specific purposes to minimize the gap in risk perception among stakeholders and to build trust between the public and public authorizes and industrial agencies.

Keywords: qualitative risk assessment; environmental risk management; risk communication; risk perception

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JANMAIMOOL Piyapong

September 2014

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CHAPTER 1: INTRODUCTION

1.1 GENERAL INTRODUCTION

Environmental Contamination in Industrial Areas

The development of industrial sectors worldwide has caused vast damage to the environment and human health [1–4]. The Maptaphut industrial development area, a chemical industry hub in Thailand, is one of many cases representing a failure in environmental risk management. After the industrial estate was established, all types of environments in the area, including soil, water resources, and air, have been contaminated with hazardous substances and compounds (see fig. 1.1) [5-8]. The most serious issue is polluted air, which has been assumed as a cause of cancer and respiratory diseases among patients in the area [9-10]. The results of air monitoring during the 2007–2013 showed that many types of volatile organic compounds (VOCs) in ambient air, including benzene, 1,3-butadiene, chloroform, and 1,2-dichloromethane, were above the annual standard [11]. In 2003, the National Cancer Institute in Thailand revealed that the number of cancer patients in the area was significantly higher than the national average and the number of patients in Bangkok City [12]. It was also found that the rate of patients with diseases caused by environmental pollution had increased rapidly in the area since 2003 [13].

Fig. 1.1 Environmental contamination in Maptaphut area
Source: Bangkok post, (May 2012) [14] and Greenpeace Thailand, (2009) [15]

Causes of Failures in Environmental Risk Management

Although environmental problems in the area have been enthusiastically solved by governments and the industrial sector, many parties are still concerned and believe that the risks associated with industrial activities still exist. One of the critical issues is a failure in risk management which cannot be operated based on the full involvement of all relevant parties, such as laypeople, non-profit organizations (NGOs), governments, and the industrial sector. Failures in multi-stakeholder risk management are relatively contributed by: (1) immense gap in risk judgment and perception among relevant stakeholders, including laypeople, public authorities, industrial sectors, members of Non-profit organizations (NGOs), and academia: (2) fragile trust between those relevant parties which consequently affects their involvement in risk management and public acceptance of industrial development in the area (see fig. 1.2). Moreover, the current risk communication is not effectively developed for coping with these issues (see fig 1.3). Under the current risk communication, the merely conveying information related to risk from experts to non-experts, technical approach to risk communication is emphasized.

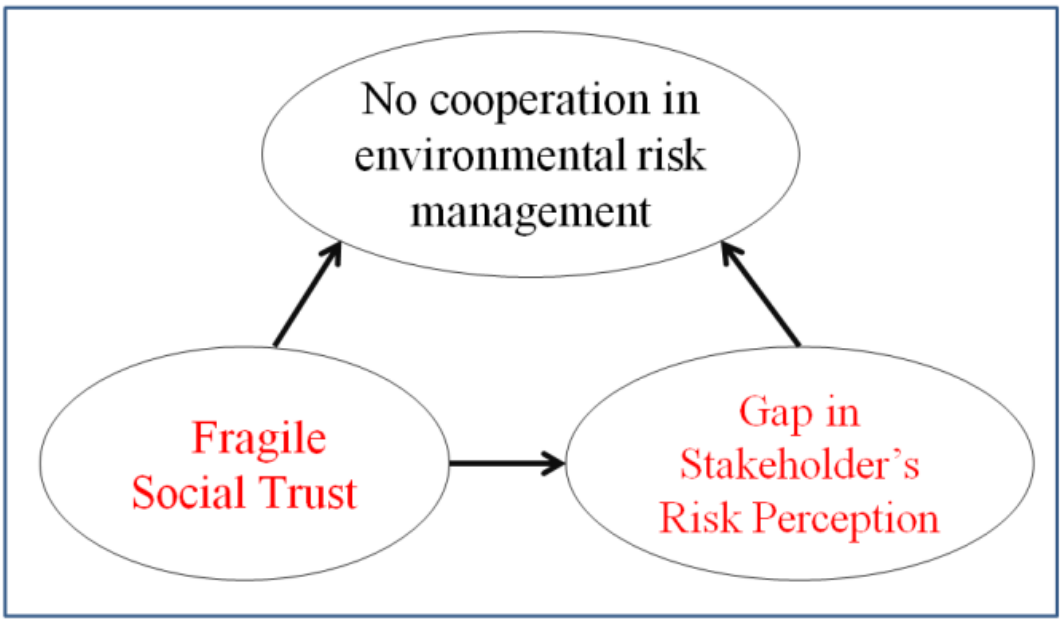

Fig. 1.2 Cases of failure in stakeholders' cooperation in risk management
Source: Adapted from Earle TC, et al (2007) [16] and Jardine et al, (2013) [17]

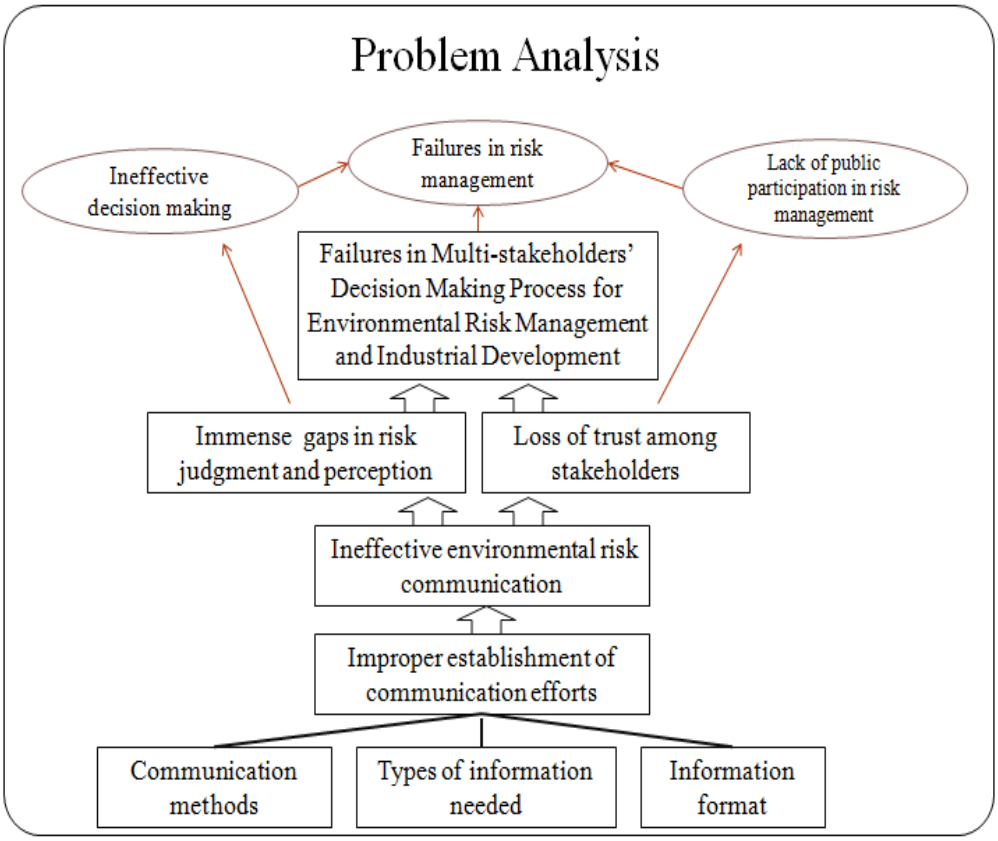

Fig. 1.3 Problem analysis
Source: Author, (2014)

Goal of the Study

The goal of this study is to development risk communication strategies which can bridge the gap in risk perception among relevant parties, and can increase lay people's trust in organizations responsible for risk management such as public authorizes and industrial agencies. In this way, to develop risk communication which can bridge the risk perception gap, determinants of risk perception held by lay people and relevant stakeholders were investigated by means of both qualitative and quantitative analyses.

In addition, regarding the communication for trust building, the study also investigated the roles of communication of uncertainty in increasing trust between the public and organizations responsible for risk management. It was previously believed that uncertainty should not be communicated to non-experts because it might result in the public developing negative perspectives of the process of risk assessment, public distrust, and confusion related to

adverse effects of a given hazard [18]. In fact, non-experts do have the ability to conceptualize the association of uncertainty in environmental risks and also to understand different kinds of uncertainty, such as uncertainty associated with the risk management process and uncertainty about potential impacts [19]. When uncertainty has been communicated to them, lay people might have more confidence in a mandatory risk management process and could recognize the importance of scientific research in order to minimize uncertainty. Therefore, ignorance regarding communicating uncertainty might eventually result in public distrust. Discussion on the roles of uncertainty communication would be also emphasized in this study.

1.2 RESEARCH OBJECTIVES

The study consists of two major research objectives as follows;

1.2.1 To identify the gap in risk judgment and perception among relevant stakeholders and to suggest risk communication model and strategies which potentially bridge the gap in risk perception

- To investigate the degree of industrial risks judged by relevant stakeholders (laypeople, NGOs, academia, environmental protection agencies, and health care service) and to investigate their fundamental understanding of risk related judgment.
- To evaluate the determinants of risk perceptions held by inhabitants of industrial communities who were experiencing different levels of hazardous gas contamination
- To identify the causes of stakeholder's risk perception gap, and to propose risk communication model and strategies

1.2.2 To investigate roles of uncertainty communication for building public trust in risk management established by public authorities and industrial agencies

- To investigating whether lay people can conceptualize uncertainty associated with both risk assessment and uncertainty about potential impacts.
- To explore how lay understandings of uncertainty are related to degrees of trust in public authorities and industrial agencies.
- To explore the contribution of uncertainty communication to building trust among relevant stakeholders

1.3 SCOPE OF THE STUDY

This study consists of two main parts. In the first part, investigations on stakeholders' risk perception and risk judgments were conducted. Then, the causes of the immense gap in risk perception held by selected stakeholders were identified, and risk communication model and strategies were proposed based on the result of empirical study. In the second part, the study investigated roles of uncertainty communication in building public trust between the public (lay people) and organizations responsible for risk management such as public authorities and industrial agencies. The details of both parts of the study could be described as follow;

1.3.1 To propose risk communication model and strategies which could minimize the gap in risk perception, the study conducted the investigation on stakeholders' risk perception and their fundamental understanding of risk-related judgment. Additionally, the evaluation of determinants of risk perception held by laypeople in contaminated sites was also statistically analyzed by means of multiple regression analysis. There are three steps in the first part of the study.

1) The study first analyzes the degree of perceived industrial risks exhibited by primary stakeholders such as laypeople, members of NGOs, academia, environmental protection agencies, and public health, and then the study identified how their perception is determined by factors related to the nature of risks such as perceived probability of environmental contamination, perceived probability of receiving impacts, perceived severity of catastrophic consequences, and other issues such as uncertainty. To measure risk perception, the study explored stakeholders' perceptions of the potential impacts of industrial activities on human health and well-being, which were classified into five aspects: (1) psychological effects, *i.e.*, the negative impacts of air pollutants on the human psychological system, such as anxiety or mental disorder; (2) physical health effects, *i.e.*, the impact of air pollutants on the human immunity system; (3) respiratory effects, *i.e.*, any respiratory diseases caused by inhalation of air pollutants; (4) lifestyle disruptions, *i.e.*, negative changes in local people's daily lives, local customs, or traditions; and (5) nuisance, *i.e.*, annoying conditions caused by the changes in living environments, for example, noise pollution. Qualitative analysis was conducted based on the result of in-depth interviews with selected primary stakeholders.

2) The study evaluates the determinants of risk perception held by laypeople living in contaminated sites. The proposed model for the investigation is shown in figure 1.4. The factors potentially affecting risk perception could be divided into three groups such as factor related to socio-demographic characteristics, factors related to the nature of risks, and psychological and cognitive factors. (see fig 1.4). This study analyzes relationships between these selected factors and the risk perceptions held by laypeople facing different degrees of air contamination. The questionnaire was created, and 181 questionnaires were distributed to people living in the selected communities which were classified into three types such as high-risk community, moderate-risk community, and low-risk community. All the collected data are statistically analyzed by using two methods. First, the analysis of variance (ANOVA) is performed to identify the significant differences in risk perception of people living in high-risk, moderate-risk, and low-risk communities. Next, to identify the factors determining the risk perception of people living in each type of community, a multiple regression analysis is performed.

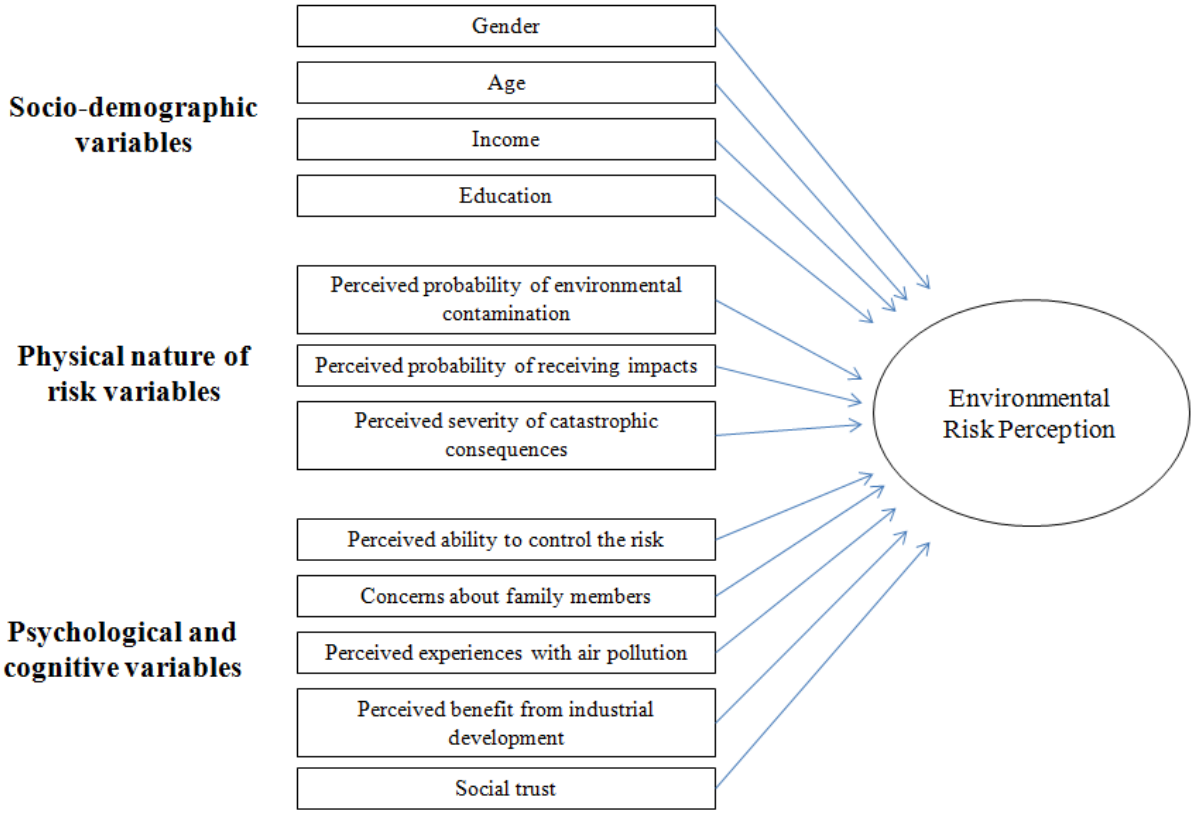

Fig. 1.4 Conceptual model of risk perception
Source: Author, (2014)

3) Based on the results of investigations, the study discusses the causes of immense gap in risk perception held by relevant stakeholders, and offer suggestions that could improve the current risk communication and management.

1.3.2 To propose risk communication strategies which could build trust between the public (laypeople) and organizations responsible for risk management such as public authorities and industrial agencies, the study explores roles of communication of information related to uncertainty which is divided into two types such as assessment uncertainty and uncertainty about potential impacts. There are also three steps in the second part of the study.

1) The study explores the capability of laypeople in conceptualizing uncertainty associated with risk assessment and uncertainty about potential impacts caused by environmental contamination.

2) The relationship between social trust and lay understanding of two types of uncertainties is examined by conducting t-test analysis. The degrees of social trust exhibited by lay people who comprehend and do not comprehend the information related to uncertainty are compared. The model for investigation of the proposed relation could be shown in figure 1.5.

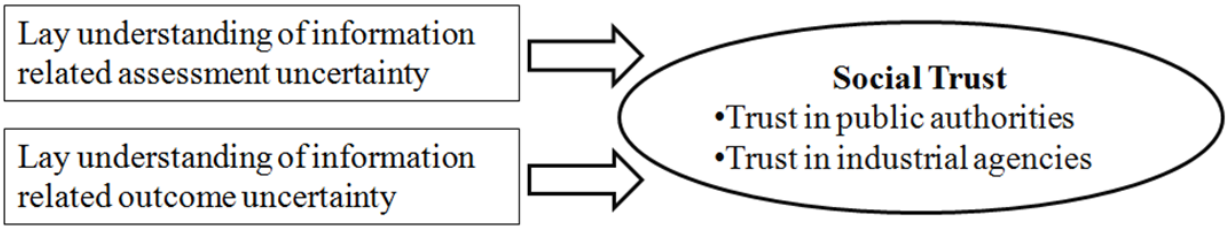

Fig. 1.5 The Model for the investigation of relationship between degree of social trust and lay understanding of uncertainty
Source: Author, (2014)

3) All findings are discussed in terms of their contribution to the development of risk communication strategies for building public trust between lay people and organizations responsible for risk management such as public authorities and industrial agencies.

1.4 OVERVIEW OF METHODOLOGY

The study employed a range of research methodologies to explore stakeholder risk judgments and perception as well as relationship between lay understanding of uncertainty and

social trust before suggesting risk communication model and strategies. Research methodologies could be divided into four steps as follows;

1.4.1 Selection of a case study

The Maptaphut municipality and related areas, located in Rayong Province, Thailand, was selected as a case study because of the seriousness of environmental contamination and the need for risk mitigation and communication strategies in this area. Up until 2013, there were 38 communities in the Maptaphut area. The population is 56,591 people (28,504 male and 28,087 female), and the number of households is 42,295 [20]. Characteristics of physical environments in the area are included in figure 1.6. The area contains five industrial estates which are surrounded by residential and commercial areas.

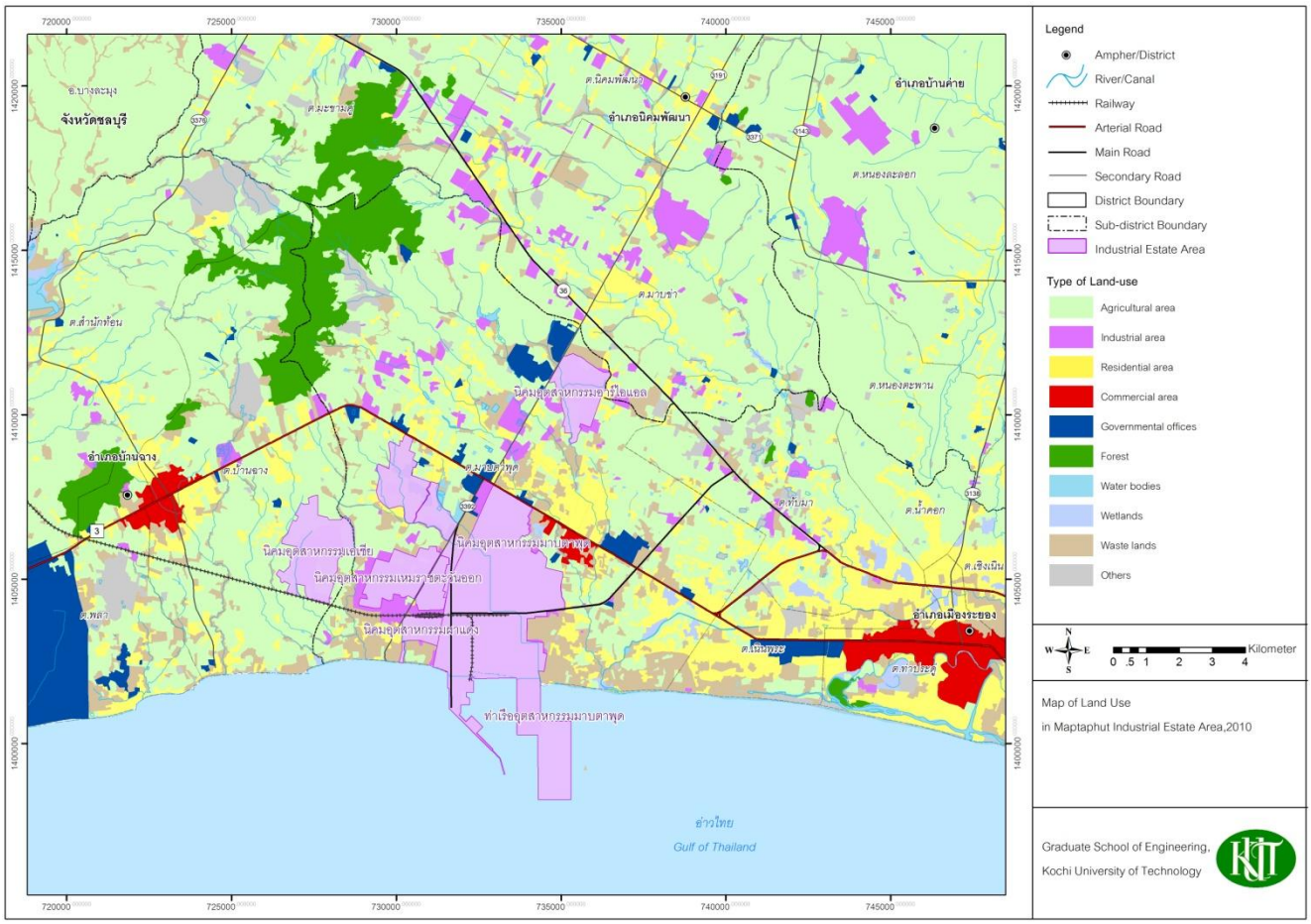

Fig. 1.6 The study area: Maptaphut municipality, Rayoung province, Thailand
Source: Created based on Geographic Information System (GIS) data (2010), Ministry of Information and Communication Technology, Thailand.

1.4.2 Development of study framework

The study frameworks shown in figure 1.4 and 1.5 were developed based on the result of primary surveys in the study area during February – March 2013 as well as the results of literature reviews. Concepts and theories related to environmental risk management, risk perception, and risk communication had been thoroughly reviewed, and applied to create the study framework. In addition, a range of relevant previous studies related to a field of engineering, social science, psychology, and management had been tremendously reviewed and considered for the development of the study structure.

Overview, the study assumed that the causes of immense gap in risk perception among relevant stakeholders are due to the different viewpoints in risk judgment among them; especially, risk perception held by laypeople which could be influenced by a range of factors. Moreover, those factors could be changed from what had already been addressed by many scholars. According to the results of primary survey, laypeople seemed to be more knowledgeable and skillful because of their strong social networks and enhancement of education quality provided by educational institutions. Factors influencing their perception could be more related to factors related to the nature of risks than psychological and cognitive factors. Understanding how each stakeholder judged and perceived environmental risks could provide basic understanding on how to develop risk communication strategies.

In addition, this dissertation also emphasized on roles of uncertainty communication in building trust between laypeople and organizations responsible for risk management. Not only public authorities and industrial agencies' expression of caring and empathy play a crucial role in building trust. Expression of honesty and faith can be also influential. Currently, information related to uncertainty is not explicitly and effectively communicated to the public due to avoidance of public anxiety. However, hiding information related to uncertainty could also reduce the public's perceived faith and honesty of organizations responsible for risk management; especially, during the emergence of environmental and health impacts suffered by local residents. Therefore, this study would verify whether laypeople could understand information related to uncertainty associated with risk assessment as well as uncertainty about potential impacts, and how their understanding related to the degree of social trust. Finally, the study discussed roles of uncertainty communication in building public trust.

1.4.3 Data collection

This study required both primary data and secondary data which could be shown in table 1.1.

Table 1.1 Data collection

Research objectives	Types of Data Required	Data Collection Method
To investigate the degree of industrial risks judged by relevant stakeholders and to investigate their fundamental understanding of risk related judgment.	*Primary data* - Stakeholders' attitude towards potential impacts of industrial risks - Stakeholders' analytical ways of thinking about risks	- In-depth interviews with key stakeholders during Feb.-Mar. 2013
To evaluate the determinants of risk perceptions held by inhabitants of industrial communities who were experiencing different levels of hazardous gas contamination	*Primary data and secondary data* - Laypeople' attitude towards potential impacts of industrial risks - Laypeople' analytical ways of thinking about risks - Socio-demographic data - Information related environmental contamination in the areas - GIS data showing physical characteristic of the study area	- In-depth interviews with laypeople during Feb.-Mar. 2013 and Oct. 2013 - Questionnaire distribution to 181 laypeople during Oct-Nov. 2013
To identify the causes of stakeholder's risk perception gap, and to propose risk communication model and strategies	*Primary and secondary data* - Current risk communication system existing in the study area - Concepts related to environmental risk communication	- Observation and interviews with relevant stakeholders - Concept reviews
To investigating whether lay people can conceptualize uncertainty associated with both risk assessment and uncertainty about potential impacts.	*Primary data* - Laypeople' attitude towards uncertainty associated with risk assessment and uncertainty about potential impacts	- Questionnaire distribution to 181 laypeople during Oct-Nov. 2013
To explores how lay understandings of uncertainty are related to degrees of trust in public authorities and industrial agencies.	*Primary data* - Laypeople' expression on confidence in capability of public authorities and industrial agencies in managing risks	
To explore the contribution of uncertainty communication to building social trust	*secondary data* - Concepts related to uncertainty communication - Lesson learnt from previous studies	- Concept reviews

1.4.4 Sampling groups

This study required participations of many individuals and organizations. For the in-depth interviews, persons and organizations participating in this study could be shown in the table 1.2. Moreover, 181 questionnaires were distributed to local residents living in communities located in Maptaphut municipality, Rayong province, Thailand.

Table 1.2 Sampling groups for the in-depth interviews

Stakeholders		***Number of interviewees***	**Place for the Interview**
Lay people	- Community Leaders - Lay people	2 11	- Watsopol Community, Rayong - Nuangfab Community, Rayong
Environmental Protection Agencies	- Officers of Maptaphut Municipality	3	- Maptaphut Municipality Office
Academia	- Biologist - Urban Environmental Planner - Public health expert	1 2 1	- Thammasat University, Rangsit Campus, Pathumtani - Thammasat University, Taphachan Campus, Bangkok
Member of NGOs	- The director of Ecological Alert and Recovery - Thailand (EARTH) - Member of green peace southeast Asia, Thailand(1) - Member of Ecological Alert and Recovery - Thailand (EARTH) - Member of public opposition to Nuclear energy - Member of Public Health Policy Foundation	1 2 2 1 2	- Chulalongkorn University, Bangkok City - Office of Ecological Alert and Recovery , Bangkok - Online
Public health sector	- Staffs of Maptaphut Hospital - Staffs of Bangkok hospital Rayong	2 2	- Maptaphut Hospital, Rayong - Online
Total		32	

1.4.5 Data analysis

Both qualitative and quantitative analyses were conducted in this study. First, to understand fundamental understanding of risk-related judgments of selected stakeholders as well as to demonstrate the degree of perceived risk, content analysis was conducted by summarizing data gained from the in-depth interviews with key stakeholders. In addition, to reveal degrees of risk judged by each stakeholder, mean scores representing the degree of risk perception exhibited by each stakeholder were also calculated, and compared one another.

For the evaluation of determinates of risk perception held by laypeople, two statistical techniques were applied. First, the analysis of variance (ANOVA) was performed to identify the significant differences in risk perception of people living in high-risk, moderate-risk, and low-risk communities. Then, to identify the factors determining the risk perception of laypeople, regression analysis was first conducted in order to evaluate the relationship between risk perception (dependent variable) and selected potential predictive factors (independent variables), such as socio-demographic characteristics, the physical nature of risks, and psychological and cognitive factors. Then, data were separated into three sets according to the degree of air contamination experienced by each area, and multiple regression analyses were performed again. This is because the study aimed to identify the factors determining the risk perception of laypeople living in three different types of communities such as high-risk community, moderate-risk community, and low-risk community. The results are presented as a set of regression equations describing the statistical relationship between the dependent and independent variables. Finally, all results are discussed in terms of their implications for the development of risk communication strategies.

In the second part of the study, roles of uncertainty communication in building public trust, the study aimed to justify the relationship between trust and lay understanding of uncertainty, the mean score, representing a level of trust held by lay people with comprehension of uncertainty, was compared to the mean score, representing a level of trust held by lay people with no comprehension of uncertainty. The statistical difference of mean scores between groups was proven by the result of the t-test analysis. All findings were discussed in terms of their contribution to the development of strategies for public trust building.

1.5 DEFINETIONS OF TERMINOLOGY

1) Stakeholders

A group or an individual who affects, or is affected by the achievement of a corporation's purpose [21]. In another world, social actors who are knowledgeable and capable and can formulate and defend decision [22]. For this study, stakeholders for environmental risk management in Maptaphut area consist of lay people, NGOs, academia, environmental protection agency, and public health sector.

2) Environmental risk

Environmental risk is defined as actual or potential threats of adverse effects on living organisms and environment by effluents, emissions, wastes, resource depletion, etc., arising out of an organization's activities.

3) Risk Perception

Risk perception is a judgment of the adverse consequences of a particular hazard and can be made by an individual, a group of people, or society. The term "risk perception" generally refers to natural hazards and threats to the environment or health [23]. Risk perception can be formed based on both belief and self-appraisal [23].

4) Risk Communication

Risk Communication is a science-based approach for communicating effectively in high-stakes, emotionally charged, controversial situations. The ultimate job of risk communication is to try to produce a citizenry that has the knowledge, the power, and the will to assess its own risks rationally, decide which ones it wants to tolerate and which ones it wants to reduce or eliminate, and act accordingly [24]. In another world, risk communication is an interactive process of exchange of information and opinion among individuals, groups, and institutions [25]. In this study, risk communication is defined as any two-way communication between stakeholders about the existence, nature, form, severity, social values, feelings, concerns, or acceptability of risks.

5) Risk Management

A risk management is a formal method for assessing and managing health risks. Most of risk management models are intended to provide a structured approach to health risk assessment,

evaluation, and management. Risk Assessment is structured to include both consideration of scientific evidence in a risk analysis step, and analysis of socioeconomic concerns in an option evaluation stage.

6) Cooperation

Any form of cooperative behavior between a person and another person or group of persons, or between a person and organization/institutes [16].

7) Trust

Trust is confidence in the capability, acts, character, honesty, or integrity of a person or organization [26]. In order word, trust is defined as the willingness to be vulnerable to a trustee based on positive expectations (beneficial outcomes) about the trustees actions and intentions [16].

8) Uncertainty

Uncertainty is a situation where the management of a firm has little information about its external environment that is in a state of flux and, hence, largely unpredictably [27]. Several types of uncertainties are associated with environmental risk management due to the complexity of management processes which are related to (1) pollutant release into the environment; (2) transports of pollutants in a variety of environmental conditions; (3) a variety of potential health impacts; (4) and the probability of adverse impacts on a human population which has different genetic characteristics [28].

9) Uncertainty Communication

Communication of uncertainty is a dissemination of information related to uncertainty. It aimed at involving policymakers and other relevant parties in policymaking. Communicating uncertainty is a crucial component of the practice of human health risk communication. Stirling [29] stated that conveying the information related to uncertainty is crucial not only so that decision makers will understand the range of evidence on which to base a decision, but also because it can make the influences of "deep intractabilities of uncertainty".

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CHAPTER 2: THEORITICAL CONTEXT

2.1 GENERAL INTRODUCTION

In this chapter, relevant concepts and theories applied to construct the study framework are described. First, the concept of environmental risk management and roles of risk communication in risk management processes are presented. Then, the study summarized the concepts of risks which were defined by many scholars. Based on those scholars' risk definitions, risks could be viewed differently based on individuals' approaches. Most importantly, the results of literature reviews, presenting potential factors which might influence organizations or individuals' risk perception are deeply shown. In the last part, the concept of uncertainty communication is presented, and the relationship between uncertainty communication and social trust building, significant to the cooperative risk management, will be demonstrated.

2.2 ENVIRONMENTAL RISK MANAGEMENT

A risk management is a formal method for assessing and managing health risks. Risk frameworks have been devised by several organizations in Canada, the United States and elsewhere [1]. All are intended to provide a structured approach to health risk assessment, evaluation, and management. In the United States, the earliest and most elaborate risk framework for environmental health was developed by the U. S. National Research Council (NRC) in 1983. In case of Canada [2], a model for risk assessment and risk management was developed in the early 1990.s by the Health Protection Branch (HPB) in Canada. It has served as a guideline to assist Health Canada in protecting Canadians against environmental hazards such as chemical pollutants and food contaminants and other public health activities to control disease and injury. Under the HPB framework, risk assessment is structured to include both consideration of scientific evidence in a risk analysis step and analysis of socioeconomic concerns in an option evaluation stage (see fig. 2.1).

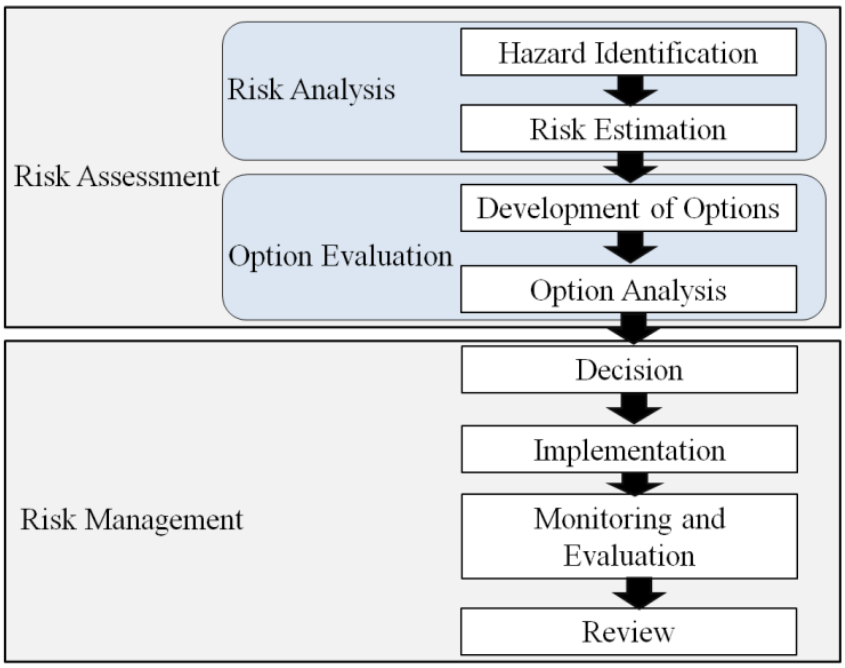

Fig.2.1 Model for risk assessment and risk management
Source: Health Canada, (1990) [2]

An environmental management system is a continuous cycle of planning, implementing, reviewing and improving the processes and actions that an organization undertakes to meet its environmental targets and requirements [3]. It is a system to comply with the requirements of international standards such as ISO 14001 and EMAS. The definition of an EMS used by ISO 14001 is *"The part of the overall management system that includes organizational structures, planning activities, responsibilities, practices, procedures, processes and resources for developing implementing achieving, reviewing and maintaining the environmental policy"* [4]. An environmental management system thus manages the environmental impacts of an organization. The expected outcome is continuous improvement in environmental management.

2.3 RISK COMMUNICATION

Risk communication plays a crucial role in risk management. Doug Powell and Bill Leiss [5] have described risk communication as "the causeway that links all the organizational elements in a well-functioning risk management process". Risk communication among stakeholders is deemed integral to all stages of the risk management processes [see table 2.1]. The definitions of risk communication are diverse. According to EPA [6], "Risk communication is the art of putting science in the hand of people, in the way they can use". Effective risk

communication must enable receivers to understand a received message, and receivers are able to use those communicated information for risk assessment and management. In another word, risk communication is a science-based approach for communicating effectively in high-stakes, emotionally charged, controversial situations [7].

The ultimate job of risk communication is to try to encourage citizens that have the knowledge, the power, and the will to assess its own risks rationally, decide which ones it wants to tolerate and which ones it wants to reduce or eliminate, and act accordingly [7]. Effective risk communication requires an interactive process for the exchange of information and opinion among individuals, groups, and institutions. Social and cultural values, as well as the technical risk data should be included in risk communication [8]. Goals of risk communication are various, ranging from informing parties about information related to risks, changing attitudes or behaviors, creating long-term public participation, and engendering trust itself [9,10].

Table 2.1 Risk communication in risk management processes

Risk Management Step	Risk Communication
Initiation	- Consult with stakeholders in defining scope of issue
Risk estimation	Discussion of source, exposure issues - Communication of results with stakeholders - Assess changes in knowledge/perception in light of new information
Risk evaluation	- Elicit stakeholder perceptions of the risks and benefits, and the reasons for these, if possible - Assess stakeholder acceptability of the risk
Risk control	- Consult with stakeholders to gain input into identifying and evaluating control options - Inform stakeholders of chosen risk control and financing strategies - Evaluate acceptance of control options and residual risks - Determine if risk trade-offs might be possible
Implementation	- Communication of risk control decision and implementation
Monitoring	- Ensure implementation of communication strategies - Monitor changes in needs, issues, concerns of existing or new stakeholders

Source: Adapted from the Presidential/Congressional Commission on Risk Assessment and Risk Management, 1997

The U.S. Presidential/Congressional Commission on Risk Assessment and Risk Management [3] identified the benefits of an open communications dialogue between risk managers and stakeholders for effective risk management.

"A good risk management decision emerges from a decision-making process that elicits the views of those affected by the decision, so that differing technical assessments, public values, knowledge, and perceptions are considered."

Source: The Presidential/Congressional Commission on Risk Assessment and Risk Management, 1997 [3]

To include stakeholders in risk management, risk communication should be a process in which stakeholders share information about hazards affecting a community. The use of the term sharing is important because risk analysts and/or organizations responsible for risk management must understand how different segments of the population at risk think about a hazard if they are to be effective in communicating with their audience. These population segments may include businesses and households that are vulnerable to a specific hazard, as well as community and industry personnel who are responsible for managing a hazard in ways that reduce the risk to a level that is acceptable to the community.

2.4 RISK RELATED CONCEPTS

Currently, risk-related concepts are diverse. According to Lash and Wynne [11], risks can be conceptualized as the probabilities of catastrophic harm caused by technological or other modernization processes. Otway and Thomas [12] mentioned at least two major risk concepts. The first is the realist approach that views risk as a physical reality that is estimated based on scientific knowledge. The second is risk as a social construct that emphasizes the contrasting definitions of risks in social reality. In other words, risk can be conceptualized into three approaches: objective, subjective, and perceptive [13]. The objective approach refers to risk as a product of scientific research conducted based on experiments and scientific methods. In contrast, the subjective approach claims that risk is not solely objective; it varies depending on people's state of mind influenced by collective experiences, social norms, and uncertainties. In the perceptive approach, risk is defined as the set of all destructive consequences that are believed to be possible by a person who has evidence about the frequency, severity, and variability of the effects [13]. However, Fischoff [14] stated that no definition of risk is ultimately correct, since no suitable one applies to

all problems. Recently, traditional risk assessment based on science alone has increasingly come into question [15] because the risks to society are exhibiting far more diverse aspects beyond the scope of scientifically estimated risks. Ropeik [15] argued that although scientific risk assessment is thoroughly conducted by using reliable methods, results will conflict with the inherent way human beings perceive risk, because how normal people live is not well understood by experts and policymakers. Many scholars are becoming increasingly interested in risk perception. Understanding how it is perceived can potentially contribute to the improvement of risk communication [16-18]. Furthermore, such understanding can also help mitigate underlying impacts [19,20] and support stakeholders' long-term engagement in risk management [21].

2.5 RISK PERCEPTION AND JUDGEMENT

Risk perception is a judgment of the adverse consequences of a particular hazard and can be made by an individual, a group of people, or society [22]. The term "risk perception" generally refers to natural hazards and threats to the environment or health [23]. Risk perception can be formed based on both belief and self-appraisal [22,23,24]. Until now, four approaches have been used to study how risks are perceived. The first approach is the sociocultural paradigm, including the cultural theory of risk or simply cultural theory. Based on the cultural theory, risk perception is constructed from beliefs influenced by social forces in society [25,26]. Although it is constructed from beliefs, this sort of risk perception reflects the interests and values of each group, the diverse meanings of the term "risk" and natural phenomena within each group [22,27].

The second approach is the psychometric paradigm, which includes the psychometric model and the basic risk perception model (BRPM). The psychometric model proposed by Fischhoff in 1978 addressed how human risk perception is significantly influenced by the physical properties of risks (voluntariness, familiarity, and catastrophic consequences), as well as psychological and cognitive factors (dread, experience, benefits associated with the risks, controllability, and knowledge) [14,17]. Psychometric studies found that each type of hazard has a specific pattern of qualities related to risk perception. Some scholars working with this approach have critiqued the cultural theory. For instance, Sjoberg's study [28] revealed the low relationship between culture adherence and risk perceptions. He explained that risk perception is

related to real risks rather than cultural aspects. In 1993, Sjoberg developed his own model, the BRPM, which explains more diverse dimensions of risk perception. It adapts the psychometric dimension [28] and includes the four factors of attitude, risk sensitivity, specific fear, and trust.

The third approach is the interdisciplinary paradigm that applies several concepts to explain risk perception. Its most distinct concept is Kasperson's social amplification of risk framework (SARF) [29], a systematic conceptualization of how scientific risk is influenced by psychological, social, institutional, and cultural processes [30]. This model explains two processes associated with risk perception: first, risk perception is affected by a variety of social processes such as social institutions' roles in communicating risk-related information, a range of communication channels existing in societies, institutional behaviors, and sociopolitical processes; second, risk messages are interpreted and perceived by individuals or society as a whole [31].

The fourth approach is the axiomatic measurement paradigm that focuses on how average people subjectively transform objective risk information [32]. It is believed that risk perception is influenced by possible catastrophic consequences (fatal outcomes, mortality rates, *etc.*) and likelihood of occurrence.

Risk perception is a dynamic process that takes place in society. The factors determining risk perception can be related to all four approaches and may differ in each specific threat. In the case of environmental health risk associated with industrial development, risk perception may not only be determined by social adherence and/or emotional factors. It is also important to understand the influence of laypeople's comprehension of the nature of risks, including probability and consequence. People need information related to the physical nature of the risk presented to them in a way they can understand.

2.6 FACTORS DETERMINING RISKS

As mentioned above, risk perception can be formed based on both belief and self-appraisal. In other words, risk perception can be processed based on a rational processing system [33,34] or an experiential processing system, which includes emotion, value, and affect in risk judgments [35], and a different set of determinate factors affects perception processed through a different system. Factors determining risk perception can be divided into three groups as follows;

2.6.1 Socio-demographic factors

A range of previous studies have addressed that several socio-demographic characteristics of individuals influences environmental risk perception. Most distinct variable is gender which was examined on its relation to risk perception in a dozens of studies. The results of those studies have shown that females tend to perceive higher risks than males do (reviewed in Slovic, 1999 [36]). Other variables which possibly influence individuals' perceived environmental risks are such as age, educational level, as well as economic status.

2.6.2 Psychological and cognitive factors

The psychological and cognitive factors include controllability, experiences, perceived benefits, concerns about family member, and social trust. Laypeople's ability to control the risk could play a profound role in shaping risk perception. First, risks would be highly perceived if individuals feel that they have no ability to control them, for instance, risks associated with nuclear power plants or with flying in an airplane [14,37,38]. Second, previous experiences also constitute a crucial factor that might have a positive relationship with individuals' perceived risks [39-41]. As stated by Paolo et al. [39], people smelling unfamiliar odors may exhibit a high-risk perception due to their concerns about respiratory diseases such as asthma and lung cancer. In the case of perception about the dangers of natural hazards, according to Wachinger et al.'s observations [42], experiences may have both positive and negative relationships with risk perceptions. With experiences of natural calamities, laypeople mostly exhibit high perception of potential disaster damages, but in some cases, risks are perceived low if people did not receive much negative impact from previous events, and the natural catastrophe does not occur often. People think that after its last occurrence, a natural disaster is unlikely to happen again in the near future. Third, perceived benefits from industrial development comprise one of the psychological factors that have been widely investigated, whether it is associated with perceived risks. Gregory and Mendelsohn [43] stated that individual risk assessment is included with the person's perceived benefits. When technologies are perceived as highly beneficial, their risks are relatively devalued [44]. It is therefore possible that laypeople who perceive high benefits might exhibit lower perception of the risks they face. The fourth factor constitutes family concerns, which could contribute to perceived high risks. Laypeople who live in large households and/or have families with a number of children might have high concerns regarding potential impacts of

contaminated air; thus, their risk perception can be perceived as high [45]. The last factor is social trust which is a measure of trust that an individual has in public authorities and industrial agencies to manage risks associated with industrial activities [46]. As addressed in many studies related to risks, individuals with greater levels of social trust may perceive less risk than do individuals with lower levels of social trust. For instance, trust has been shown to be a crucial factor effecting perception of risks associated with nuclear power, pesticide use, and artificial sweetener [46].

2.6.3 Factors related to the nature of risks

Besides psychological and cognitive factors, laypeople's perceived risks could be constructed based on their analytical way of thinking about the nature of risks [33,34], including the perceived probability of environmental contamination, probability of receiving impacts, and perceived severity of catastrophic consequences [23,33,34,37]. The relationships between the factors related to the nature of risks and risk perception are explained in the axiomatic approach; namely, an individual's perceived risk is influenced by the probability of its occurrence and the likelihood of a negative outcome [32]. Currently, the contribution of factors related to the nature of risks and to environmental risk perception is still unclear and scarcely investigated in previous studies. One related research conducted by Yong et al. [47] found that the likelihood of injury is not a significant factor contributing to perceptions of risks associated with consumer products, but the most influential factor is severity of injury. In the case of environmental health risks, Slovic [35] found that laypeople's risk judgments are highly related to characteristics of catastrophic potential rather than probability; if there is substantial adverse damage associated with the disaster, the perceived risk is high, though there is low probability. Furthermore, many previous studies showed that laypeople's perception of environmental risks is a function of their psychological and cognitive characteristics, but factors related to the nature of risks have less power in explaining risk perception [48,49]. However, regarding the current situation, particularly in democratic societies (where laypeople can easily access risk information due to their strong social networks with other organizations and the enhanced quality of education), the determinants of risk perception held by laypeople could be changed.

2.7 SOCIAL TRUST, RISK PERCEPTION, COOPERATION

Earle *et al.* [50] defined the definition of trust as the willingness to be vulnerable to a trustee based on positive expectations (beneficial outcomes) about the trustees actions and intentions. In another word, trust can be defined as confidence in the capability, acts, character, honesty, or integrity of a person or organization [51]. Trust relies on several components, including perceived competence, objectivity (lack of bias), fairness, consistency, and faith [52]. Covello [53] suggested that trust is determined by the following four factors: caring and empathy; commitment; competence and expertise; and honesty and openness. Many previous research studies discussed the contribution of social trust to environmental risk perception or environmental concerns [46, 54-56]. These studies mostly concluded that social trust has a reverse relationship with perceived environmental risks. Assumedly, people have limited knowledge of science and insufficient capability to determine risks [57]. Therefore, they have to rely on other parties. However, the power of social trust in explaining risk perception or environmental concerns is varying and limited because perceived environmental risk could also be affected by other factors such as knowledge, experiences, and ability to control the risk [17]. The study conducted by Duan [58], for example, showed that the correlation between environmental risk perception and social trust was very small. It was assumed that people's knowledge and experiences related to environmental risks might be influential factors. Several studies, however, suggested that trust plays a crucial role in the development of risk communication and decision making in risk management [59,60]. For instance, Jardine et al.'s study [61] found that a lack of cooperation in environmental risk management, identified by delayed mitigation and remediation measures and a prolonged and costly consultation process, had been caused by the misrecognition of issues related to trust, including value similarity and past performance of public institutions.

2.8 UNCERTAINTY COMMUNICATION AND TRUST

Several types of uncertainties are associated with environmental risk management due to the complexity of management processes which are related to:

A) pollutant release into the environment;
B) transports of pollutants in a variety of environmental conditions;

C) a variety of potential health impacts;
D) the probability of adverse impacts on a human population which has different genetic characteristics (U.S. EPA, 2005) [62].

According to Finkel [63], uncertainty can be classified into the following four types:

A) variable uncertainty (some variables in a risk assessment model cannot be precisely measure);
B) model uncertainty (created for applicability in average situations, the model may not be able to simulate all realistic phenomena);
C) decision-rule uncertainty (it arises because of the need to balance a variety of environmental concerns and because of difficulty in determining the degree of risk acceptance); and
D) uncertainty associated with variability (using a single point risk estimate may ignore variability).

More simply, Brown and Ulvilla [64] proposed the following two distinct types of uncertainty: outcome uncertainty, which refers to a variety of degrees of potential damages caused by a hazard, and assessment uncertainty, which refers to the probability that the results of risk estimates are likely to change. In the past, it was thought that communication of uncertainty to the public might cause public distrust in science and technology [65]. However, some scholars have argued that non-experts have the potential to assess risks and recognize uncertainty. Ignorance regarding communicating uncertainty might result in the public having a negative perspective of the risk management process and institutions responsible for risk assessment. Although communicating information related to uncertainty to non-experts may lower the public's perceived competence associated with organizations responsible for risk management, it could potentially increase perceived faith [66]. However, the contribution of low perceived competence to trust can be compensated by faith and honesty [67].

In summary, communicating information related to uncertainty might increase public trust in risk management and institutions since it is believed that non-experts are also capable of performing an individual risk assessment and conceptualizing different kinds of uncertainties.

Avoidance in communicating this sort of information might create non-transparency in the whole process of environmental risk assessment, ultimately resulting in public distrust.

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CHAPTER 3: METHODOLOGY

3.1 GENERAL INTRODUCTION

In this chapter, the details of research methodology are described. First, the framework of this study is presented by showing the proposed relationship between stakeholders' risk perception and its determinants as well as relationship between lay understanding of uncertainty and social trust. In addition, the case study, Maptaphut municipality in Rayong province, Thailand is also presented in term of its current physical condition and environmental problems existing in the area. In the final part of this chapter, development of variables, data collection and analysis are explained.

3.2 STUDY FRAMEWORK

3.2.1 Investigation on stakeholders' risk perception and identification of causes of risk perception gap

To develop risk communication model and strategies, the study conducts investigation on stakeholders' risk perception and identify risk perception gap. According to the literature reviews and primary surveys, the factors potentially affecting risk perception could be divided into three main groups. The first group comprises factors related to the nature of risks, such as perceived probability of environmental contamination, probability of receiving impacts, and perceived severity of catastrophic consequences. The second group consists of psychological and cognitive factors, including perceived ability to control risks, concerns about family members, previous experiences with air pollution, perceived benefits from industrial development, and social trust. The third group is factors related to socio-demographic characteristics of residents such as gender, age, income, and education. This study investigates the relationships between these selected factors and risk perception held by lay people in contaminated sites. For other stakeholders such as members of NGOs, academia, environmental protection agencies, and public health sectors, determinants of their risk perception are investigated based on the examination of factors related to the nature of risks. Factors related to psychological and cognitive factors as well as demographic characteristics might not have high influence on their judgment and perception. The study defined stakeholder's risk perceptions as expected losses or

potential adverse consequences caused by environmental contamination [1]. To measure risk perception, the study explores laypeople's perceptions of the potential impacts of industrial activities on human health and well-being, which were classified into five aspects: (1) psychological effects, *i.e.*, the negative impacts of air pollutants on the human psychological system, such as anxiety or mental disorder; (2) physical health effects, *i.e.*, the impact of air pollutants on the human immunity system; (3) respiratory effects, *i.e.*, any respiratory diseases caused by inhalation of air pollutants; (4) lifestyle disruptions, *i.e.*, negative changes in local people's daily lives, local customs, or traditions; and (5) nuisance, *i.e.*, annoying conditions caused by the changes in living environments, for example, noise pollution. Figure 3-1 shows an overview of the framework of this study.

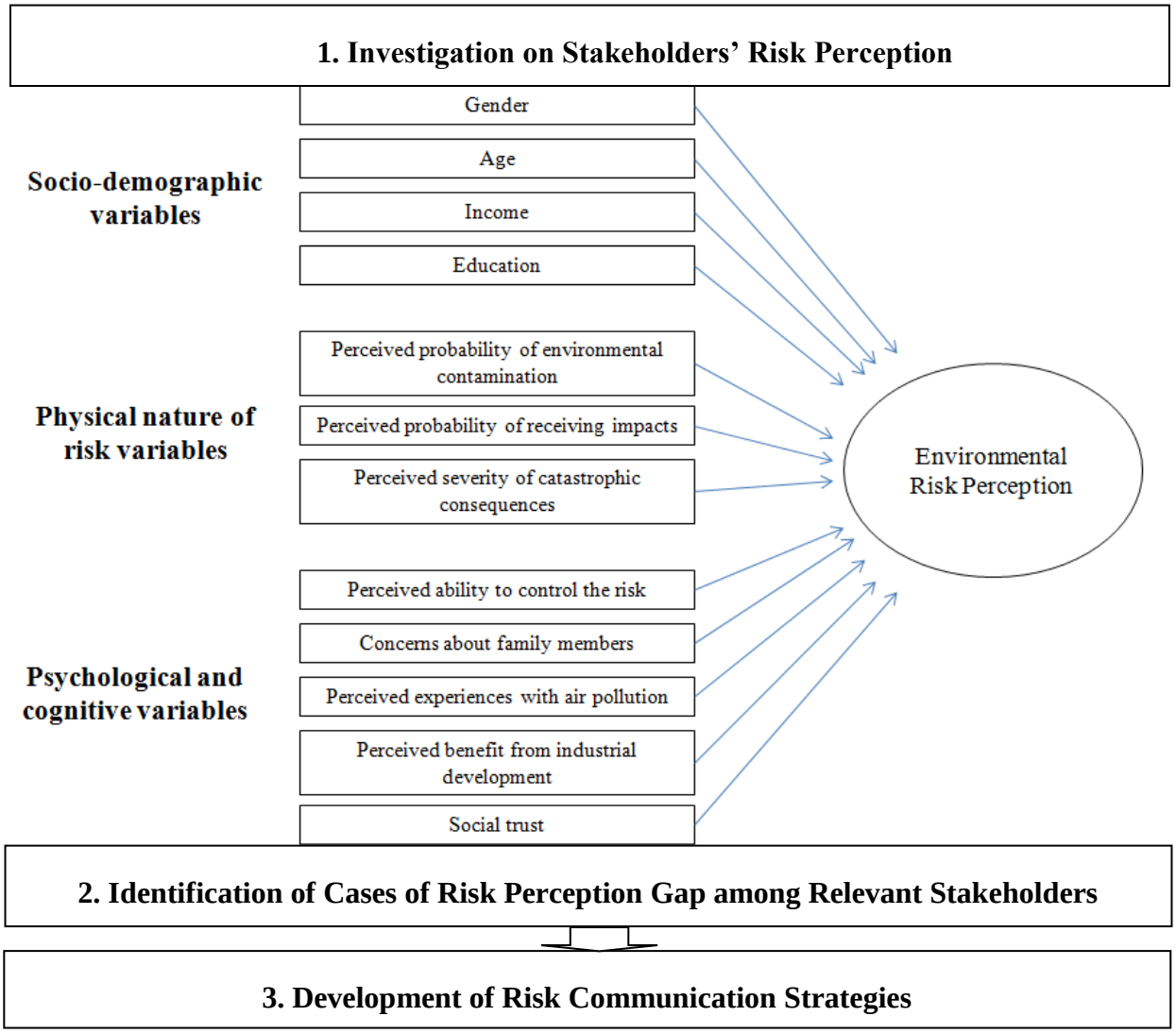

Fig. 3.1 Study framework 1
Source: Author, (2014)

3.2.2 Investigation on the significance of uncertainty communication to social trust building

Risk communication for building trust between the public and the organizations responsible for risk management is emphasized in the second part of this dissertation. The study aims to propose the role of uncertainty communication in building trust which is not much considered in the previous research. Therefore, the study conducts investigation on the relationship between lay understanding of information related to uncertainties and the degree of social trust in order to demonstrate the significance of uncertainty communication. According to the results of literature reviews, uncertainty can be classified into two types; (1) uncertainty associated with risk assessment; and (2) uncertainty about potential health impacts caused by environmental contaminations. The study first observes whether lay people can conceptualize both types of uncertainties; then, analyzes how their understandings of uncertainties are related to the degree of social trust which, in this study, is defined as the confidence in capability of public authorities and industrial agencies to manage environmental health risks [2]. The proposed framework for the investigation could be shown below;

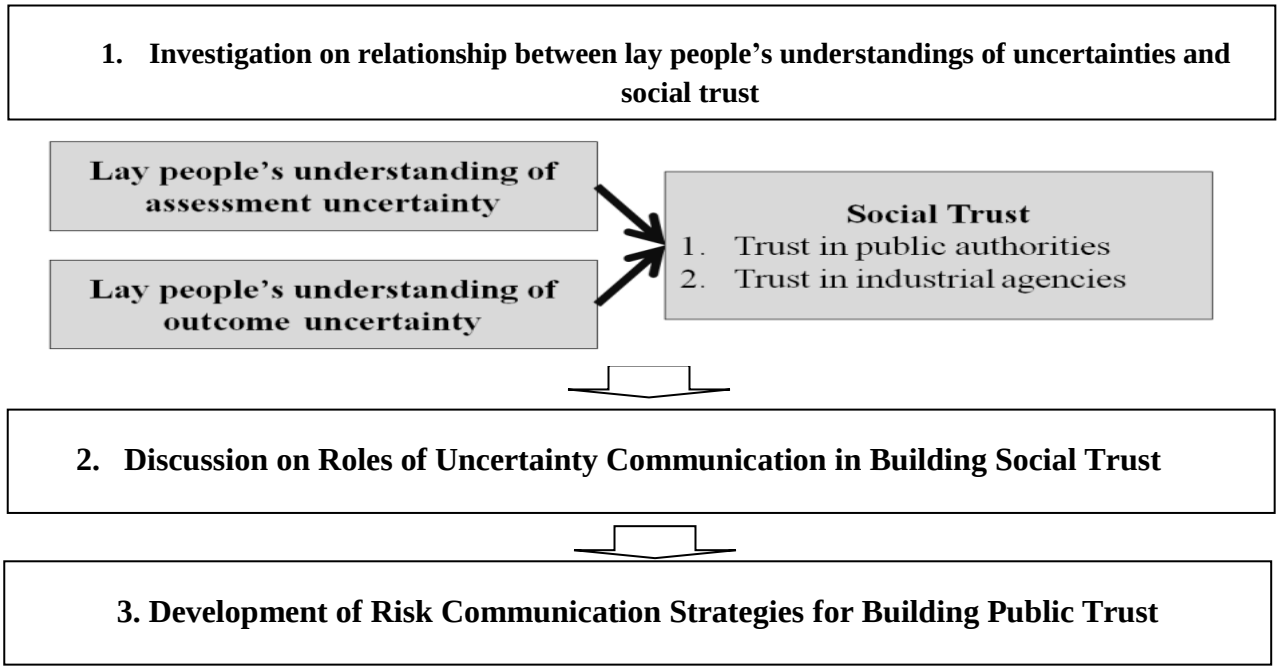

Fig. 3.1 Study framework 2
Source: Author, (2014)

3.3 CASE STUDY: MAPTAPHUT MUNICIPALITY

3.3.1 General physical characteristics of Maptaphut Municipality and industrial estate

Maptaphut Municipality, officially established in January 1992, was located in Rayong Province, Thailand. Its area is approximately 165.565 square kilometer. Approximately 13 % of its area is ocean. Maptaphut Municipality is 204 kilometer far from Bangkok city, the capital city of Thailand. In 1989, Maptaphut industrial estate (MIE) was developed in the area. It is one of the 29 industrial estates in Thailand. It is located at approximately 12.5° N (latitude) and 101.5° E (longitude), near the Gulf of Thailand. The project was established by the state enterprise, the Industrial Estate Authority of Thailand (IEAT), and the Ministry of Industry [3]. The MIE initially comprised a total area of 6.72 km^2 that consisted of agricultural farms, wasteland, and small rural farming and fishing communities. Originally, the total investment was said to be THB 370 billion (USD 11.4 billion), with the generation of approximately 11,500 jobs. In 2002, the area was expanded to 11.2 km^2, and it was later found that many factories are situated in nearby residential areas [4]. Currently, there are five industrial estates in the Maptaphut area: Maptaphut, East Hemaraj, Asia, Padaeng, and RIL. About 1800 factories and a seaport are situated in the area [3]. Most of the industrial plants are petrochemical factories, coal-fired power plants, chemical fertilizer factories, and oil refineries (see fig. 3.3). The area's five industrial estates are surrounded by residential and commercial areas (see fig. 3.4). The industrial development in the area has been critiqued by the public due to the adverse health impacts suffered by the local people, as well as other negative social impacts, including drug abuse, crime, and pregnancy among young women [5].

Fig. 3.3 Industrial plants in Maptaphut industrial estate
Source: Taken by author, (March, 2013)

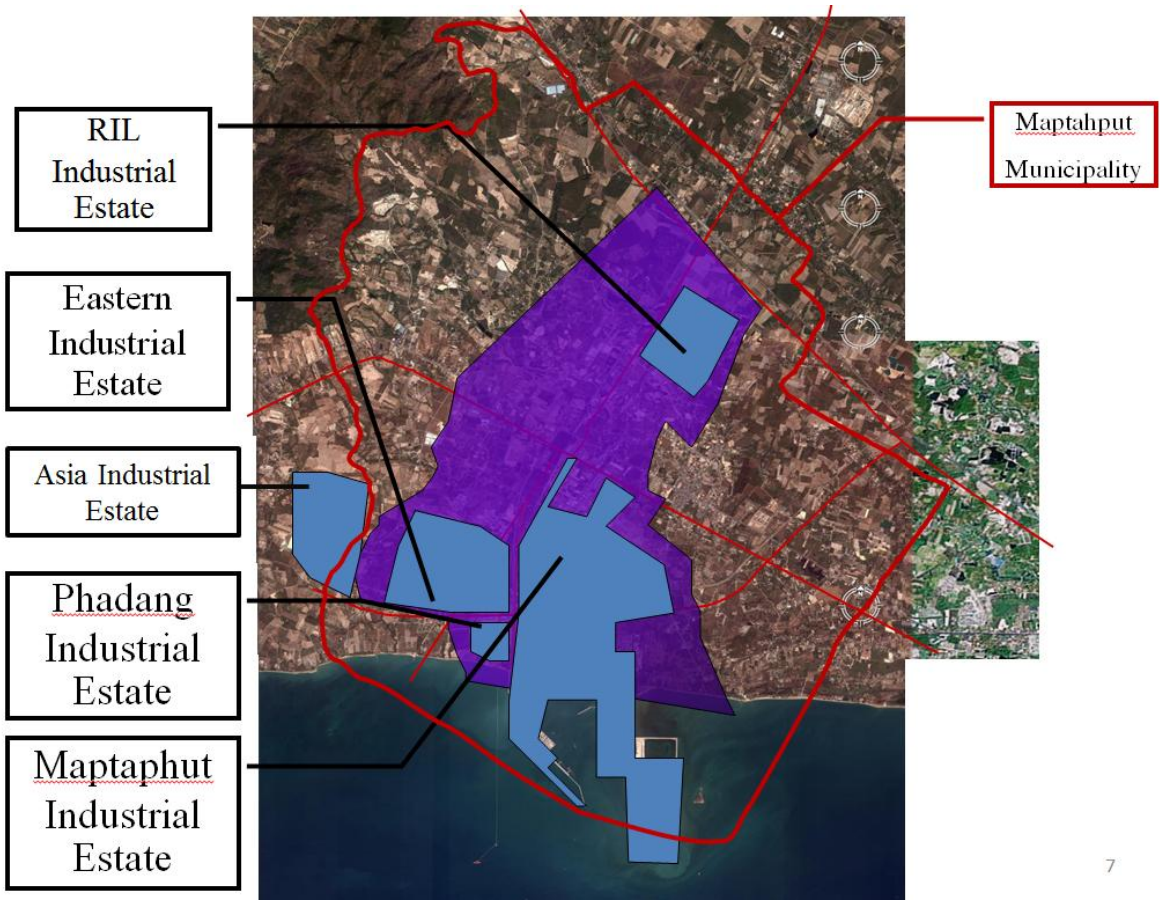

Fig. 3.4 Industrial estates in Maptaphut municipality
Source: Adapted from data provided by Maptaphut Municipality, (2013)

3.3.2 Role of Japanese Government in supporting the industrial estate development in Maptaphut

During the 1982-1993, Japan provided loans for the implementation of the Eastern Seaboard Development Program. The loans were meant to develop industrial estates, ports, roads and highway, railway, water reservoir and pipeline, etc. The loans recognized the strategic value of the Eastern Seaboard in the over-all economic development of Thailand. Several of the loans involved projects in Maptaphut area, which was planned as the place for heavy chemical industry [6].

The study supported by Japan Bank for International Cooperation (JBIC) (2000) noted the need to investigate measures used for controlling and preventing environmental impacts especially in the Maptaphut area. The survey of the environmental condition in 1988 did not reveal serious environmental and health problems because of the advanced technology used by

the industrial companies in the area. But at that time, the "current primary environmental issue was the odor which has attracted attention in Thailand, in connection with complaints from people living around the industrial complex constructed in the past two or three years." The complaints began in 1996. In 1997, the case of students and teachers in a school in Maptaphut area, suffering from the industrial odor became the main example of the problem. The Thai government established countermeasures to reduce the odor.

3.3.3 Socio-economic characteristics of residents in Maptaphut Municipality

Until 2013, there were 38 communities in the Maptaphut area. The population consisted of 56,591 people (28,504 male and 28,087 female), with 42,295 households [8]. The number of in-migration population is 543 persons, and the number of out-migration population is 381 persons. Regarding the residents' religious, 79.5 percent of its residents are Buddhism, and 16.3 percent are Islamism. Christians occupied only 4.2 percent. There are 10 Buddhist temples in area [9].

3.3.4 Environmental problems

Over two decades of industrial development have turned the area, once characterized by small rural farming and fishing communities, into the country's number-one toxic hot spot. Rapid industrialization has led to deteriorating natural resources and changes in social and economic structure following by numerous social, socio-economic, environmental, and health problems. Accumulated pollution and environmental problems as well as mysterious diseases have emerged, intimately linked to each other. They drastically affect locals who lack the capacity to negotiate with the powerful industries or bureaucratic agencies [10].

The impacts of industrial development on environments could be divided into three aspects as followings: (reviewed from Hassarungsee R., and Kiatiprajuk, S., 2010) [23]

*1. Air pollution***:** For more than 10 years, Maptaphut residents have suffered from environmental contaminations, especially air pollution caused by volatile organic compounds (VOCs). Over 200 smoke and flare stacks in Maptaphut industrial estate have been emitting voluminous amount of pollutants into the atmosphere and spreading them to communities located nearby industrial plants. A range of studies have indicated links between exposure of residents to

pollutants such as benzene, styrene and xylene and the increase in diseases related to the respiratory system, nervous system, reproductive system, muscle system, and mental disorder.

The pollution hazards for Maptaphut Panphittayakarn School were brought to public attention in 1997. Around 1,000 pupils and teachers suffered from illnesses after inhaling toxic emissions and had to be hospitalized for breathing difficulties, headaches, nasal irritation and nausea. In 2005, the Ministry of Education approved the school's relocation to a site five kilometers away from the original compound [11]. Since then, the area has been recognized nationwide as the most obvious and serious case of undesirable impacts from unsustainable industrialization [10]. A test carried out in 2005 by US-based Global Community Monitor (GCM) demonstrated that airborne cancerous toxic chemicals such as benzene, vinyl chloride and chloroform released by Map Ta Phut Industrial Estate exceeded safety standards of developed nations by 60 to 3,000 times.

The results of air quality monitoring during 2007-2013 reported by the Pollution Control Department [12] showed that some kinds of compounds in ambient air in Maptaphut municipality have been over the annual standard. According to the monitoring system settled by pollution control department, there are seven monitoring spots located in Maptaphut area. Those are Maptaphut hospital, Machalood temple, Nuangfab school, Muangmai, Banplong community, Bantakuan public health center, and Noppaket community. The monitoring results show that four types out of nine types of monitored Volatile Organic Compounds (VOCs) were found over the annual standard in many monitoring spot (see figs. 3.5-3.8). Those compounds are Benzene which has been found over annual standard at every monitoring spot, except at Nuangfab school, 1,3- Butadiene which has been over the standard at Maptaphut hospital, Muangmai, and Bantakuan public health center, 1,2-Dichloroethane which has been over the standard at Maptaphut hospital, Muangmai, and Banplong community, and Choroform which was found over the standard at Nuangfab school during 2010-2011and 2012-2013. According to United state environmental protection agency (US' EPA), VOCs potentially cause several kinds of disease such as eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system.

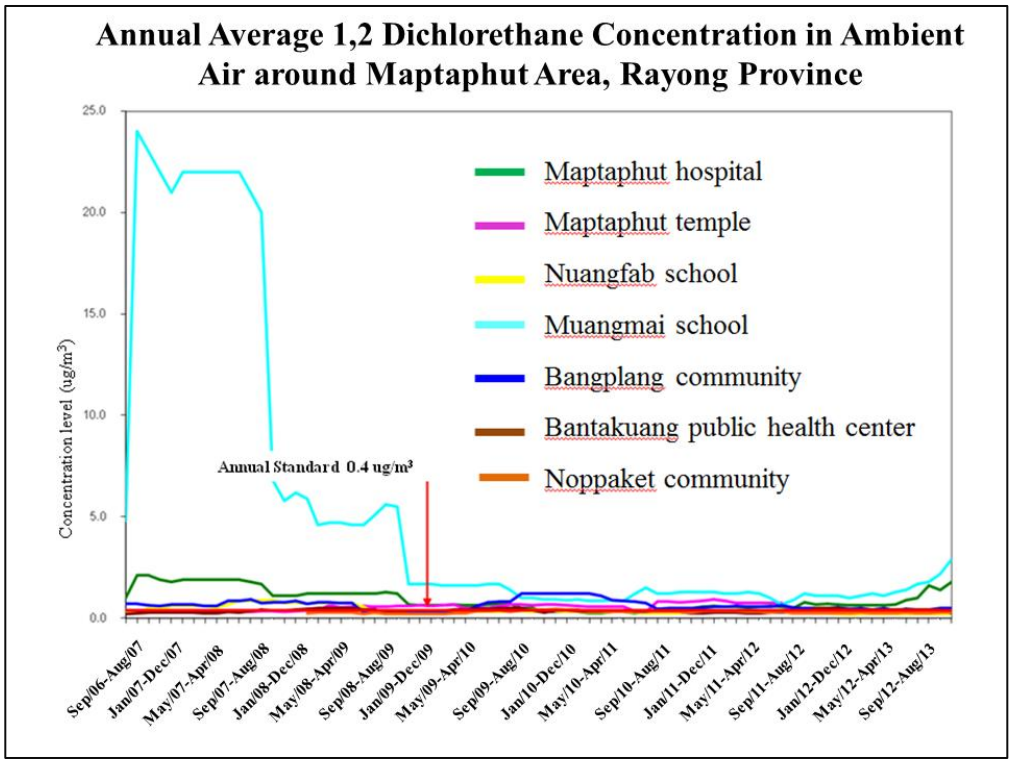

Fig. 3.5 1,2 Dicholorethne concentration in Maptaphut municipality
Source: Pollution Control Department, Thailand, (2013)

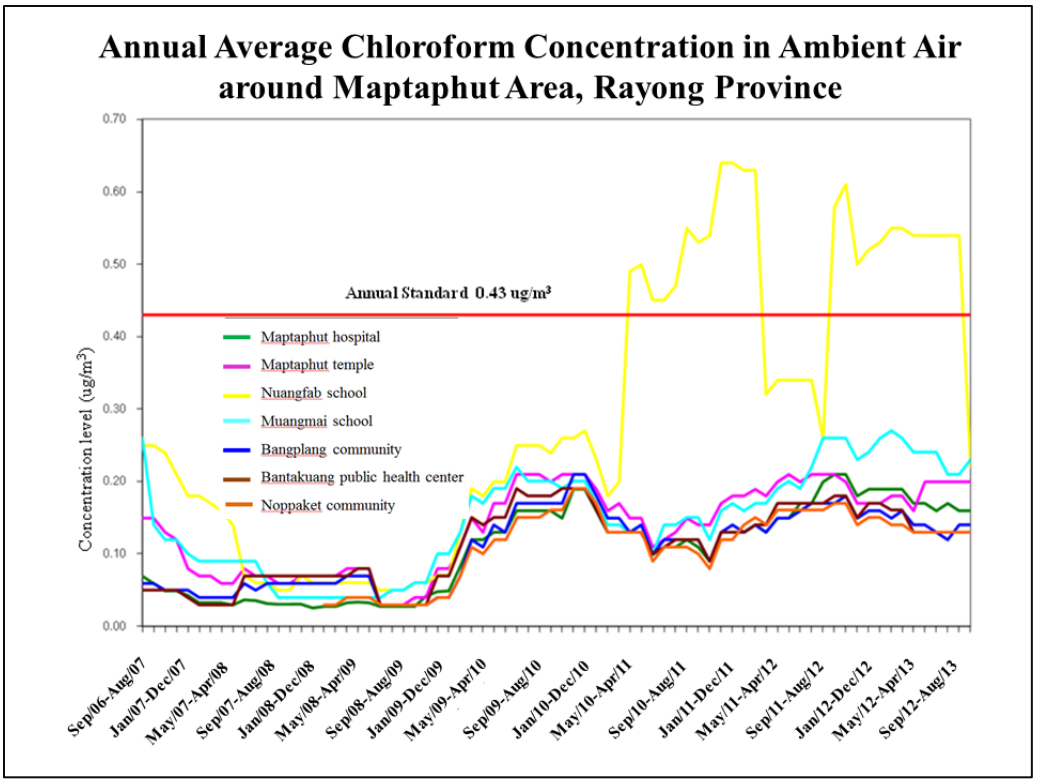

Fig. 3.6 Chloroform concentration in Maptaphut municipality
Source: Pollution Control Department, Thailand, (2013)

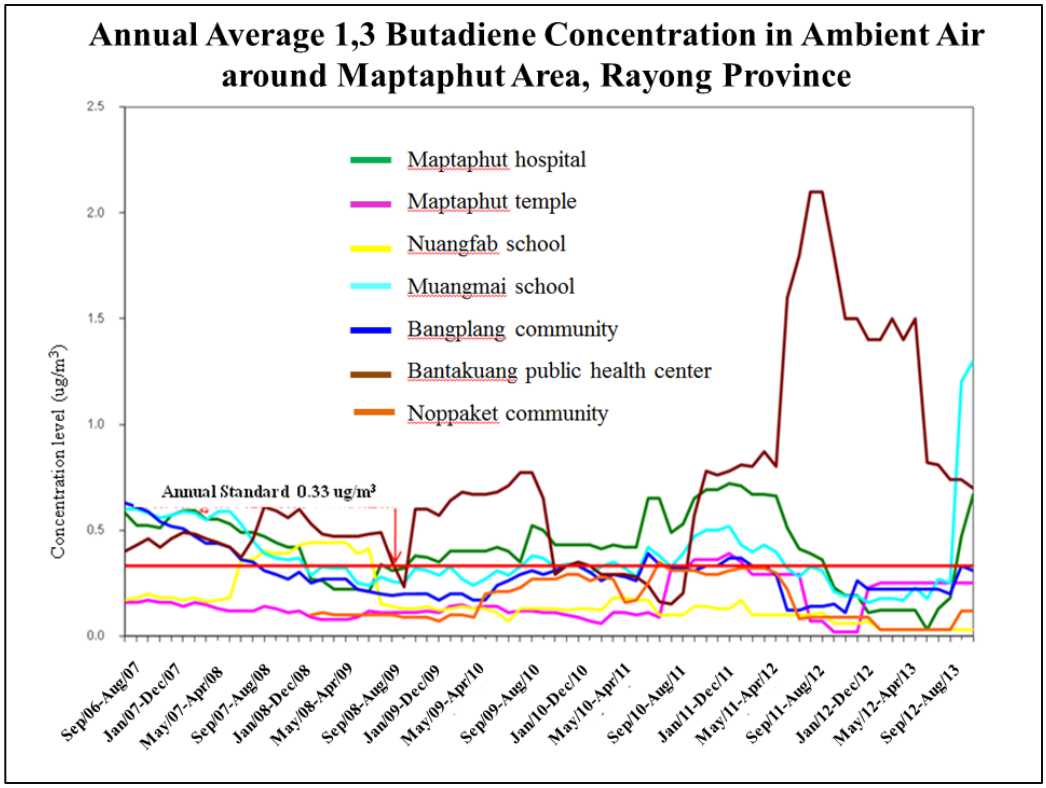

Fig. 3.7 1,3 Butadiene concentration in Maptaphut municipality
Source: Pollution Control Department, Thailand, (2013)

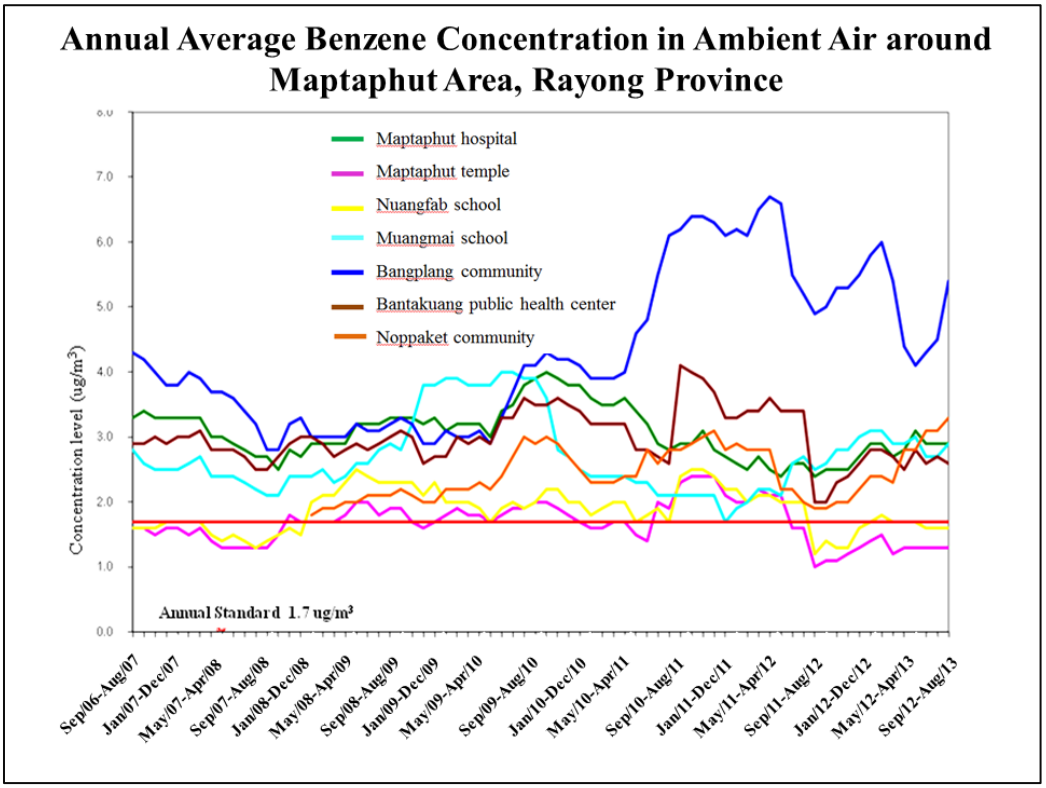

Fig. 3.8 Benzene concentration in Maptaphut municipality
Source: Pollution Control Department, Thailand, (2013)

2. Water pollution: Currently, every household in Maptaphut and the Muang district in Rayong province have to buy water for daily consumption because water from their ponds cannot be used. Water resources, including ponds, the sea, lakes are contaminated with hazardous chemicals due to illegally dumping of hazardous and toxic waste, which the rainwater flushed into the rivers and then the sea. Water resources in the area around the estate have been found to be contaminated with metallic elements. Water samples tested from 25 public ponds in the Maptaphut municipality indicated the presence of hazardous levels of toxic substances. Cadmium was six times the safety level, zinc 10 times, manganese 34 times, lead 47 times and iron 151 times [11]. The report from the Rayong public health office confirmed the contamination with iron, lead, manganese, and chloride over drinking water standard, in many groundwater sources. Since only two communities have access to public pipe-water, therefore over 22 communities have to pay much higher costs for buying drinking, potable water. Fruit farmers also complain that the acid rainwater damages their fruit trees [10].

3. Illegal hazardous waste dumping and seashore erosion: Ms Penchom Saetang of Ecological Alert and Recovery – Thailand (Earth), addressed that every year since 1998 there has been illegal dumping and a continuing erosion of the coastal area: "Residents have asked the Industrial Estate Authority of Thailand (IEAT) to stop the expansions of the industrial estate areas but their request was ignored by IEAT [13]".

Environmental problems in Maptaphut, such as polluted air, wastewater, polluted groundwater, and soil contamination, have concerned the public, industrial investors, governments, and nongovernmental organizations (NGOs). Among these problems, air contamination is perceived as the most serious one [14]. Several types of VOCs were found to be above the national standard. Other air pollutants are also distributed throughout the area, including NO_2, SO_2, carbon monoxide (CO), and particulate matter (PM10) [14,15].

3.3.5 Health impacts suffered by residents

The study carried out by an expert from Silpakorn University in 2010 revealed that thirty-five of the seventy-six industrial plants suspended (in 2009) in Maptaphut industrial estate would use hazardous chemicals that could cause several ailments. Twenty-one plants would use carcinogenic substances in their production process. Other toxic substances to be used would be

harmful to the respiratory system (thirty-four projects), neurological system (twenty-four projects), reproductive system (ten projects), foetus (four projects), blood system (eighteen projects), liver and renal (twenty-five projects), skin and eyes (thirty- three projects) [16, reviewed from Hassarungsee R., and Kiatiprajuk, S., 2010]. Since Maptaphut has been declared a pollution control zone, pollution emissions must be limited. The serious health and pollution problems in Rayong province were not new. Several studies had shown the rise of cancer cases in the province many years before the court cases came about.

Thailand's National Cancer Institute found in 2003 that rates of cervical, bladder, breast, liver, nasal, stomach, throat and blood cancers experienced by male population were highest in Rayong Province, where Maptaphut and other industrial zones are located (see fig. 3.9). A study led by Italian researchers and released in 2007 found that people living near Maptaphut had 65 percent higher levels of genetic damage to blood cells than people in the same province who lived in rural areas. Such cell damage, which is a possible precursor to cancer, was 120 percent higher for refinery workers than for residents of Rayong Province's rural communities. Considering life expectancy of residents in Rayong province, it also shows that life expectancy of Rayong residents was also lower than the national average and residents in Bangkok city (see fig. 3.10).

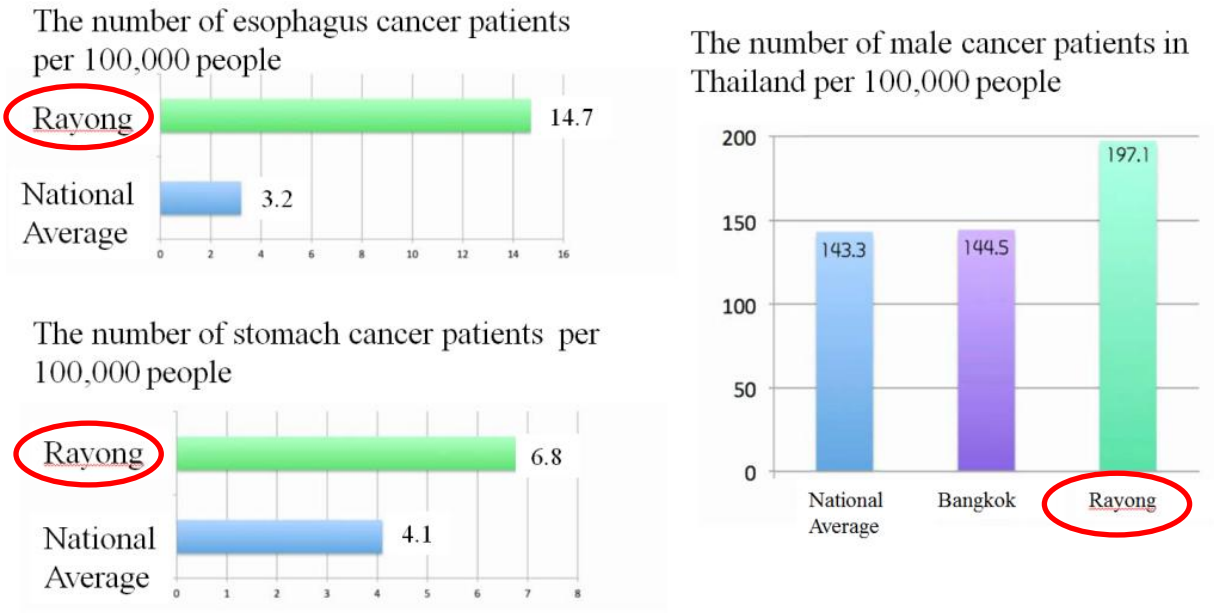

Fig. 3.9 The number of male cancer patients in Rayong province 2013
Source: Reviewed from the report conducted by the Thai Health Foundation Promotion, 2012 [17]

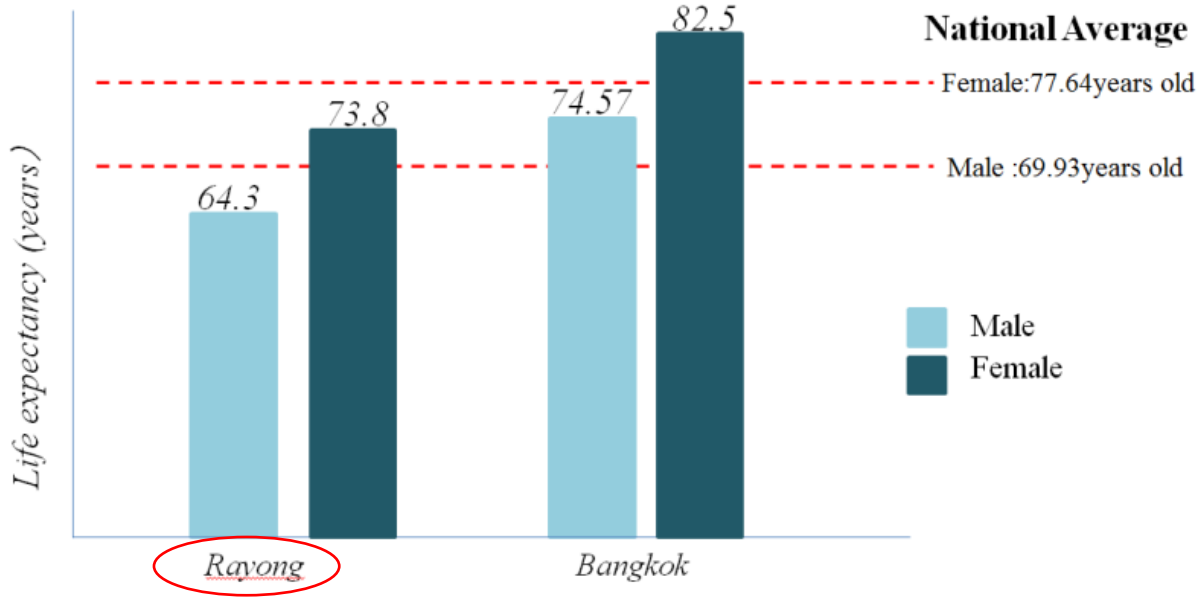

Fig. 3.10 Life expectancy of residents in Rayong province
Source: The report on the survey of population change 2005-2006, the National Statistical Office, Thailand [18]

3.3.6 The current risk communication

According to the results of primary surveys, it was found that at least three kinds of risk information are currently communicated to lay people. The first type is information related to the characteristics of pollutants released. The types of pollutants and the amounts released in comparison with national safety standards have been announced on a daily and monthly basis by public authorities, industrial agencies as well as NGOs and educational institutes. The results of air quality monitoring are currently publicly available; however, the results revealed by each organization have varied several times. This causes a lot of confusion among the public. A transparent risk assessment is, therefore, requested. The second type of information is related to diseases potentially caused by polluted air, such as respiratory disease and several types of cancer. This type of information has mostly been conveyed by NGOs and educational institutes. The goal of the current risk communication mostly emphasizes informing lay people with risk information rather than the efforts to involve the public in risk management and foster mutual information sharing among parties. In this way, lay people's attitudes about risks are not considered in risk management processes.

According to the review study carried out by Excell Carole [7], in 2010, Thai government issued new rules under its Official Information Act, requiring state agencies to create certain types of environmental and health information publicly available to citizens even if they haven't filed official information requests (which are similar to Freedom of Information Act (FOIA) requests). This includes information on pollutants, their health impacts, and efforts to monitor and resolve environmental health issues caused by industrial activities. The Access Initiative and the Thailand Environment Institute have been working to assess whether community members living around the Maptaphut Industrial Estate can, in fact, received the information specified under these new rules.

In June 2011, Thailand Environment Institute held a meeting with 15 villagers from various communities around Maptaphut community members and other stakeholders prepared a list of information they sought. A few examples from the community include:

1. A list of factories in the Maptaphut estate that fail to adhere to government air and water quality standards;
2. Safety of drinking water;
3. What pollutants factories release into the air and water;
4. Information about the health impacts associated with the pollutants released.

Community members and Thailand Environment Institute searched government agencies' websites and local offices for this information, but found that none of it was available. Citizens then made official information requests—with mixed results. In almost all of the cases referenced above, agencies provided information after an unreasonable delay. For two of the requests, information was only obtained after citizens filed an appeal with the information commissioner's office, which hears appeals regarding government agencies' failure to obey the Official Information Act. Ultimately, agencies never released a list of factories violating standards, nor did they provide information on pollutants' health impacts. Some relevant information was released on factories' impacts on water quality as well as locations where factories released pollutants into rivers.

3.4 DETERMINING SAMPLING GROUPS

According to the scope of the study which emphasizes on analyzing stakeholders' risk perception and its determinants, in-depth interviews with keys stakeholders who are responsible for risk management are conducted. In the second part of the study, relationship between lay understanding of uncertainty and degree of social trust is also targeted to examine. The study also conducts questionnaire surveys by distributing questionnaires to residents living in Maptaphut municipality area. The sampling groups for the investigations could be divided into two major groups

3.4.1 Sampling groups for in-depth interviews

Table 3.1 shows the number and types of stakeholders which are included in this study.

Table 3.1 Sampling groups for the in-depth interviews

Stakeholders		*N*	Place for the Interview
Lay people	- Community Leaders - Lay people	2 11	- Watsopol Community, Rayong - Nuangfab Community, Rayong
Environmental Protection Agencies	- Officers of Maptaphut Municipality	3	- Maptaphut Municipality Office
Academia	- Biologist - Urban Environmental Planner - Public health expert	1 2 1	- Thammasat University, Rangsit Campus, Pathumtani - Thammasat University, Taphachan Campus, Bangkok - Online
Member of NGOs	- The director of Ecological Alert and Recovery - Thailand (EARTH) - Member of green peace southeast Asia, Thailand - Member of Ecological Alert and Recovery - Thailand (EARTH) - Member of public opposition to Nuclear energy - Member of Public Health Policy Foundation	1 2 2 1 2	- Chulalongkorn University, Bangkok City - Office of Ecological Alert and Recovery , Bangkok - Online
Health Care Service	- Staffs of Maptaphut Hospital - Staffs of Bangkok hospital Rayong	2 2	- Maptaphut Hospital, Rayong - Online
Total		32	

3.4.2 Sampling groups for the questionnaire surveys

A sampling group for the questionnaire surveys was determined based on the degree of hazardous gas contamination throughout the Maptaphut area. To classify the levels of potential threat faced by the communities, the study employed the results of Thepanondh *et al.* study [19] on VOC (benzene and 1,3-butadiene) contamination, as well as the results of Chusai *et al.* study [15] on SO_2 and NO_2 concentrations. The hazardous gases and compounds investigated in those two studies have been assumed to be a cause of cancer and respiratory diseases in the area [20].

Regarding the study conducted by Thepanondh and colleagues, VOC concentrations across the Maptaphut area were measured by means of gas chromatography/mass spectrophotometer (GC/MS) and conducted based on the United States Environmental Protection Agency's toxic organic compounds (USEPA TO-15) procedure. The results showed that the VOC concentrations in the area varied according to the proximity to emission sources and types of compounds. Although this investigation was conducted during the 2007–2008 period, the results remain consistent with those of air monitoring conducted on a monthly and annual basis by Department of Pollution Control [12]. More specifically, benzene and 1,3-butadiene have thus far been found to be higher than the annual national standard. In the case of SO_2, and NO_2 concentrations, the study carried out by Chusai and colleagues included observations of these two compounds' dispersion throughout the Maptaphut area by using a spatial model called the American Meteorological Society-Environmental Protection Agency Regulatory Model (AERMOD). The results showed varying degrees of NO_2 and SO_2 concentrations caused by both stack and nonstack sources; the differences in the findings also depended on the geographic and atmospheric conditions in each particular area.

To determine the degrees of hazardous gas and compound contaminations experienced by different areas in the Maptaphut municipality, the study employed geographic information systems (GIS) to assess contamination situations based on data provided by those two studies. The degree of concentration in each area was divided into three levels, according to the Air Quality Index (AQI) established by the USEPA [21] (see table 3.2). Low concentration means that it potentially generates health impacts, and it is suggested that people with respiratory diseases, children, and the elderly avoid any outdoor activities. Moderate concentration means that it potentially generates high health impacts, and it is recommended that people with

respiratory diseases avoid any outdoor activities. For general people, especially children and the elderly, outdoor exercise should be limited when high levels of pollutants are present in the air. High concentration means that it could generate severe health impacts, and it is strongly recommended for the general public to remain inside a building or shelter.

Table 3.2 Determining degrees of pollutant concentration experienced by local communities.

Type of Gas and Compound	Degree of Concentration ($\mu g/m^3$)			National Standard *
	High	Moderate	Low	
NO_2	500–3000	200–500	<200	320 (1 h)
SO_2	1000–2700	600–1000	<600	300 (24 h)
Benzene	3.5–4.7	2.5–3.5	1.7–2.5	1.7 (year)
1,3 Butadiene	0.48–0.58	0.38–0.48	0.33–0.38	0.33 (year)

***** According to Department of Pollution Control, Thailand.

The results of the GIS analysis demonstrated the distribution of hazardous gases and compounds throughout the Maptaphut area (see Figure 3.11). The numbers shown in Figure 2 represent the respective locations of selected communities. Ten local communities, all of which were relatively old and established before the industrial projects, were selected for this study. These selected communities were categorized into four types, according to their respective levels of hazardous gas contamination. In classifying a type of community, communities located in areas with a high concentration of each type of hazardous gases or compounds (benzene, 1,3-butadiene, SO_2, or $NO_{2)}$ were given a score of 3. Communities, located in areas with a moderate concentration were assigned a score of 2, and communities located in areas with a low concentration were assigned a score of 1. A score of 0 was given to communities located in areas associated with a degree of pollutant concentration lower than the national standard. Then, the average score assigned to each community was calculated, and classified as one of the four categories such as lowest-risk community, low-risk community, moderate-risk community, and high-risk community. The results are shown in table 3.3.

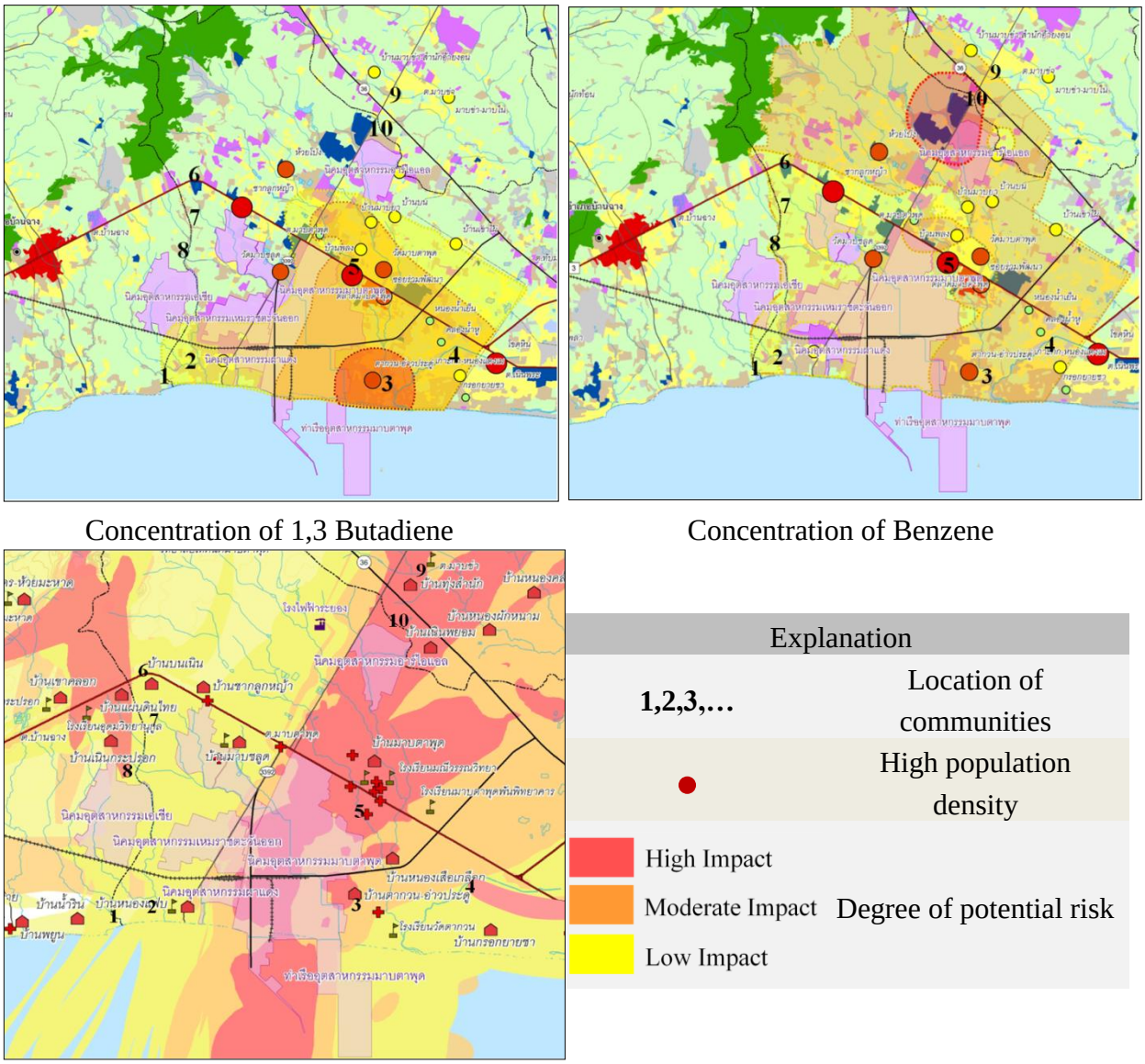

Fig. 3.11 Distribution of hazardous gases and compounds throughout the Maptaphut area.
Source: Created based on the results of the study carried out by Chusai et al (2012). and Thepanondh et al (2010).

Table 3.3 Degrees of potential risks faced by Maptaphut communities

Community	1,3 Butadiene Concentration	Benzene Concentration	NO_2 and SO_2 Concentration	Average *	Potential Risk	*N.*
1. Banprayoon and Namrin	1	1	1	1.00	low	19
2. Nuangfab	1	1	1	1.00	low	11
3. Bantrakual	3	2	2	2.33	high	20
4. Nuenpra	2	2	3	2.33	high	31
5. Maptaphut	2	1	3	2.00	moderate	40
6. Banbonnuen	0	1	2	1.00	low	14
7. Banpandintai	0	1	1	0.67	low **	8
8. Nuenkrapork	0	1	3	1.33	low	8
9. Mapkha	0	2	3	1.67	moderate	18
10. Nuenpayom	0	3	3	2.00	moderate	12
Total						181

Notes: ***** (0–0.75 = lowest-risk community, 0.76–1.50 = low-risk community, 1.51–2.25 = moderate-risk community, 2.26–3 = high-risk community). ****** Only one community was defined as a lowest-risk community. To effectively perform the statistical analysis, the study, therefore, included this community in low-risk communities. In addition, the community is also located nearby the other low-risk communities. The degree of potential risk faced by this community might not enormously differ from those low-risk communities.

3.5 DATA COLLECTION AND DATA ANLYSIS

3.5.1 In-depth interviews

In-depth interviews with the local people and key stakeholders were conducted in March 2013. All selected stakeholders were asked about potential impacts of environmental contamination on people's health and well-beings. The interviews are based on a total of twelve semi-structured in-depth interviews conducted with five different stakeholder groups. Types of questions can be shown in table 3.4. In each question, respondents were asked to answer freely, and also asked to identify one of alternative choices.

Table 3.4 Questions for the interview

Qualitative Risk Assessment	***Indicators***	***Questions***		***Alternative Choices***
Degree of risk judged by stakeholders	Life style disruption	Do you think that people's life style has been changing since the establishment of industrial estate in your area?		0=Not at all 1= Less 2= Medium 3= High 4= Very high
	Psychological effects	As a result of industrial development, do you think how much people feel worried about their health? As a result of industrial development, do you think how much people feel worried about your income and your future?		
	Respiratory health	Do you think that air quality in the area has caused respiratory disease among residents?		
	Physical health	Do you think that air quality in the area has caused several kinds of cancer among residents? Do you think that air quality in the area has caused disease related to self-immunity systems such as immunity disorder, fever, etc.?		
	Nuisance effects	Do you think that industrial activities have caused nuisance such as noise, smell, etc.?		
Fundamental Understanding of Risk-related Judgments	Probability	Why do you believe or judge that risk associated with industrial activities is low or high?	What do you think about possibility that industrial activities have contaminated air and the contamination exceeds the level that human body can accept? What do you think about possibility that human will be influenced by contaminated air?	Open
	Severity		How severe does contaminated air in the area have effects on human health?	
	Capacity		Do you think people in Maptaphut know how to protect themselves from contaminated air?	

Source: Author, (2013)

3.5.2 Questionnaire survey

In addition, the questionnaire was created and distributed to 200 people living in the selected communities during October and November 2013. In total, 181 questionnaire sheets

(about 90%) were completed. The factors, variables, and types of questions used to collect the data are shown in table 3.4 The measurement of variables is presented below.

(1) Risk perception: A Likert scale, a single-select, rating scale question method [22], was used to collect the data related to respondents' attitudes about industrial risks. Respondents were asked to rate their level of concern about potential impacts of air pollutants on their health and well-being, divided into five aspects (see Table 3.5). In contrast to previous research in risk perception, where the relevant characteristics of risk and rating scales have been based on literature reviews [23], this study created judgment scales reflecting degrees of risk perception based on information received from the in-depth interviews with laypeople. Based on the results of in-depth interviews, laypeople often simply exhibited degrees of concerns about potential impacts of air contaminations, such as "no impact", "low impact", or "high impact". In this study, the 5- point rating scale ranged from 0 ("not at all concerned") to 4 ("strongly concerned"). Respondents were asked nine questions, and the results obtained would be tested for their correlation before being added and calculated as a mean score, representing a level of risk perception.

(2) Factors related to the nature of risks, including perceived probability of environmental contamination, probability of receiving impacts, and severity of catastrophic consequence: These factors were measured using single-select rating questions. Based on the results of in-depth interviews with laypeople, 4-point Likert scale questions were created. Respondents were asked to rate each question, ranging from 1 ("no possibility/no severity") to 4 ("high probability/high severity").

(3) Psychological and cognitive factors, including perceived ability to control the risks, family concerns, previous experiences with air pollution, perceived benefits from industrial development and social trust: To measure respondents' perceived ability to control the risks, they were asked to rate their degree of capability in protecting themselves from the dangers of polluted air. Based on the results of in-depth interviews with laypeople, a 3-point Likert scale question was created. The rating scale ranged from 1 ("not at all") to 3 ("highly capable"). In the case of measuring their concerns about family members, the survey simply asked about the household size. Regarding their previous experiences with air pollution, respondents were asked to indicate the frequency of feeling irritated in their eyes or nose when staying near the plants. The rating scale of frequency ranged from 1

("never") to 3 ("always"). To measure the factor related to perceived benefits from industrial development, respondents were asked whether their household incomes increased since the development of industrial activities in the area, and the rating scale ranged from 0 ("not at all") to 4 ("significantly increased"). In case of social trust which, in this study, is defined as laypeople's confidence in capability of industrial agencies and public authorities to provide effective risk management. The degree of trust was measured by using Likert questions with the rating scales ranged from 1 ("No capability at all") to 4 ("High capability")

(4) Socio-demographic factors, including gender, age, income, and education: The study imply asked respondents to give those information (see table 3.5).

(5) Factors related lay understanding of uncertainty, including lay understanding of assessment uncertainty and outcome uncertainty. In identifying lay understanding of uncertainty associated with risk assessment, lay people's knowledge related to the cause of VOCs contamination is investigated. People who comprehend the issue are identified as being able to conceptualize uncertainty associated with risk assessment and management established by responsible organizations. In addition, to identify lay understanding of outcome uncertainty, lay people's understanding of potential factors contributing to the seriousness of health problems is explored. People were simply asked whether they know about these issues.

Table 3.5 Factors, variables, and development of questionnaire

Factors	Variables	Questions
Risk perception	Lifestyle disruption	- Have industrial activities in the area impacted your original career? - As a result of industrial development, how much can you use local resources for your leisure activities?
	Respiratory effect	- Has air quality in the area caused respiratory diseases among residents?
	Physical health effect	- Has air quality in the area caused several kinds of cancer among residents? - Has air quality in the area caused diseases related to self-immunity systems such as immunity disorder, fever, *etc.*?
	Psychological effect	- As a result of industrial development, do you feel worried about your health? - As a result of industrial development, do you feel worried about your future life in Maptaphut?
	Nuisance effect	- Have industrial activities caused nuisance such as noise or smells? - Has the current condition of the community caused nuisance such as traffic jam, congestion, noise, smells, *etc.*?

Table 3.5 *Cont.*

Factors	Variables	Questions
Nature of environmental risks	Probability of contamination	- What is the possibility that industries still generate polluted air in the area?
	Probability of receiving impacts	- What is the possibility that you will be impacted by air pollution in the area?
	Severity of consequences	- How severely can contaminated air in the area affect humans?
Psychological and cognitive factors	Perceived ability to control the risks	- Do you know how to protect yourselves from contaminated air?
	Concerns (number of family members)	- How many family members do you have?
	Previous experiences with air pollution	- Have you ever felt irritated in your eyes or nose when staying near the vicinity of factories?
	Perceived benefits from industrial development	- Has industrial development in the area generated more income for your family?
	Social Trust (Trust in public authorities and trust in industrial agencies)	- Do you think that public authorities have the capability to prevent an occurrence of air pollutants in the area? - Do you think that public authorities have the capability to prevent an occurrence of air pollutants in the area?
Socio-demographic factor	Gender	- Please identify your gender
	Age	- Please identify your age
	Income (Average per month)	- How much is your average income per month?
	Educational degree received	- What is your highest educational level?
Uncertainties	Lay understanding of assessment uncertainty	- Do you know how VOCs are released during the industrialization process?
	Lay understanding of outcome uncertainty	- Do you know which factors contribute to the seriousness of health damages caused by air pollutants?

Source: Author, (2013)

3.5.3 Data analysis

Data analysis has been carried out by using a combination of both qualitative and quantitative analyses

1. Qualitative analysis: Content analysis is conducted by summarizing data gained from the interviews with key stakeholders. Stakeholders' fundamental understanding of risk-related their judgments is analyzed. Factors determining their perception would be demonstrated. In addition, to reveal degrees of risk judged by each stakeholder, descriptive statistics such as mean is also calculated.

2. Quantitative analysis: All the collected data from questionnaire surveys were statistically analyzed by using three methods. In the first part of study, the analysis of variance (ANOVA) was first performed to identify the significant differences in risk perception of people living in high-risk, moderate-risk, and low-risk communities. Next, to identify the factors determining the risk perception, a multiple regression analysis was performed in order to evaluate the relationship between risk perception (dependent variable) and selected potential predictive factors (independent variables), such as the physical nature of risks, perceived ability to control the risks, family concerns, and previous experiences. The results are presented as a set of regression equations describing the statistical relationship between the dependent and independent variables. A multiple regression was performed again in order see the determinants of risk perception held by lay people living in each type of community. All results are discussed in terms of their implications for the development of risk communication strategies which potentially bridge the risk perception gap. In the second part of the study, to justify the relationship between trust and lay understanding of uncertainty, the mean score, representing a level of trust held by lay people with comprehension of uncertainty, was compared to the mean score, representing a level of trust held by lay people with no comprehension of uncertainty. The statistical difference of mean scores between groups was proven by the result of the T-test analysis. All findings were discussed in terms of their contribution to the development of strategies for public trust building.

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CHAPTER 4: STAKEHOLDERS' RISK PERCEPTION: DEVELOPMENT OF RISKCOMMUNICATION MODEL AND STRATEGIES

4.1 GENERAL INTRODUCTION

In this chapter, the study demonstrates the gap in risk perception held by stakeholders responsible for risk management, including laypeople, non-governmental organizations (NGOs), academia, environmental protection agencies, and public health sector. Then, risk communication model and strategies would be proposed. First, the study demonstrates stakeholders' risk perception and its determinants which were analyzed based on the result of in-depth interviews. Then, results of multiple regression analyses are presented in order to reveal laypeople`s perceived risks and predictive factors. The results from both qualitative analysis and statistical analyses would be discussed on its implication for the development of risk communication strategies which can bridge the gap in risk perception held by stakeholders.

4.2 RISK PERCEPTION AND JUDGMENT MADE BY STAKEHOLDERS

4.2.1 Degree of industrial risk perceived by stakeholders

According to the results of observations (see table 4.1), stakeholders have various opinions pertaining to impacts of industrial activities on human health and well-being. Lay people, NGOs, and academic sector thought that current situation related to air contamination in the area still has very high impacts on human's respiratory system and high impact on physical health. While environmental and health protection agencies and public health sector viewed the impacts of industrial activities lower than lay people, NGOs, and academic sector in all aspects. Difference in risk judgment among stakeholders may contribute to problems in risk managements. For instance, decision making for selection of mitigation measures cannot be done with satisfaction of all stakeholders. Consensus building among stakeholders can be hardly achieved. In addition, environmental actions created based on risks judged by a group of people who have an official authority may not be able to minimize risks judged by the public. However, all groups of stakeholders believe that risks still exist in the area. To bridge the gap of perception

difference, risk communication and information sharing among those stakeholders can play an important role.

Table 4.1 Degree of risk perception exhibited by stakeholders according to the result of in-depth interviews

Stakeholders	n	Degree of risk perception exhibited by stakeholders				
		Life Style Disruption	Psychological effects	Respiratory health	Physical health	Nuisance effects
Laypeople	13	3.00	3.31	3.54	3.23	2.46
NGOs	8	3.50	3.67	3.67	3.50	3.33
Academia	4	3.3	2.4	3.6	3.2	3
Environmental Protection Agencies	3	2.33	2.00	3.00	2.00	2.33
Health Care Service	4	2.25	2.50	3.00	2.50	1.75
Total/Average	32	2.88	2.77	3.36	2.89	2.58

Note: 0 = No impact, 1 = Less, 2= Moderate, 3= High, 4 Very High

Source: Survey by author, (Feb.-Mar. 2013)

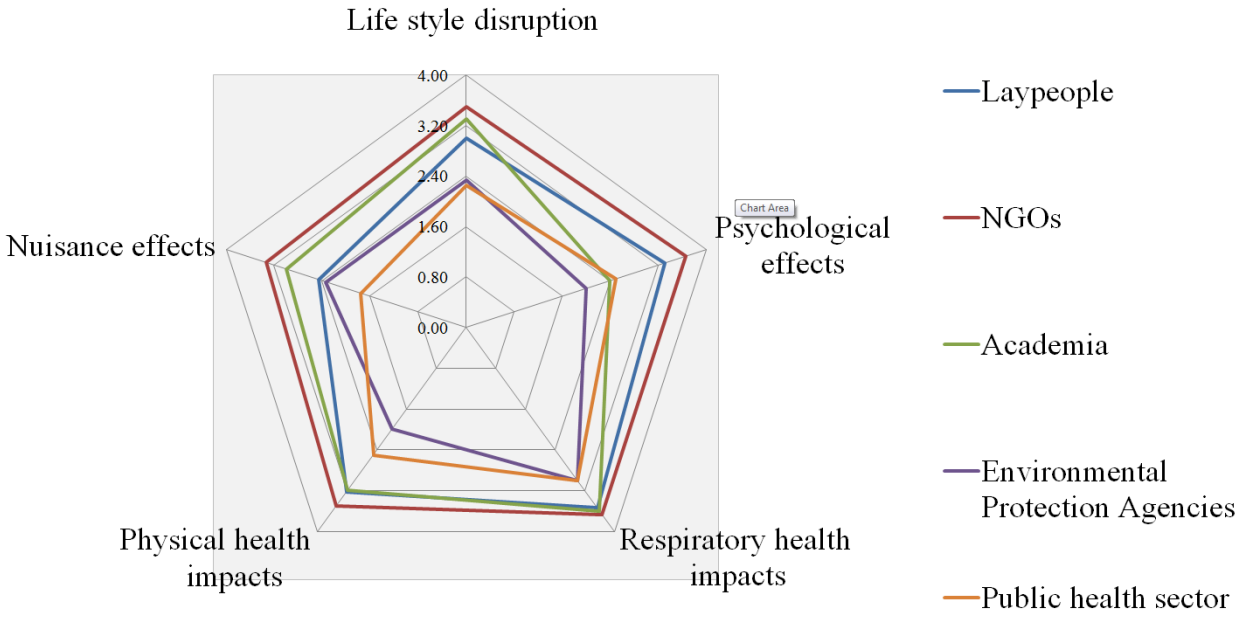

Fig. 4.1 Degree of risk perception exhibited by stakeholders according to the result of in-depth interviews
Source: Survey by author, (Feb.-Mar. 2013)

Table 4.2 Explanation of the degree of risk perception judged by stakeholders

Stakeholders (persons)	Degree of Industrial Risks Perceived by Stakeholders				
	Life Style Disruption	**Psychological Effects**	**Respiratory Health Impacts**	**Physical Health Impacts**	**Nuisance Effects**
Lay people (13)	Many people have to change their career from agriculture to service sector, labor, and factories 'workers. People cannot use natural resources for their leisure activities anymore.	People feel panic when seeing back smoke released from factories 'stacks. They are afraid of touching rain. When touching rain, some people develop skin rashes. They feel unsecured to live in this community.	The number of respiratory disease patients in the area has increased over time. People can feel irritated in their eyes and nose.	Compared to the past, people are nowadays easy to get sick. A lot of people have got serious sickness such as canner.	In the night time, people can still hear the sound of operated machine. People can hear the sound of traffic all the times. It became crowed in communities. People feel that they have lost their privacy.
NGOs (8)	Previously, a major career of Maptaphut people was agriculture. It has changed since the establishment of factories. Change of career structure significantly impacts on life style of people	Many people in Maptaphut have got cancer, and many of them died. This situation makes people nervous and feeling unsecure to live in environment.	Air has been contaminated with several kinds of hazardous gases such as benzene, 1,3 –Butadiene, and 1,2 Dichloroethane. These kinds of compounds still exceed EPA standard.	Long term accumulation of released hazardous gas potentially causes several kinds of diseases such lung disease, self-immunity disease and cancer.	Rapid increase in the number of population destroyed communities' quiet atmosphere. Increase in volume of traffic are also annoying residents.
Academia (4)	People's life is tied with their environments, so deterioration of environments in the area must change the way they live.	People feel panic when seeing back smoke released from factories 'stacks	Increase in the number of local clinics can imply to health problems of Maptaphut people. Several kinds of released compounds such as benzene, 1,3 –Butadiene and 1,2 Dichloroethane potentially impact on respiratory system.	Many kinds of released compounds found in this area can ruin several parts of human body. For instance, Vinyl Chloride can impact on human lung, blood, brain and skin.	Previously, local people had quite and slow life. Rapid increase in population and traffic volume may annoy them.
Environmental Protection Agency(3)	More people work in factories. Some change their career due to the deterioration of environment.	Some people feel panic when they can smell chemicals that may be evaporated from factories	Most factories use chemicals that potentially cause cancer, such as chemicals in group 1, group 2A, and group 2B. During manufacturing, those chemicals can accidently release.	The urgent impact may not manifest immediately. However, accumulated hazardous compounds in human body can cause serious sickness.	Smell and noise of traffic sometimes annoy people. There are a lot of trucks in the area.
Public Health Sector(4)	More people work in factories, and some open a small shop instead of fishery and agriculture	People feel nervous when they were found exceeding substance in their body.	Some kinds of VOCs, are still found over the standard in the area.	Long term accumulation of released hazardous gas potentially causes several kinds of diseases such as lung disease, self-immunity disease and cancer.	It may have some extents

Source: Survey by author, (Feb.-Mar. 2013)

4.2.2 Understanding health risks based on statistic records pertaining to the number of patients with disease caused by environments

Considering rate of patients with diseases caused by environments during 2003-2011 (see table 4.3), it was found that rate of patients with each type of disease in Rayong province had considerably increased. Patients with respiratory illness such as acute upper respiratory infections, pneumonia, chronic lower respiratory diseases, asthma and acute severe asthma, and other diseases of the respiratory system considerably increased in 2004 which was the year that environmental crisis first happened in Maptaphut area. All types of environments in the area were found contaminated with hazardous substances and gas. In 2006 rate of patients was dramatically reduced, and then kept stable until 2011. However, when compared to the case of Nakornpathom province, the number of patients in Rayong province was still far higher than that in Nakornpathom province. Considering rate of patients with physical illness in Rayong province, it was found that the number of patients had been increased since 2003. Until in 2011, number of patients per 1,000 people was 14.5 cases. This was far higher than the number of cases found in Nalornpathom province. Considering the rate of patients with psychological illness, the number of patients in 2011 was not much different from 2003. However, when compared to the case in Nakornpathom, rate of patients with psychological illness was still higher and tended to increase since 2007. Rate of patients with disease related to environments in Rayong province can imply that industrial activities in the area have potentially caused health problems. Though, causes of diseases may be influenced by several factors, it hardly denies that environments in Maptaphut area will not be one of those factors.

Table 4.3 Rate of patients with disease caused by environments during 2003-2011

Type of Disease	Province	Number of patients per 1,000 people								
		2003	2004	2005	2006	2007	2008	2009	2010	2011
Respiratory Illness (Acute upper respiratory infections , Pneumonia, Chronic lower respiratory diseases, Asthma and acute severe asthma, and Other diseases of the respiratory system)	Rayong	15.17	26.13	25.35	17.60	17.13	18.80	18.28	18.67	18.73
	Nakornpathom	10.47	11.53	12.55	11.03	11.35	11.51	10.59	11.29	10.73
Physical Illness (Ca liver, Ca lung, Ca breast, Ca cervix, Diseases of the blood and blood forming organs and certain disorders involving the immune mechanism)	Rayong	2.66	3.56	4.76	4.67	6.60	7.86	11.99	12.31	14.54
	Nakornpathom	1.64	1.85	2.67	3.70	5.09	5.82	6.35	6.82	9.21
Psychological Illness (Mental disorders, Mental and behavioral disorders due to psychoactive substance use, Schizophrenia, schizotypal and delusional disorders, Mood (affective) disorders, Neurotic, stress-related and somatoform disorders)	Rayong	2.13	2.06	2.07	1.93	1.73	1.97	2.40	2.51	2.62
	Nakornpathom	1.03	1.47	1.38	1.03	2.12	2.12	1.38	1.19	1.23

Source: Calculated from statistic data reported by ministry of public health, Office of the Permanent Secretary, Ministry of Public Health, Thailand, 2012 [1]

Regarding this finding, the study could not indicate which stakeholders had created false risk judgment because each stakeholder has a different piece of information for judging risks. In addition, a range of information used for risk judgment is still not widely shared among them. Moreover, their experiences in living in the area are also different. Some are not local residents, and some are new comers. The influence of development of industrial activities on each stakeholder is therefore different. As a result, risk judgment and perception could be therefore significantly varying.

4.2.3 Factors determining risk judgment of stakeholders

In this section, factors determining risk judgment of stakeholders will be presented. According to the results of in-depth interviews (see appendix 3), it was found that those stakeholders have different viewpoints in judging and perceiving risks. Each stakeholder addressed the degree of risks based on different issues regarding the physical nature of risks. Interviewees from environmental protection agencies and health care sectors mostly emphasized relationship between the levels of health risks and probability of environmental contamination. As stated by an interviewee from public health sector, "*Risk associated with industrial activities tends to decrease because of the reduced amount of hazardous gas contamination reported by an industrial sector*". Another interviewee from environmental agencies stated that *"The overall environmental situation is getting better because industrial sectors have settled a range of protective measures to reduce a chance of contamination".* It was noticed that interviewees from these two organizations broadly viewed risks based on probability of occurrence or environmental contamination, and the relationship between probability of occurrence and the potential impacts was mentioned several times during the interviews. Besides addressing probability of air pollutants released by industrial plants, interviewees from public health also moderately emphasized relationship between potential health impacts and severity of catastrophic consequences caused by air pollutants. For instance, it was addressed that *"At high levels of exposure, many VOCs can cause central nervous system depression. All can be irritating upon contact with the skin, or to the mucous membranes if inhaled"* and *"long-term accumulation of VOCs in human body can cause health impacts, but severity of impacts depends on health condition of residents as case by case"*. However, compared to the statement of probability of contamination, relationship between potential industrial impacts and severity of catastrophic consequences was less emphasized by interviewees from public health sectors. For the interviewees from environmental protection agencies, they also slightly mentioned the issue related to uncertainty; for instance, "*a chemical accident sometimes occurs because of human errors, as residents always called for the inspection of chemical odors*".

In case of interviewees from NGOs, most interviewees strongly emphasized relationship between serious health impacts faced by residents and severity of catastrophic consequences caused by air pollutants in the area. Most of them similarly stated that "*Several kinds of gases*

found in the area potentially damage human body. For instance, long term accumulation of VOCs can cause damage to liver, kidney, and central nervous system. Some substances are suspected or known to cause cancer in humans. Considering statistics, cancer rate patients in Rayoug province was revealed high. The number of respiratory disease patients in Rayong hospital is still high, and increase every year." Moreover, interviewees from NGOS also moderately emphasized issued related to probability of pollutant released and uncertainty. They still believe that some industrial plants do not have an effective protective measure to entirely prevent environmental contamination, and some plants illegally and intentionally polluted the environment. It was stated that *"chemical accidents often occurring in the area extensively damages the environment, and residents inevitably receive the impacts. The major cases of chemicals accidents are both human and mechanical errors"* and *"Many factories solely consider the standard. What they think is maximum point that they can release. If all factories think the same things, the area may not have enough capacity to tackle with pollution".* It was also noticed that NGOs also slightly mentions the issue related to lay people's probability of receiving impacts; for instance "*People do not have enough capability to fully understand air quality because evaporation of hazardous gas is invisible"* and *"When air, water, soil are polluted, there are high possibility that people will get impacts. They live there 24 hours. They consume those resources every day".* However, it was less emphasized when compared to other issues. Most of interviewees from NGOs mostly stated relationship between health impacts and severity of catastrophic consequences caused by air pollutants in the area.

Regarding the fundamental understanding of risk related judgment of interviewees from academia, what most emphasized is severity of catastrophic consequences and probability of receiving impacts respectively. Biological experts mentioned the result of her study in 2004 which found that Marine snails, especially mussels, which eat by filtering food, were found to be abnormal, when compared with the ones in another area, Sriracha city. These problems indicated that environments must be contaminated with toxins that damage their genes. Additionally, she also stated that "*some studies found that 58% of sampling groups (adults) had abnormal cells which contain micronucleus, and found 46.71% in sampling groups who were children*". Other experts addressed that chemical used in those industrial plants are very dangerous to human health, and those chemicals have been prohibited to use in some developed countries. In addition, it was noticed that experts from academic often explained the potential impacts of air pollutants

on human health; for instance "*The impact of heavy metals and VOCs can lead to many health problems, which may not appear immediately, but the severe health impacts may occur in the future and its seriousness depends on human genetic characteristics. 1,3 Butadiene can cause eye, nose and throat irritation. 1,2 Dichloroethane can cause damage to liver, kidney, and lung.*" In addition, probability of environmental contamination caused by industrial plants and issues related to uncertainty were also slightly stated by experts from academia such as "*VOCs can be generated from various point sources such as combustion, transportation, or evaporation from fugitive sources at various components in the piping system such as joints and valves*" and "*chemical accidents occurring in the area imply that industrial sector has not had effective protective measures and effective plans for coping with the emergency situation*".

For lay people, most of their expression reflects that risks were viewed based on probability of receiving impacts and severity of catastrophic consequences respectively. Most laypeople often mentioned the significance of human and nature relation. When one is destroyed, it is inevitable that another one will not be impacted. As stated by one laypeople, *"We had survived by utilization of our local resources (water, air, soil, and forest) since we were born. We lived very close to the nature, but we are now living very close to many factories. We could easily smell chemical odors and sometime get irritated in eyes"* This expression implies to their susceptibility to the pullulated air in the area. Most of lay people also stated about the severity of catastrophic consequences; for instance *"according to information received from Medias, attending several meetings, information from experts, those pollutants might cause severe health impacts in the future. Many people in our communities died because of cancers, and several causes could not be clearly explained*. Issues related to probability of environmental contamination and uncertainties were also addressed by lay people, it was not often; for instance "*Increase in the number of factories may increase probability of contamination. Many factories have kept operating the whole day-and night. Even the night time, I can see bright lights at factories*" and "*Some people's relatives died without clear reasons provided by the doctors. They assumed that they must get some influences from industrial activities. For instance, people working as a security for an industry, died without clear explanation. Responsible organization cannot provide people with clear understanding of relationship between sickness and polluted air*"

Table 4.4 shows summary of stakeholders' fundamental understanding of risk-related judgments. It showed that each stakeholder viewed risk differently. This might cause the difference in risk judgment and perception. As a result, cooperation among stakeholders for environmental risk management can be achieved.

Table 4.4 Stakeholders' fundamental understanding of risk related judgments

Stakeholders	Physical Nature of Risks			*Other issues (uncertainty due to human errors, natural disaster, mechanical errors)*
	Probability of Environmental Contamination	*Probability of Receiving Impacts*	*Severity of Catastrophic Consequences*	
NGOs (8)				**Uncertainty: human error**
Academia (4)				**Uncertainty: human error**
Environmental protection agencies (3)				**Uncertainty: mechanical error/ natural disaster**
Public health sector (4)				
Lay people (13)				**Emotion: fear Uncertainty: human error,/natural disaster**

*Note Most emphasized Moderately emphasized Less emphasized Never emphasized

Source: Survey by author, (Feb.-Mar. 2013)

4.3 DERTERMINANTS OF RISK PERCEPTION HELD BY LAYPEOPLE

4.3.1 General characteristics of respondents

The number of male respondents is slightly higher than female respondents (51.4 and 48.6%, respectively) (see tables 4. and 5). Most of the respondents are of working age; namely, respondents between the age of 30–39 and 20–29 years old occupied a major proportion of the total population, (30.4 and 28.7%, respectively). Most of them have only a high school degree, with which they are considered sufficiently eligible for several kinds of low-skilled jobs, including as construction workers and as laborers in the agricultural sector, the service sector, and the industrial manufacturing sector. The survey showed that people working in the agricultural sector and as laborers comprise the majority of the respondents (31.5%); the number

of people working as an industrial staff totaled 17.1%. Considering the type of communities in relation to the degree of hazardous gas concentrations, the results of the survey showed that 70 people (almost 39%) live in moderate-risk communities, while 60 people (33%) live in low-risk communities. Respondents living in high-risk communities totaled 28.2%.

Table 4.5 General characteristics of respondents

General Characteristics of Respondents	Number (n =181)	Percentage
Gender		
Female	88	48.6
Male	93	51.4
Age		
Less than 20 years old	18	9.9
20-29 years old	52	28.7
30-39 years old	55	30.4
40-54 years old	45	24.9
55 and more than 55 years old	11	6.1
Education		
Primary school	21	11.6
High school	100	55.2
Vocational degree and Associate degree	11	6.1
Undergraduate degree	44	24.3
Higher than undergraduate degree	5	2.8
Career		
Public servant	18	9.9
Labor in agriculture sector and service sector	57	31.5
Industries' staff	31	17.1
Private company	21	11.6
Self-employment such as self-business, services, and merchants	34	18.8
Student	15	8.3
Housewife	5	2.8
Types of community in relation to a degree of air contaminations		
Low-risk community	60	33.1
Moderate-risk community	70	38.7
High-risk community	51	28.2

Source: The result of questionnaire survey, (Oct.-Nov., 2014)

Table 4.6 shows the general characteristics of respondents in the three types of communities. The distributions of gender, age, and educational levels were not significantly different, based on the results of the Chi-square test. Most of them were within the working age range; respondents in the 30–39 and 20–29 age groups occupied a major proportion of those living in the moderate-risk and low-risk communities. Most of the respondents in the high-risk communities belonged to the 30–39 and 40–54 age brackets. Regarding their educational levels, the majority of the respondents in the three communities only finished high school, which is considered sufficiently eligible for several kinds of low-skilled jobs such as those in the service and industrial manufacturing sectors, construction work, as well as labor in the agricultural sector. The survey also showed that the careers and incomes of the respondents in the three types of communities were significantly different, according to the results of the Chi-square and ANOVA tests. Most of the respondents in the high-risk communities worked as industrial employees and in private companies, respectively. The majority of the respondents in the moderate-risk and low-risk communities were laborers in the agriculture and service sectors, with relatively lower incomes than their counterparts in the high-risk communities.

Table 4.6 General characteristics of respondents in three types of communities

Characteristic		**High-risk community [N= 51]**		**Moderate-risk community [N = 70]**		**Low-risk community [N=60]**		**Test statistics**
		N/Mean	%	N/Mean	%	N/Mean	%	
Gender	Male	30	58.8	36	51.4	27	45.0	$X^2 = 2.109$
	Female	21	41.2	34	48.6	33	55.0	
Age	Under 20 years old	3	5.9	8	11.4	7	11.7	$X^2 = 9.613$
	20–29	12	23.5	27	38.6	13	21.7	
	30–39	17	33.3	18	25.7	20	33.3	
	40–54	15	29.4	11	15.7	12	20.0	
	55 and above	4	7.8	6	8.6	8	13.3	
Education	Primary school	5	9.8	8	11.4	8	13.3	$X^2 = 4.982$
	High school	28	54.9	41	58.6	31	51.7	
	Vocational degree and Associate degree	3	5.9	3	4.3	5.0	8.3	
	Undergraduate degree	13	25.5	18	25.7	13	21.7	
	Higher than undergraduate degree	2	3.9	0	0.0	3	5.0	

Table 4.6 *Cont.*

Characteristic		High-risk community [N= 51]		Moderate-risk community [N = 70]		Low-risk community [N=60]		Test statistics
		N/Mean	%	N/Mean	%	N/Mean	%	
Career	Public servant	8	15.7	4	5.7	6	10.0	$X^2 = 19.956$*
	Laborer in agriculture sector and service sector	6	11.8	28	40.0	23	38.3	
	Industrial worker	13	25.5	10	14.3	8	13.3	
	Private company employee	10	19.6	5	7.1	6	10.0	
	Self-employed, such as business owner, service provider, and merchant	8	15.7	16	22.9	10	16.7	
	Other	6	11.8	7	10.0	7	11.7	
Income	Average income/month (Thai Baht ± SD)	14,458 ± 6774.86		11,464 ± 4547.91		11,650 ± 7546.6		F = 3.908*

*p < .05

Source: The result of questionnaire survey, (Oct.-Nov., 2014)

4.3.2 Lay people's risk perception

1. Risk perception exhibited by laypeople

Table 4.7 shows the mean scores of the risk perception variables and their correlations. Respondents exhibited higher perceptions of physical health effect, nuisance, and respiratory effect than those of psychological health impacts and lifestyle disruption. The results of the Pearson correlation analysis revealed that most of the perception variables were positively correlated with one another. The results of Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy also manifested high correlations among all variables, indicating that all these variables can represent a degree of risk perception. All variables were added and calculated as a mean score representing a degree of risk perception. Higher scores represented higher perceived risks. The table 4.8 shows an average risk perception score and descriptive statistics of potential predictors. Generally, it is found that all factors related to the nature of risks are more correlated with laypeople's risk perception than psychological and cognitive factors.

The results of the surveys show that people have high concerns regarding environment and health due to the severely contaminated air caused by the heavy industrial activities in the

area. People living nearby factories were highly concerned with the impacts of pullulated air on physical health, respiratory health, and nuisance; furthermore, lay people were moderately concerned with the impacts on local lifestyle and psychological health (see table 4.7). Physical and respiratory health problems cause by polluted air could be recognized by the general public due to statistical records revealed in many research studies and by many relevant organizations. Besides analyzing residents' health concerns, this study placed greater emphasis on other dimensions of industrial impacts, including local lifestyle disruption, psychological health problems, and nuisance.

Lifestyle disruption: Due to the rapid change of local environments, deterioration of natural resources, and a massive migration of laborers into the area, typical local lifestyles have been gradually disrupted. For instance, lay people can no longer use their natural resources for leisure activities, such as gardening, fishing, and swimming in the sea. Furthermore, their original careers developed from local wisdom, such as rural farming and fishing, have been negatively influenced. It is generally known that the area was previously plentiful in fruit cultivation. Several kinds of delicious fruits, including mangosteen, rambutan, and durian were produced in this area; agriculture had also been a major source of income for many households. Although they did not earn a high income from agricultural farming, people could live sustainably with a balance between natural resource consumption and environmental conservation. When the air and other types of local natural resources were found contaminated, many households decided to stop operating agricultural farms, and some finally became involved in the service and industrial sectors. This phenomenon also caused diminished social interaction among people because of psychological stress and a decrease in social activities conducted together.

Psychological health problems: Since many people suffered from health problems and/or passed away without a clear explanation from responsible organizations, people have felt unsecure living under the current environmental condition. Moreover, although they receive a significant amount of money from working in a factory, some people have to spend some of that money for health treatment and/or surgery. It was questioned by the public several times whether industrial development in the area could bring real prosperity to the local citizens. This situation

caused public anxiety as well as psychological problems among lay people. As found in the report, the suicide rate in this area was far higher than the national average.

Nuisance: The transition from rural farming communities to urban industrial communities without proper environmental planning has also created nuisance problems. Many residential areas are situated very close to industrial plants. People could face irritation in their eyes or nose when staying nearby the plants. Furthermore, since the area became highly populated due to a massive migration, the local atmosphere, including safety, calm, and peace, has been rapidly destroyed. A lot of problems have occurred, including traffic congestion, drug abuse, and crime. As shown in table 4.7, respondents exhibited concerns related to nuisance caused by the local environmental change as high as concerns about respiratory and physical health.

Table 4.7 Mean scores of risk perception variables and their correlations

		Lifestyle disruption		**Psychological impacts**		**Respiratory impact**	**Physical health impact**		**Nuisance**	
	Variable	1	2	3	4	5	6	7	8	9
1	Have industrial activities in the area impacted your original career?	1.000								
2	As a result of industrial development, how much can you use local resources for your leisure activities?	.439**	1.000							
3	As a result of industrial development, do you feel worried about your health?	.309**	.529**	1.000						
4	As a result of industrial development, do you feel worried about your future life in Maptaphut?	.427**	.464**	.614**	1.000					
5	Has air quality in the area caused respiratory diseases among residents?	.170*	.353**	.645**	.504**	1.000				
6	Has air quality in the area caused several kinds of cancer among residents?	.204**	.372**	.552**	.522**	.701**	1.000			
7	Has air quality in the area caused diseases related to self-immunity systems such as immunity disorder, fever, etc.?	.124	.381**	.523**	.506**	.689**	.773**	1.000		
8	Have industrial activities caused nuisance such as noise or smells?	.234**	.442**	.469**	.458**	.511**	.515**	.595**	1.000	
9	Has the current condition of the community caused nuisance such as traffic jams, congestion, noise, smells, etc.?	.226**	.291**	.252**	.247**	.276**	.275**	.327**	.644**	1.000
	Mean	2.24	2.36	2.57	2.40	2.71	2.77	2.82	2.85	2.61
	SD	1.152	1.059	0.924	0.993	0.868	0.920	0.885	0.853	0.934

*p < .05, **p < .01.
Bartlett's test of sphericity = 806.773, df = 36, *P = .000,* Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy = .847

Source: The result of questionnaire survey, (Oct.-Nov., 2014)

Table 4.8 Average risk-perception score and descriptive statistics of potential predictors

Items		Mean/N (%)	SD	Correlation with RP
Risk perception (RP)	Risk perception (RP)	2.604	.665	1
Socio-demographic factors	Gender (Dummy variable)			
	- Female (1)	88(48.6%)	-	-.231
	- Male (2)	93(51.4%)	-	
	Age(years old)	33.85	11.341	.057
	Income (Baht)	12,368	6409.771	.259
	Education			
	Primary school	21(11.6%)	-	.067
	High school	100(55.2%)	-	
	Vocational degree and Associate degree	11(6.1%)	-	
	Undergraduate degree	44(24.3%)		
	Higher than undergraduate degree	5 (2.8%)	-	
Factors related to the nature of environmental risks	Perceived probability of environmental contamination	3.381	.661	0.422
	Perceived probability of receiving impacts	3.293	.705	0.426
	Perceived severity of catastrophic consequences	3.265	.712	0.340
Psychological and cognitive factors	Perceived ability to control the risk			
	- Not at all	39(21.5%)	-	.017
	- Moderately capable	117(64.6)	-	
	- Highly capable	25(13.9)	-	
	Concerns about family members	4.133	1.912	-.214
	Pervious experiences with air pollution			
	- Never	29(16%)	-	.264
	- Sometimes	109(60.2%)	-	
	- Often	43(23.8%)	-	
	Perceived benefit from industrial development	2.276	1.221	.246
	Trust in public authorities	2.452	0.943	-.294
	Trust in industrial agencies	2.559	0.983	-.286

Source: The result of questionnaire survey, (Oct.-Nov., 2014)

2. Risk perception exhibited by lay people experiencing the different degree of hazardous gas concentration

The mean scores of perception of environmental risks exhibited by respondents from high-risk, moderate-risk, and low-risk communities were compared, and the differences among the groups were statistically proven by the results of the one-way ANOVA. First, the test of

homogeneity of variances showed unequal variances across groups (*sig* = .001). Therefore, the results of Welch's t-test were used instead of the regular ANOVA test. The findings showed that the degrees of risk perception significantly differed among respondents living in different communities facing varying levels of hazardous gas contamination, F (2,178) = 12.908, p = .000, η_p^2 = .138. Because of the unequal variances across groups, a post-hoc analysis using Dunnett T3 was then performed to demonstrate multiple comparisons (see table 4.9)

Table 4.9 Differences in means of risk perception scores given by respondents in three types of communities

Type of Community	N	Mean	SD	Mean Difference (Multiple Comparison)		
				High-risk Communities	Moderate-risk Communities	Low-risk Communities
High-risk	51	2.96	.759		.38989*	.62775*
Moderate-risk	70	2.57	.601	-.38989*		.23786*
Low-risk	60	2.34	.501	-.62775*	-.23786*	
Total	181	2.60	.665			

(Welch's t-test analysis) F = 12.908, P = .000

*The mean difference is significant at 0.05.

Source: The result of questionnaire survey, (Oct.-Nov., 2014)

The results indicated that the average risk perception score given by respondents in low-risk communities was significantly lower than those in moderate-risk (p = .045) and high-risk communities (p = .000). Similarly, respondents in moderate-risk communities had significantly lower risk perception scores than those in high-risk communities (p = .009), but higher than those in low-risk communities. The risk perception scores given by the respondents showed that those in high-risk and moderate-risk communities believed that the existence of industrial risks was still high and would potentially bring significant losses to their lives. In contrast, respondents in low-risk communities exhibited low risk perception, which signified minimal expected losses caused by air contamination in the area.

An interpretation of the analysis results could be that risks perceived by laypeople are related to the degrees of hazardous gas contaminations estimated by experts [2-4]. The results of this analysis could support Sjoberg's [5] claim that the relationship between cultural adherence and risk

perception was low, and laypeople's perceptions were significantly related to real risks. In this study, which emphasized environmental health risks, the cultural theory [6,7] might not be an appropriate concept to explain how environmental health risks are determined by laypeople. Although most of the respondents in this study shared a similar culture, they had significantly different degrees of risk perception.

4.3.3 Determinants of risk perception held by lay people

A multiple regression analysis was performed to test if the factors related to social-demographic characteristics of residents, the nature of environmental risks, and psychological factors significantly predicted respondents' risk perceptions. The predictors were the eleven indices, while the criterion variable was the degree of risk perception. The results indicated that the linear combination of the three types of predictors could predict the degree of risk perception exhibited by respondents. Three regression models are shown in table 4.10. In model 1, only variables related to socio-demographic characteristics of respondents were included in the analysis, and the result showed that the linear combination of those four variables, including gender, age, income, and education, was significantly related to the degree of risk perception, $F(4,176) = 5.735$, $p = .000$. The multiple correlation coefficient was .340, indicating that only 11.5% of the variance in risk perception can be accounted for by the linear combination of those selected predictors. In model 2, factors related to socio-demographic characteristics of respondents and factors related to the nature of risks, including lay people's perceived probability of environmental contamination, perceived probability of receiving impacts, and perceived severity of catastrophic consequences, were included in the analysis, the results showed that the linear combination of those variables was also significantly related to the degree of risk perception, $F(7,173) = 10.742$, $p = .000$. The multiple correlation coefficient was .550, indicating that approximately 30.3% of the variance in risk perception can be accounted for by the linear combination of selected predictors. In model 3, all types of factors were analyzed, and the result shown that the linear combination of those variables was significantly related to the degree of risk perception, $F(13,165) = 11.028$, $p = .000$. The multiple correlation coefficient was .682, indicating that approximately 46.5% of the variance in risk perception can be accounted for by the linear combination of selected predictors. However, only seven variables showed significant relationship with the degree of risk perception. Those variables were gender, income, lay people's perceived probability of environmental contamination, perceived

probability of receiving impacts, perceived severity of catastrophic consequences, perceived benefit from industrial development, and trust in public authorizes.

A multiple regression was performed again by including only variables which showed significant relationship with the degree of risk perception. The result (see table 4.11) shown that the linear combination of those variables was significantly related to the degree of risk perception, $F(8,170) = 17.506$, $p = .000$. The multiple correlation coefficient was .672, indicating that approximately 45.2% of the variance in risk perception can be accounted for by the linear combination of selected predictors.

Considering the influence of each variable in predicting risk perception, the result showed that all variables related to the factor related to nature of risks had a significant positive regression weight such as perceived probability of environmental contamination ($\beta = .148$, t = 2.055, $p < .05$), perceived probability of receiving impacts ($\beta = .222$, t= 3.086, $p < .01$), and perceived severity of catastrophic consequences ($\beta = .182$, t= 2.721, $p < .01$). Considering Beta (β), the variable of perceived probability of receiving impacts from environmental contamination, is the most influential among all those variables in the same group as well as among all analyzed variables. Notably, a variable related to perceived benefit from industrial development has a positive relationship with the degree of risk perception, and it is also highly influential ($\beta = .219$, t= 3.844, $p < .01$). It implies that risk is highly perceived if benefits from industrial development in the area are greatly perceived though. The variable of trust in public authorities had a negative regression weight ($\beta = -.216$, t= -3.620, $p < .01$), indicating that respondents with higher trust in public authorities tend to have lower perceived risks.

In the case of variables related to socio-demographic characteristics of respondents, gender and income, the results showed that both gender and income could also predict the degree of risk perception constructed by respondents. The variable of income ($\beta = .181$, t= 3.330, $p < .01$) is more influential than gender ($\beta = -.149$, t(= -2.569, $p < .05$). Respondents with higher income appeared to exhibit higher risk perception. The result contradicts with many previous risk studies. However, it could reflect the actual fact that people might realize the existence of environmental risks which are always associated with benefits.

Table 4.10 Summary of hierarchical regression analysis for variables predicting environmental risk perception (n = 180) missing 1

Variable		Model 1				Model 2				Model 3			
		B	**SE B**	**β**	**VIF**	**B**	**SE B**	**β**	**VIF**	**B**	**SE B**	**β**	**VIF**
Socio-demographic Variables	Gender	-0.281	0.095	-0.211***	1.013	-.184	.087	-.139**	1.060	-.179	.079	-.134**	1.082
	Age	0	0.004	0.007	1.075	.001	.004	.023	1.088	.000	.004	.007	1.149
	Income	3.09E-05	0	0.297***	1.478	2.253E-05	.000	.216***	1.522	1.736E-05	.000	.167**	1.563
	Education	-0.051	0.037	-0.114	1.407	-.023	.034	-.052	1.491	.006	.032	.014	1.619
Physical nature of risk variables	Perceived probability of environmental contamination					.254	.078	.253***	1.472	.143	.075	.143*	1.694
	Perceived probability of receiving impacts					.176	.075	.186**	1.569	.203	.071	.213***	1.721
	Perceived severity of catastrophic consequences					.108	.067	.116	1.274	.169	.062	.177***	1.290
Psychological and cognitive variables	Perceived ability to control the risk									.076	.070	.064	1.074
	Concerns about family members									-.055	.021	-.157	1.087
	Perceived experiences with air pollution									.085	.065	.080	1.164
	Perceived benefit from industrial development									.118	.033	.217***	1.135
	Trust in public authorities									-.119	.054	-.169**	1.810
	Trust in industrial agencies									-.046	.050	-.068	1.691
R square			0.115				0.303				0.465		
F for change in R square			5.735				10.742				11.028		

Note: ***p < .01. **p < .05.*p < .10

Source: The result of questionnaire survey, (Oct.-Nov., 2014)

Table 4.11 Summary of regression analysis based on the inclusion of significant variables predicting environmental risk perception exhibited by lay people in Maptaphut (n =181)

Variable	Mean	Std. Error	Correlation with environmental and health concerns	Multiple regression weights	
				b	β
Risk perception	2.6	0.66	1		
Gender (Female = 1, Male =2)	1.5	0.50	-0.22	-0.199	-.149*
Income	12,397	6387.9	0.25	1.990E-005	.181**
Perceived probability of environmental contamination	3.4	0.66	0.41	.149	.148*
Perceived probability of receiving impacts	3.3	0.71	0.44	.208	.222**
Perceived severity of catastrophic consequences	3.3	0.71	0.39	.165	.182**
Perceived benefit from industrial development	2.5	0.95	0.25	.121	.219**
Trust in public authorities	2.3	1.22	-0.28	-.153	-.216**

Note: **p < .01. *p < .05.

Source: The result of questionnaire survey, (Oct.-Nov., 2014)

The result shown in table 4.11 demonstrated the predictive variables which could significantly predict risk perception constructed by lay people in Maptaphut municipality. The equation for predicting risk perception is as follows:

$$Y = 1.266 + 0.208X_1 + 0.121X_2 - 0.153X_3 + 0.165X_4 + 1.990(E\text{-}0.005)\ X_5 - 0.199X_6 + 0.149X_7 \quad (1)$$

Note:

Y = *Risk perception*

X_1 = *Perceived probability of receiving impacts*

X_2 = *Perceived benefit from industrial development*

X_3 = *Trust in public authorities*

X_4 = *Perceived severity of catastrophic consequences*

X_5 = *Income*

X_6 = *Gender*

X_7 = *Perceived probability of environmental contamination*

E = *Standard Error (Coefficients)*

4.3.4 Determinants of risk perception held by lay people living in a community experiencing the different levels of environmental contaminations

In this section, the study aims to examine determinants risk perception held by lay people living in a community experiencing the different levels of hazardous gas contaminations. Respondents were classified into three groups according to the level of pollutant concentrations experienced by their communities; high-risk community, moderate-risk community, and low-risk community (details regarding classification methods are shown in chapter 3; determining sampling group).

The results indicated that the linear combination of the twelve predictors could predict the degree of risk perception exhibited by respondents, but its power to explain the degrees of risk perception held by the respondents in the three types of communities was different (see Table 4.12). In high-risk communities, the linear combination of the selected predictors was significantly related to the degree of risk perception, $F(13,36) = 7.467$, $p = .000$. The multiple correlation coefficient was .854, indicating that approximately 72.9% of the variance in risk perception can be accounted for by the linear combination of selected predictors. The linear combination of these predictors could also explain a significant proportion of the variance in the risk perception score given by respondents in moderate-risk communities ($R^2 = .559$, $F(13,56) = 5.460$, $p = .000$) and low-risk communities ($R^2 = .520$, $F(13,46) = 3.829$, $p = .000$).

The significance of individual variables in predicting risk perception scores is presented in Table 4.9. It was found that the variables significantly predicting risk perceptions held by the respondents in the three types of communities were different. For respondents in high-risk communities, two of the twelve predictors were statistically significant: perceived probability of environmental contamination and perceived benefits from industrial development. In contrast, the perception score given by respondents in moderate-risk communities was significantly predicted by the variables of perceived probability of receiving impacts and perceived severity of catastrophic consequences. The perception score given by respondents in low-risk communities was significantly predicted by two predictors: perceived experiences with air pollution in the area and trust in public authorities. A regression model with significant predictors of risk perception held by respondents in each type of community could be presented as follows.

Table 4.12 Summary of regression analysis for variables predicting environmental risk perception exhibited by laypeople in three types of community

Variable		High-risk Community [N=50] missing 1				Moderate-risk Community [N=70]				Low-risk Community [N=60]			
		B	SE B	β	VIF	B	SE B	β	VIF	B	SE B	β	VIF
Socio-demographic Variables	Gender	-.230	.170	-.149	1.627	-.119	.121	-.098	1.245	-.184	.118	-.184	1.328
	Age	.003	.008	.037	1.538	.001	.007	.025	2.009	-.004	.004	-.104	1.110
	Income	-1.181E-05	.000	-.105	3.007	2.641E-05	.000	.197	1.923	9.560E-06	.000	.144	1.699
	Education	.080	.073	.162	2.922	.045	.046	.104	1.434	-.016	.048	-.051	2.084
Physical nature of risk variables	Perceived probability of environmental contamination	.581	.215	.433***	3.400	.069	.096	.075	1.359	.050	.098	.069	1.737
	Perceived probability of receiving impacts	.157	.219	.132	4.506	.329	.081	.413***	1.325	.068	.102	.098	2.049
	Perceived severity of catastrophic consequences	.001	.162	.001	1.937	.199	.080	.242**	1.201	-.016	.090	-.022	1.534
Psychological and cognitive variables	Perceived ability to control the risk	-.105	.157	-.075	1.679	.000	.094	.000	1.066	-.034	.103	-.039	1.294
	Concerns about family members	-.040	.035	-.120	1.421	-.055	.038	-.143	1.272	-.041	.027	-.162	1.106
	Perceived experiences with air pollution	.011	.138	.009	1.629	-.084	.103	-.075	1.089	.334	.095	.428***	1.405
	Perceived benefit from industrial development	.232	.059	.446***	1.715	.063	.052	.122	1.278	.093	.057	.180	1.165
	Trust in public authorities	-.207	.165	-.266	5.953	-.061	.077	-.090	1.606	-.135	.073	-.260*	1.860
	Trust in industrial agencies	-.019	.150	-.025	5.389	-.060	.071	-.091	1.467	.025	.071	.050	1.899
R square		0.729				0.559				0.5200			
F for change in R square		7.467				5.460				3.829			

Note: ***p < .01. **p < .05.*p < .10

Source: The result of questionnaire survey, (Oct.-Nov., 2014)

- High-risk communities

The result showed that the potential predictor variables are perceived probability of environmental contamination and perceived benefit from industrial development. People who have high scores of these variables tend to have a higher risk perception score. The regression model with two predictors produced R = 0.773, R^2 = 0.598, $F(2,48) = 35.728$, $p = 0.000$. Perceived probability of environmental contamination had a significant positive regression weight ($\beta = .624$, $p = .000$), as did perceived benefit from industrial development ($\beta = .413$, $p = .000$). This indicates that respondents with high perceived probability of environmental contamination and high perceived benefit from industrial development gave relatively high scores of environmental risk perception. The equation for predicting risk perception held by respondents in high-risk communities is as follows:

$$Y = -0.535 + 0.829X_1 + 0.215X_2 \quad (2)$$

(Note: where Y is a degree of risk perception. X_1 is a degree of perceived probability of environmental contamination, and X_2 is a degree of perceived benefit from industrial development.).

This result contradicts with many previous studies which addressed the negative relationship between perceived benefits and risk perception, but the result of this study was opposite. In this way, the study deeply investigates what caused this outcome. It was assumed that career of respondents might be related to the degree of perceived risks because most of respondents in high-risk communities were industrial's staffs which usually gain higher income than do other careers (see table 4.3). Respondents in this group might realize the high existence of risks in the area. The study performed analysis of variance (ANOVA) in order to justify whether respondents with different career would exhibit significant difference in risk perception.

The result in Table 4.13 showed that the degrees of risk perception held by respondents in different careers were significantly different ($F(6,44) = 2.823$, $P = .021$). Self-employed respondents (such as business owner, service provider, and merchant), industrial workers, laborer in agriculture sector and service sector, and housewife significantly perceived higher risks than did public servant, private company employee, and students. It is possible that respondents with higher income will perceive higher risk than lower-income respondents, but a particular group of low-income residents, laborer in agriculture sector and service sector in particular, also constructed a high risk perception as well.

Table 4.13 Differences in means of risk perception scores given by respondents with different careers

Career of Respondents	n	Mean	SD.
- Public servant	7	2.471	.594
- Laborer in agriculture sector and service sector	8	3.112	.664
- Industrial workers	12	3.242	.709
- Private company employee	10	2.560	.687
- Self-employed, such as business owner, service provider, and merchant	8	3.463	.644
- Student	2	2.100	.990
- Housewife	4	3.125	.810
Total	51	2.963	.759
F (6,44) = 2.823, *P* = .021 (< .05)			

Source: The result of questionnaire survey, (Oct.-Nov., 2014)

- Moderate-risk communities

It was found that two variables related to the nature of environmental risks could predict risk perception held by respondents in moderate-risk communities. Those two variables are perceived probability of receiving impacts and severity of catastrophic consequence. Respondents who gave high scores for those variables tend to exhibit higher risk perception. The regression model with two predictors produced R = 0.643, R^2 = 0.414, $F(2,67) = 23.675$, $p = .000$. Perceived probability of receiving impacts had a significant positive regression weight ($\beta = .496$, $p = .000$), as did perceived severity of catastrophic consequences ($\beta = .280$, $p = .006$). When considering standardized coefficients (Beta) of each variable, it was found that the variable of perceived probability of receiving impacts was more influential than the variable of perceived severity of catastrophic consequence. The equation for predicting risk perception is as follows:

$$Y = 0.649 + 0.23X_1 + 0.395X_2 \quad (3)$$

(Note: where Y is a degree of risk perception. X_1 is a degree of perceived severity of catastrophic consequences, and X_2 is a degree of perceived probability of receiving impacts).

- Low-risk communities

The result showed that no factors related to lay understanding of the nature of risks could predict risk perception held by people in low-risk communities. Two variables showed a significant influence on the risk perception score, i.e., previous experiences in facing polluted air ($\beta = .554$, $p = .000$) and a level of trust in public authorities ($\beta = -.232$, $p = .030$). Respondents who gave high scores for this variable tend to exhibit higher risk perception. The regression model with one predictor produced $R = 0.621$, $R^2 = 0.385$, $F(2,57) = 17.852$, $p = .000$. The result can be interpreted that people in low-risk communities might not judge risk based on self-appraisal. Instead, they might possibly judge risk based on their belief, which could be influenced by their previous experiences.

$$Y = 1.694 + 0.433X_1 - 0.121X_2 \quad (4)$$

(Note: where Y is a degree of risk perception, and X_1 is a number of previous experiences in facing polluted air, and X_2 is a level of trust in public authorities).

Based on the findings, environmental risks were determined differently by respondents who lived in the three different types of communities. Similar to what Aven [8] addressed, this study found that respondents may either use beliefs or self-appraisal to judge and perceive risks. The risk perceptions of respondents from high-risk and moderate-risk communities have been proven as significantly related to how they think about the nature of risks. This finding is partly related to the results of Slovic's [10] and Leiserowitz's research [9], which suggested the influence of the nature of risks on the public's environmental risk perceptions. Respondents in high-risk communities judged risks based on their perceived probability of environmental contamination; however, respondents in moderate-risk communities assessed risks by considering the probability of being impacted by the contamination, as well as the potential adverse impacts they might face. On the other hand, the perceptions exhibited by respondents from low-risk communities were not particularly determined by factors related to the nature of risks, but were instead significantly influenced by one of the psychological and cognitive variables, that is, previous experiences with air pollution. Possibly, the perceptions of residents in low-risk communities were not processed based on the rational system but formed based on their beliefs, which were affected by previous experiences.

Besides being determined by perceived probability of contamination, the risk perceptions of respondents in high-risk communities were also significantly influenced by their perceived benefits generated from industrial development in the area. This finding is related to those of the studies conducted by Slovic [11] and Gregory and Mendelsohn [12], which also stated the influence of perceived benefits on perceived risks; however, the positive relation between perceived benefits and perceived risks found in this study was unexpected and different from the results of previous studies [12,13]. For instance, Gregory and Mendelsohn [12] concluded that individual risk assessment is included with one's perceived benefits, whereas Alhakami and Slovic [13] argued that when technologies are perceived as highly beneficial, risks are relatively devalued. In this study, respondents in high-risk communities seemed to understand that the more benefits they gained, the more risks they faced, whereas respondents in the other two types of communities did not include benefits at all in their risk assessments and perceptions. This situation could be explained that most of respondents in high-risk community work in the industrial complex (see Table 4.13), and relatively have higher income than those respondents from moderate-risk and low-risk communities. It is possible that respondents in high-risk communities are certain that there are potential risks associated with industrial activities, and they tend to accept those risks as long as benefits are gained.

Overall, the results indicated that laypeople used different processing systems to judge and perceive risks. Moreover, the factors related to the physical nature of environmental risks played more important roles in shaping the risk perceptions of laypeople in high-risk and moderate-risk communities than psychological and cognitive factors did. Possibly, people became more knowledgeable, and thus they judged risks based on their rational processing system [14,15].

4.3.5 Implications for development of risk communication

Generally, the study implies that laypeople living in contaminated sites are knowledgeable, since the respondents' degrees of risk perception are related to the levels of hazardous gas and compound concentrations estimated by experts. Additionally, laypeople are not emotional when judging and perceiving risks. As evidenced by the findings, most of the psychological factors are not associated with perceptions of environmental risks. Risk is determined based on laypeople's understanding of the nature of environmental risks, such as perceived probability of contamination caused by industrial activities, perceived probability of

receiving impacts, and perceived severity of catastrophic consequences. With the exception of residents in low-risk communities, the respondents' perceived risks are formed based on their experiences with air pollution. Inhabitants of low-risk communities may possibly pay less attention to facing risks that are less serious for them. However, this particular case may not be applicable in explaining the risk perceptions of people in every contaminated site, since this study's participants have been struggling with environmental problems for a long time and have exerted much effort in fighting against organizations that have failed to manage risks. Furthermore, they have been educated with a variety of information and have gained many experiences.

Additionally, the study demonstrates that perceived benefits generated by industrial activities are not considered when risks are judged by respondents in moderate-risk and low-risk communities. As for study participants in high-risk communities with commercial areas, they have realized the correlation between gaining substantial benefits and taking high risks. In this regard, the institutions involved may be unsuccessful in their efforts to mitigate the public's perceived risks by merely providing different types of compensation and facilities without demonstrating an initiative to effectively minimize risks. Reducing or increasing people's risk perceptions significantly depends on how they understand the nature of risks. Communicating information related to the physical nature of risks is therefore vital; on the contrary, poor communication can lead to high public anxiety and high risk perception.

This study also helps relevant parties identify the gaps in risk perception when laypeople's fundamental understanding of risk-related judgment is compared to those of other stakeholders. If the causes of the risk perception gap among parties are accurately indicated, then risk communication strategies, including the goals and methods of communication efforts, as well as information types and formats, can be properly designed to bridge this gap [16, 17]. This study's results suggest that appropriate information, such as knowledge of community sensitivities that influence the public's perceived probability of receiving impacts, should be mutually exchanged among involved parties. Lay people with a solid understanding of such sensitivities can play a crucial role as messengers. Two-way or collaborative communication between and among stakeholders should therefore be established. Moreover, due to the diverse risk perspectives among residents of different types of communities, those in high-risk and

moderate-risk communities might be more interested in information about the nature of environmental risks, such as the probability that industries might cause contamination, the amount of pollutants released, and the potential of contracting diseases. Scientific data regarding the nature of risks can gain higher acceptance among people in high-risk and moderate-risk communities but might be completely rejected by inhabitants of low-risk communities. Therefore, in designing an effective environmental risk communication, the broad range of the public's risk judgments should be seriously taken into consideration.

4.4 THE CAUSE OF IMMENSE GAP IN RISK PERCEPTION HELD BY STAKEHOLDERS

According to the results of empirical studies, this study provides understandings on the causes of immense gap in risk perception among stakeholders, and deep understandings on risk perception hold by laypeople, and its determinants factors. It could be indicated that the major cause of immense gap in risk perception is the different viewpoints in risk judgments created by each stakeholder. Environmental health risks were viewed based on different aspects in regard to the physical nature of risks.

Some stakeholders have a narrow viewpoint in judging and perceiving risks; whereas, some stakeholders have a boarder view. As shown in table 4.4, interviewees from environmental protection agency and public health sectors significantly judged the degree of risks based upon the probability of environmental contamination. Public health sector slightly mentioned the severity of catastrophic consequences, but did not address the issued related to residents' probability of receiving impacts, and other relevant issues like uncertainty at all. This could be understandable because most of staffs from public health sectors do not live in the area. They might lack understanding the issues related to local contexts such as local daily's activities, local culture, custom, and tradition. Same as interviewees from public health sector, staffs of environmental protection agencies did not addressed the issue related to residents' probability of receiving impacts; however, issues related to uncertainty associated with risks of chemical accidents was stated.

For interviewees from academia and NGOs and lay people, those stakeholders seem to have a boarder view in risk judgment and perception. Environmental health risks were viewed

based upon several aspects related to the nature of risks. However, their viewpoints in risk judgment are still different in some extent. Severity of catastrophic consequences caused by pullulated air was strongly emphasized by academia and NGOs; whereas, probability of receiving impacts was most emphasized by lay people. The result of in-depth interview with laypeople also coincides with the result of a multiple regression which demonstrated the significant factors predicting risk perception of lay people. Lay people appeared to have a comprehensive viewpoint in risk judgment and perception. Besides strongly addressing an issue related to probability of receiving impacts, they also moderately emphasized severity of catastrophic consequences, and slightly emphasized probability of environmental contamination and uncertainties. In case of NGOs, besides strongly emphasizing on an issue related severity of catastrophic consequences, they also moderately addressed probability of environmental contamination and uncertainties; while, an issue of probability of receiving impacts was slightly addressed. Academia demonstrated that severity of catastrophic consequences was a core component of environmental risks; however, residents' probability of receiving impacts was also moderately emphasized. In addition, academia also slightly emphasized probability of environmental contamination and uncertainties.

The study apparently showed that these stakeholders differently judged the degree of environmental health risks, and they also have a different viewpoint in risk judgment and risk perception. This could be considered as a problematic situation for cooperative environmental risk management, and effective risk communication could take a crucial role in bridging the gap in risk perception.

4.5 DEVELOPMENT OF RISK COMMUNICATION MODEL AND STRATEGIES

Currently, management of environmental health risk has become increasingly difficult. This is because of the nature of risk which is tremendously uncertain [18] and hard to quantify. People in a society have different beliefs and understandings of risks associated with environmental contamination. The result of empirical studies showed that lay people NGOs, and academia have a boarder view on environmental risk than do environmental protection agencies and public health sector. Laypeople themselves also viewed the degree of risks based on different viewpoints, and there are some external values influencing the risk judgment and

perception held by lay people in low-risk communities, such as factor related to social trust and collective experience. Lay people looks at risk more broadly than the expert whose expertise is narrow and therefore likely to "miss something" of importance to the boarder community [19]. The public is more concerned about what experts do not know and have a much stronger belief in the existence of "unknown effects" [20]. Those scholars' statement could be considered correct when their statement is compared to the evidence provided by this study. Difference in risk judgments among stakeholders has given rise to barriers in stakeholders' cooperation in risk management. In this part, the study would propose risk communication model and strategies which can bridge the gap in risk perception held by each stakeholder.

4.5.1 Risk communication model

The model was created based on the result of this study' findings which could be summarized as follows;

1. Stakeholders have diverse viewpoints in risk judgments. Some stakeholders did not consider the issue that lay people strongly considered when judging risks.

2. Laypeople living in contaminated sites are knowledgeable, since the respondents' degrees of risk perception are related to the levels of hazardous gas and compound concentrations estimated by experts.

3. Outrage is not actually associated with risk judgment and perception held by laypeople. This might be related to their religious, Buddhism, which forgiveness and logical reasoning practices are two of key fundamental principles of this religious. Approximately 75% of people in the area are Buddhist [21].

4. Overall, risk perception held by lay people is constructed based on their rational processing system influenced by lay understanding of the nature of risks and their psychological and cognitive factors; except, people in low-risk communities whose risk perception is judged based on experimental processing system influenced by only social trust and collective experiences.

Based on the finding, all stakeholders actually have occupied information necessary for risk assessment, and each stakeholder naturally conducts their own qualitative risk assessment

based on variable information. An effective qualitative risk assessment is also significant to a mandatory risk management process; namely, all stakeholders' concerns and stakes could be taken into consideration. The model proposed by this study consists of two sections (see fig. 4.2).

In the first section, it was proposed that collaborative information sharing among stakeholders should be established, so that, all significant information including science, social aspects, culture, values of communities as well as feeling, could be shared. All stakeholders have important roles as both information sender and receiver, not either of these. When, stakeholders receive the same information, they could process their qualitative risk assessment more comprehensively, and the result might not be significantly different. Each stakeholder's problems and concerns can be mutually shared. Then, the most important component is that the result of qualitative risk assessment must be included in risk management (integrated risk assessment and management).

In the second section, the study proposed that to bridge the gap in risk judgment and perception and to construct a cooperative environmental risk management, the proposed risk communication model must be implemented before risk identification in order to ensure that people would assess risks based on the same pieces of information. During risk assessment, risk communication among stakeholders must be intensively implemented again. In this stage, a lot of information that possibly affect risk perception should be presented and be understood by all stakeholders; particularly, a comprehensive structure of the process creating an environmental risks, including social and economic values of communities, sensitiveness, concerns, etc. Finally, cooperative risk management can be achieved. It is suggested that risk communication should be fostered as often as possible, even after management processes. Public should be kept updated how risk has been managed. This could also increase public involvement in risk management.

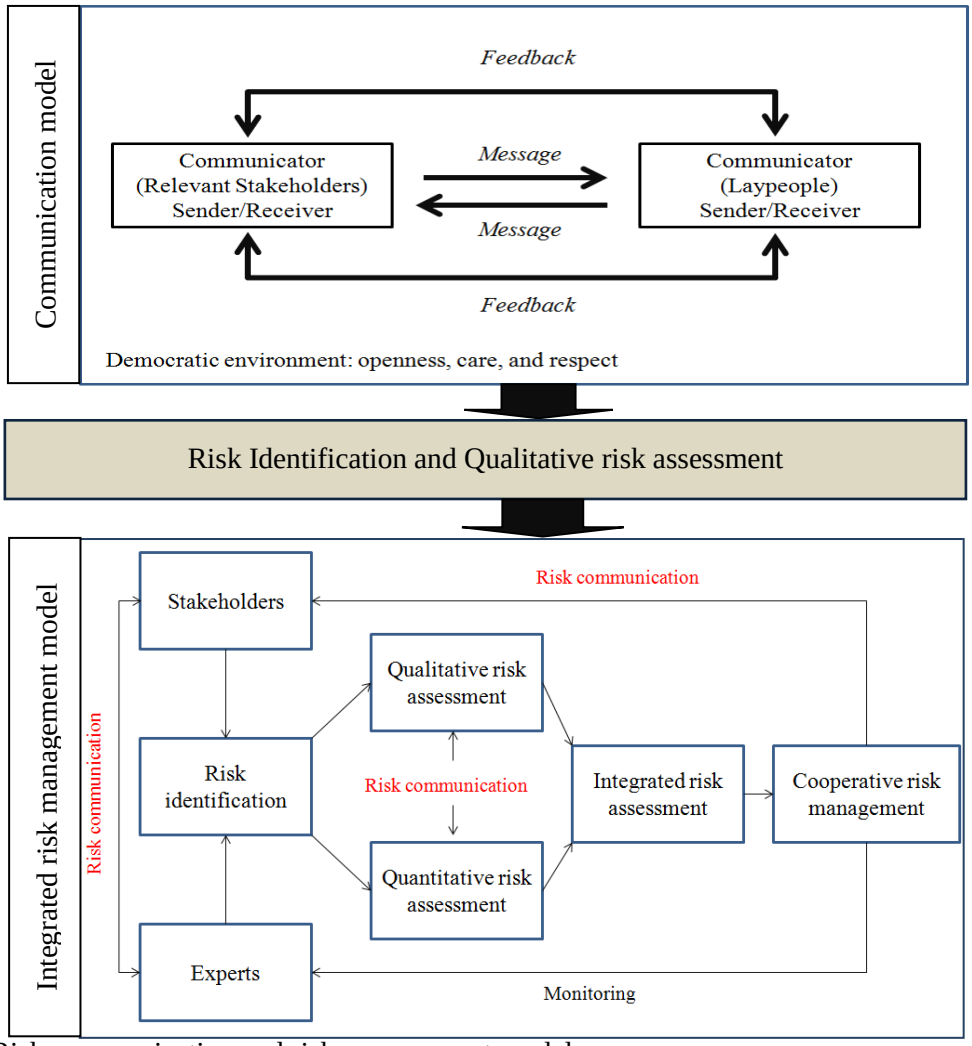

Fig. 4.2 Risk communication and risk management model
Source: Author, (2014)

4.5.2 Risk communication strategies

Risk communication strategies could be proposed as follows;

1. A comprehensive structure of the process creating an environmental risk should be included in risk communication, and those relevant information need to be communicated in the way that each particular group of people can comprehend. Laypeople experiencing the different degree of risks assessed risks based on a different system. Laypeople in low-risk community judged risks on belief, and psychological and cognitive factors are significantly influential. Information related science must be hardly accepted for those people.

2. Knowledge of community sensitivities that influences the public's perceived probability of receiving impacts should be mutually exchanged among involved parties. Laypeople with a solid understanding of such sensitivities can play a crucial role as messengers.

3. Risk communication should go beyond only communicating science, and social and cultural values of communities should be taken into consideration. This is because those communities' elements influenced lay people's perceived probability of receiving impacts.

4. Public should be kept updated with what organizations holding authorities to manage risks have done. Those organizations must consider local communities as a partner.

5. Cooperative risk communication should be implemented in each stage of risk management in order to ensure that each stakeholder has judged risks based on the same pieces of information.

6. Organizations responsible for risk management should bear in mind that risk perception held by the public is reality. Outrage does not actually influence.

7. To foster communication with many parties, it will be successful if stakeholders' fundamental understanding of risk-related judgment is clearly understood. The methods and information formats used for communication could be properly selected.

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CHAPTER 5: SIGNIFICANCE OF UNCERTAINTY COMMUNICATION TO TRUST BUILDING

5.1 GENERAL INTRODUCTION

In this chapter, the study aims to demonstrate the significance of uncertainty communication to trust building. First, the study demonstrates the degree of laypeople' trust in public authorities and industrial agencies, and also demonstrates relationship between the public's trust and risk perception exhibited by laypeople. Second, lay people's capability to conceptualize uncertainty associated with risk assessment and uncertainty about potential impacts will be presented. In addition, in order to reveal the significance of uncertainty communication to trust building, the study conducts the analysis on relationship between lay understanding of uncertainty and degree of social trust. Finally, discussion on the roles of uncertainty communication in building social trust is presented, and risk communication strategies for building social trust is also proposed.

5.2 SOCIAL TRUST AND ITS INFLUENCES ON ENVIRONMENTAL RISK PERCEPTION

One of the study hypotheses is that a degree of trust in public authorities and industrial agencies might be associated with the level of environmental and health concerns exhibited by lay people. Correlation and a multiple regression were performed to examine the extent to which possibility variables of trust could predict environmental and health concerns. First, the result of the survey revealed that 40.3% of respondents have moderate trust in the capability of public authorities, while 36.5% of respondents have moderate trust in industrial agencies (see table 5.1). More than 47% of respondents have either low trust or no trust in industrial agencies in public authorities; approximately 45% have either low trust or no trust in industrial agencies. Overall, considering a mean score representing a degree of trust, people seem to have higher trust in industrial agencies than in public authorities.

Table 5.1 Trust in public authorities and industrial agencies

Level of Trust	Social Trust	
	Trust in public authorities	**Trust in industrial agencies**
Not at all	36 (19.9%)	32 (17.7%)
Low	50 (27.6%)	50 (27.6%)
Medium	73 (40.3%)	66 (36.5%)
High	22 (12.2%)	33 (18.2%)
Total	181 (100%)	181 (100%)
Mean/SD.	2.448/0.945	2.552/0.985

Source: The result of questionnaire survey, (Oct.-Nov., 2014)

In conducting correlation and multiple regression, the scores representing a degree of environmental and health concerns in each aspect (see chapter 4) were added together and calculated into a mean score. The score ranges from 0 (no concerns) to 4 (high concerns). Table 5.2 summarizes descriptive statistics and analysis results. As can be seen, trust in public authorities and trust in industrial agencies are negatively and significantly correlated with environmental and health concerns, indicating that respondents with high trust scores tend to have lower environmental and health concerns. The multiple regression model with two predictors produced $R^2 = 0.109$, F (2,178) = 8.645, $p < 0.05$. Trust in public authorities is more influential (β=-0.195, t(178) = -2.205, $p < 0.05$.) than trust in industrial agencies (β = -0.174, t(178) = -1.973, p = 0.05.). The regression model showed that trust could predict only 10.9% of the variance in environmental and health concerns. This can be explained by the fact that environmental and health concerns could also be predicted by other more influential factors, such as experiences, the knowledge and skill of the respondents, readiness to cope with adverse consequences, etc. However, trust still plays an important role in creating a collaborative risk management process and strengthening environmental risk communication. Without trust among stakeholders, public participation in the decision-making process as well as public support in the development of industrial activities cannot be achieved.

Table 5.2 Summary statistics, correlations, and results from the regression analysis

Variable	Mean	Std. Error	Correlation with environmental and health concerns	Multiple regression weights	
				b	β
Environmental and health concerns	2.604	.665	1.000		
Trust in public authorities	2.448	.945	-.299*	-0.137*	-0.195
Trust in industrial agencies	2.552	.985	-.291*	-0.118*	-0.174

*p < 0.05

Source: The result of questionnaire survey, (Oct.-Nov., 2014)

5.3 LAY PEOPLE' S UNDERSTANDING OF UNCERTAINITIES AND SOCIAL TRUST

The study assumed that under the current risk communication in which people are poorly communicated with regarding information related to assessment uncertainty and outcome uncertainty, people who are able to conceptualize uncertainty might exhibit lower trust than people who are not able to conceptualize uncertainty. This is because of the low perceived transparency in risk assessment and the low perceived honesty of the relevant institutions. The result of the analysis showed that 40% of respondents understood how VOCs are possibly released into the ambient air (see table 5.3). People can understand the possibility of VOCs contamination. In fact, no matter how effective risk management is, it will continue to be associated with uncertainty for several reasons, including human or mechanical errors, weather conditions, and natural disasters. In addition, the results of the survey also showed that about 60% of respondents could understand outcome uncertainty (see table 5.4). Namely, those people have understood a number of factors potentially contributing to varying seriousness of diseases, such as self-immunity systems, the amount of compounds which entered the body, and genetic characteristics. Therefore, it could be stated that most people, i.e., at least 40% and 60%, could conceptualize both assessment uncertainty and outcome uncertainty respectively.

To understand relationship between lay understanding of uncertainty and the degree of trust in public authorities and industrial agencies, test of variances and t-test analysis were performed. It was found that degrees of trust in public authorities and industrial agencies are significantly different between people who recognized and those who did not recognize assessment uncertainty. As shown in table 5.3, people that can comprehend the causes of VOCs

contamination have significantly lower scores of trust in public authorities than those who could not comprehend the same issue; as expected, people recognizing uncertainty exhibited lower trust. Scores of trust in industrial agencies were also significantly different between people with comprehension and no comprehension of the causes of VOCs contamination.

Considering the effect of lay understanding of outcome uncertainty on levels of trust in public authorities (see table 5.4), there was also a significant effect for respondents in terms of recognizing and not recognizing outcome uncertainty, with recognizing respondents giving relatively lower scores than unrecognizing respondents. The result also indicated that scores of trust in industrial agencies are not significantly different (t [179] = 1.093, p = .276). No matter whether respondents did or did not recognize outcome uncertainty, scores of trust in industrial agencies were not significantly different. It could be explained that industrial agencies do not have a direct responsibility to provide residents with health care services, and thus lay people do not rely on industrial agencies.

Overall, the results demonstrated that lay understanding of both types of uncertainties had a significant effect on trust in public authorities. Only lay understanding of assessment uncertainty significantly influenced trust in industrial agencies; lay understanding of outcome uncertainty did not have an effect.

Table 5.3 Summary statistics, and results from the t-test analysis

Trust	**comprehension of assessment uncertainty (causes of contamination) N = 71**		**no comprehension of assessment uncertainty (causes of contamination) N = 110**		**T-test**			**Test of Variances**	
	M	SD.	M	SD.	t-value	df	Sig. (2-tailed)	F	Sig
- Trust in public authorities	2.028	1.000	2.718	.803	4.887	126.36	.000	5.081	.025
- Trust in industrial agencies	2.296	1.074	2.718	.890	2.758	129.40	.007	7.296	.008

Source: The result of questionnaire survey, (Oct.-Nov., 2014)

Table 5.4 Summary statistics, and results from the t-test analysis

Trust	comprehension of outcome uncertainty N= 107		no comprehension of outcome uncertainty N= 74		T-test			Test of Variances	
	M	SD.	M	SD.	t-value	df	Sig. (2-tailed)	F	Sig
- Trust in public authorities	2.271	.927	2.703	.918	3.092	179	.002	.429	.513
- Trust in industrial agencies	2.486	0.965	2.649	1.013	1.093	179	.276	.172	.679

Source: The result of questionnaire survey, (Oct.-Nov., 2014)

5.4 SIGNIFICANCE OF UNCERTAINTY COMMUNICATION TO SOCIAL TRSUT BUILDING

According to the result of data analysis, most people, at least 40% of the respondents, could conceptualize uncertainty associated with risk assessment and at least 60% of the respondents could conceptualize uncertainty about potential damages. Those who could conceptualize uncertainty significantly have lower trust in public authorities and industrial agencies than people who could not, with the exception of lay understanding of outcome uncertainty which is not statistically related to lay people's trust in industrial agencies. This might be because people do not rely on industrial agencies in terms of receiving health protection as industrial agencies do not have any direct responsibility for providing health care. To discuss the cause of low trust in public authorities and industrial agencies among lay people recognizing uncertainty, the current risk communication was investigated. It was found that while information related to uncertainty is available to the public, it is not explicitly communicated to lay people. Most of the communicated information involved, for example, the amount of gas released on a daily or monthly basis; measurements used to protect the environment and prevent contaminations; types of potentially developed disease; and skills needed for self-protection. Avoidance of communicating uncertainty could make risk assessment and the management process less transparent, ultimately contributing to the destruction of trust [1]. In Maptaphut, people with comprehension of uncertainty and who have experienced real environmental pollution and are experiencing health problems might feel that risk assessments performed by the responsible institutions are not accurate and transparent. However, it has been debated in academic circles whether communicating uncertainty will be able to increase trust [1,2]. Johnson

and Slovic [3] suggested that communication of uncertainty can give rise to increasing institutional honesty, but that doing so will also probably minimize the level of competence perceived by the public. Frewer *et al.* [4] found that public distrust occurred because of institutions' failure to properly communicate information related to uncertainty to the public. People tend to accept uncertainty caused by insufficiency of scientific knowledge rather than uncertainty caused by a failure of the relevant organizations to minimize scientific uncertainty [5].

To enhance public trust in capability of public authorities and industrial agencies to manage risk, this study suggests two aspects. First, information related to assessment uncertainty and outcome uncertainty should be included in risk communication. Communicating uncertainty can show transparency in risk management and willingness to consult with the public, thereby potentially leading to greater institutional credibility and trust. Honesty and openness are important components of trust building. Though communicating uncertainty might decrease the public's perceived competence in risk management, the contribution of low perceived competence to trust can be compensated by faith and honesty of institutions. Therefore, information related to outcome uncertainty (types of potentially developed diseases in relation to genetic characteristics), uncertainty associated with environmental risk assessment (limitation of scientific knowledge in measuring contaminations or emissions or limitation of technology in controlling emissions) should be clearly explained when risk communication is conducted. In addition, how uncertainty is managed and controlled by responsible organizations should be emphasized as well. Second, to effectively communicating uncertainty, collaborative communication approach should be implemented. Risk management is a task responsible by many organizations such as public health sector, industrial agencies, academia, and governmental agencies. Each type of uncertainties is well understood by a specific party, and degree of uncertainty acceptance by each party might be different. Those relevant parties should have full opportunity to express their concerns, and a final decision on the development of industrial activities under uncertainty should be made based on all stakeholders' agreement. This can lead to trust building among stakeholders.

5.5 RISK COMMUNICATION STRATEGIES FOR BUILDING SOCAIL TRUST

Most hazards are unpredictable and uncertain. Therefore, the degree of control and the degree of knowledge about a risk affect the perception of the risk. Education and information sharing can make a difference in risk perception; however, it has to come from a trusted source. There are ways that credibility and trust can be improved. According to Covello [6], credibility and trust could be gained through empathy, competence; honesty and commitment (see fig. 5.1). In this part, the study will discuss how uncertainty communication can increase or can support the factors contributing to trust building based on the model proposed by Covello [6]. First, problems related the current risk communication for building trust in the Maptaphut area would be discussed. Then, study presented how communication of uncertainty could increase the degree of social trust. Finally, the study proposes risk communication strategies for building trust between the public and organizations responsible for risk management.

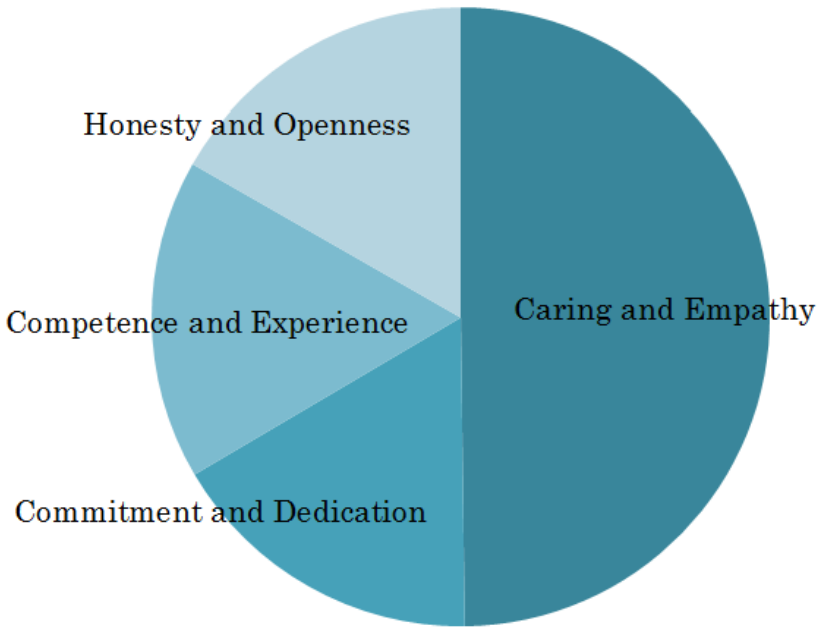

Fig. 5.1 Factors contributing to trust.
Source: Covello, (1993) [6]

5.5.1 Problems of risk communication in Mapthaphut Municipality

During the past three decades, risk communication in Mapthaphut was never effectively carried out. Industrial factories never explicitly communicated information related to hazardous substances, compounds utilized or uncertainty to local residents, NGOs, academia or local governmental agencies. As an interviewee from an NGO stated, 'when a chemical accident was occurring, and people were impacted by inhaling released toxic gas, it was hard for the public health sector to inspect the impacts and provide an effective treatment because the doctor did not immediately know what kinds of toxic gas those victims had inhaled'. Communication failures contributed significantly to a fragile trust and affected several parities' decision to be involved in risk management. According to the result of the questionnaire surveys, it was found that most laypeople (40.3% of respondents) have moderate trust in the capability of public authorities, while 36.5% of respondents have moderate trust in industrial agencies. More than 47% of respondents have either low trust or no trust in industrial agencies or public authorities; approximately 45% have either low trust or no trust in industrial agencies. Overall, considering a mean score as representing the degree of trust, people seem to have higher trust in industrial agencies than in public authorities.

After the environmental crisis and severe health problems suffered by the inhabitants of the industrial communities surfaced, a lot of people felt unsecure, frustrated and stressed out. Consequently, they lost trust in public authorities and industrial sectors. Recently, many stakeholders made many efforts to conduct risk communication; however, there are underlying problems that have caused a failure in risk communication among stakeholders. According to the result of in-depth interviews with relevant stakeholders, the causes of the communication failures that resulted in a fragile trust could be depicted as follows.

Lack of caring and empathy perceived by the public

At the time of the environmental crisis in which many people were suffering from various kinds of pollutants, people started blaming industrial sectors and the government. Demonstrations in public streets became a common tool used by the affected people against the development of industrial activities in the area. The government and industrial sectors did not show empathy and caring to those affected people. In contrast, industrial sectors seemed not to

take responsibility for this situation by reasoning that the pollution in the area was not a core reason for causing people to become severely ill [31, 32]. The government was put in the difficult situation of solving this problem because it needed to consider both economic development and residents' well-being. The conflict among government, industrial sectors and civilians was brought to the court [32], which was not good for any of the sides. One resident stated in an interview that 'the industrial sector argued that environmental pollution in the area and health impacts suffered by people are probably caused by mining activities in the past' and that 'Many plants do not feel responsible for people's health and well-being'. Lack of caring and empathy has ruined trust and credibility among stakeholders; consequently, risk communication and effective management cannot be achieved.

Lack of openness and honesty of organizations responsible for risk management

Openness and honesty are also dominant factors that cause communication failures in the Mapthaphut area. Before the environmental problems surfaced, information about hazardous substances in each factory was not revealed and reported to all agencies responsible for risk reduction, including local residents, NGOs, academia and local governmental agencies. A member of NGOs stated that 'Environmental and health impact assessment became a tool used by industrial plants to receive permission to construct their projects. Public hearings with local residents were often not transparent because some participants were paid money. The potentially affected people did not actually express their concerns. This is a case reflecting the lack of openness and honesty of the organizations responsible for risk management. Moreover, there was a rumour that some factories illegally released a large amount of wasted air. Although it was a rumour, it potentially destroyed trust and credibility among stakeholders. Additionally, there were other examples of actions taken by many factories which made them appear dishonest to the public, such as illegally dumping garbage in public places, hesitating to report accidents to public organizations and hiding information about discharged hazardous substances. One interviewee from an industrial community stated that 'I sometimes saw a lot of industrial waste in public areas'. Similar to local residents' statements, an expert working in a university also mentioned that 'I was asked by residents in Maptaphut area to inspect illegal dumping of hazardous wastes produced by industrial plants'. These kinds of activities demonstrate the dishonesty and un-openness of industrial sectors that can ruin trust and credibility among

stakeholders; consequently, messages sent by this organization may not be accepted by the public. Another issue is the unclear explanations provided by public authorities when people with a disease related to environmental pollution passed away. This particular situation has increased the public's perceived risks and uncertainty. As one resident stated, 'my relatives passed away, but the doctor did not provide clear reasons. It is possible that some information were concealed'.

Lack of competence and dedication perceived by the public

The public has lost trust in the capability of public authorities and industrial agencies to manage risks. During the past three decades since the establishment of the Maptaphut industrial estate development, environmental problems, including air, soil and water contamination, have occurred in the communities located nearby the factories. This situation leads to fragile trust between the public and the institutions responsible for risk management, particularly public authorities and industrial agencies. Moreover, when problems occur, those organizations have not made any significant efforts to solve them. Up until now, such problems still cause the public to question these institutions' competence and dedication to managing risks. A resident from Maptaphut area said that 'A chemical accident always occurs in the area. When it occurred, no representatives of the industrial sector took responsibility to solve the problem. We were not immediately informed by the industrial sector or by a public authority. We could only rely on information from the media on TV.' In addition, the same resident also stated that 'I can always smell a chemical odour, and sometimes I feel irritated'. These expressions can imply that people have low perceptions of the competence and dedication of organizations in the area to effectively manage risks.

These three factors are major causes of communication failure in Maptaphut. While these factors are mostly related to trust and credibility building, they are also related to human feelings that can lower one's ability to process received information. To solve the communication problems in Maptaphut Municipality, these factors must be taken into consideration and immediately eliminated.

5.5.2 Roles of uncertainty communication in building trust and communication strategies

According to the literature review, trust between the public and the organizations responsible for risk management can be achieved through the communication of uncertainty. The result of the empirical study also demonstrated the significance of uncertainty communication for trust building. Theoretically, trust is based on information with value or morality implications, contributing to decisions on shared values. In this study, trust is combined with confidence which is based on information with performance implications, contributing to decisions on past performance and/or expectations for future performance. Some studies separate trust and confidence as different issues. Communication of uncertainty conducted by organizations responsible for risk management potentially expresses their morality and performance, leading to social trust and cooperation in risk management (Figure 5.2). The roles of uncertainty communication in building trust and communication strategies can be proposed as follows.

Morality

Uncertainty communication can exhibit the transparency and honesty of institutions in assessing and managing risks. It was found that the general public could conceptualize uncertainty associated with risk assessment and uncertainty about potential impacts. Therefore, information related to various types of information-related uncertainty (such as the potential impact of natural disasters on industrial activities, the probability of chemical accident occurrences, the development of disease caused by pullulated environment etc.) should be explicitly communicated to the public. Otherwise, people may feel suspicious regarding what industrial agencies and public authorities have been doing. When a chemical accident occurs, people will hardly accept it, and may feel that those organizations are irresponsible. Communicating this type of information can show the public how risks are assessed, and how results can be changed due to some significant factors. However, along with uncertainty communication with the public, how uncertainty is controlled by institutions is also significantly important. Moreover, institutions must communicate emergency plans established for coping with crisis situations to the general public.

Uncertainty communication can exhibit institutions' openness to consult with the public. This can make people feel that nothing is being hidden. Caring expressions can be also achieved

through communicating this type of information. People may feel that their benefits and values will be exhaustedly protected by organizations responsible for risk management, and will not be intentionally destroyed due to the consequences of developed industrial activities in the area. In the case of Maptaphut, people often feel unclear regarding the causes of diseases suffered by lay people; however, public authorities did not demonstrate any efforts to explain these situations. This particular case has damaged the trustworthiness of the public authorities.

Performance

Uncertainty communication can actually increase perceived competence. The general public understands the limitation of scientific knowledge [22]; for instance, people have known that a range of factors contributing to the seriousness of health disease and/or realized that VOCs could be released from several channels. Communicating countermeasures or policies established for controlling or minimizing uncertainty to the public can increase their perceived competence of the relevant institutions.

Uncertainty communication can exhibit an institution's dedication and commitment. When the general public is communicated with regarding how uncertainty is controlled and minimized, and how the consequences caused by those uncertainties will be handled, people could realize and appreciate the institution's efforts to minimize risks and protect the public's benefits and values. In addition, public authorities and industrial agencies should continue conducting research that aims to minimize uncertainty and keep people updated with the results. This could increase the general public's perception of the relevant institutions' dedication and commitment.

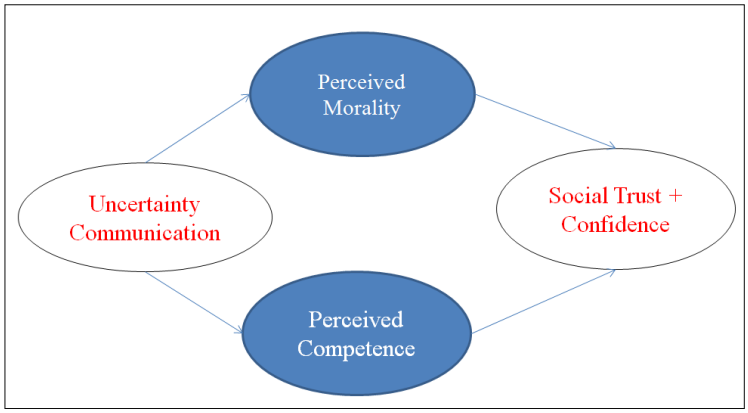

Fig. 5.2 Roles of communication of uncertainty in building trust
Source: Author, (2014)

In conclusion, the study investigated the roles of communicating uncertainty in building trust between the public and organizations responsible for risk management. It was found that respondents, approximately 40%, could conceptualize assessment uncertainty and 60% could conceptualize outcome uncertainty. These same respondents exhibited relatively lower trust than people who did not recognize the uncertainties. The study suggested that since people could recognize uncertainty, information related to uncertainty should be explicitly and carefully communicated to the public. At the very least, doing so can increase the transparency of risk management and show the institution's willingness to consult with the public, thereby leading to greater institutional credibility and trust. In addition, to effectively communicating uncertainty, collaborative communication approach should be implemented as each type of uncertainty is well understood by a specific party. A degree of uncertainty acceptance by each party might be also different. Those relevant parties should have full opportunity to express their concerns, and a final decision on the development of industrial activities under uncertainty should be made based on all stakeholders' agreement. This can lead to trust building among stakeholders.

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CHAPTER 6: CONCLUSION

6.1 CONCLUSION

Overall, the goal of this study is to develop risk communication model and strategies which can minimize the gap in risk perception among stakeholders as well as to propose risk communication strategies which can increase trust between public and organizations responsible for risk management. When, the risk perception gap is minimized, and trust among stakeholders is high, it potentially constitutes to cooperation among parties to manage risks. The study is divided into two parts. In the first part, the study aims to identify the cases of the gap in risk perception among relevant stakeholders responsible for risk management. Then, risk communication model and strategies are proposed. In the second part, the study investigates the significance of uncertainty communication to trust building. Communication strategies for increasing public trust in organizations responsible for risk management are proposed.

6.2 THE GAP IN RISK PERCEPTION AMONG STAKEHOLDERS AND RISK COMMUNICATION STRATEGIES FOR MINIMIZING THE RISK PERCEPTION GAP

According to the results of empirical studies, this study provides understandings on the causes of immense gap in risk perception among stakeholders, and deep understandings on risk perception hold by lay people, and their determinants factors. The result of in-depth with stakeholders demonstrated that stakeholders have various opinions on impacts of industrial activities on human health and well-being. Lay people, NGOs, and academic sector thought that pullulated air in the area has a very high impact on human's respiratory system and high impact on physical health. While, environmental protection agencies and public health sector viewed the impacts of industrial activities lower than lay people, NGOs, and academic sector in all aspects. It could be indicated that the major cause of immense gap in risk perception is the different viewpoints in risk judgments created by each stakeholder. Environmental health risks were viewed based on different aspects in regard to the physical nature of risks. Some stakeholders

have a narrow viewpoint in judging and perceiving risks; whereas, some stakeholders have a boarder view. It could be summarized as table 6.1

Table 6.1 Summary of stakeholders' fundamental of risk-related judgment

Stakeholders	Risk judgment	Relationship with risk perception
NGOs	1. Severity of Catastrophic Consequences 2. Probability of Environmental Contamination 3. Uncertainty 4. Probability of receiving impacts	High Moderate Moderate Less
Academia	1. Severity of Catastrophic Consequences 2. Probability of receiving impacts 3. Probability of Environmental Contamination 4. Uncertainty	High Moderate Less Less
Environmental protection agencies	1. Probability of Environmental Contamination 2. Uncertainty	High Less
Public health service	1. Probability of Environmental 2. Contamination Severity of Catastrophic Consequences	High Less
Lay people	1. Probability of receiving impacts 2. Severity of Catastrophic Consequences 3. Probability of Environmental Contamination 4. Uncertainty	High Moderate Less Less

Source: Author, (2014)

In addition, multiple regression analysis was performed to test if the factors related to socio-demographic characteristics of residents, the nature of environmental risks, and psychological factors significantly predicted laypeople' risk perceptions. The result showed that risk perception held by lay people actually reflects reality of risks, and is also influenced by some social and economic values**.** Emotional factors are not much influential. According to the result of regression, the linear combination of seven variables was significantly related to the

degree of risk perception. Those variables are gender, income, perceived probability of environmental contamination, perceived probability of receiving impacts, perceived severity of catastrophic consequences, perceived benefit from industrial development, and trust in public authority. However, their power to predict risk perception is different. Perceived severity of catastrophic consequences is the most powerful factor which influenced laypeople's risk perception; whereas, perceived probability of environmental contamination and gender are less influential.

Moreover, environmental risks were also determined differently by respondents who live in different communities experiencing a different level of hazardous gas contaminations. Risk perception held by respondents from high-risk and moderate-risk communities have been proven to be significantly related to how they think about the nature of risks. Respondents in high-risk communities judged risk based on their perceived probability of environmental contamination and perceived benefit from industrial development; however, respondents in moderate-risk communities judged risks by considering the probability that they might be impacted by the contamination as well as the potential adverse impacts they might face. Different from the perception held by respondents in those two types of communities, the perception exhibited by respondents from low-risk communities was not significantly determined by factors related to the nature of risks, but was instead significantly influenced by the psychological and cognitive variables, i.e., previous experiences in facing polluted air and trust in public authorities. It is possible that perceptions held by those in low-risk communities might not be processed based on the rational process system, but was instead formed based on their belief which was affected by previous experiences and social trust.

Based on the finding, all stakeholders actually have occupied information necessary for risk assessment, and each stakeholder naturally conducts their own qualitative risk assessment based on available information. An effective qualitative risk assessment is significant to a mandatory risk management process; namely, all stakeholders' concerns and stakes could be taken into consideration. The model proposed by this study consists of two sections. The first section presents information sharing model (see chapter 4), and the second section presents how to integrate qualitative risk assessment in risk management, and roles of risk communication.

6.3 ROLES OF UNCERTAINTY COMMUNICATION IN BUILDING PUBLIC TRUST

To propose risk communication strategies which could build trust between the public (lay people) and public authorities and industrial agencies, the study explored roles of communication of information related to uncertainty which is divided into two types such as assessment uncertainty and uncertainty about potential impacts. The result of the analysis showed that 40% of respondents understood how VOCs are possibly released into the ambient air. People can understand the possibility of VOCs contamination. In fact, no matter how effective risk management is, it will continue to be associated with uncertainty for several reasons, including human or mechanical errors, weather conditions, and natural disasters. In addition, the results of the survey also showed that about 60% of respondents could understand outcome uncertainty. Namely, those people have understood a number of factors potentially contributing to varying seriousness of diseases, such as self-immunity systems, the amount of compounds which entered the body, and genetic characteristics. Therefore, it could be stated that most people, i.e., at least 40% and 60%, could conceptualize both assessment uncertainty and outcome uncertainty respectively.

Additionally, it was found that degrees of trust in public authorities and industrial agencies are significantly different between people who recognized and those who did not recognize assessment uncertainty. People that can comprehend the causes of VOCs contamination have significantly lower scores of trust in public authorities than those who could not comprehend the same issue. There was also a significant effect for respondents in terms of recognizing and not recognizing outcome uncertainty, with recognizing respondents giving relatively lower scores than unrecognizing respondents. The result also indicated that scores of trust in industrial agencies are not significantly different. It could be explained that industrial agencies do not have a direct responsibility to provide residents with health care services, and thus lay people do not rely on industrial agencies.

To enhance public trust in capability of public authorities and industrial agencies to manage risk, this study suggests two aspects. First, information related to assessment uncertainty and outcome uncertainty should be included in risk communication. Communicating uncertainty

can show transparency in risk management and willingness to consult with the public, thereby potentially leading to greater institutional credibility and trust. In addition, how uncertainty is managed and controlled by responsible organizations should be emphasized as well. Second, to effectively communicate uncertainty, collaborative communication approach should be implemented. Risk management is a task responsible by many organizations such as public health sector, industrial agencies, academia, and governmental agencies. Each type of uncertainties is well understood by a specific party, and degree of uncertainty acceptance by each party might be different. Those relevant parties should have full opportunity to express their concerns, and a final decision on the development of industrial activities under uncertainty should be made based on all stakeholders' agreement. This can lead to trust building among stakeholders.

6.4 RECOMMENDATIONS FOR THE FUTURE STUDY

In practicing environmental risk communication for risk management, all stakeholders must be included in all steps. Each stakeholder has their own specific reasons to participate in risk communication. The practical ways to encourage each stakeholder in risk communication may be relied on the further study. For instance, the ways to encourage an industrial sector to fully participate in risk communication should be emphasized. Factors contributing to participation of all stakeholders and factors hindering the participation should be addressed in future studies as well.

In addition, to verify whether the risk communication model/framework and strategies proposed in this study would be successfully implemented. It requires a future study, particularly an empirical study, to examine the effectiveness of the model and/or framework. This study could provide theoretical background for creating hypotheses for future studies. For instance, to increase trust between the public and organizations responsible for risk management, the study addressed that communication of information related to uncertainty should be communicated to the public. This is because uncertainty communication could express institutions' morality and competence in managing risks. However, to verify this statement, it requires the future study for empirical investigation. All of these suggestions for the future study might help to improve risk communication.

Reference:

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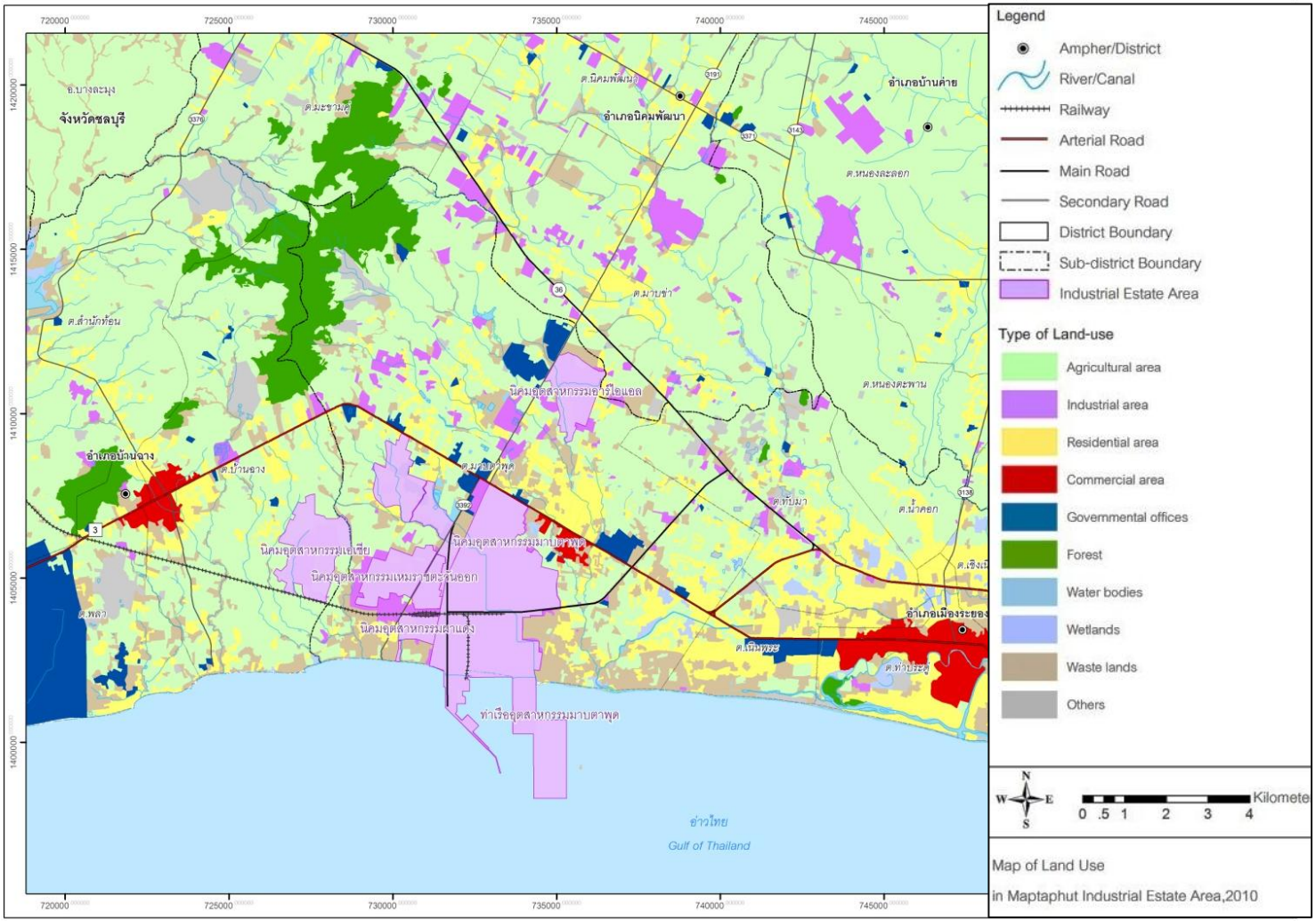
APPENDIX

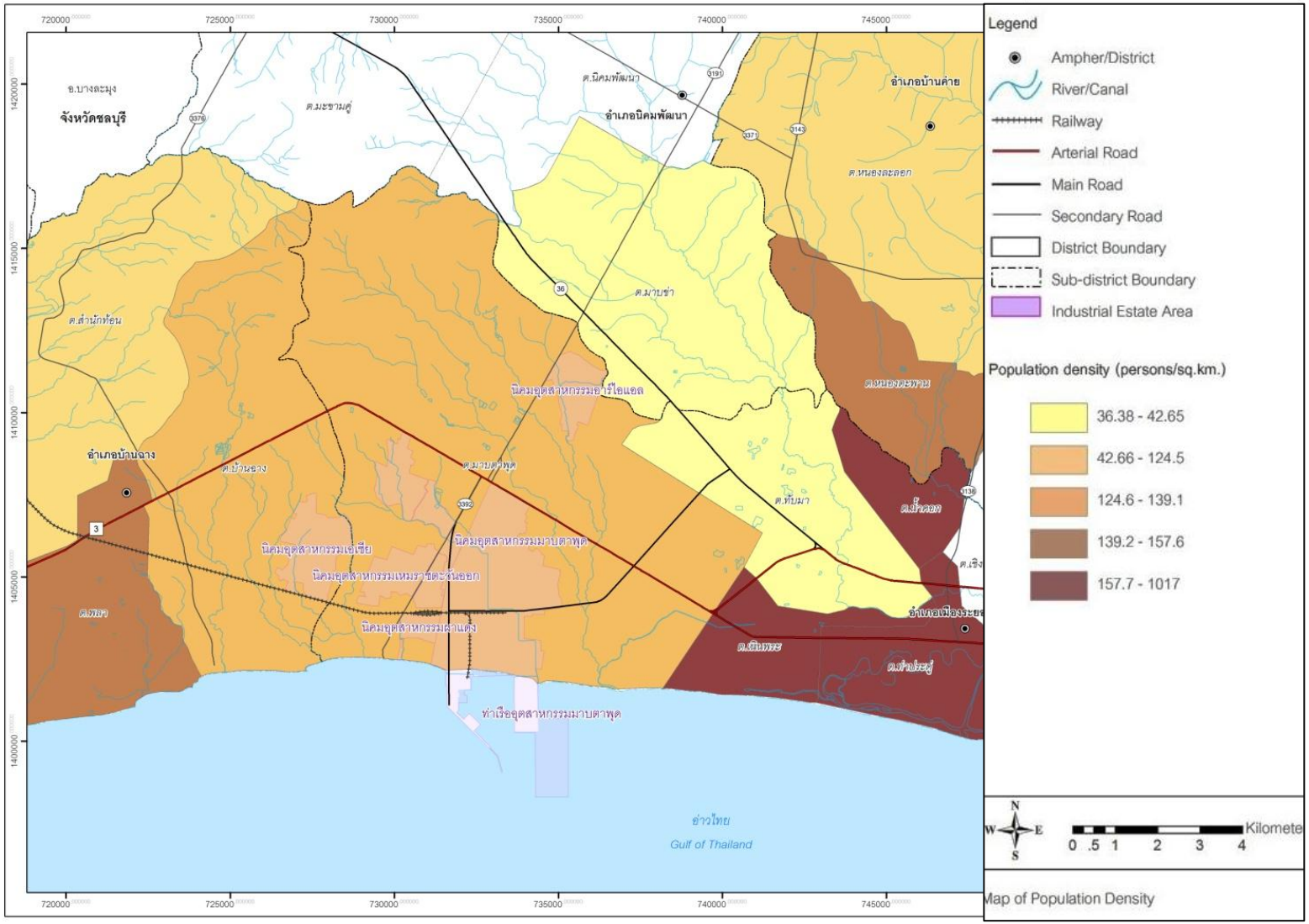
APPENDIX 1: GENERAL CHARACTERISTIC OF MAPTAPHUT AREA

1. Land-use



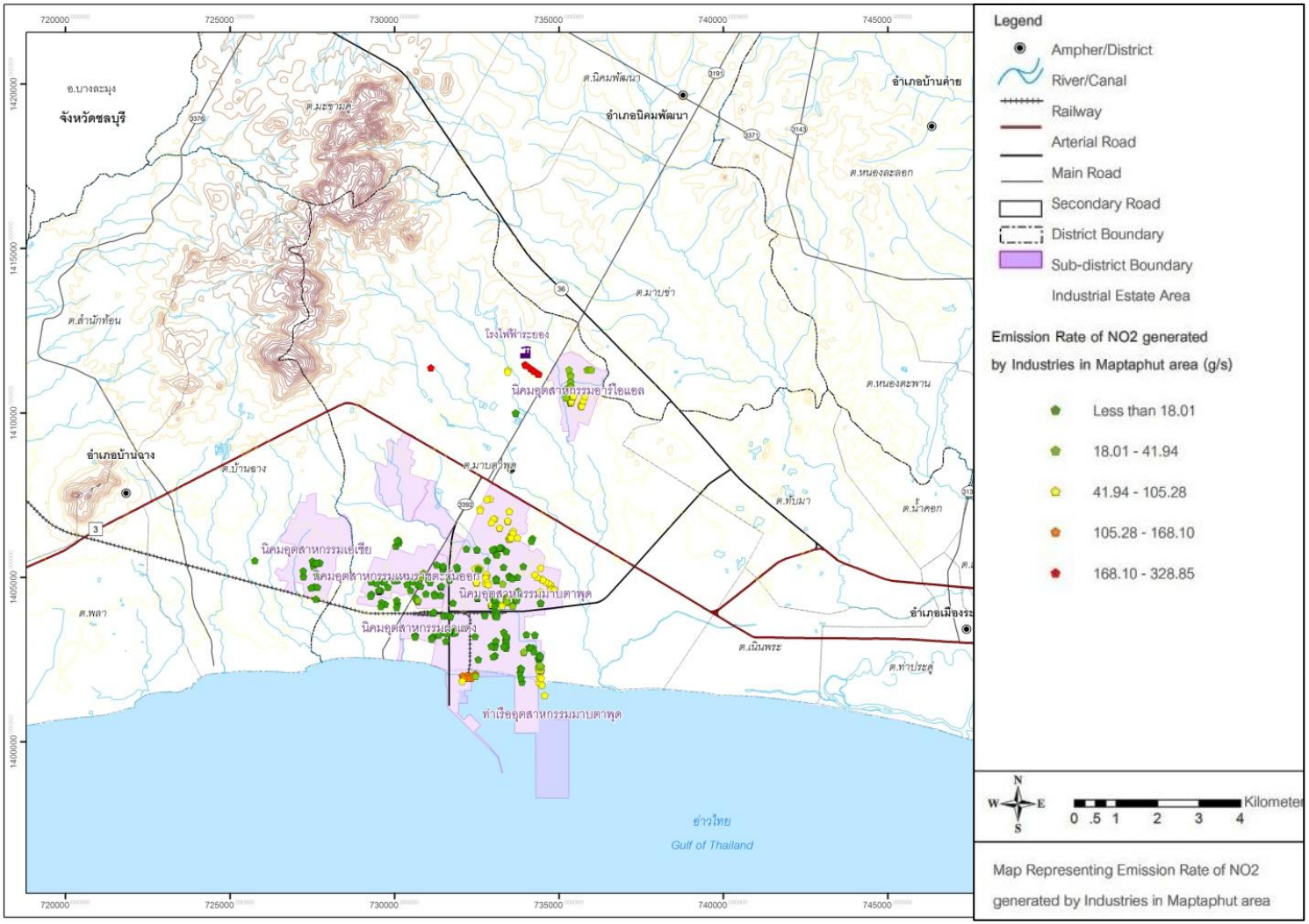
Source: Created based on Geographic Information System (GIS) data (2010), Ministry of Information and Communication Technology, Thailand.

2. Population density



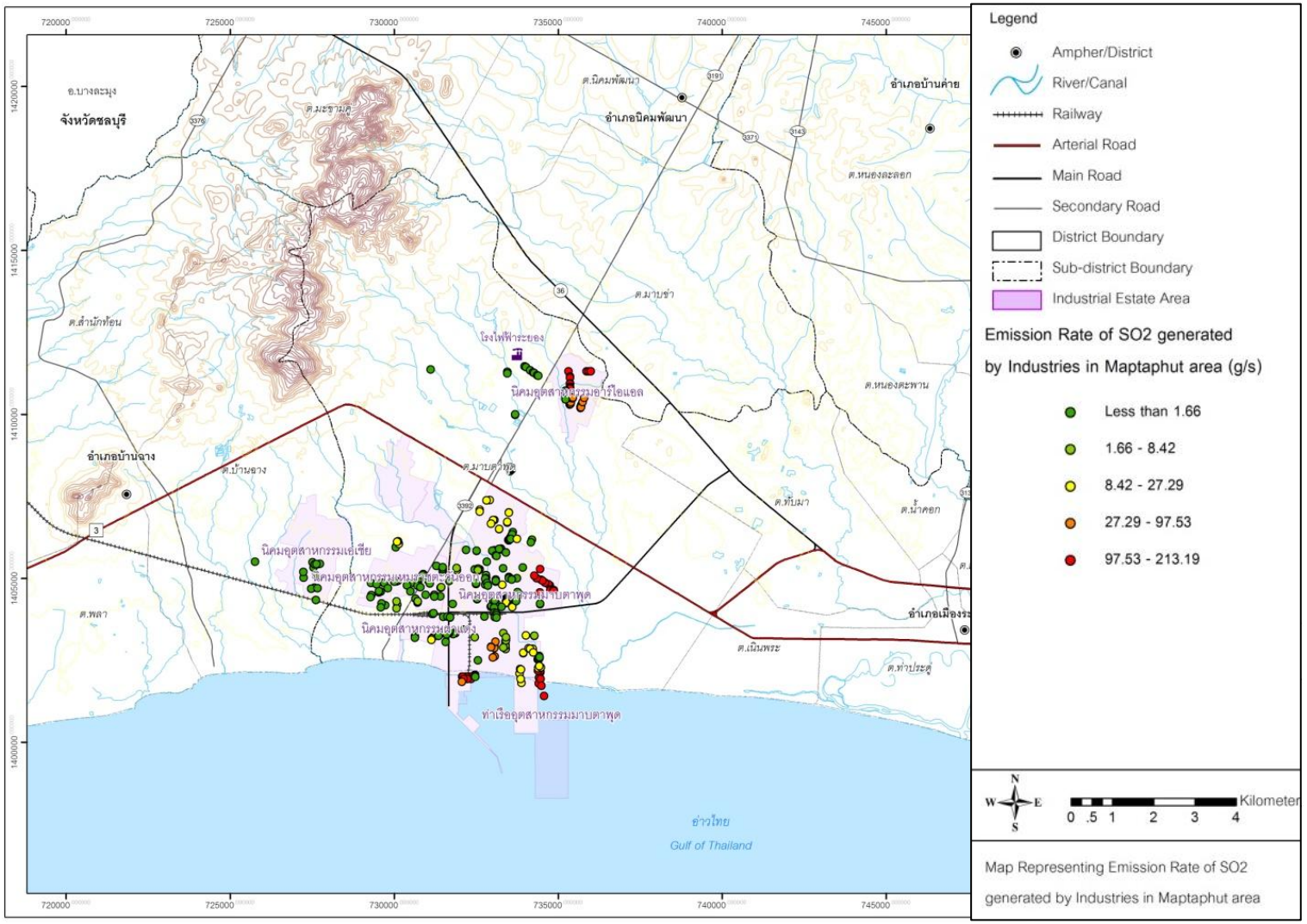
Source: Created based on Geographic Information System (GIS) data (2010), Ministry of Information and Communication Technology, Thailand.

3. Factories generating NO_2 in Maptaphut area



Source: Created based on Geographic Information System (GIS) data (2010), Ministry of Information and Communication Technology, Thailand, and Chusai *et al*. (2012).

4. Factories generating SO_2 in Maptaphut area



Source: Created based on Geographic Information System (GIS) data (2010), Ministry of Information and Communication Technology, Thailand, and Chusai *et al*. (2012).

APPENDIX 2: FIELD SURVEYS

5. The first field survey during 4st February – 22st March 2013

1.1 Objectives

- To obtain data necessary for research analysis
- To discuss issues relevant to proposed research project with another research institute's members who have been working in the similar field.
- To attend seminars and meetings on the topics related to the proposed research project
- To create academic network between research institutes and to foster academic collaboration between Thammasat University, Thailand and Kochi University of Technology, Japan

5.2 Research activities

Date	Research Activities	Place
1st Week (4-8 Feb. 2013)	1. Research discussion with host professor 2. Documentary reviews such as current situation of pollution problems in Mapthaphut, Current measurements, policy and regulation related to industrial development and pollution management, etc., 3. Development of data collection process 4. Development of data collection instruments	Faculty of Architecture and Planning, Thammasat University, Pathumtani Province
2nd Week (11-15 Feb. 2013)	1. 1st Field survey in case study area 2. In-depth interviews with local residents 3. In-depth interviews with representatives of industrial sectors	Maptaphut District, Rayong Province
3rd Week (18-22 Feb. 2013)	1. Summary of the results obtained from the 1st survey 2. Discussion with host professor 3. Identification of additional data	Faculty of Architecture and Planning, Thammasat University, Pathumtani Province
4th Week (25-28 Feb. 2013)	1. Interviews with non-profit organizations such as Burananives foundation, Environmental litigation and advocacy for the wants and Healthy public policy foundation 2. Consultations with experts from universities that have been working with communities 3. Development of data collection instruments for the 2nd field survey such questionnaire sheets and dialogue for the interviews	Bangkok City

5th Week (4-8 Mar. 2013)	1. 2nd field survey in case study 2. In-depth interviews with local residents 3. In-depth interviews with relevant public authorities such as Rayong Provincial Public Health Office, Division of Public Health and Environment in Maptaphut, Maptaphut Hospital 4. Others such as attending meeting hosted by local communities	Maptaphut District, Rayong Province
6th Week (11-15 Mar. 2013)	1. Summary of the results obtained from the 2nd survey 2. Discussion with host professor 3. Identification of additional data	Faculty of Architecture and Planning, Thammasat University, Pathumtani Province
7th Week (18-22 Mar. 2013)	1. 3rd field survey in case study 2. Questionnaire distribution	Maptaphut District, Rayong Province
	1. Final discussion with host professor 2. Summary of results obtained from surveys	Faculty of Architecture and Planning, Thammasat University, Pathumtani Province

- Physical survey

Fig. A -2.1 Maptaphut port
Source: Taken by author, (March, 2013)

Fig. A -2.2 Erosion along the Maptaphut coast
Source: Taken by author, (March, 2013)

Fig. A -2.3 Maptaphut municipality
Source: Taken by author, (March, 2013)

Fig. A -2.4 Maptaphut industires during the night time
Source: Taken by author, (March, 2013)

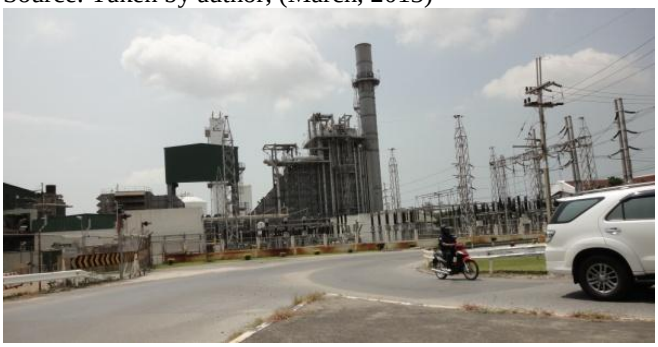


Fig. A -2.5 Maptaphut industries (1)
Source: Taken by author, (March, 2013)

Fig. A -2.6 Maptaphut industries (2)
Source: Taken by author, (March, 2013)

- In-depth interviews with key stakeholders and attending the meeting

Fig. A-2.7 The meeting on Maptaphut Environmental Crisis
Source: Taken by author, (March, 2013)

Fig. A-2.8 The international conference on development of risk communication in Maptaphut area
Source: Taken by author, (March, 2013)

6. The Second field survey During 16 September 2013 - 8 November 2013

2.1 Objectives

a. To interview local residents and relevant stakeholders

b. To survey physical environments around Maptaphut industrial development area, Rayong Province, Thailand

c. To distribute questionnaires to residents living in Maptaphut district

d. To gather documentary data needed for the study

2.2 Research activities

Date	Research Activities	Place
Arrival Day 16 Oct 2013	-	
19 Oct 2013	Survey (Accompanied by Prof. Tsunemi Watanbe)	Maptaphut Municipality
20 Oct 2013	Survey (Accompanied by Prof. Tsunemi Watanbe)	1.) Maptaphut Municipality, Rayong 2.) Banjamrung Community, Rayong
21 Oct 2013	Discuss with Prof Chaweewan Denpaiboon (Confirmed)	Thammasat University, Bangkok, Thailand
22 Oct 2013	Interview with the Director of Health Commission Office (Accompanied by Prof. Tsunemi Watanbe) (Confirmed)	National Health Commission Office: Bangkok
28-31 Oct 2013	Questionnaire Survey	Maptaphut Municipality
5-6 Nov. 2013	Interview	Bangkok
Returning Day 8 Nov 2013	-	-

1.) Interviewed with key stakeholders such as Lay people, NGOs, Previous Governmental Office. The main topics discussed during the interviews were about impacts of pullulated air on health of local people, environmental situation in the area, future solution for pollution management, and role of relevant organizations.

2.) Questionnaires Surveys

Questionnaires were distributed to 200 people living in areas adjacent to Maptaphut industrial development area.

Fig. A-2.9 Questionnaire survey
Source: Taken by author, (November, 2013)

Fig. A-2.10 Questionnaire survey
Source: Taken by author, (November, 2013)

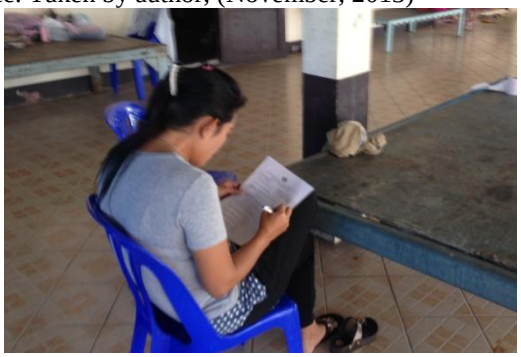


Fig. A-2.11 Questionnaire survey
Source: Taken by author, (November, 2013)

Fig. A-2.12 Questionnaire survery
Source: Taken by author, (November, 2013)

Fig. A-2.13 Questionnaire survey
Source: Taken by author, (November, 2013)

Fig. A-2.14 Questionnaire survey
Source: Taken by author, (November, 2013)

Fig. A-2.15 Questionnaire survey
Source: Taken by author, (November, 2013)

Fig. A-2.16 Questionnaire survey
Source: Taken by author, (November, 2013)

Fig. A-2.17 Questionnaire survey
Source: Taken by author, (November, 2013)

Fig. A-2.18 Questionnaire survey
Source: Taken by author, (November, 2013)

APPENDIX 3: RESULTS OF IN-DEPTH INTERVIEWS WITH STAKEHOLDERS

1.1 Summary of the results of in-depth interview with staffs of non-profits organizations (NGOs).

Question	Answer
What do you think about environmental health risks existing in the area?	a. Previously, a major career of Maptaphut people was agriculture. It has changed since the establishment of factories. Change of career structure significantly impacts on life style of people b. Many people in Maptaphut have got cancer, and many of them died. This situation makes people nervous and feeling unsecure to live in environment. c. Air has been contaminated with several kinds of hazardous gases such as benzene, 1,3 –Butadiene, and 1,2 Dichloroethane. These kinds of compounds still exceed EPA standard. d. Long term accumulation of released hazardous gas potentially causes several kinds of diseases such lung disease, self-immunity disease and cancer. e. Rapid increase in the number of population destroyed communities' quiet atmosphere. f. Increase in volume of traffic are also annoying residents.
Why do you believe that risk associated with industrial activities is low or high?	a. Many heavy industries are still allowed to construct in the area. The more industries expand, the more environmental problems can occur. b. Many factories solely consider the standard. What they think is maximum point that they can release. If all factories think the same things, the area may not have enough capacity to tackle with pollution. Possibility of contamination must be high. c. Many factories use hazardous chemical as main material for manufacturing such as Methyl Tertiary Butyl Ether （MTBE. Some type of chemicals is prohibited to use in some developed countries. d. Several kinds of gases found in the area potentially damage human body. For instance, long term accumulation of VOCs can cause damage to liver, kidney, and central nervous system. Some substances are suspected or known to cause cancer in humans. e. Considering statistics, cancer rate patients in Rayoug province was revealed high. The number of respiratory disease patients in Rayong hospital is still high, and increase every year. f. People do not know what to do when facing serious contamination due to chemical accidents. g. People do not have enough capability to fully understand air quality because evaporation of hazardous gas is invisible. h. Impacts of VOCs on health are still ambiguous, so it must be hard for people to decide to take some actions i. When air, water, soil are polluted, there are high possibility that people will get impacts. They live there 24 hours. They consume those resources every day. Many factories use hazardous chemical as main material for manufacturing such as Methyl Tertiary Butyl Ether （MTBE. Some types of chemicals are prohibited to use in some developed countries.

1.2 Summary of the results of in-depth interview with experts from **academia**

Question	Answer
What do you think about environmental health risks existing in the area?	a. People's life is tied with their environments, so deterioration of environments in the area must change the way they live. b. People feel panic when seeing back smoke released from factories 'stacks c. Increase in the number of local clinics can imply to health problems of Maptaphut people. Several kinds of released compounds such as benzene, 1,3 –Butadiene and and 1,2 Dichloroethane potentially impact on respiratory system. d. Many kinds of released compounds found in this area can ruin several parts of human body. For instance, Vinyl Chloride can impact on human lung, blood, brain and skin. e. Previously, local people had quite and slow life. Rapid increase in population and traffic volume may annoy them.
Why do you believe that risk associated with industrial activities is low or high?	a. Because of the economic force, many dangerous factories are still allowed to construct in Maptaphut area. The rapid expansion of factories can increase probability of environmental contamination and health impacts of Maptaphut people b. Though, EIA and EHIA are used as tools to select factories that have a clear plan to protect the environment and people health, no organization can confirm that those factories will strictly follow the plan. It is hard to monitor effectively. VOCs are volatized or released into the air mostly during manufacturing or use of everyday products and materials c. When air, water, soil are polluted, there are high possibility that people will get impacts. They live there 24 hours. They consume those resources every day. d. Key signs or symptoms associated with exposure to VOCs include conjunctival irritation, nose and throat discomfort, headache, allergic skin reaction, dyspnea, declines in serum cholinesterase levels e. VOCs can be generated from various point sources such as combustion, transportation, or evaporation from fugitive sources at various components in the piping system such as joints and valves. f. When air and water are polluted, there is high possibility that people will get impacts. They live there 24 hours. g. In Maptaphut, the density of factories is very high, and many of them are located nearby communities h. The impact of heavy metals and VOCs can lead to many health problems, which may not appear immediately, but will occur from accumulation in the body over time. i. 1,3 Butadiene can cause eye, nose and throat irritation. j. 1,2 Dichloroethane can cause damage to liver, kidney, and lung

1.3 Summary of the results of in-depth interview with staffs of **environmental protection agencies**

Question	Answer
What do you think about environmental health risks existing in the area?	a. More people work in factories. Some change their career due to the deterioration of environment. b. Some people feel panic when they can smell chemicals that may be evaporated from factories c. Most factories use chemicals that potentially cause cancer, such as chemicals in group 1, group 2A, and group 2B. During manufacturing, those chemicals can accidently release. d. The urgent impact may not manifest immediately. However, accumulated hazardous compounds in human body can cause serious sickness. e. Smell and noise of traffic sometimes annoy people. There are a lot of trucks in the area.
Why do you believe that risk associated with industrial activities is low or high?	a. Benzenze, 1,2 dichoroethane, 1,3 butadiene were found exceeding the standard. Those compounds could be evaporated from tanks or during oil refinery. b. Most factories use chemicals that potentially cause cancer, such as chemicals in group 1, group 2A, and group 2B. During manufacturing, those chemicals can accidently release. c. Historically, environments there were very plentiful. People life are dependent on the environment. Their culture and life styles cannot be separated from nature. d. Our organization monitored air quality every month. We found some types of VOCs exceeding the standard at some monitoring points. e. Some factories have expanded the volumes of manufactures. For instance, they first asked to expand 30% of manufacture. 4 Years later, they ask to increase 30% more. f. Factories are still allowed to construct in the areas. g. Some kinds of discharged hazardous gas and compounds are suspected or known to cause cancer in humans

1.4 Summary of the results of in-depth interview with staffs of **public health sector**

Question	Answer
What do you think about environmental health risks existing in the area?	a. More people work in factories, and some open a small shop instead of fishery and agriculture b. People feel nervous when they were found exceeding substance in their body. c. Some kinds of VOCs, are still found over the standard in the area. d. Long term accumulation of released hazardous gas potentially causes several kinds of diseases such lung disease, self-immunity disease and cancer.
Why do you believe that risk associated with industrial activities is low or high?	a. In general, amount of hazardous gas and VOCs tend to decrease. b. Factories are more active to take action to reduce a chance of accidents. c. At high levels of exposure, many VOCs can cause central nervous system depression. All can be irritating upon contact with the skin, or to the mucous membranes if inhaled. d. We do our best to monitor the health impacts suffered by people e. Every time, we receive a call from residents, or are informed by people. We actively meet them and provider any information in regard to people's answers. f. Regarding PM, there are various sizes. Some sizes of PM are not actually dangerous, but some sizes are very dangerous. g. The number of patients coming to our hospital in each year is not significantly different. h. We do not hesitate to help people. We understand people's feeling.

1.5 Summary of the results of in-depth interview with **lay people**

Question	Answer
What do you think about environmental health risks existing in the area?	a. Many people have to change their career from agriculture to service sector, labor, and factories 'workers. b. People cannot use natural resources for their leisure activities anymore. c. People feel panic when seeing back smoke released from factories 'stacks. They are afraid of touching rain. When touching rain, some people develop skin rashes. They feel unsecured to live in this community. d. The number of respiratory disease patients in the area has increased over time. e. People can feel irritated in their eyes and nose. f. Compared to the past, people are nowadays easy to get sick. g. A lot of people have got serious sickness such as canner. h. In the night time, people can still hear the sound of operated machine. People can hear the sound of traffic all the times. It became crowed in communities. People feel that they have lost their privacy. i. I have lived in the area since I was born. I have known well the difference between the current environments and the past one.
Why do you believe that risk associated with industrial activities is low or high?	a. My relatives passed always without clear reasons provided by the doctors. I assumed that they must get some influences from the industrial sector. One of my son in law, working as a security for an industry, also died without clear explanation b. I heard that many people in the area have got respiratory disease. c. No public organizations are able to confirm the relationship between people sickness and contaminated environment. d. Increase in the number of factories may increase probability of contamination. e. Many factories have kept operating the whole day-and night. Even the night time, I can see bright lights at factories f. Based on people's experiences in smelling chemicals around factories, probability of contamination is considered high for them. g. Some people's relatives passed always without clear reasons provided by the doctors. They assumed that they must get some influences from industrial activities. For instance, a people working as a security for an industry, died without clear explanation. h. Responsible organization cannot provide people with clear understanding of relationship between sickness and polluted air. i. Many people still do not know clear impacts of hazardous chemicals. j. People have learnt from the past experiences. Some can recognize when air quality is worse.

	k. When it rains, they release chemicals and gases into the air, and we developed rashes on our skin. l. Our daily life is tied with local environment. If it is contaminated, we will inevitably receive impacts. m. We can unconsciously breathe polluted air every day. The chemicals can get into our body 24 hours. n. We usually consume local agricultural goods such as mango, guava, rambutant, basil, as well as local vegetables and fishes. They must be contaminated with heavy mental and other substances inevitably. o. VOCs can be contaminated in the natural water source and water supplied. If we consume aquatic animals living in polluted water, or consume contaminated water supplied, we can receive health impact. p. I like fishes. I like mangos and durians. I like swimming. When what I like is contaminated, there are high possibilities that I will be suffering from contamination. q. I work near the factories. I cannot avoid the polluted air. r. It (VOCs evaporation) is invisible, and it is hard to be inspected. I am not sure whether the factories are able to monitor them. The cause of evaporation are various such as combustion, loading and keeping in storage tanks. s. I know that many factories use hazardous chemical as main ingredients for manufacturing, and VOCS compounds are products of those manufacturing such as benzene, 1,3 -Butadiene. t. Many plants were permitted to increase volumes of manufacture. u. Of course, all people here must be able to smell, especially when the wind is so strong. v. The dead of my family members make me feel unsecured to live among this environment, and I am not certain how long I can live. w. Rayong people die every day, whereas, doctors cannot confirm the reason. This makes me afraid. x. I know that there is exceeding benzene in my blood, but I do not the impacts. y. Many types of cancer are caused by VOCs such as chloroform, benzene, Viny chloride. They are harmful to lung, liver and kidney. z. I am afraid that my life will end up like many cancer patients in Rayong.

APPENDIX 4: RESULTS OF STATISTIC ANALYSIS

1.1 Result of regression analysis: Model 1 (relationship between risk perception and socio-demographic factors)

Descriptive Statistics

	Mean	Std. Deviation	N
Risk Perception	2.60	.665	181
Gender	1.51	.501	181
Age	33.81	11.285	181
Average Income/month	12397.11	6387.862	181
Education	3.81	1.495	181

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.340[a]	.115	.095	.63266	.115	5.735	4	176	.000	1.169

a. Predictors: (Constant), Education, Age, Gender, Average Income/month

b. Dependent Variable: Risk Perception

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.182	4	2.295	5.735	.000[b]
	Residual	70.445	176	.400		
	Total	79.627	180			

a. Dependent Variable: Risk Perception

b. Predictors: (Constant), Education, Age, Gender, Average Income/month

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.824	.239		11.815	.000		
	Gender	-.281	.095	-.211	-2.963	.003	.987	1.013
	Age	.000	.004	.007	.091	.928	.930	1.075
	Average Income/month	3.091E-005	.000	.297	3.444	.001	.677	1.478
	Education	-.051	.037	-.114	-1.350	.179	.711	1.407

a. Dependent Variable: Risk Perception

1.2 Result of regression analysis: Model 2 (relationship between risk perception and socio-demographic and factors related to the nature of risks)

Descriptive Statistics

	Mean	Std. Deviation	N
Risk Perception	2.60	.665	181
Gender	1.51	.501	181
Age	33.81	11.285	181
Average Income/month	12397.11	6387.862	181
Education	3.81	1.495	181
How much possibility do industrial activities in the area still generate air pollution?	3.38	.660	181
How much possibility are you impacted by air pollution in the area?	3.29	.705	181
How severe does contaminated air in the area effect on human health?	3.27	.712	181

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.550[a]	.303	.275	.56642	.303	10.742	7	173	.000	1.319

a. Predictors: (Constant), How severe does contaminated air in the area effect on human health, Age, Education, Gender, How much possibility do industrial activities in the area still generate air pollution, Average Income/month, How much possibility are you impacted by air pollution in the area

b. Dependent Variable: Risk Perception

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	24.124	7	3.446	10.742	.000[b]
	Residual	55.503	173	.321		
	Total	79.627	180			

a. Dependent Variable: Risk Perception

b. Predictors: (Constant), How severe does contaminated air in the area effect on human health, Age, Education, Gender, How much possibility do industrial activities in the area still generate air pollution, Average Income/month, How much possibility are you impacted by air pollution in the area

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.856	.370		2.315	.022		
	Gender	-.184	.087	-.139	-2.127	.035	.943	1.060
	Age	.001	.004	.023	.347	.729	.919	1.088
	Average Income/month	2.253E-005	.000	.216	2.764	.006	.657	1.522
	Education	-.023	.034	-.052	-.676	.500	.671	1.491
	How much possibility do industrial activities in the area still generate air pollution?	.254	.078	.253	3.280	.001	.679	1.472
	How much possibility are you impacted by air pollution in the area?	.176	.075	.186	2.341	.020	.637	1.569
	How severe does contaminated air in the area effect on human health?	.108	.067	.116	1.615	.108	.785	1.274

a. Dependent Variable: Risk Perception

1.3 Result of regression analysis: Model 3 (relationship between risk perception and socio-demographic, factors related to the nature of risks, and psychological/cognitive factors)

Descriptive Statistics

	Mean	Std. Deviation	N
Risk Perception	2.61	.666	179
Gender	1.51	.501	179
Age	33.85	11.341	179
Average Income/month	12368.02	6409.771	179
Education	3.79	1.494	179
How much possibility do industrial activities in the area still generate air pollution?	3.38	.662	179
How much possibility are you impacted by air pollution in the area?	3.30	.700	179
How severe does contaminated air in the area effect on human health?	3.28	.695	179
Do you know how to protect yourselves from contaminated air?	1.86	.562	179
Family members?	4.12	1.913	179
Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories?	2.07	.627	179
Has industrial development in the area generated more income to your family?	2.28	1.227	179
Do you think that public authorities have capacity to protect and manage air pollution in the area?	2.45	.943	179
Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area?	2.56	.983	179

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.682[a]	.465	.423	.50649	.465	11.028	13	165	.000	1.247

a. Predictors: (Constant), Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area, Gender, Industrial development in the area has generated more income to your family, Average Income/month, Do you know how to protect yourselves from contaminated air, Family members, How severe does contaminated air in the area effect on human health, Age, Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories, How much possibility do industrial activities in the area still generate air pollution, Education, How much possibility are you impacted by air pollution in the area, Do you think that public authorities have capacity to protect and manage air pollution in the area

b. Dependent Variable: Risk Perception

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	36.778	13	2.829	11.028	.000[b]
	Residual	42.327	165	.257		
	Total	79.105	178			

a. Dependent Variable: Risk Perception

b. Predictors: (Constant), Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area, Gender, Industrial development in the area has generated more income to your family, Average Income/month, Do you know how to protect yourselves from contaminated air, Family members, How severe does contaminated air in the area effect on human health, Age, Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories, How much possibility do industrial activities in the area still generate air pollution, Education, How much possibility are you impacted by air pollution in the area, Do you think that public authorities have capacity to protect and manage air pollution in the area

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.964	.452		2.133	.034		
	Gender	-.179	.079	-.134	-2.266	.025	.924	1.082
	Age	.000	.004	.007	.107	.915	.870	1.149
	Average Income/month	1.736E-005	.000	.167	2.345	.020	.640	1.563
	Education	.006	.032	.014	.196	.845	.618	1.619
	How much possibility do industrial activities in the area still generate air pollution?	.143	.075	.143	1.923	.056	.590	1.694
	How much possibility are you impacted by air pollution in the area?	.203	.071	.213	2.856	.005	.581	1.721
	How severe does contaminated air in the area effect on human health?	.169	.062	.177	2.730	.007	.775	1.290
	Do you know how to protect yourselves from contaminated air?	.076	.070	.064	1.082	.281	.931	1.074
	Family members	-.055	.021	-.157	-2.646	.009	.920	1.087
	Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories?	.085	.065	.080	1.309	.192	.859	1.164
	Has industrial development in the area generated more income to your family?	.118	.033	.217	3.573	.000	.881	1.135
	Do you think that public authorities have capacity to protect and manage air pollution in the area?	-.119	.054	-.169	-2.200	.029	.552	1.810
	Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area?	-.046	.050	-.068	-.916	.361	.591	1.691

a. Dependent Variable: Risk Perception

1.4 Results of regression analysis: Model 4 (relationship between risk perception and selected significant variables)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.672[a]	.452	.426	.50511

a. Predictors: (Constant), Industrial development in the area has generated more income to your family, Gender, Average Income/month, How much possibility do industrial activities in the area still generate air pollution, Do you think that public authorities have capacity to protect and manage air pollution in the area, How severe does contaminated air in the area effect on human health, How much possibility are you impacted by air pollution in the area

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	35.732	8	4.466	17.506	.000[b]
	Residual	43.374	170	.255		
	Total	79.105	178			

a. Dependent Variable: Risk Perception

b. Predictors: (Constant), Industrial development in the area has generated more income to your family, Gender, Average Income/month, How much possibility do industrial activities in the area still generate air pollution, Do you think that public authorities have capacity to protect and manage air pollution in the area, How severe does contaminated air in the area effect on human health, How much possibility are you impacted by air pollution in the area

Coefficientsa

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.266	.361		3.504	.001
How much possibility are you impacted by air pollution in the area?	.208	.067	.222	3.086	.002
Do you think that public authorities have capacity to protect and manage air pollution in the area?	-.153	.042	-.216	-3.620	.000
Has industrial development in the area generated more income to your family?	.121	.031	.219	3.844	.000
How severe does contaminated air in the area effect on human health?	.165	.061	.182	2.721	.007
Average Income/month	1.990E-05	.000	.181	3.330	.001
Gender	-.199	.077	-.149	-2.569	.011
How much possibility do industrial activities in the area still generate air pollution?	.149	.072	.148	2.055	.041

a. Dependent Variable: Risk Perception

1.5 Results of regression analysis (High - risk community)

Descriptive Statistics

	Mean	Std. Deviation	N
Risk Perception	2.96	.767	50
Gender	1.58	.499	50
Age	36.04	10.246	50
Average Income/month	14307.52	6836.906	50
Education	3.90	1.555	50
How much possibility do industrial activities in the area still generate air pollution?	3.60	.571	50
How much possibility are you impacted by air pollution in the area?	3.54	.646	50
How severe does contaminated air in the area effect on human health?	3.40	.571	50
Do you know how to protect yourselves from contaminated air?	1.94	.550	50
Family members	4.10	2.279	50
Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories?	2.10	.614	50
Has industrial development in the area generated more income to your family?	2.44	1.473	50
Do you think that public authorities have capacity to protect and manage air pollution in the area?	2.36	.985	50
Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area?	2.38	1.028	50

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.854[a]	.729	.632	.46553	.729	7.467	13	36	.000

a. Predictors: (Constant), Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area, Industrial development in the area has generated more income to your family, Age, Gender, Education, Do you know how to protect yourselves from contaminated air, How much possibility do industrial activities in the area still generate air pollution, Family members, Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories, How severe does contaminated air in the area effect on human health, How much possibility are you impacted by air pollution in the area, Average Income/month, Do you think that public authorities have capacity to protect and manage air pollution in the area

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21.036	13	1.618	7.467	.000[b]
	Residual	7.802	36	.217		
	Total	28.838	49			

a. Dependent Variable: Risk Perception

b. Predictors: (Constant), Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area, Industrial development in the area has generated more income to your family, Age, Gender, Education, Do you know how to protect yourselves from contaminated air, How much possibility do industrial activities in the area still generate air pollution, Family members, Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories, How severe does contaminated air in the area effect on human health, How much possibility are you impacted by air pollution in the area, Average Income/month, Do you think that public authorities have capacity to protect and manage air pollution in the area

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.743	.807		.920	.364		
	Gender	-.230	.170	-.149	-1.351	.185	.614	1.627
	Age	.003	.008	.037	.348	.730	.650	1.538
	Average Income/month	-1.181E-005	.000	-.105	-.700	.488	.333	3.007
	Education	.080	.073	.162	1.093	.282	.342	2.922
	How much possibility do industrial activities in the area still generate air pollution?	.581	.215	.433	2.709	.010	.294	3.400
	How much possibility are you impacted by air pollution in the area?	.157	.219	.132	.717	.478	.222	4.506
	How severe does contaminated air in the area effect on human health?	.001	.162	.001	.007	.995	.516	1.937
	Do you know how to protect yourselves from contaminated air?	-.105	.157	-.075	-.671	.507	.596	1.679
	Family members	-.040	.035	-.120	-1.158	.254	.704	1.421
	Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories?	.011	.138	.009	.082	.935	.614	1.629
	Has industrial development in the area generated more income to your family?	.232	.059	.446	3.928	.000	.583	1.715
	Do you think that public authorities have capacity to protect and manage air pollution in the area?	-.207	.165	-.266	-1.258	.216	.168	5.953
	Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area?	-.019	.150	-.025	-.126	.900	.186	5.389

a. Dependent Variable: Risk Perception

1.6 Results of regression analysis (Moderate - risk community)

Descriptive Statistics

	Mean	Std. Deviation	N
Risk Perception	2.58	.613	70
Gender	1.51	.503	70
Age	31.43	10.649	70
Average Income/month	11635.71	4569.053	70
Education	3.71	1.426	70
How much possibility do industrial activities in the area still generate air pollution?	3.36	.660	70
How much possibility are you impacted by air pollution in the area?	3.01	.771	70
How severe does contaminated air in the area effect on human health?	3.23	.745	70
Do you know how to protect yourselves from contaminated air?	1.86	.597	70
Family members	4.04	1.6107	70
Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories?	1.96	.550	70
Has industrial development in the area generated more income to your family?	2.14	1.183	70
Do you think that public authorities have capacity to protect and manage air pollution in the area?	2.53	.896	70
Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area?	2.67	.928	70

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.748[a]	.559	.457	.45197	.559	5.460	13	56	.000

a. Predictors: (Constant), Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area, How severe does contaminated air in the area effect on human health, Industrial development in the area has generated more income to your family, Do you know how to protect yourselves from contaminated air, Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories, Average Income/month, How much possibility do industrial activities in the area still generate air pollution, Gender, Family members, How much possibility are you impacted by air pollution in the area, Do you think that public authorities have capacity to protect and manage air pollution in the area, Education, Age

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.500	13	1.115	5.460	.000[b]
	Residual	11.439	56	.204		
	Total	25.939	69			

a. Dependent Variable: Risk Perception

b. Predictors: (Constant), Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area, How severe does contaminated air in the area effect on human health, Industrial development in the area has generated more income to your family, Do you know how to protect yourselves from contaminated air, Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories, Average Income/month, How much possibility do industrial activities in the area still generate air pollution, Gender, Family members, How much possibility are you impacted by air pollution in the area, Do you think that public authorities have capacity to protect and manage air pollution in the area, Education, Age

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.944	.731		1.292	.202		
	Gender	-.119	.121	-.098	-.990	.326	.803	1.245
	Age	.001	.007	.025	.202	.841	.498	2.009
	Average Income/month	2.641 E-005	.000	.197	1.599	.115	.520	1.923
	Education	.045	.046	.104	.976	.333	.697	1.434
	How much possibility do industrial activities in the area still generate air pollution?	.069	.096	.075	.721	.474	.736	1.359
	How much possibility are you impacted by air pollution in the area?	.329	.081	.413	4.046	.000	.755	1.325
	How severe does contaminated air in the area effect on human health?	.199	.080	.242	2.492	.016	.833	1.201
	Do you know how to protect yourselves from contaminated air?	.000	.094	.000	-.004	.997	.938	1.066
	Family members	-.055	.038	-.143	-1.433	.158	.786	1.272
	Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories?	-.084	.103	-.075	-.811	.421	.919	1.089
	Has Industrial development in the area generated more income to your family?	.063	.052	.122	1.215	.230	.783	1.278
	Do you think that public authorities have capacity to protect and manage air pollution in the area?	-.061	.077	-.090	-.798	.428	.623	1.606
	Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area?	-.060	.071	-.091	-.849	.400	.682	1.467

a. Dependent Variable: Risk Perception

1.7 Results of regression analysis (Low - risk community)

Descriptive Statistics

	Mean	Std. Deviation	N
Risk Perception	2.34	.502	60
Gender	1.45	.502	60
Age	34.78	12.513	60
Average Income/month	11700.00	7548.263	60
Education	3.83	1.553	60
How much possibility do industrial activities in the area still generate air pollution?	3.22	.691	60
How much possibility are you impacted by air pollution in the area	3.17	.717	60
How severe does contaminated air in the area effect on human health?	3.15	.709	60
Do you know how to protect yourselves from contaminated air?	1.82	.567	60
Family members	4.18	1.961	60
Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories?	2.17	.642	60
Has industrial development in the area generated more income to your family?	2.47	.965	60
Do you think that public authorities have capacity to protect and manage air pollution in the area?	2.45	.964	60
Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area?	2.58	.997	60

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.721[a]	.520	.384	.39384	.520	3.829	13	46	.000

a. Predictors: (Constant), Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area, Family members, Gender, Industrial development in the area has generated more income to your family, Age, How much possibility do industrial activities in the area still generate air pollution, Do you know how to protect yourselves from contaminated air, Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories, Average Income/month, How severe does contaminated air in the area effect on human health, How much possibility are you impacted by air pollution in the area, Do you think that public authorities have capacity to protect and manage air pollution in the area, Education

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.721	13	.594	3.829	.000[b]
	Residual	7.135	46	.155		
	Total	14.856	59			

a. Dependent Variable: Risk Perception

b. Predictors: (Constant), Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area, Family members, Gender, Industrial development in the area has generated more income to your family, Age, How much possibility do industrial activities in the area still generate air pollution, Do you know how to protect yourselves from contaminated air, Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories, Average Income/month, How severe does contaminated air in the area effect on human health, How much possibility are you impacted by air pollution in the area, Do you think that public authorities have capacity to protect and manage air pollution in the area, Education

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.917	.613		3.126	.003		
	Gender	-.184	.118	-.184	-1.565	.124	.753	1.328
	Age	-.004	.004	-.104	-.970	.337	.901	1.110
	Average Income/month	9.560 E-006	.000	.144	1.080	.286	.589	1.699
	Education	-.016	.048	-.051	-.343	.733	.480	2.084
	How much possibility do industrial activities in the area still generate air pollution?	.050	.098	.069	.509	.613	.576	1.737
	How much possibility are you impacted by air pollution in the area?	.068	.102	.098	.668	.507	.488	2.049
	How severe does contaminated air in the area effect on human health?	-.016	.090	-.022	-.174	.863	.652	1.534
	Do you know how to protect yourselves from contaminated air?	-.034	.103	-.039	-.332	.741	.773	1.294
	Family members	-.041	.027	-.162	-1.507	.139	.904	1.106
	Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories?	.334	.095	.428	3.534	.001	.712	1.405
	Has industrial development in the area has generated more income to your family?	.093	.057	.180	1.630	.110	.858	1.165
	Do you think that public authorities have capacity to protect and manage air pollution in the area?	-.135	.073	-.260	-1.865	.069	.538	1.860
	Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area?	.025	.071	.050	.357	.723	.527	1.899

a. Dependent Variable: Risk Perception

APPENDIX 5: QUESTIONNAIRE SHEET

Questionnaire Survey for the Study of Stakeholders' Qualitative Risk Assessment
Conducted by Mr.Piyapong Janmaimool and Prof. Tsunemi Watanabe
Graduate School of Engineering, Kochi University of Technology, Japan

Part 1 Demographic Characteristics

1.1 Gender_____
1.2 Age_____Years old
1.3 Name of community_____
1.4 Career_____
1.5 Average Income/month_____Baht
1.6 Educational level_____
1.7 Period of living in the community_____years
1.8 Years expected to live in the community_____ years
1.9 Number of family members_____persons

Part 2 Degree of Industrial Risks Judged by Residents

No	Potential Impacts of industrial activities on human health and well-being	Degree of Impact/Level of Agreement with Statement				
		Very High	High	Medium	Less	Not at all
2.1	Industrial development in the area has generated more income to your family					
2.2	Industrial activities in the area have impacted on your career					
2.3	As a result of industrial development, you cannot use local resources for your leisure activities					
2.4	As a result of industrial development, you feel worried about your health					
2.5	As a result of industrial development, you feel worried about your future life in Maptaphut					
2.6	Air quality in the area has caused respiratory disease among residents					
2.7	Air quality in the area has caused several kinds of cancer among residents					
2.8	Air quality in the area has caused disease related to self-immunity systems such as immunity disorder, fever, etc.					

2.9	Industrial activities have caused nuisance such as noise, smell, etc.					
2.10	The current condition of community has caused nuisance such as traffic jam, congestion, noise, smell, etc.					

Part 3 Fundamental Understanding of Risk-related Judgment

3.1 How much possibility do industrial activities in the area still generate air pollution?

___ High ___ Medium
___ Less ___ Not at all

3.2 How much possibility are you impacted by air pollution in the area?

___ High ___ Medium
___ Less ___ Not at all

3.3 How long do you think that contaminated air can be illuminated?

___ More than 5 years ___ More than 2 years
___ More than 1 year ___ Less than 1 year

3.4 How severe does contaminated air in the area effect on human health?

___ Highly severe ___Moderately severe
___Slightly severe ___Not severe

3.5 Do you know how to protect yourselves from contaminated air?

___ Well know ___ Slightly know
___Not at all

Part 4 Factors Associated with Stakeholders' Qualitative Risk Assessment

4.1 Have you ever experienced chemical accidents in the area?

___ Often ___ Sometimes
___Rarely ___ Never

4.2 Have you ever felt irritated in your eyes or nose when staying near in the vicinity of factories?

___ Often ___Somehow
___Not at all

4.3 Do you think that industries in Maptaphut have capacity to protect and manage air pollution in the area?

___ High ___Medium
___Low ___ Not at all

4.4 Do you think that public authorities have capacity to protect and manage air pollution in the area?

___ High ___Medium
___Low ___ Not at all

Part 5 Uncertainty

5.1 Do you think that VOCs can be completely controlled by advanced technologies?

___ Yes I do ___No I do not

5.2 Do you know how VOCs or SO2/NO2 are contaminated in the air?

___ Yes I do ___No I do not

5.3 Do you know which factors contribute to the seriousness of health damages caused by air pollutants?

___ Yes I do ___No I do not
If you know, please identify_____

Thank you very much

LISTS OF PUBLICATION

4.1 International journals

Janmaimool P. and Tsunemi W. Evaluating Determinants of Environmental Risk Perception for Risk Management in Contaminated Sites. *International Journal of Environmental Research and Public Health*. **2014**; 11(6):6291-6313. (ISSN: 1660-4601) (Impact Factor: 1.993) doi:10.3390/ijerph110606291 (ISI and Scopus)

Janmaimool, P. and Tsunemi W. Environmental Concerns and Uncertainty Communication for Building Public Trust in Environmental Risk Management: A case study of Maptaphut Municipality, Thailand, *International Journal of Development and Sustainability*. **2014**; 3(5):1152-1173. (ISSN: 2186-8662)

4.2 Conferences and peer-reviewed journals

Janmaimool, P. and Tsunemi W. Environmental Health Risk Management Based on Stakeholder' Qualitative Risk Assessment: A Case of Maptaphut Municipality, Rayong Provinve, Thailand, *Journal of Society for Social Management Systems*. **2013**; ID. SSMS-1056, (Sydney, Australia, December 2013)

Janmaimool, P. and Tsunemi W. Enhancement of Disaster Preparedness among Elderly People by Strengthening Environmental Risk Communication, *Journal of Society for Social Management Systems*. **2012**; ID. SSMS12-8634. (Kaohsiung, Taiwan, May 2012)