Master's Thesis, Department of Geosciences

Landslide risk management perceptions in territories

Comparative case studies of Hong Kong and Norway

Jessica Ka Yi Chiu

UNIVERSITY OF OSLO
FACULTY OF MATHEMATICS AND NATURAL SCIENCES

Landslide risk management perceptions in territories

Comparative case studies of Hong Kong and Norway

Jessica Ka Yi Chiu

Master's Thesis in Geosciences

Discipline: Environmental Geology and Geohazards

Department of Geosciences

Faculty of Mathematics and Natural Sciences

University of Oslo

June 2015

Supervisors: Dr. Farrokh Nadim, Dr. José Cepeda, Dr. Graziella Devoli

This work is published digitally through DUO – Digitale Utgivelser ved UiO
http://www.duo.uio.no
It is also catalogued in BIBSYS (http://www.bibsys.no/english)

Summary

Poor landslide risk management can lead to destructive impacts to a community. Therefore, it is very important to evaluate the effectiveness of landslide risk management. A well-established indicator for performance is the Risk Management Index (RMI) proposed by Cardona et al. (2004). The methodology for calculating this index is based on a survey of technical staff, decision-makers, and stakeholders involved in all stages of risk reduction strategies.

The Risk Management Index, RMI, is a composite index that measures perceptions of performance of risk management in four public policies, which are represented by indices, namely Risk Identification index, Risk Reduction index, Disaster Management index, and Governance and Financial Protection index.

The Risk Management Index (RMI) is calculated as the mean of the four public policy indices. Each policy index can take a value from 0 to 100. Therefore, RMI also varies from 0 to 100, where the lowest and highest values correspond to the poorest and best performance of risk management (i.e., RMI and policy indices increase as the performance of risk management improves).

The RMI is an innovative and useful procedure for measuring perceptions holistically from selected actors. However, the method allows for expansion of the input resources and modification of the survey so that comparisons between territories and further analysis of the survey results can be made. Therefore, the present study will focus not only on the assessment of a territory's landslide risk management performance, but it will also develop several techniques to achieve the aforementioned points. For example, a method for selecting and prioritizing regions for RMI evaluations within a territory is added, which may be useful in optimizing the resources for performing the opinion surveys. The method of the present study is illustrated by comparative case studies between Hong Kong and Norway and between counties in Norway. Hong Kong is renowned for its outstanding efforts and achievements in mitigation of landslide risk in the densely populated city, while landslide risk management is a new topic in general in Norway. Additionally, different regions in Norway are threatened by different types of landslides at various degrees. The comparative studies carried out here are based on the same set of parameters, therefore this study can give a more holistic view of the conditions of different places. Moreover, a modified algorithm for calculating a RMI from a

fuzzy set is developed in the present study. The algorithm is considered to be more reliable than the one that is possibly used by Cardona et al. (2015).

For the present study, surveys on landslide risk management perceptions in Hong Kong and Norway were conducted separately between late January and early March, 2015, using two questionnaire tiers: a simplified version and a complete survey. A total of twelve and nine responses were received for Hong Kong and Norway, respectively. Results show that the performance of landslide risk management in Hong Kong is better than in Norway in 2004 and 2014, but Norway is perceived to be better than Hong Kong in 2024. In particular, Norway has a higher RMI_{FP} than Hong Kong in all the years. Additionally, Hong Kong put higher relative weights on budget allocation and mobilization for vulnerability reduction as well as environmental protection security, whereas Norway focuses more on insurance and reinsurance coverage for the housing and private sector. The survey results can thus reveal the two key differences between the two territories' policies in landslide risk management, which are related to budget allocation and financial protection. Moreover, results of the comparative study between counties in Norway indicate a possible trend of more negative perceptions on landslide risk management with increasing landslide hazards, risk, and severity and density of landslide incidents. This trend may indicate that more effective landslide risk management is needed in counties with high landslide hazards and risks.

Based on the survey response, diversity of the backgrounds of respondents, and reliability of the simplified tier of the questionnaire, it is concluded that the reliability and representativeness of the survey results may not be sufficient. Therefore, several aspects of improvements are suggested to increase the reliability of the survey results. Nevertheless, it is considered that the survey results are generally consistent with the real situations learnt from the related policies of both territories. As a result, the current survey results can still provide valuable information regarding the effectiveness of landslide risk management of a territory and can be a useful reference for decision-makers to evaluate and design policies. Besides, the method and techniques developed for the present study are considered feasible for similar kinds of studies in the future. They can also be optimized and expanded in terms of the scope of application to put forward the understanding of existing problems and facilitate policy-making in landslide risk management.

Acknowledgements

First, I would like to express my deepest appreciation to my supervisor at the Norwegian Geotechnical Institute (NGI), Dr. José Cepeda, for introducing me to the topic, as well as his patient guidance, persistent help, and inspiring suggestions throughout the process of this master's thesis. I would like to thank my other supervisor at NGI, Dr. Farrokh Nadim, for giving me the opportunity to write this thesis and his support on the way. I would like to give very special thanks to my supervisor at the University of Oslo, Dr. Graziella Devoli, for taking up the role as an internal supervisor and providing me useful comments on this work and contacts with the survey participants in Norway.

My special thanks are extended to Ms. Denise Tang, who has assisted me in distributing questionnaires around the Geotechnical Engineering Office (GEO), the Government of the Hong Kong Special Administrative Region.

I would also like to thank the participants in the survey for taking their valuable time to provide opinions and feedback. Without their support, this thesis would not have been possible.

I thank Jennifer Porter for proofreading the manuscript of this thesis.

I would like to thank the colleagues who I have met at NGI for their support and giving me a great time during the writing of this thesis at the NGI office. I would also like to thank the IT staff at NGI for their technical support.

In addition, a thank you to Professor Andrew Malone of the University of Hong Kong, who introduced me to engineering geology and encouraged my academic exploration in this field throughout the years.

I thank the Head of GEO and the Director of Civil Engineering and Development, the Government of the Hong Kong Special Administrative Region, for the permission of using the copyrighted photographs as part of my thesis.

Furthermore, I am particularly grateful to have met all my lovely friends in Oslo and Trondheim. Without them, these two years of studies would not have been so enjoyable.

Finally yet importantly, I wish to thank my family in Hong Kong for their unconditional love and support throughout my studies. To them I dedicate this thesis.

Table of Content

List of Figures

List of Tables

1 Introduction

A landslide is one of the geological hazards that can cause injury, loss of life, as well as disasters to a society. A landslide is defined as the movement of soil, rock, and organic materials downslope under the action of gravity (Highland & Bobrowsky 2008). Mass movement of landslides encompasses a wide range of failure modes including falls, topples, slides, spreads, and flows. Landslides are mainly controlled by geomorphological and geological factors (van Westen et al. 2011) and can be triggered by various factors such as precipitation, earthquakes, volcanic activity, changes in groundwater, and anthropogenic activities (Highland & Bobrowsky 2008).

The annual global economic losses due to landslides are estimated to be billions of US dollars (Dai et al 2002; Baum et al. 2014). Statistics show that between 2004 and 2010, an average of 374 fatal landslides occurred and more than 4000 lives were lost due to landslides worldwide each year, however, these recorded figures are concluded to be underestimated (Petley 2012). Schuster (1996) summarized the 25 most catastrophic landslides in the 20th century (USGS 2013). For example, the Nevado del Ruiz landslide in 1985 in Colombia, which was triggered by a volcanic eruption, caused more than 20 000 deaths and four towns and villages were destroyed (Mileti et al. 1991; Voight 1990; Schuster 1996; USGS 2013). Another example is the Reventador landslides that were triggered by earthquakes in 1987 in Ecuador, with a death toll of 1000 and kilometers of oil pipelines and highways being damaged, resulting in US$ 1 billion loss at that time (Schuster 1991, 1995 & 1996; USGS 2013). In addition, the Uttarakhand Himalayan region of India has been suffered from frequent landslides triggered by extreme precipitation as revealed from historical records (Kala 2014). Subsequent landslides during the June 2013 extreme event in the area caused over 4000 fatalities and affected hundreds of thousands of people (Kala 2014).

1.1 Importance of landslide risk management

In the field of natural hazards, risk is defined as the probability of losses as a result of interactions between hazards and vulnerability conditions (van Westen et al. 2011):

$$Risk = Hazard \times Vulnerability \times Exposure \quad (1.1)$$

Vulnerability refers to the susceptibility of a community to the impact of hazards and is determined by physical, social, economic and environmental aspects (van Western et al. 2011). Given the direct relationship between risk and vulnerability, although disasters are frequent outcomes of natural hazards, they can be seen as socio-environmental in nature (Cardona et al. 2005) or a product of the complicated relationship between the nature and the organization structure of a society (UNISDR 2005; van Westen et al. 2011). As a result, even though the occurrence of natural events may not be controllable, the consequences of landslides can be reduced by proper risk management. Disaster risk management refers to the identification, reduction and controlling of risk, as well as strengthening of a society's capacity to hazard impacts through a systematic process of organizational, development, operational, capacity, and institutional actions (van Westen et al. 2011; Carreño et al. 2007).

The significance of good practices of landslide risk management in the safety of a community has been demonstrated by numerous cases around the world:

A positive example is demonstrated by Hong Kong. Landslides in Hong Kong have caused over 480 deaths since the late 1940s. A central policing body was established in 1977 in Hong Kong to carry out strategic planning, geotechnical control and systematic maintenance of slopes. Since then, the number of landslide fatalities in the territory has significantly dropped. The comprehensive slope safety system implemented in Hong Kong reveals the fundamental concepts of landslide risk management at policy administration level (Chan et al. 2007; Wong 2009; Ng et al. 2010). An overview of landslide risk management in Hong Kong is included in Section 2.1.

On the other hand, the Casita landslide occurred during Hurricane Mitch in 1998 and killed about 2500 people in Nicaragua (Devoli et al. 2009). This catastrophe happened at relatively recent settlements (since the 1970s) which were identified to be located in a prehistoric landslide pathway during the forensic investigation for the event (Scott et al. 2005). The disaster could indeed be prevented if sufficient field studies had been carried out to identify the hazard conditions and appropriate land use planning had been implemented to minimize the exposure. Poor landslide risk management may not be exempt from developed countries. For example, the controversy that the recent Oso (Steelhead) landslide in the United States (occurred on 22 March 2014, at least 28 deaths) was foreseeable indicates the significance of risk identification among the general public. It was discussed in a local newspaper that residential development in the landslide area was approved in spite of warnings of probable landslides by local experts (Armstrong et al. 2014).

1.2 Measuring effectiveness of landslide risk management

Based on the destructive impacts to a community due to poor landslide risk management, it is important to evaluate the effectiveness of landslide risk management. Not only can evaluation tools of landslide risk management performance help understand the existing problems, it can also orient decision-makers on follow-up policies and actions (Cardona et al. 2004, 2005). Unlike objective indicators such as hazards, vulnerability, exposure, and risk; performance of risk management is a subjective perception and cannot be measured quantitatively. Cardona et al. (2004) first proposed the Risk Management Index (RMI) that quantifies a country's effectiveness of disaster risk management. The effectiveness reflects the performance of the collaborated actions taken for vulnerability and losses reduction, crisis preparation and post-disaster recovery (Cardona et al. 2004). The methodology for calculating this index is based on opinion questionnaires to technical staff, decision-makers and stakeholders involved in all stages of risk reduction strategies. The RMI is thus an innovative and useful procedure for measuring perceptions holistically from selected actors.

1.3 Comparative case studies

Usual landslide hazard assessment is conducted as drill-down studies in a country, e.g. El Salvador by NGI (2013). This type of study can provide a thorough evaluation of parameters of a country; although not all parameters are applicable to other countries, due to different topographic and geological settings. However, a comparative study based on the same set of parameters can give a more holistic view of the conditions of different places. Comparison implies the use of a point of reference or benchmark. In addition, via comparisons, it is possible to learn from the good practices in leader countries and identify appropriate measures for less developed countries to adopt in order to reduce landslide risk.

Hong Kong and Norway are selected as case studies in the present study. The primary reason for choosing Hong Kong and Norway is simply due to the connections available in both territories. Since the present study mainly aims at developing and implementing methods, it is more practicable to conduct the case studies in territories where there are connections with plenty of potential survey participants. This can guarantee some survey responses within limited time. Another reason is that both territories are threatened by landslide hazards. On the other hand, Hong Kong and Norway differ in many aspects; therefore, it is interesting to make comparisons between them. For example, Hong Kong is a small and densely populated city whereas Norway is a large country with little population. The former has a long tradition and experience in landslide risk management, while landslide risk management in the latter is just at initial stage. Additionally, different regions in Norway are threatened by different types of landslides to varying degrees. It is thus also interesting to make comparisons of the perceptions on landslide risk management between counties in Norway. As a result, the present study conducts comparative studies both between Hong Kong and Norway and between counties in Norway.

1.4 Scope of the study

The method proposed by Cardona et al. (2004) allows for expansion of the input resources and modification of the questionnaires so that comparisons between territories and further analysis of the survey results can be made. The present study focus not only on the assessment of a territory's landslide risk management performance, but it will also develop several techniques to achieve the aforementioned points. For example, a method for selecting and prioritizing regions for RMI evaluations within a territory can be added, which may be useful in optimizing the resources for performing the opinion surveys. Background information of respondents should also be surveyed to help interpret the survey data. In addition, the opinion questionnaires may be simplified to increase response rate and broaden the pool of target participants. Furthermore, a time scenario can be introduced to study the temporal trend of perceptions. Besides, it may be worthwhile to relate RMI and objective indicators such as landslide hazards, exposures, and risk so as to explore how these aspects influence the practices in landslide risk management.

The present study thus has four major objectives:

1) To implement and develop improvements to the current RMI method to measure and analyze the perceptions on landslide risk management performance in Hong Kong and Norway.

2) To develop techniques to compare the perceptions on landslide risk management performance between territories.

3) To apply the aforementioned methodology to Hong Kong, Norway, and selected counties in Norway.

4) To evaluate the feasibility and reliability of the method used in the present study.

Due to limited time for collecting survey data for the present study, survey response is deemed limited. Therefore, readers should bear in mind that the obtained results may not be representative of the majority. As a result, the case studies conducted in the present study should be regarded as a pilot investigation.

In addition, both experience and available data indicate that landslides due to seismic activity are generally not significant in either Hong Kong or Norway. Therefore, landslides triggered by earthquakes are not considered in the present study.

This report provides details regarding methodology, tools as well as already available datasets so that similar studies and/or result analysis can be reproduced and compared. Background and key achievements of landslide risk management of both study areas are first presented in Section 2 to enable an overview of the activities carried out by each territory in landslide risk management. The methodology including the proposed improvements is then described in Section 3. Available datasets, which are open to the public and suitable for the purpose of comparative study, are suggested in Section 4. Detailed analyses of the study results are described and illustrated in Section 0. Finally, interpretations of the results, evaluation of the presented methodology, and recommendations for improvement are discussed in Section 6. Questionnaires, raw survey data and codes used in various stages of the method are included in the Appendices.

2 Landslide risk management in case study areas

2.1 Landslide risk management in Hong Kong

2.1.1 Landslide hazards and risk in Hong Kong

Hong Kong has a small land area of about 1100 km^2, over 60% of which is located on hilly terrain (Figure 2.1a). The population of Hong Kong increased steadily from 2 million in 1950 to over 7 million at present. This led to a huge demand for land for residential use and infrastructure and resulted in a substantial portion of urban development to be located on or close to man-made slopes and natural hillsides (Chan & Mak 2007; Chan el al. 2007). Situated on the southeastern coast of China, Hong Kong has a sub-tropical climate with annual average rainfall of 2300 mm, peaking in the summer. Man-made slopes formed by poor techniques and steep hillsides are susceptible to landslides during heavy rainfall. As a result, landslides are a common form of natural hazard in Hong Kong that can cause significant casualties and social-economic impacts owing to the close proximity of steep hillsides to developments (Ng et al. 2010). For example, two destructive landslides occurred on 18th June 1972 after days of heavy rains in Sau Mau Ping and at Po Shan Road in Hong Kong (Figure 2.1b and c, respectively). One hundred thirty-eight people were killed in these events, in which a resettlement area was covered by tons of landslide debris and a building collapsed completely. Heavy rainfall in 2008 (30% above normal) also triggered a large number of landslides in the natural hillsides in Hong Kong. Certain critical transport corridors were seriously disrupted and communication services in some areas were downed due to landslide debris (Figure 2.1d).

In the aftermath of various fatal landslide disasters in Hong Kong during the 1960s and 1970s, a central policing body, the Geotechnical Control Office (GCO) (now the Geotechnical Engineering Office (GEO)), was set up in 1977 to strategically implement a comprehensive system to maintain slope safety in Hong Kong. Since then, the annual landslide fatalities in Hong Kong have been significantly reduced (see Figure A.1 in Appendix A). Every year, an average of 300 landslides are reported to the government (Ng et al. 2010). The major types of landslides in Hong Kong include failures of man-made slopes and retaining walls, as well as open hillslope landslides and channelized debris flows in natural terrain. Even though the historical landslide fatalities in Hong Kong were mainly caused by landslides related to man-made slopes, many cases of natural terrain landslides were regarded as 'near-misses' (Ng et al. 2010), which highlight the potential severe consequences of these events.

Figure 2.1 Urban development and examples of serious landslides in Hong Kong. (a) Urban development in Hong Kong in proximity to steep hillsides (adopted from Chan & Mak 2007). (b) Sau Mau Ping Landslide at a resettlement area in 1972. (c) Po Shan Road Landslide in 1972 caused a complete collapse of a 6-storey house. (d) Channelized debris flow above Yu Tong Road in 2008 caused blockage of 2 lanes of the road. (Photo courtesy of GEO)

2.1.2 The Slope Safety System of Hong Kong

The Slope Safety System of Hong Kong developed by GEO embraces several initiatives to combat landslide risk in Hong Kong in a holistic manner (Chan et al. 2007; Wong 2009; Ng et al. 2010). In Appendix A, a summary of the key components of the Slope Safety System of Hong Kong and a timeline of important landslide risk management activities are included. Following this comprehensive landslide risk management system for over 30 years, significant improvement in slope safety has been brought about in Hong Kong. Several key results are highlighted below:

1) *Comprehensive enforcement of geotechnical standards and technical advancement*. The GEO has published over 250 documents, including a series of guides, technical reports, and guidance notes to promulgate slope engineering practices (Ng et al. 2010). Geotechnical control has also been enhanced. For instance, geotechnical control is enforced in public and private developments and auditing is carried out by competent geotechnical engineers for all types of geotechnical works (Chan & Mak 2007).

2) *Reduction of landslide risk*. The landslide fatality rate dropped drastically since the establishment of the GEO in 1977 (Figure A.1). In addition, with systematic retrofitting of old substandard man-made slopes, the overall landslide risk associated with these slopes has been reduced 75% from 1977 to 2010 (Lo & Cheung 2005; Cheng & Ko 2010; Ng et al. 2010).

3) *Community participation for slope safety*. The GEO has made efforts to ensure slope owners to take up responsibility for slope upgrading and maintenance via various forms of public education and assistance from the government (Chan & Mak 2007). In 1999, GEO set up a Community Advisory Unit which proactively approaches slope owners and provides advice on slope improvement or maintenance works (Chan & Mak 2007). The GEO also partners with the media to promote slope safety and personal precautionary measures, as well as to address the tolerability of risk in public. Results of the annual public opinion surveys from 1997 to 2006 show that the majority is aware of slope safety, understand slope owners' maintenance responsibility, and the importance of slope maintenance (Chan & Mak 2007).

4) *Systems for early warning and emergency*. The Landslip Warning System in Hong Kong, based on rainfall data, was set up to alert the public during heavy rainfall to take appropriate actions in order to reduce their exposure to possible landslide hazards (Chan & Pun 2004; Chan & Mak 2007). The warnings also trigger an emergency system among government departments to deal with landslide incidents (Chan & Mak 2007). The warnings have proved to be reliable based on the fact that over 90% of landslide fatalities happened during the time of the warnings over the past 27 years (Chan & Mak 2007).

5) *Comprehensive databases*. Hong Kong keeps a catalogue that registers all sizable man-made slopes and mitigation measures in natural hillsides within the territory. The

maintenance responsibility of each of the registered features has also been assigned. The GEO has also compiled comprehensive inventories of landslides and vulnerable catchments in the natural terrain. Currently, there are some 60,000 features in the slope catalogue (CEDD 2015a) and about 109,000 inventoried natural terrain landslides (updated to 2009) (CEDD 2015b). These databases are necessary for landslide hazard identification and landslide risk assessment, as well as to establish any risk-based priority system for effective landslide prevention and mitigation.

2.2 Landslide risk management in Norway

2.2.1 Landslide hazard and risk in Norway

Mainland Norway has an area of about 323,800 km^2 and a population of approximately 5.1 million. Landslides are major natural hazards in Norway and landslide hazards caused by heavy rainfall, erosion, flood, and anthropogenic activities commonly pose threats on land (Lacasse & Nadim 2007). Related to Norway's topography and geological setting, quick clay slides and rockslides are the two types of landslides that occur and can bring about severe consequences to humans and property in the country (Pelling et al. 2011).

Since the last deglaciation, large areas in eastern and mid-Norway were left covered by clay deposits. Conversely, high mountains rose with respect to postglacial uplift and deep valleys were eroded in western and northern Norway (Lacasse & Nadim 2007). Many of these mountainsides and leached clay deposits are unstable and many landslides have occurred (Lacasse & Nadim 2007). Today, around 5,000 km^2 of land in Norway is covered by soft marine clay deposits, nearly 20% of which consist of highly sensitive or quick clay (Lacasse & Nadim 2007). Quick clay slides are often triggered in these deposits without warning and can involve large volumes of soil via progressive failure (Lacasse & Nadim 2007). For example, the quick clay slide that occurred at Rissa near Trondheim in 1978 resulted in almost 6 million m^3 of clay debris (Gregersen 1981; Lacasse & Nadim 2007) (Figure 2.2a). On the other hand, rockfalls and rockslides plunging into fjords, lakes, or reservoirs can trigger tsunamis and such disasters are responsible for 175 fatalities in Norway in the 20^{th} century alone (Figure 2.2b and c).

Statistics show that more than 2000 deaths were caused by all types of landslides over the past 150 years (Lacasse & Nadim 2007; Pelling et al. 2011). Since 1960, 1 to 3 fatalities occur every year (see Figure B.1 in Appendix B). Additionally, it is expected that 10 large slides will occur in Norway within the next 50-100 years and each of these slides may cause 20 to 100 deaths (Lacasse & Nadim 2007).

2.2.2 Key landslide risk management activities in Norway

The aim of landslide risk management in Norway is to offer all citizens an 'as low as reasonably practicable' (ALARP) risk level (Lacasse & Nadim 2007). Landslide risk management in Norway is mainly engaged by several ministries, through the Planning and Building Act, Natural Perils Act (Act on Natural Damage) and Civil Protection Act. The first two acts came into force for the whole of Norway in the 1960s, triggered by catastrophic landslide events (Pelling et al. 2011). These acts decree restrictions regarding building and construction practices, actions of private landowners and municipalities to carry out safety measures against natural hazards, and establish citizens' rights to compensation for natural disasters (Pelling et al. 2011). On the other hand, the Civil Protection Act puts forward local authorities' preparedness for landslide disasters. A summary and time of the key landslide risk management activities in Norway are included in Appendix B.

A more holistic and integrated approach in landslide risk management in the country was observed when the Norwegian Water Resources and Energy Directorate (NVE) was assigned as the operative authority for landslides in Norway in 2009 (Pelling et al. 2011; DSB 2013). The directorate is responsible for inter-ministerial coordination on landslide prevention (Lacasse & Nadim 2007). In addition, it issues national landslide warnings and provides professional help to municipalities and society to manage landslide risks through hazard mapping, guidance on land use planning, implementation of protective measures, monitoring and warning, as well as assistance during events (DSB 2013; Saunders et al. 2015).

Below highlights the key achievements of landslide risk management in Norway:

1) *Risk reduction and mitigation at local, regional and national levels*. At the national level, the Norwegian Directorate for Civil Protection (DSB) conducts national risk assessment for landslides every year since 2010 (Saunders et al. 2015). Since 2008, risk and vulnerability analysis (ROS-analysis) is legally bound in the Planning and Building Act in connection to land use planning and new area developments (Pelling et al. 2011). As a result, at the local level, municipalities are required to run a comprehensive ROS

analysis to establish the existence of landslide hazards and potential consequences before the regulation plan can be approved by the county authorities (Lacasse & Nadim 2007). For the building requests to be approved, municipalities also need to provide a proper geotechnical investigation (Pelling et al. 2011) and consider safety or mitigation measures (Lacasse & Nadim 2007). Municipalities are also required to prepare and update a contingency plan based on the ROS-analysis.

2) *Nationwide 1:50,000-sacled landslide hazard zonation*. A national program for hazard mapping was launched in Norway in 1979. In connection to the Planning and Building Act, detailed hazard plans with corresponding detailed maps have to be used if they are available (Lacasse & Nadim 2007). Although not legally binding, planners and contractors were requested to use these maps starting from 1985 (Pelling et al. 2011). At present, over 100 maps of landslide hazards and risks zonation in Norway at 1:50,000 scale have been published (Lacasse & Nadim 2007). The mapping is still ongoing and estimated to be completed around 2022 (Lacasse & Nadim 2007). Quick clay risk zonation and debris flow hazard zonation techniques have also been developed. In addition, a decision-making scheme on remedial measures for quick clay has also been established (Lacasse & Nadim 2007).

3) *National landslide warning system*. Accompanied by monitoring and weather forecasting, NVE started its national warning service for debris slides and debris flows in 2013 to alert local and regional emergency authorities as well as the public of the increased likelihood of these types of landslides (NVE 2013).

4) *National landslide inventory and registration platform.* There are multiple online platforms that provide general public access to historical landslide records, meteorological and groundwater information, as well as a channel to register any nature danger related observations. Excluding snow avalanches incidents which are also available, there are about 30,000 landslide records in the database dated as early as the year 900. However, the landslide database has several problems. These problems are described in details in Section 4.2.2.

5) *Rock avalanche monitoring and early warning systems at local level.* Monitoring large slope deformations that can evolve in large rock avalanches with potentially triggered tsunamis was initiated in 2004 as part of the Åknes/Tafjord Project (now managed by

NVE). Monitoring instruments have been installed in counties such as Møre og Romsdal (Mannen), Troms (Nordnes) and in Sogn og Fjordane (Åknes) to obtain and integrate movement data into a database for analyses (Lacasse & Nadim 2007; NVE 2015a). An alarm and response system has also been implemented in the area. In addition, a 24-hour operating emergency preparedness center in Stranda was established in 2007 (Lacasse & Nadim 2007; Pelling et al. 2011). Moreover, the project is regarded to have boosted collaboration between authorities from local to national levels as well as public participation in landslide risk management (Pelling et al. 2011).

6) *Dual compensation insurance system for natural damage*. Since 1980, any damage caused by natural hazards can normally be fully compensated (Lacasse & Nadim 2007). This is achieved through a combined insurance system of the private natural disaster insurance scheme (managed by the Norwegian Natural Perils Pool) and the National Fund for Natural Disaster Assistance (Pelling et al. 2011). Under the system, any objects that are insured against fire are normally also insured against natural disasters, whereas other valuables that cannot be insured against fire are covered by the public fund (Pelling et al. 2011).

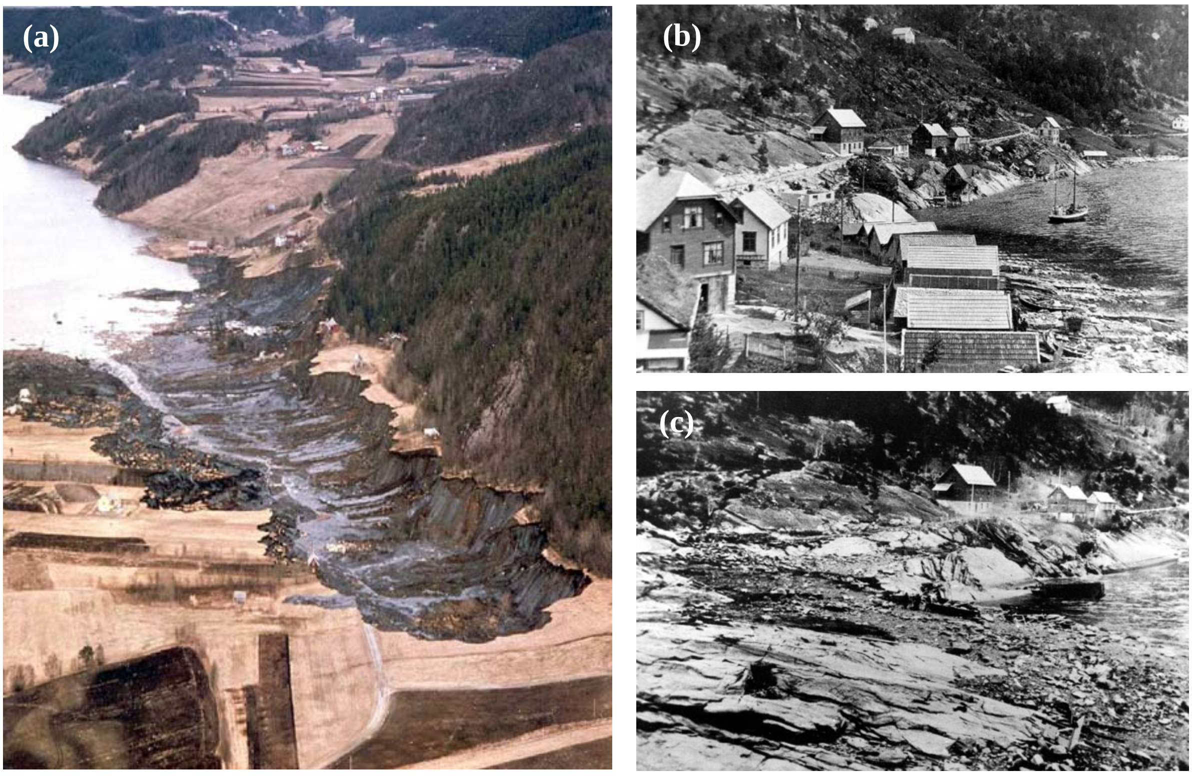


Figure 2.2 Examples of important landslides in Norway. (a) Rissa quick clay slide in 1978 (photo courtesy of Aftenposten). Tafjord (b) before and (c) after the tsunami triggered by a rockslide into the fjord in 1934 (Lacasse & Nadim 2007, photo courtesy of NGU).

3 Methodology

The present study collects perceptions of practitioners in case study areas regarding landslide risk management performance in their territories. In addition, it also makes use of already available spatial data concerning landslide hazards.

Procedures and principles of the method are summarized in Table 3.1.

Table 3.1 Procedures and principles of method.

Procedure	Major purposes	Major tools	Section in report
1. Extraction of statistics of landslide databases	• To prioritize surveying targets based on administrative regions • To select clusters of interest for further analysis • To help evaluate RMI	ArcGIS	3.1
2. Survey for evaluation of performance of landslide risk management	• To obtain performance level and weighting of component indicators in RMI	Questionnaires	3.2
3. Processing of survey data	• To obtain RMI	Matlab	3.3
4. Analysis of survey results	• To evaluate and compare RMI between territories • To study relationships between objective landslide indicators and landslide risk management perception • To evaluate reliability of results	ArcGIS, other data processing tools	3.4

3.1 Extraction of statistics of landslide data based on administrative divisions

Statistics of landslide data of a territory, such as hazard (frequency), economic exposure, physical exposure, risk, etc. can be extracted based on geographic or administrative divisions in a territory using the spatial statistics tool of Geographical Information System (GIS) software. The purpose of obtaining statistical parameters of the data is twofold: to first prioritize surveying targets based on administrative regions divided in the territory, and to later study the relations between these objective indicators and landslide risk management perceptions. The latter is mentioned in Section 3.4.6.

Prioritization is not essential. However, in view of possible time-constraints and practical issues, response to the landslide risk management evaluation survey is not always available from every administrative region. Therefore, in order to obtain data from a sufficiently wide spectrum of a territory within limited time, it is recommended to group administrative regions in clusters that share similar characteristics and then take samples from each cluster.

Clustering of regions is carried out using the statistical parameters of the landslide data. Based on Equation 1.1, there exists a direct relationship between landslide risk and hazard/exposure. By plotting landslide hazard or exposure against risk, with respect to their relative values (low, moderate and high), five classes of data are grouped (Figure 3.1):

1) Low risk and low hazard/exposure

2) Moderate risk and moderate hazard/exposure

3) High risk and high hazard/exposure

4) Relatively high hazard/exposure with respect to risk

5) Relatively low hazard/exposure with respect to risk

Next, for each cluster of regions, a priority list is produced roughly based on the 'outlying-ness' of the regions in the class. Classes (1), (2), and (3), follow the general trend of the dataset. Administrative regions, which appear to conform more to the general trend, are of higher priority. Classes (4) and (5), which are outliers, indicate that the hazard/exposure factor on the plot does not play a dominant role in controlling landslide risk based on Equation 1.1. In these classes, administrative regions which are more outlying are of higher priority. The extreme ends of the data are of greater interest, therefore the classification uses mean plus one standard deviation (Figure 2.1).

Figure 3.1 illustrates an example of clustering and prioritization of the twenty regions in Italy using economic exposure and risk. These data are extracted from the online Global Risk Data

Platform (see Section 4.1.1). The data points, which represent each region, are the calculated results of spatial statistical analysis.

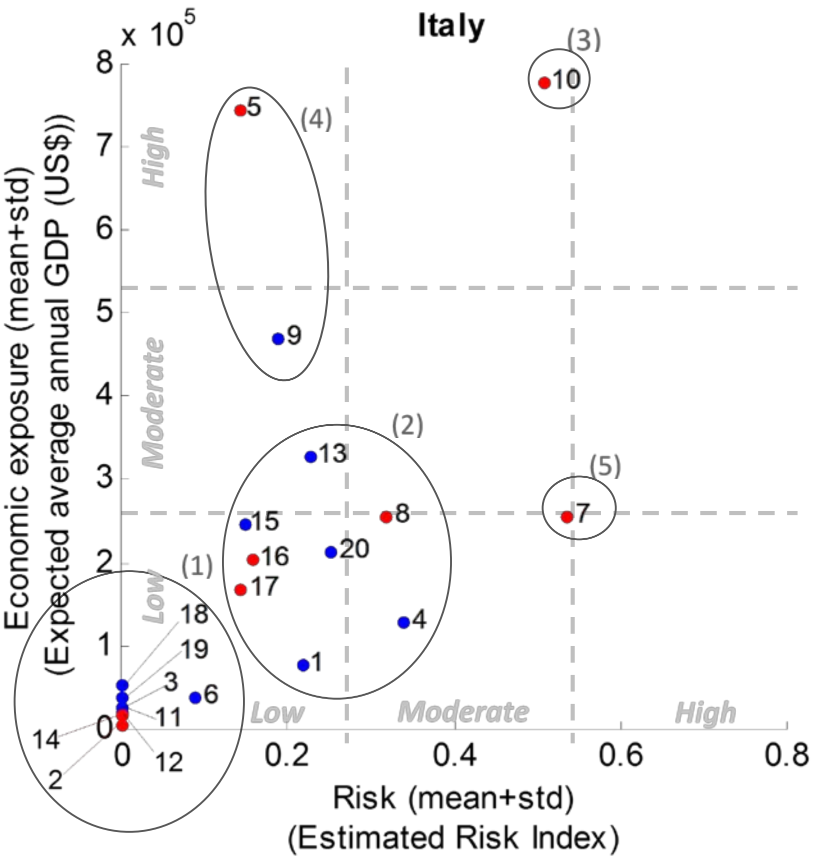


Figure 3.1   Prioritization of landslide data based on sub-national administrative divisions. Exemplified by mean plus one standard deviation of economic exposure (to landslides triggered by precipitation) and landslide risk data of the 20 regions in Italy (labelled with numbers). The regions are grouped into five classes ((1) to (5)), in each of which the red dots are used as representative samples of each group for performing the survey.

3.2 Survey for evaluation of performance of landslide risk management

The survey used to assess the performance of landslide risk management is based on the Risk Management Index (RMI), which was first proposed by Cardona et al. (2004) and later modified and applied by Cardona et al. (2005) and Carreño et al. (2007) to assess risk management performance of general disasters in countries in Latin America and the Caribbean. The index is included as an output in the project on disaster risk management indicators under the Inter-American Development Bank/Institute of Environmental studies of the National University of Colombia (IADB/IDEA) program.

3.2.1 Background on Risk Management Index (RMI)

To assess risk management, criteria involving incommensurable units and information which can only be evaluated by linguistic estimates are often involved (Cardona et al. 2005; Carreño et al. 2007). To handle these criteria simultaneously so as to give a quantitative measure of effectiveness of risk management, Cardona et al. (2004) suggested combining the 'multi-attribute technique' and fuzzy sets theory.

The multi-attribute technique agrees with ISDR draft framework (ISDR 2003) for guiding and monitoring disaster risk reduction. This outlines various thematic areas, components, and tentative performance evaluation criteria in disaster risk management. By adopting such a systematic and generally agreed upon framework of multiple disaster reduction initiatives, risk reduction approaches and trends can be analyzed and compared (ISDR 2003).

On the other hand, fuzzy sets theory gives flexibility to modelling which uses linguistic or qualitative expressions for management performance levels, e.g. 'low', 'significant', 'optimal' etc. (Cardona et al. 2004, 2005; Carreño et al. 2007). These linguistic values are the same as a fuzzy set of bell-shaped and sigmoidal-shaped membership functions (Cardona 2001; Carreño 2001; Cardona et al. 2004, 2005; Carreño et al. 2007), as shown in Figure 3.2a.

3.2.2 RMI as a system of 'composite indicators'

Under the multi-attribute technique, following the draft framework compiled by ISDR (2003) and considering public policy makers as users, Cardona et al. (2004) constructed the RMI as a system of four ‘composite indicators’, each of which represents a public policy and comprises of six ‘component indicators’.

The four public policies (also used in the present study) include Risk Identification (RI), Risk Reduction (RR), Disaster Management (DM), and Governance and Financial Protection (Loss Transfer) (FP). In the present study, context of the public policies is modified to be implemented in landslide hazards as summarized in Table 3.2.

Table 3.2 Public policies/composite indicators considered in landslide risk management (adopted from Cardona et al. 2005; Carreño et al. 2007).

Public policy/ Composite indicator	**Policy index**	**Description**
Risk Identification	RMI_{RI}	Individual and social risk awareness of landslide hazards and methodological approaches in landslide hazard assessment
Risk Reduction	RMI_{RR}	Prevention and mitigation measures against landslides
Disaster Management	RMI_{DM}	Response and recovery following a disaster
Governance and Financial Protection (Loss Transfer)	RMI_{FP}	Allocation and use of financial resources for dealing with disaster

The RMI is defined as the average value of the four composite indicators (policy indices):

$$RMI = \frac{RMI_{RI} + RMI_{RR} + RMI_{DM} + RMI_{FP}}{4} \tag{3.1}$$

Component indicators of each public policy are listed in Table 3.3.

Procedures of how the RMI of a country is obtained are schematically presented in Figure 3.2. Each composite indicator is quantified by the weighed values of its component indicators. The weighed values are based on performance levels and relative weights, which are attributed to the component indicator via separate questionnaires (see Section 3.2.5). The principle of obtaining the relative weights of component indicators and subsequently the policy indices are described in Sections 3.2.3 and 3.2.4, respectively.

Table 3.3 Public policies and their corresponding component indicators for the RMI in the present study (adopted from Cardona et al. 2005; Carreño et al. 2007)

Public Policy (policy index)	**Component Indicators**
Risk Identification (RMI_{RI})	RI1. Systematic disaster and loss inventory
	RI2. Hazard monitoring and forecasting
	RI3. Hazard evaluation and mapping
	RI4. Vulnerability and risk assessment
	RI5. Public information and community participation
	RI6. Training and education in risk management
Risk Reduction (RMI_{RR})	RR1. Risk consideration in land use and urban planning
	RR2. Hydrographic basin intervention and environmental protection
	RR3. Implementation of hazard-event control and protection techniques
	RR4. Housing improvement and human settlement relocation from prone-areas
	RR5. Updating and enforcement of safety standards and construction codes
	RR6. Reinforcement and retrofitting of public and private assets
Disaster Management (RMI_{DM})	DM1. Organization and coordination of emergency operations
	DM2. Emergency response planning and implementation of warning systems
	DM3. Endowment of equipment, tools and infrastructure
	DM4. Simulation, updating and test of inter-institutional response
	DM5. Community preparedness and training
	DM6. Rehabilitation and reconstruction planning
Governance and Financial Protection (Loss Transfer) (RMI_{FP})	FP1. Inter-institutional, multi-sectoral and decentralizing organization
	FP2. Reserve funds for institutional strengthening
	FP3. Budget allocation and mobilization
	FP4. Implementation of social safety nets and funds response
	FP5. Insurance coverage and loss transfer strategies of public assets
	FP6. Housing and private sector insurance and reinsurance coverage

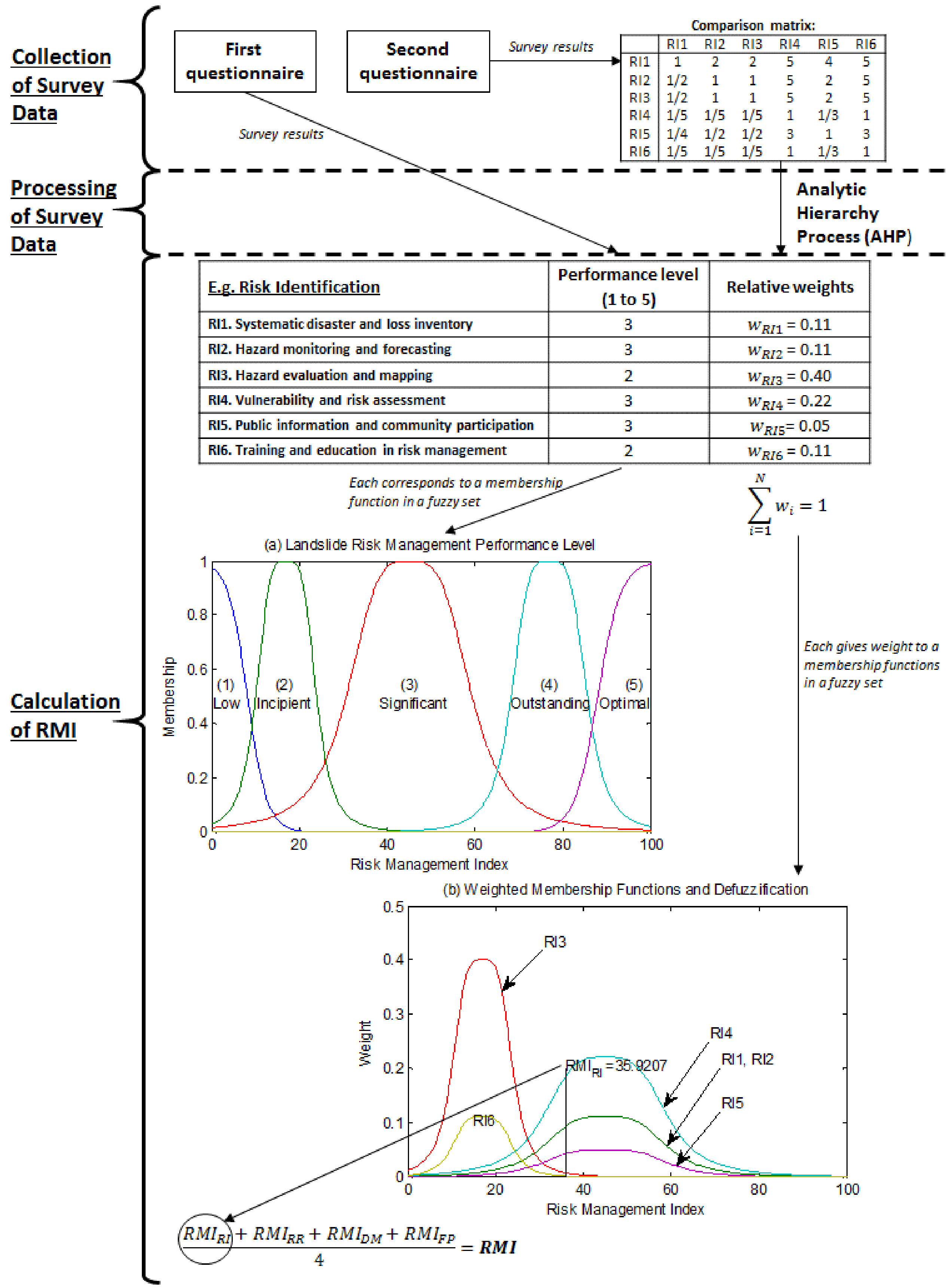


Figure 3.2 Procedures to obtain RMI of a territory, exemplified by the public policy of RI.

3.2.3 Assignment of weights to component indicators, the Analytic Hierarchy Process (AHP)

For each component indicator within a public policy, a weight is allocated to represent the relative importance of the indicator within the public policy. The process of allocating the weights follows the Analytic Hierarchy Process (AHP).

AHP is widely used in decision making for multiple attributes (Saaty 1980, 1987; Saaty and Vargas 1991; Cardona et al. 2005; Carreño et al. 2007). It enables a decision making problem to be decomposed into hierarchy, such that the problem can be evaluated based on both qualitative and quantitative aspects. The basic idea of AHP is that attributes (component indicators in this study) are compared pairwise. For each pair of indicators, comparisons are made via two steps by perception: (1) 'Which of the two indicators is perceived as more important?' and (2) 'In which degree?' Also, the degree of preference between each pair of indicators is rated within the same order of magnitude from 1 to 9. A degree of 1 represents that both indicators are equally important, whereas a degree of 9 represents that one indicator is 9 times more important than the other one.

Results of each comparison are tabulated to form a comparison matrix (see example in Figure 3.2). Relative weights are then calculated using an eigenvector technique. While calculating relative weights, the eigenvalue (λ_{max}), which is the largest positive eigenvalue, and the principal eigenvector of a comparison matrix are obtained. Consistency across the comparisons is also checked with respect to the eigenvalues:

$$\text{Consistency Index (CI)} = \frac{\lambda_{max} - n}{n - 1} \tag{3.2}$$

$$\text{Consistency Ratio (CR)} = \frac{CI}{CI_{random}} \leq 0.1 \tag{3.3}$$

It is suggested that if CR exceeds 0.1, the elements of the pairwise comparison matrix have to be re-examined (Saaty 1987) and modified (Carreño et al. 2007). Two examples demonstrating how CR changes with the values in a 3-by-3 comparison matrix are given in Appendix L. In addition, the principles of modification of inconsistent entries in a comparison matrix are described in Section 3.3.2.

Within an acceptable consistency, the corresponding principal eigenvector is then standardized by having a value sum of 1. The standardized vector is called the priority vector.

The calculation of relative weights is undertaken by Matlab. The Matlab script is included in Appendix D and an example showing the results of relative weights calculated from a comparison matrix is shown in Figure 3.2 ('Processing of Survey Data').

3.2.4 Fuzzy sets of risk management performance levels

Each of the management performance levels used in the valuation of component indicators represents the membership function of a fuzzy set, as shown in Figure 3.2a. A membership value of 1 represents total membership, whereas 0 represents non-membership. For the five fuzzy sets (i.e. five performance levels), two types of membership functions are involved:

(1) Performance levels 1 and 5 are represented by a bell-shaped function:

$$bell(x;a,b,c) = \frac{1}{1 + \left|\frac{x-c}{a}\right|^{2b}} \tag{3.4}$$

(2) Performance levels 2, 3 and 4 are represented by a sigmoidal function:

$$sigmoidal(x;a,b,c) = \frac{1}{1 + exp[-a(x-c)]} \tag{3.5}$$

The relative weights determined by AHP for each component indicator (standardized to a sum of 1) give the height to the membership function of each fuzzy set (Figure 3.2b). A weighted fuzzy set thus contains $w_1 \times \mu_C(C_1), \ldots, w_n \times \mu_C(C_n)$, where w_1 to w_n are the weights assigned to the component indicators $\mu_C(C_1)$ to $\mu_C(C_n)$.

Defuzzification is carried out next using the method of centroid of area, which estimates the area and the centroid of a fuzzy set and determines a concentrated value, X, by the division of the sum of the product by the sum of the areas (see also Figure 3.2b). The policy index of a public policy, RMI_p is thus obtained by:

$$RMI_p = \frac{\int_X \mu_A(x)xdx}{\int_X \mu_A(x)dx} \quad (3.6)$$

Recall that the RMI is given by the average of the four policy indices (Equation 3.1).

A Matlab function, which makes use of the Fuzzy Logic Toolbox, has been written for the calculation of the RMI (Appendix E). Figure 3.2b shows an example of the calculated result of a policy index using the developed script. The current algorithm is probably different from that used by Cardona et al. (2005), since significant differences are observed by attempting to reproduce the RMI results of Cardona et al. (2005). However, the current script is considered more reasonable. Details regarding the verification of the RMI results of Cardona et al. (2005) are found in Appendix F.

3.2.5 Questionnaires

As illustrated in Figure 3.2 'Collection of Survey Data', two questionnaires, which are anonymous, are used in the survey.

The forms in Appendix G and Appendix G collect ratings of performance level for each component indicator. Following Cardona et al. (2004), five performance levels are designated to the valuation of each component indicator (Cardona et al. 2005, Carreño et al. 2007). These performance levels correspond to linguistic expressions including 'low', 'incipient', 'significant', 'outstanding', and 'optimal' or numerically in a scale from 1 to 5, respectively. This questionnaire is generally based on the detailed description of the performance levels in Tables 2.4.1 to 2.4.4 and 2.4-1.1 to 2.4-1.4 in Cardona et al. (2005), but the descriptions of performance levels have been modified such that the RMI can be implemented in landslide hazards instead of general disasters. Occupational information of participants is also surveyed. Since it is likely that participants have experience with some but not all the public policies related to landslide risk management, the information about participants' organizations, disciplines of work, and role of responsibility can help with interpreting the survey results. The performance levels are assessed in terms of different time scenarios (10 years before, present, and 10 years later). For Norway, the performance levels are also surveyed at two administrative levels -- county and national (Appendix G). To encourage a better response, a flexible length of the survey is introduced. Participants can choose to answer a shorter version (i.e. Tier 1), which summarizes the detailed description of the performance levels of each component indicator (as in Tier 2) into a short list of criteria for benchmarks. Completion of either tier leads to the same format of results.

Appendix H consists of a form for allocating relative weights between pairs of component indicators based on the Analytic Hierarchy Process (AHP). The same form is used for both Hong Kong and Norway. The questionnaire is adopted from Tables 3.4.9 to 3.4.12 in Cardona et al. (2005). In the present study, the relative weights are assumed constant over time and the same set of AHP weights is used for both national and county levels. Additionally, at the end of the questionnaire, respondents are asked to indicate which public polices they are most familiar with. This information is used in analyzing the RMI results.

In addition, it is not obligatory to answer all the questions in the questionnaire. Respondents are asked to leave the entries open if they do not feel they are in the position to answer or they think the questions are not relevant.

3.2.6 Sampling method, delivery mode and response format of survey

Target participants for this questionnaire are invited from authorities and stakeholders related to landslide risk management in Hong Kong and Norway. They are invited from various types of organizations, such as government agencies, local authorities, consultants, contractors, research institutes as well as academic bodies. In the present study, most of the target participants have backgrounds in geology, engineering geology and geotechnical engineering. Due to limited time, target participants who are assumed to have experience at the county level in Norway are invited from the counties that are at higher priority (Section 5.1.2, Table 5.2).

To facilitate and reduce errors during handling of the data, all the questionnaires are delivered electronically as Adobe™ Portable Document Format (PDF) survey forms, which can be opened by a common application. Survey participants can answer most of the questions just by selecting the buttons in the survey forms. In addition, the survey form making application also provides an interface to compile a database and export all responses to a spreadsheet file that can be opened in other applications for subsequent analyses.

Email invitations to the survey are first sent to target participants. Survey forms will then be distributed as email attachments to those who show interest. The completed survey forms are submitted either as email attachment or by a click of the 'submit' button in the completed form, by which the form will be automatically sent to a designation email address.

Paper or scanned survey forms are also accepted at respondents' convenience. However, this requires data entry to the database.

3.3 Data Processing

3.3.1 Missing data

Missing entries in the valuation of component indicators (i.e. first questionnaire) are left open to ensure the quality of the data, since these missing entries may represent irrelevant questions in respondents' opinions.

A complete comparison matrix is required for calculating the AHP weights. In this case, a value of 1, which represents equal importance between two component indicators, will be assumed. However, this will only be applied to a comparison matrix with no more than two blanks in order to minimize the influence of the missing entries on the results. Any comparison matrix with more than two blanks is not be included in the calculation of AHP weights.

3.3.2 Manual correction of inconsistent weights

When the CR of a pairwise comparison matrix exceeds 0.1, the elements in the matrix that lead to inconsistency is modified manually to reduce CR to the acceptable limit. To begin with, one has to determine which element is most sensitive to CR, i.e. only a small change in the value of the element can lead to a big difference in CR. In the present study, a graphical method of plotting the elements of a comparison matrix as clustered columns is introduced. Using the example in Table L.1b, assuming $y = 1/2$, CR becomes 0.1874, which exceeds 0.1. Figure 3.3a shows that the inconsistency among the elements in a comparison matrix can be visualized as the inconsistent patterns across the clustered columns. Normally, there is more than one possible way to modify the elements in order to reach an acceptable CR. In short, two principles are generally followed during the manual correction in order to preserve the opinions of the respondents as well as possible:

1) Preserve the 'direction' of relative importance as this is probably the perception that respondents are most confident in. For example, if the value is greater than 1, avoid reducing it to smaller than 1.

2) Change of a value should be as small as possible. For example, instead of significantly reducing a large value of an entry, one may consider slightly reducing the values of more than one entry instead.

Figure 3.3b to Figure 3.3d demonstrate three possible ways to reach consistent weights. In this case, the modification shown in Figure 3.3c is chosen since the 'direction' of relative importance has not been converted and the degree of change in the value is relatively small.

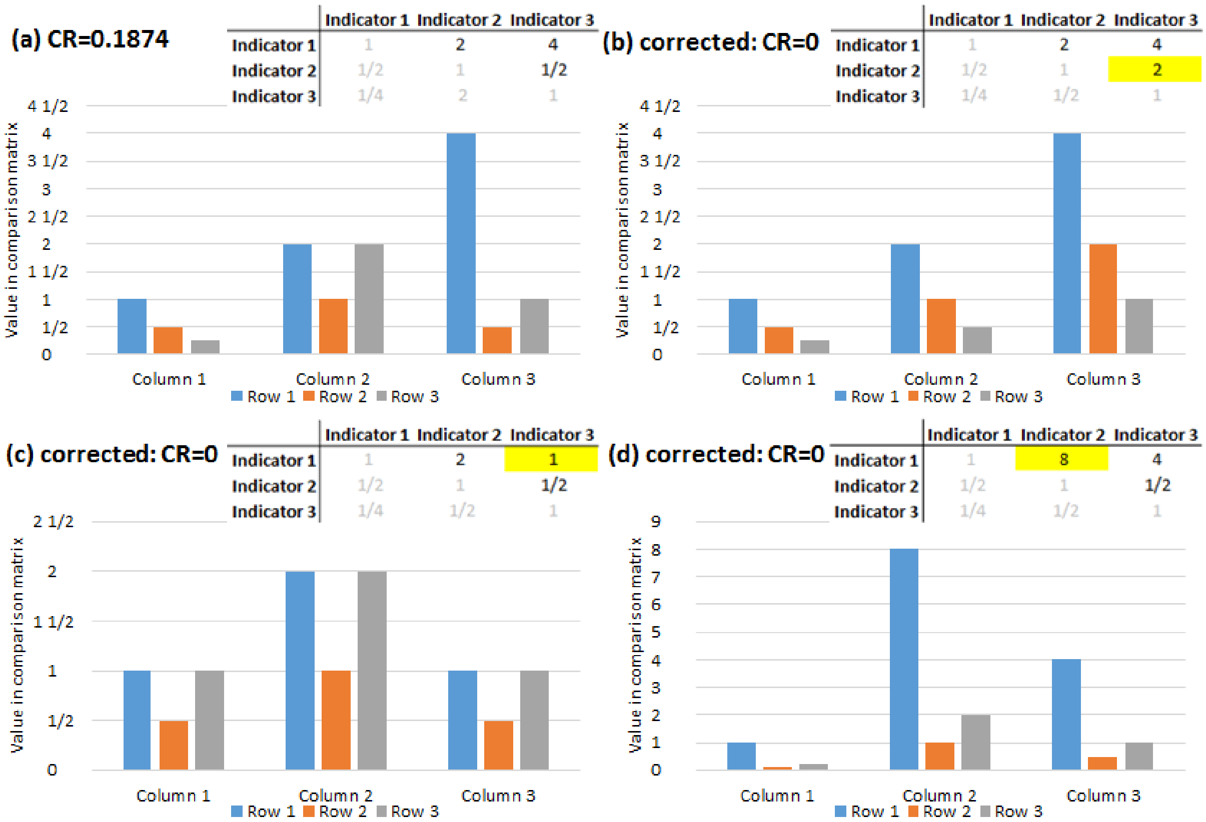


Figure 3.3 Graphical method used in modifying elements in a comparison matrix. The comparison matrix (top right on each chart) is schematically plotted as clustered columns. (a): Inconsistency is visualized as inconsistent patterns among the clustered columns. (b) to (d): There is more than one possible way to solve the inconsistency so that the patterns of the clustered columns become as uniform as possible. The entry of the comparison matrix that has been modified is highlighted in yellow.

3.3.3 Obtaining RMI from survey results

Cardona et al. (2005) and Carreño et al. (2007) published the single values and relative weights for each of the component indicators in their results. These values are then used to compute the RMI. However, it is not mentioned how these single values or relative weights have been compromised or consolidated from a survey data set.

In the present study, qualification of a component indicator is represented by the median value rounded down to the nearest performance level.

The relative weight of a component indicator within a particular public policy is obtained first by calculating the mean of priority vector components obtained from all comparison matrices, and then by standardization all the mean values to a sum of 1.

As a result, a RMI for a territory in a particular year can be obtained from sets of qualifications and relative weights.

3.4 Analyses of survey results

Various methods of analyzing the survey results are introduced in this section. These methods allow:

1) Evaluation of the representativeness of the samples among the population of interest.
2) Quantitative comparisons between case study areas at regional and national levels.
3) Assessment of the reliability of the newly introduced simplified tier of the 1st questionnaire.
4) Characterization of experts' opinions and justification of the results.
5) Analysis of uncertainty of RMI results.
6) Evaluation of the RMI results with objective indicators.

3.4.1 Background of respondents

Condition of survey response as well as distribution of gender, age group, education level, organization, job discipline and role of responsibility of respondents is analyzed in Section 5.2.1 and Section 5.2.2 The purpose is to understand the width of the spectrum of the backgrounds of respondents. Moreover, certain categories under organization, job discipline and role of responsibility are selected as independent variables to study how the values of component indicators are related to the backgrounds of respondents (Section 5.2.3.1).

3.4.2 Comparisons between territories

Quantitative comparisons of landslide risk management performance between territories are carried out based on the following aspects:

(1) Qualification of component indicators: distribution and median values of component indicators (Sections 5.2.3.1 and 5.2.4.1)

(2) AHP weights: distribution of standardized mean AHP weights of component indicators within a public policy (Section 5.2.3.2)

(3) RMI results: policy indices and RMI (Sections 5.2.3.3 and 5.2.4.2)

For only two territories (e.g. Hong Kong and Norway, Section 5.2.3), similarities and differences between two territories can be determined quantitatively based on the differences of values between territories.

For more than two territories (e.g. counties in Norway, Section 5.2.4), the territories can be ranked based on the values or the distances from a reference value, e.g. the median value of all the data.

3.4.3 Reliability of Tier 1

A simpler tier (i.e. Tier 1) is proposed in the first questionnaire (Appendix G and Appendix G). Ideally, both tiers would give the same qualifications if answered by the same person. Nonetheless, Tier 2 is regarded as more reliable since the description of each performance level is in greater detail. Discrepancies between the values of Tiers 1 and 2 are therefore useful for assessing the reliability of Tier 1.

3.4.4 Experts' opinions

Respondents are likely familiar with one or more public policies but not all. As a result, one may assume that the opinions given by these experts are more reliable. In the present study, respondents are classified into experts and non-experts in a particular public policy based on their job disciplines and familiarity with the public policy. For example, in the first questionnaire, respondents whose role of responsibility includes emergency response is considered as an expert in disaster management. In the second questionnaire, if a respondent is familiar with any of the public policies, he/she will automatically be classified as an expert in that public policy(ies). Classification of experts and non-experts for the survey results is annotated in Appendix K.

Discrepancies between experts and non-experts in the survey results are first assessed. This is done by examining the differences of the values as well as their degree of divergence based on standard deviation. Not only can the discrepancies dispute the accuracy of the majority's answers, they may also reveal the different perceptions between experts and non-experts.

Next, a sensitivity test on the policy indices and RMI using different weights of experts' opinions is performed. The incentive of proposing a sensitivity test for the present study is to develop a way to justify the accuracy of the survey results that is based on data from all the respondents. The sensitivity test allows the study of the influence of experts' opinions on the RMI results. Reliable survey results may be indicated by little difference upon increased weights of experts' opinions, as this means the general perceptions are comparable to the experts' perceptions. The sensitivity test performed in the present study considers double and triple weights of experts’ entries in AHP weights and/or values of component indicators.

3.4.5 Uncertainty analysis of RMI of counties in Norway

Uncertainty analysis of policy indices and RMI is carried out for Norwegian counties to assess the uncertainties resulting from the errors in the values of the component indicators, as well as the uncertainties associated with the weights of these indicators. The uncertainty analysis follows the method proposed by Saisana & Tarantola (2002), which is similar to the Monte-Carlo Simulation, in which a repeated simulation with randomly selected values of variables is carried out. Results of the uncertainty analysis enables simple ranking of the counties based on their RMI indices. Confidence bounds for the indices are also obtained to make a rough estimate of the uncertainty.

It is assumed that the weights of the component indicators are uncertain since different people's perceptions can be divergent (Saisana & Tarantola 2002). For the uncertainty analysis, the policy indices and RMI for each county in Norway are calculated 2000 times, using 2000 sets of random weights and the median values of the component indicators obtained via the survey. Following Saisana & Tarantola (2002), the random weight samples are generated based on a uniform distribution between the 10^{th} and 90^{th} percentiles of the AHP weights calculated from survey data. Random distribution results in the most conservative estimate of uncertainty among other distributions since its standard deviation is the largest (NIST/SEMATECH 2013). If there are sufficient survey data, a distribution that characterizes the survey data better may be used instead in order to obtain more realistic uncertainty analysis results. The distribution of the survey data can be visualized from histograms.

Results of the uncertainty analysis, i.e. 2000 values of policy indices and RMI, are presented as bars, based on their median values (50^{th} percentile). The corresponding confidence bounds, which represent the 5^{th} and 95^{th} percentiles, are also shown.

The width of the confidence bounds of a policy index is connected to the variance of the weights and the median values of the component indicators within a public policy. However, if the median values of a set of component indicators are the same, the RMI index does not vary with the relative importance of the component indicators. As a result, the confidence bounds will overlap and any uncertainty will be hidden. This is related to the 'centroid of area' method adopted for defuzzification (see Section 3.2.4) and this results in a major drawback for the uncertainty analysis.

3.4.6 Evaluation of RMI results

The missing entries in the questionnaires and inconsistent weights evaluated during AHP may provide insights about the relevance of and further perceptions about the indicators. For instance, inconsistent weights may indicate a lack of holistic view regarding the relative importance between particular component indicators within the public policy.

The RMI results are also compared with the existing landslide data to assess any correlations between the subjective perceptions on landslide risk management performance and the objective landslide hazard conditions. This may help interpret the RMI results. For example, the number of landslides and fatalities due to landslides may be connected to the achievement in identification and reduction or landslide risk. Therefore, RMI_{RI} and RMI_{RR} of a particular year can be evaluated with the use of the number of landslides and fatalities during the previous 10 years. In addition, the RMI results can also be evaluated against quantitative indicators such as landslide hazards (frequency), exposure and risk.

4 Existing datasets and sources of information

Existing datasets and sources of information are used in the present study mainly to understand the landslide hazard and risk of the case study areas on spatial and temporal bases. As described in Chapter 3.1, statistics of landslide hazard datasets are extracted based on administrative regions for simple clustering. These statistics, together with the landslide records (as presented schematically in Figure A.1 and Figure B.1), are applied again to evaluate the survey results. The datasets and sources of landslide records are summarized in Table 4.1 and described accordingly in this section.

Table 4.1 Summary of existing datasets and sources of landslide information used in the case studies.

Type	Dataset/source of information	Coverage	Years	Stage(s) for which data are used
Raster-based landslide data	Global Assessment Report on Disaster Risk Reduction (GAR)	Global	Published in 2009	Extraction of landslide statistics based on administrative divisions; Evaluation of RMI results
	Safeland project	Europe	Published in 2010	
Landslide records	Annual factual reports/reviews on landslides in Hong Kong	Hong Kong	1984-2011	Evaluation of RMI results
	Number of reported landslide incidents extracted from annual report of Civil Engineering and Development Department in Hong Kong	Hong Kong	2010-2013	Evaluation of RMI results
	Landslide inventory of Norway www.skrednett.no	Norway	1960-2014	Evaluation of RMI results
Administrative boundaries	Global Administrative Areas: www.gadm.org	Global	Published in 2012	Extraction of landslide statistics based on administrative divisions

4.1 Raster-based landslide data

4.1.1 Global Assessment Report on Disaster Risk Reduction (GAR)

Homogeneous datasets allow comparisons to be made based on the same unit and resolution. The online Global Risk Data Platform (www.preventionweb.net) developed for the Global Assessment Report on Disaster Risk Reduction (GAR) versions 2009, 2011 & 2013 provides a set of raster-based landslide data on a global scale (UNEP / UNISDR 2013) (Table 4.2). As a result, comparative analysis can be carried out between territories at levels ranging from international to inter-municipal in many parts of the world. The dataset used for the present study was published in 2009 (hereinafter referred to as GAR2009).

Table 4.2 List of global data related to landslide available from the Global Risk Data Platform.

Data	**Unit**	**Pixel size (km)**	**Original data sources**
Landslide hazard (frequency)	Expected annual probability and percentage of pixel of occurrence of a potentially destructive landslide event x 1000000*	1	Norwegian Geotechnical Institute (NGI)*
Physical exposure	Expected Average Annual Population (inhabitants)	1	UNEP/GRID-Geneva
Economical exposure	Expected Average Annual Global Domestic Product (GDP) (US$)	1	UNEP/GRID-Geneva
Risk	Estimated risk index from 1 (low) to 5 (extreme)	10	The World Bank

*In the case studies, landslide hazard data is standardized to expected annual probability, i.e. the percentage of pixel of occurrence is omitted.

**Frequency data retrieved from the Global Risk Data Platform are classified from certain frequency scores. The scores, which are of the same grid extent and resolution, are also available from NGI.

The landslide hazard frequency is calibrated from landslide events in selected countries (mainly in Europe) based on susceptibility factors including slope gradient, lithological conditions, vegetation cover and soil moisture condition, and a triggering factor of either precipitation or earthquakes (UNEP/GRID 2013).

Physical exposure is calculated by multiplying the frequency grid by the population grid for the year 2010 provided by LandScan^{TM} Global Population Database (UNEP/GRID 2013). Economic exposure is calculated similarly, using the GDP grid for the year 2010 provided by the World Bank (US$ currency according to year 2000) (UNEP/GRID 2013). The data downloaded from online Global Risk Data Platform has been aggregated and the non-aggregated values of the data are unfortunately lost. Therefore, no statistical information for exposure can be obtained at the time of the present study. However, the exposure maps portrayed via the Web Map Service (WMS) from the online platform can be used for qualitative analysis.

The estimated risk index is a logarithmic classification based on the average of absolute risk (average killed per year) and relative mortality risk (killed per million per year). The classification from the extracted data used for the case studies is simpler than the Mortality Risk Index given in the related report (Peduzzi et al. 2009) as shown in Table 4.3. However, the table provides a reference for the magnitude of the estimated risk index.

Table 4.3 Classification of Mortality Risk Index in GAR2009 Report (adopted from Peduzzi et al. 2009).

Classes	Absolute risk (average killed per year)	Relative risk (killed per million per year)	Mortality Risk Index (average of both indicators)
10	>3000	>300	Extreme
9	1000-3000	100-300	Major
8	300-1000	30-100	Very high
7	100-300	10-30	High
6	30-100	3-10	Medium high
5	10-30	1-3	Medium
4	3-10	0.3-1	Medium low
3	1-3	0.1-0.3	Low
2	0.3-1	0.03-0.1	Very low
1	>0-0.3	>0-0.03	Negligible
0	0	0	Unknown exposure

Accuracy is likely a major problem in using global datasets due to the poor availability of local data in certain places and crude resolution of input data (e.g. vegetation cover and lithology index used to calculate hazard (UNISDR 2009)). However, since the present study uses the GAR2009 dataset only for simple comparison and ranking, the accuracy of the datasets is considered sufficient.

4.1.2 Safeland project

The Safeland project, which was completed in 2012, involves a uniform landslide risk analysis for Europe. Output from the project includes landslide hazard and physical exposure for individual European countries (Table 4.4). The Safeland dataset was delivered in 2010, contemporaneous with the GAR2009 dataset. Therefore, the Safeland data can serve as supplementary data to the GAR2009 data in Norway.

Table 4.4 List of data related to landslide available from the Safeland Project.

Data	**Unit**	**Pixel size (km)**
Landslide hazard (frequency)	Annual frequency in 1 km^2 grid cell	1
Physical exposure	Exposed population in 1 km^2 grid cell	1

The landslide hazard used for the present study is calculated using the International Centre for Geohazards (ICG) model in the Safeland project, in which all gravity-driven rapid mass movements are considered. The hazard is obtained based on combining and weighting of susceptibility factors including slope, lithology, vegetation and land use, and the triggering factor by precipitation or earthquake (Jaedicke et al. 2010). Weighting of these factors is calibrated to available landslide inventories and knowledge on physical processes (Jaedicke et al. 2010).

The physical exposure is computed by the landslide hazard with respect to population density in each grid cell (Jaedicke et al. 2010). The data population used was prepared by the Center for International Earth Science Information Network (CIESIN) under the Global Rural-Urban Mapping Project (GRUMP) (Jaedicke et al. 2010).

4.2 Landslide records

Landslide records of a territory may provide insights on the performance of landslide risk management performance in the territory. Researchers around the world have been trying to compile and standardize global inventories of landslide events and landslide hazards. For example, the EM-DAT dataset, which is maintained by the Catholic University of Louvain in Belgium, includes natural and technological disasters from 1900 until present (International Disaster Database www.emdat.be). However, the dataset is limited to significant events such as those that have caused at least 10 fatalities or affected 100 people. For the present study, the annual number of landslides and fatalities are of interest. As a result, complete records from the national-based landslide inventories are used. Nonetheless, the reliability of a territory's landslide inventory is often questionable due to incomplete records and varied cataloguing methods.

4.2.1 Landslide records in Hong Kong

Since 1984, GEO has published an annual review of the landslides incidents reported to its office. The reviews summarize the annual number of landslide occurrence, both on man-made slopes and natural hillsides. In addition, the number of fatalities and injuries is also reported. The review has been updated to the year 2011. In addition, the annual report from the Civil and Engineering Development Department (CEDD), which manages GEO, provides similar kinds of figures and the reports are available for the years 2010 to 2013.

4.2.2 Landslide records in Norway

NVE is responsible for visualization of landslide and snow avalanches data (www.skrednett.no) compiled from several databases with incidents registered primarily by the authorities for roads and railways, and also by general public, municipalities, consultants and other government agencies. Only the landslide data are used in the present study. Significant consequences on the people due to landslides and events that occurred during the past few decades are deemed to have been reported quite well. However, there exists problems of double registration. In addition, the number of landslides that can be extracted from the database is not complete to a consistent degree, particularly because the events located far away from inhabited areas and infrastructure are often not recorded and there is a lack of systematic registration by the road authority in some counties, such as Oppland and Hedmark. Nevertheless, for the remaining part of the country, the records in the database are fairly to nearly complete, spanning from 1990 to 2014. Therefore, the landslide records within this period from all the counties, except Hedmark and Oppland, are used for result analyses.

4.3 Administrative boundaries

Polygons of administrative boundaries within countries are available from the GADM database (www.gadm.org) for non-commercial purposes. The polygons are derived from internet sources, spatial databases of government bodies, or other organizations (GADM, accessed 2015).

Note that Magerøya island in northern Norway is missing. Therefore, the polygon layer of Norway had to be fixed before further processing.

5 Results

5.1 Existing landslide data

In this section, the existing landslide data from GAR2009 (Hong Kong and Norway) and Safeland (Norway) are briefly described and compared. Results of extraction of statistics of GAR2009 data based on counties in Norway are also presented. Only landslides triggered by precipitation are considered.

5.1.1 Overview

Table 5.1 Summary of statistics of existing landslide data fromGAR2009 and Safeland (2010). Statistics of exposure data from GAR2009 are not available due to problems in the downloaded dataset (see Section 4.1.1).

Data	Unit	Dataset								
		GAR2009 – Hong Kong			GAR2009 - Norway			Safeland (2010) - Norway		
		Max	Mean	Standard deviation	Max	Mean	Standard deviation	Max	Mean	Standard deviation
Hazard	Expected annual probability (%)	0.1	0.0110	0.0216	0.1	0.00202	0.00658	10	0.0236	0.186
Physical exposure	Expected Average Annual Population (inhabitants)	n/a	n/a	n/a	n/a	n/a	n/a	182	1.13	4.90
Risk	Estimated risk index from 1 (low) to 5 (extreme)	5	3	1.57	3	0.304	0.508	n/a		

Maps of landslide hazard, physical exposure, economical exposure, and risk based on GAR2009 data for Hong Kong and Norway are presented in Figure J.1 to Figure J.4 (Appendix I). Hazard and physical exposure maps for Norway based on Safeland data are also presented in Figure J.1 and Figure J.2.

Considering the GAR2009 data, landslide hazards and risk exist over the entirety of Hong Kong except the southwest; whereas western, southern, and central Norway are subjected to landslide hazards and risk. Comparing both territories, the highest landslide hazards in both territories are 'moderate', which attributes to 0.1% of annual frequency per km^2 (Table 5.1 and Figure J.1). However, the average landslide hazard in Hong Kong is about 5 times greater than that of Norway (Figure 5.1). On the other hand, physical and economic exposures due to landslides are much higher in Hong Kong than in Norway. For physical exposure, many areas in Hong Kong have an expected average annual population of greater than 1000 inhabitants, whereas only negligible to 100 inhabitants are exposed for the majority of Norway (Figure J.2). For economic exposure, a significant area in Hong Kong has an expected average annual GDP of greater than US$ 10,000 GDP, whereas generally only negligible to US$ 10,000 expected average annual GDP are exposed in Norway (Figure J.3). In addition, landslide risk in Hong Kong is generally much higher than that in Norway (Figure 5.1). The highest landslide risk in Hong Kong and Norway is 'extreme' and 'medium', respectively, while the average risk is 'medium' and less than 'low', respectively (Table 5.1). Figure J.4 also shows that among the available risk data, Hong Kong has a general range from 'medium' to 'high', whereas Norway is dominated by 'low' risk.

The Safeland data in Norway is different from the GAR2009 data in several aspects. For example, the annual landslide frequency extracted from Safeland is higher than that from GAR2009 – the maximum annual frequency in Norway based on Safeland data is as high as 10% per km^2 (i.e. 'very high') (Table 5.1). The mean annual frequency is also about 10 times higher for Safeland data. In addition, Safeland data show that landslide hazards in eastern Norway are not negligible (Figure J.1). On the other hand, the physical exposure based on Safeland data is generally less than that based on GAR2009 data.

5.1.2 Statistics based on administrative divisions

Figure 5.1 shows the mean plus one standard deviation of landslide hazards and risk data from GAR2009 of counties in Norway and Hong Kong. The extreme values of landslide hazards and risk in Hong Kong is significantly higher than Norway.

As mentioned above, the landslide hazards data from GAR2009 and Safeland vary in terms of values and spatial distribution. Here, the extreme statistics for landslide hazards from both datasets are compared systematically as shown in Figure 5.2. Counties in eastern Norway, including Akershus, Oslo, Hedmark, and Vestfold, which have negligible landslide hazards based on GAR2009 data, have considerable landslide hazards based on Safeland data. Landslide hazards for Rogaland and Møre og Romsdal have appreciably different rankings for

GAR2009 and Safeland. The former county has a lower ranking (i.e. higher hazards than the other) in Safeland than in GAR2009, whereas the latter has a higher ranking (i.e. smaller hazards than the others) in Safeland than in GAR2009. Nevertheless, Hordaland and Sogn og Fjordane have the highest mean plus one standard deviation landslide hazards for both datasets.

Based on GAR2009 data and following the clustering procedures as described in Section 3.1, five classes of counties in Norway are assigned based on the descriptions in Section 3.1. These classes form five lists of counties correspondingly (List A to List E). In each list, one to two counties are selected as prioritized surveying targets. In total, eight out of 19 counties in Norway are prioritized. Selection of these counties is based on the 'outlying-ness' of the statistical results. Safeland data are also taken into account. For instance, Akershus is selected because it has the highest extreme landslide frequency in List A based on Safeland data (Figure 5.2). Vestfold is selected in List B because much higher hazards than the rest of the list have also been identified in the Safeland data. Results of clustering and prioritization are presented in Table 5.2.

Table 5.2 List of clusters of counties in Norway. Prioritized counties are highlighted.

List A	List B	List C	List D	List E
1 Akershus	4 Buskerud	8 Møre og Romsdal	7 Hordaland	3 Aust-Agder
2 Østfold	11 Oppland	10 Nordland	14 Sogn og Fjordane	9 Nord-Trøndelag
5 Finnmark	17 Troms	13 Rogaland		15 Sør-Trøndelag
6 Hedmark	19 Vestfold			16 Telemark
12 Oslo				18 Vest-Agder

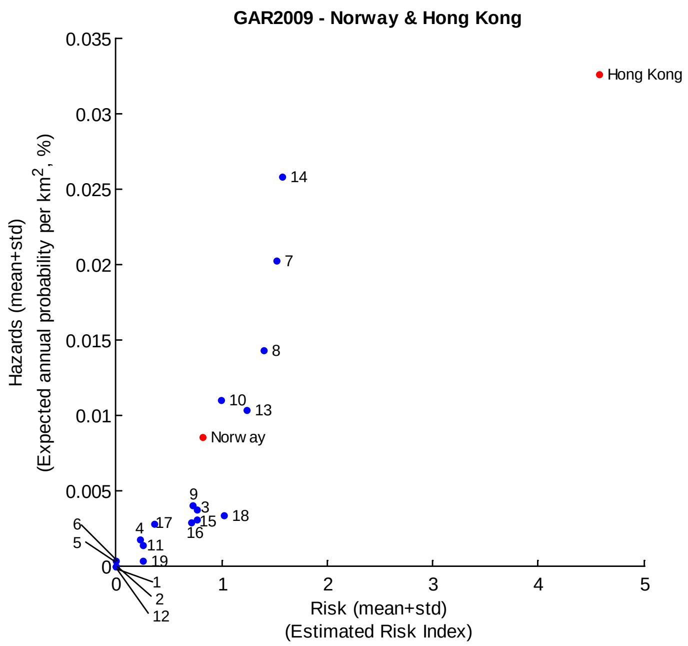


Figure 5.1 Mean plus one standard deviation of landslide hazards and risk of GAR2009 in Norway (red), Hong Kong (red), and 19 counties in Norway (blue) based on GAR2009 data. County code refers to Figure 5.3.

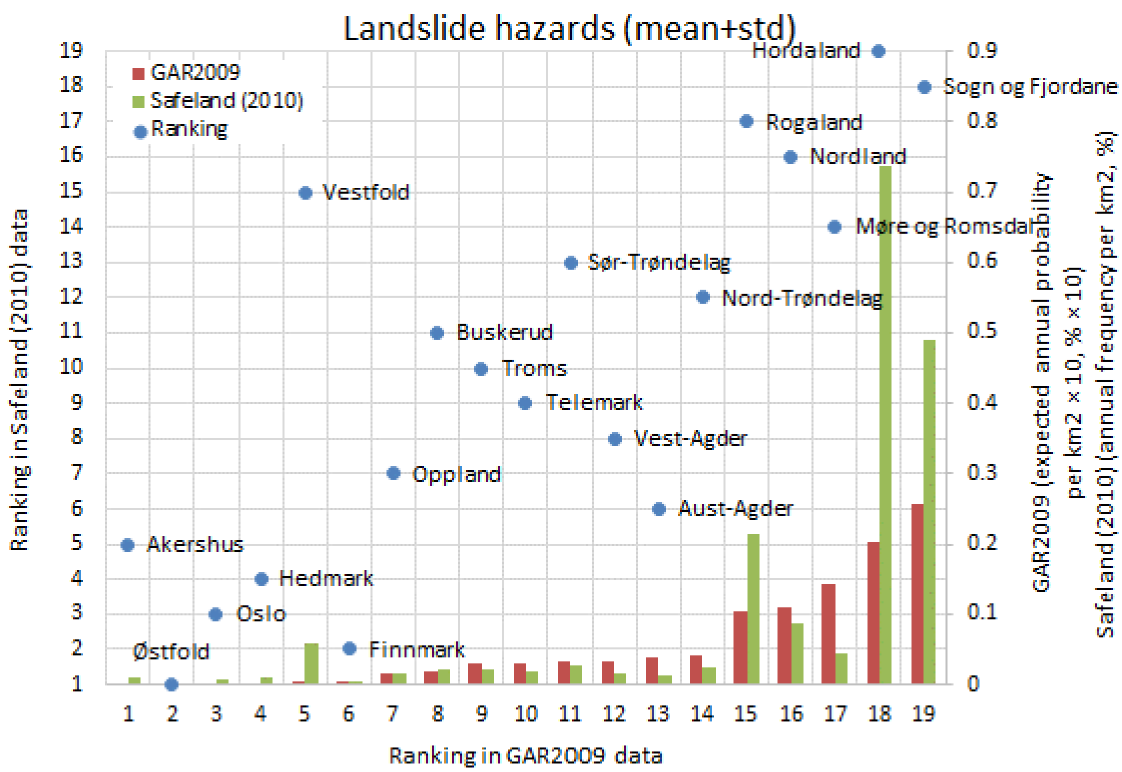
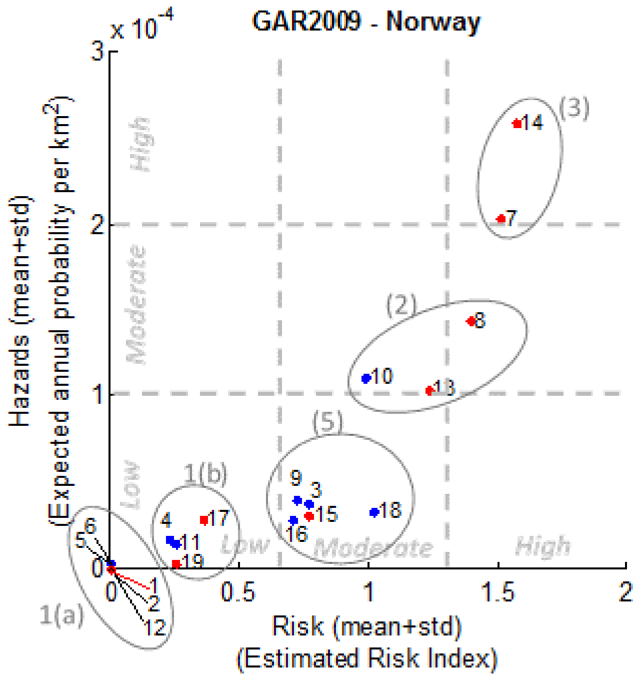


Figure 5.2 Ranking and values of extreme (mean plus one standard deviation) landslide hazards data of counties in Norway based on GAR2009 and Safeland (2010) data. Rank #1 refers to the smallest hazards. Note that in order to visualize the data better, the GAR2009 data has been multiplied by 10.



County Code	County Name
1	Akershus
2	Østfold
3	Aust-Agder
4	Buskerud
5	Finnmark
6	Hedmark
7	Hordaland
8	Møre og Romsdal
9	Nord-Trøndelag
10	Nordland
11	Oppland
12	Oslo
13	Rogaland
14	Sogn og Fjordane
15	Sør-Trøndelag
16	Telemark
17	Troms
18	Vest-Agder
19	Vestfold

Figure 5.3 Mean plus one standard deviation of landslide hazards and risk in counties in Norway based on GAR2009 data. The counties in Norway are clustered into five classes (1a, 1b, 2, 3 and 5) based on the descriptions in Section 3.1. The prioritized counties (red dots and line) in each cluster are selected by considering the 'outlying-ness' of the statistical results (as described in Section 3.1) and Safeland data.

5.2 Survey results

5.2.1 Survey response for 1st Questionnaire and organizations

Between early January and late March, 2015, a total of 103 invitations were sent to people from Hong Kong and Norway between late January to early March, whose work is related to landslide risk management in their territory. Among these invitees, 21 of them answered the first questionnaire, i.e. rating of landslide risk management performance. The remainder did not give any response to the invitation or did not answer the survey. Figure 5.4 and Figure 5.5 summarize the status of invitations and responses in Hong Kong and Norway for the questionnaire.

5.2.1.1 Hong Kong

A total of 45 invitations were sent to Hong Kong, most of which were sent to GEO (73%), the government agency which is responsible for slope safety in Hong Kong (Figure 5.4b). The rest of the invitations were shared between four international consultants (including AECOM, Arup, GeoRiskSolutions and Jacobs), Fugro (a contractor and consultant in slope engineering works in Hong Kong), and one professor from the University of Hong Kong.

Thirty-six percent of the invitees agreed to take part in the survey. In the end, a total of 12 responses for the first questionnaire was received, corresponding to a 27% response rate. Among these 12 respondents, more than half of them work at GEO, the rest includes consultants and the university professor (Figure 5.4c). The response rate for these organizations are comparable (78% to 100% of those who agreed to participate).

5.2.1.2 Norway

A total of 68 invitations were sent to Norway and 66% of these invitations were sent to difference government agencies (Figure 5.5a to c). Twenty-two percent of the invitations were sent to six international consultants including Asplan Viak, Multiconsult, NGI, Norconsult, Rambøll and Sweco. Invitations were also sent to different regional offices of Mesta, a contractor which provides operation and maintenance services for landslide mitigation measures for the road authority in Norway (Mesta AS, accessed 2015). In addition, three professors from Sogn og Fjordane University College (HiSF), University of Tromsø (UiT) and Norwegian University of Science and Technology (NTNU) were also invited to the survey.

Thirty-three percent of invitees agreed to take part in the survey. However, only nine responses were received in the end, which corresponds to a 13% response rate. The distribution of respondents based on organizations is similar to that for Hong Kong. Respondents for Norway are mostly from government agencies, including two respondents from NVE and County Governors (Figure 5.5c and d). The others include three respondents from NGI, one respondent from DSB, and one respondent from NTNU. The response rates for these organizations are about 30% to 50%. Several participants who had agreed to take part in the survey later decided to withdraw (including three County Governors, one from academia and one consultant). In their feedback, they generally pointed out that the questionnaires were too complicated and they did not understand the questions (see also Section 5.2.5). Additionally, five out of nine respondents also completed the evaluation at the county level.

5.2.1.3 Other occupational backgrounds of respondents

According to Figure 5.6a and b, all the respondents are at least 35 years old and the majority is between 45 and 54 years old.

Figure 5.6b and d show that all the respondents have received university education and more than 80% of them have master’s degree. The distribution based on job discipline is similar for Hong Kong and Norway.

Given that respondents may work in crossed-disciplines, half of the respondents work in risk identification, slightly less than 50% work in risk reduction and one respondent from both territories works in emergency response (Figure 5.6e and f). There are also respondents working in other disciplines such as training, finance, public information and community preparation and legislation.

Technical and management roles are popular among the respondents in Hong Kong and Norway. Apart from that, almost half of the respondents from Hong Kong have an executive role.

Hong Kong

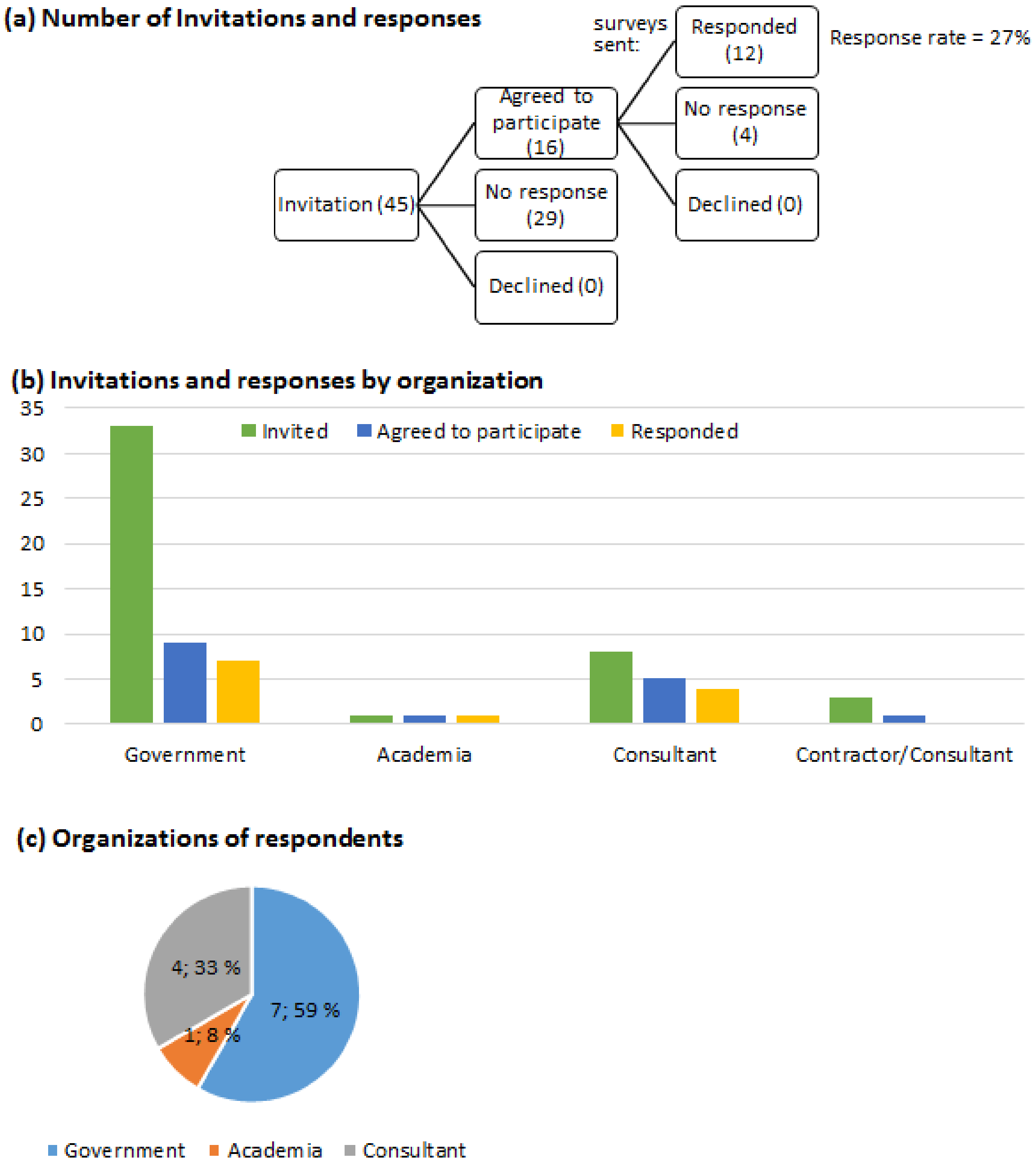
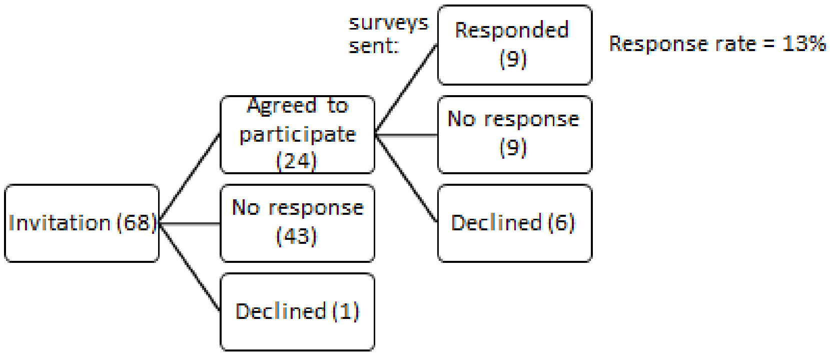


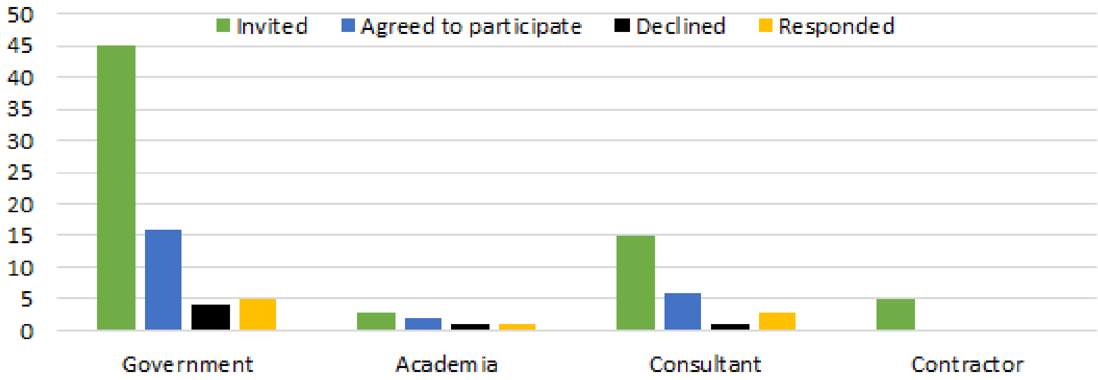
Figure 5.4 Statistics on invitations and responses to the survey in Hong Kong.

Norway

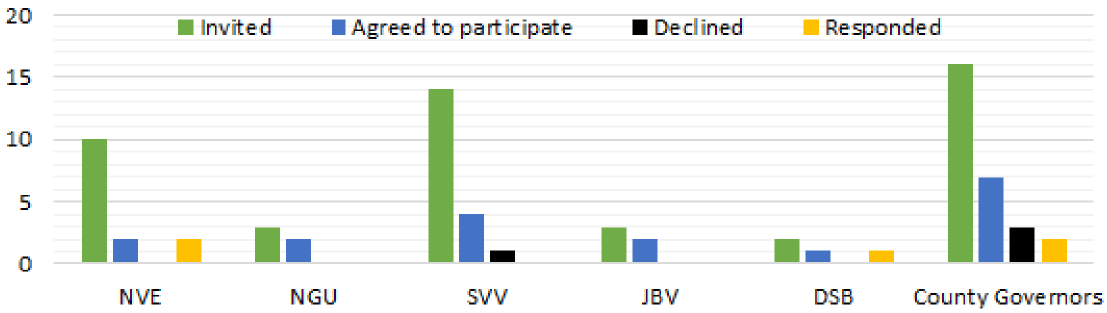
(a) Number of Invitations and responses



(b) Invitations and responses by organization



(c) Invitations and responses in government agencies



(d) Organizations of respondents

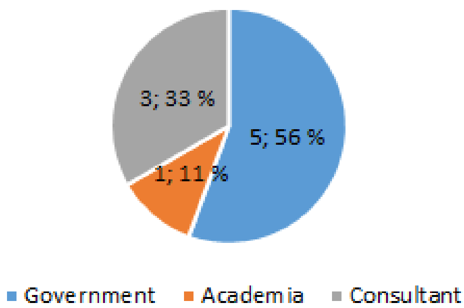


Figure 5.5 Statistics on invitations and responses to the survey in Norway (NVE=Norwegian Water Resources and Energy Directorate; NGU=Norwegian Geological Survey; SVV=Statens Vegvesen; JBV=Jernbaneverket; DSB=Norwegian Directorate for Civil Protection).

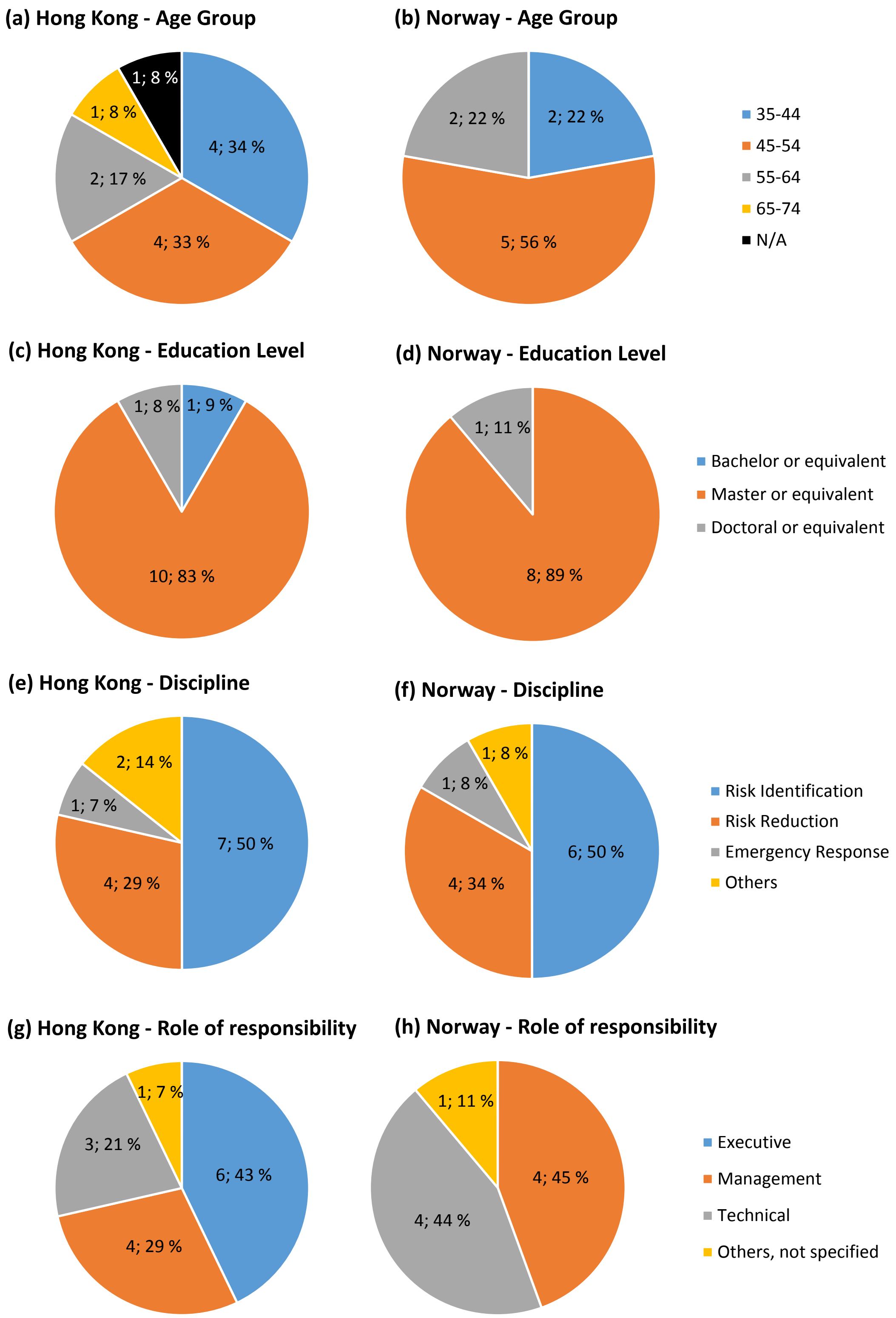


Figure 5.6 Background of respondents in Hong Kong and Norway. Some respondents have more than one job discipline and role of responsibilities.

5.2.2 Survey response for 2nd Questionnaire and fields of expertise

Both Hong Kong and Norway received 7 responses for the second questionnaire. All of the respondents, except one from Norway, also answered the first questionnaire. Figure 5.7 summarizes the disciplines in landslide risk management with which the respondents are most familiar. The majority of respondents from Hong Kong and Norway are familiar with risk identification (RI) and risk reduction (RR). Some respondents from Hong Kong are familiar with disaster management (DM) while only one respondent from Norway is. For governance and financial protection (FP), only one respondent from Hong Kong is familiar, but none of the respondents from Norway is.

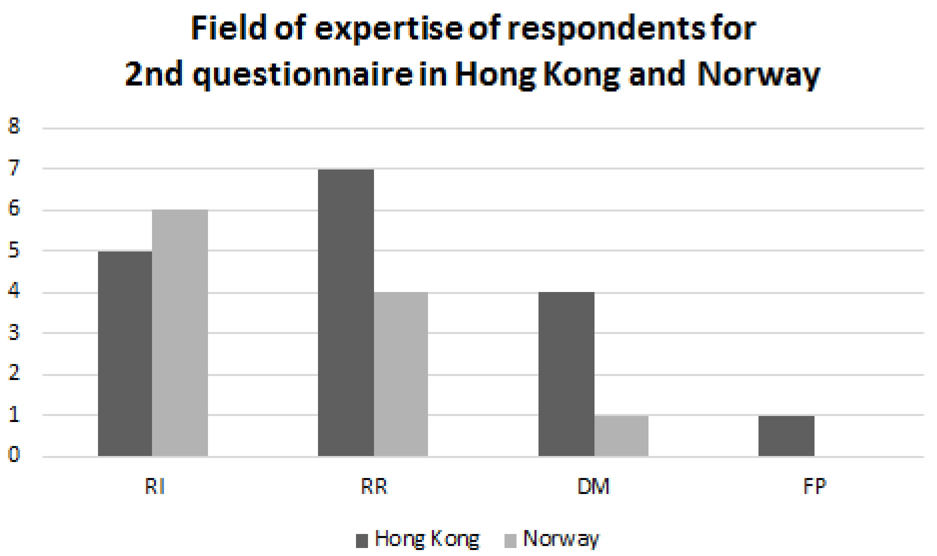


Figure 5.7 Field of expertise of respondents for 2nd questionnaire in Hong Kong and Norway. Note that respondents can have more than one field of expertise.

5.2.3 National level results of Hong Kong and Norway

5.2.3.1 Values of component indicators

This section focuses on the survey results in Hong Kong and Norway at a national level. Results from each territory are presented and compared.

Figure 5.8 shows the values of component indicators in 2004, 2014 and 2024 given by all respondents. Values from 1 to 5 are equivalent to the five performance levels from ‘low’ to ‘optimal’. Values for Hong Kong and Norway are presented separately in the figure. Distribution of the values of each component indicator for each year can be studied in the upper part of each territory’s figure, whereas the corresponding median values are shown in the lower part indicating pattern and trend. The median values presented have been rounded down to the nearest integers.

The distribution plots of both territories in Figure 5.8 also provide information about which component indicators respondents chose not to answer either due to lack of knowledge or irrelevance of the question. One to two respondents from both Hong Kong and Norway left chose not to answer *RR2 Hydrographic basin intervention and environmental protection* and *FP4 Implementation of social safety net and funds response*. Single respondents left the question open also for other component indicators in the RR, DM and FP public policies.

Hong Kong

Component indicators in the RI, RR and DM public policies of Hong Kong generally have higher median values than those in the FP public policy throughout the two decades. This is also indicated by the larger proportion of green and blue in the distribution plot for RI, RR and DM than for FP, meaning that these component indicators are mainly perceived to be ‘outstanding’ or ‘optimal’. In addition, based on the median values, improvement from 2004 to 2024 is generally perceived for most the component indicators. The degree of improvement within 10 years is mostly one performance level, except for *DM5 Community preparedness and training*, for which the improvement from 2014 to 2024 is perceived to be in terms of two performance levels. Five of the component indicators, including *RR4 Housing improvement and human settlement relocation from prone-areas, DM1 Organization and coordination of emergency operations, DM6 Rehabilitation and reconstruction planning, FP3 Budget allocation and mobilization and FP6 Housing and private sector insurance and reinsurance coverage* do not show any improvement throughout the decades.

Norway

Among all four public policies, the median values of the component indicators for Norway are comparable. The evolution of the median values of the component indicators in the RI, RR and DM public policies are mostly the same: from ‘incipient’ in 2004, to ‘significant’ in 2014, and to ‘outstanding’ in 2024. Median values of FP component indicators do not follow this trend because some of the component indicators remain as ‘significant’ for one to two decades. It can also be schematically observed that the values of the component indicators for Norway are smaller than those for Hong Kong since yellow and gray dominate the distribution plot for Norway. In addition, none of the median values reaches the highest performance level at any time point.

Comparisons between Hong Kong and Norway

Figure 5.9 enables quantitative comparisons of the performance of individual component indicators between Hong Kong and Norway. Figure 5.9 shows that more component indicators are perceived to have better performance in Hong Kong than in Norway. These component indicators belong only to the RI, RR and DM public policies. The differences between these median values are mostly one performance level at any time point, except for *RR5 Updating and enforcement of safety standards and construction codes, DM1 Organization and coordination of emergency operations* and DM2 *Emergency response planning and implementation of warning systems*, for which Hong Kong led by two performance levels, mainly in 2004.

Both territories are perceived to perform similarly in several component indicators, especially *RI5 Public information and community participation* and *DM4 Simulation, updating and test of inter institutional response*.

On the other hand, Norway is perceived to perform better than Hong Kong mainly in DM and FP public policies. The better performance for these component indicators is mostly by one performance level in 2004 and 2014, whereas by two to three performance levels in 2024. It is observed that Norway performs much better than Hong Kong in *FP4 Implementation of social safety nets and funds response* and *FP5 Insurance coverage and loss transfer strategies of public assets*.

Based on occupational backgrounds

In the beginning of the survey, respondents are asked to provide information about their occupation, such as their affiliated organization, job discipline and role of responsibility. Based on the available data, most of the respondents from Hong Kong and Norway are categorized according to their occupational backgrounds into the following: (1) affiliated organization: public or private organization; (2) job discipline: risk identification or risk reduction; (3) role of responsibility: management or technical. Note that some respondents have multiple job disciplines, roles or responsibilities.

Figure 5.10 presents how the median values of component indicators differ versus each other in each territory. For instance, it is observed that respondents from both territories who work in the public sector give a less positive validation than those in the private sector. However, respondents in the public sector in Hong Kong give better ratings for year 2024 for most of the DM component indicators, as well as component indicators about budget and funds (FP3 and FP4 respectively), than those in the private sector. No significant difference in the validation can be observed between respondents working in risk identification and risk reduction. An exceptions is those in Norway who work with risk reduction perceive slightly better performance in the RI public policy than those who work with risk identification. For different roles of responsibility, it is noticed that respondents from Hong Kong who have management roles give less positive ratings for RI and FP component indicators, whereas those from Norway generally give better ratings for the component indicators in all the public policies.

Tier 1 and Tier 2

Two respondents from Hong Kong answered both Tier 1 and Tier 2 in the first questionnaire. Results between the two tiers for each respondent are compared as shown in Figure 5.11. One to two performance levels of discrepancies and sometimes even three levels are observed. One of the respondents (respondent A in Figure 5.11) has discrepancies between two tiers for most of the component indicators for 2004, and some for 2014 and 2024. Most of the respondent's answers for Tier 1 are more positive than Tier 2. The other respondent (Respondent B) has discrepancies in his answers for almost all of the component indicators for 2014, most for 2024 and some for 2004. On the contrary, this respondent has more negative answers for Tier 1 than Tier 2.

A number of component indicators are highlighted in Figure 5.11 indicate those which have a consistent direction of discrepancies for each of the respondents throughout the year. These include all DM component indicators, most FP component indicators and two RI and RR component indicators.

The differences in the answers between Tier 1 and Tier 2 for all respondents in Hong Kong and Norway are schematically shown in Figure 5.12. The valuation in Tier 1 is generally more positive in 2004 and 2024 but more negative in 2014 for Hong Kong. On the other hand, the valuation in Tier 1 is generally more positive for all the years for Norway.

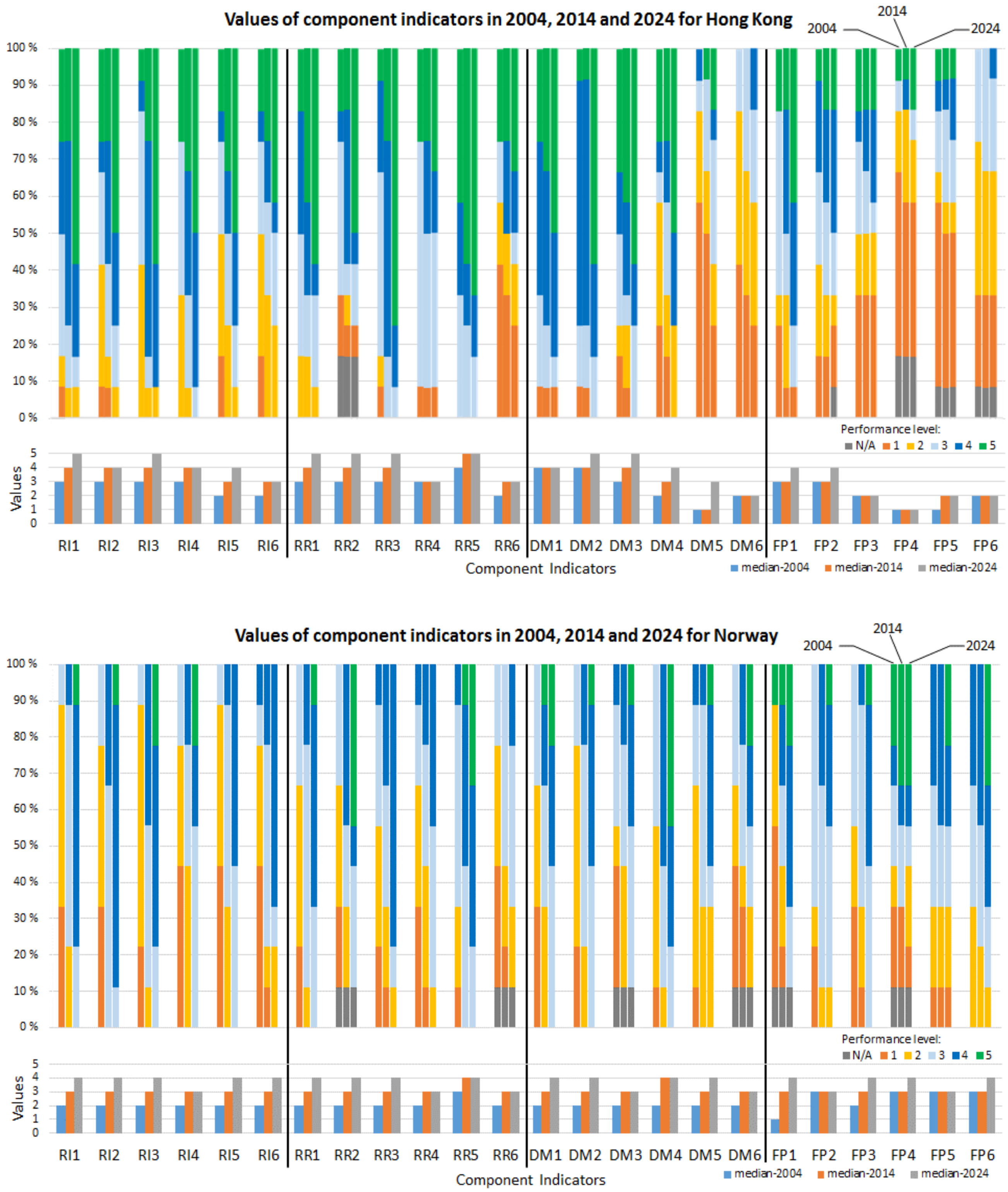


Figure 5.8 Values of component indicators in 2004, 2014 and 2024 for Hong Kong (top) and Norway (bottom). The upper part of each figure for each territory represents the distribution of performance levels (1 to 5) rated by the respondents from the territory for each component indicator, whereas the lower part shows the corresponding median value for each component indicator. (Performance levels: 1='low', 2='incipient', 3='significant', 4='outstanding', 5='optimal')

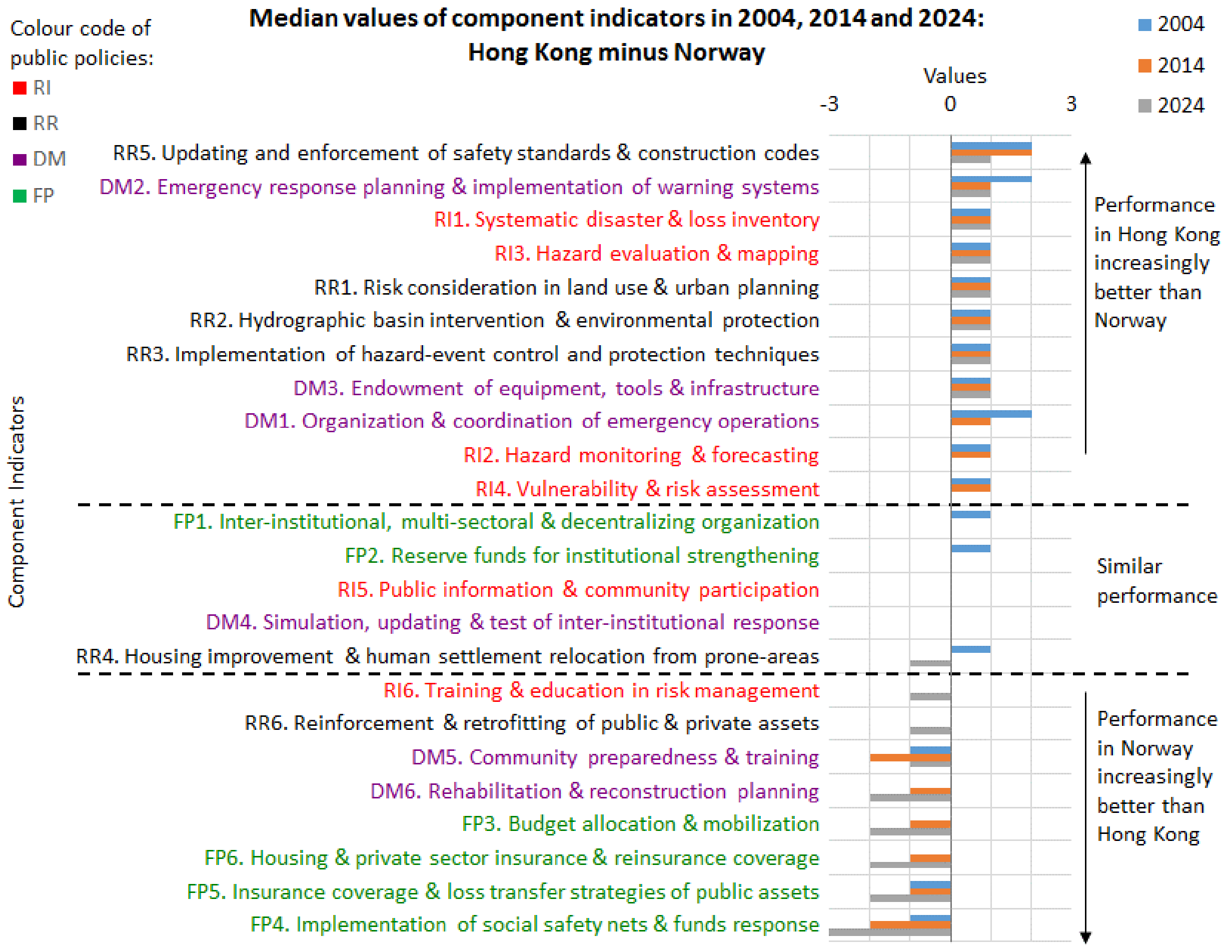


Figure 5.9 Performance comparisons between Hong Kong and Norway for each component indicator in 2004, 2014 and 2024 based on median differences. The component indicators are arranged by descending order of the median differences first in 2004 and then in 2024. This allows to see which component indicators are perceived to have better performance in Hong Kong and Norway, as well as similar performance in both territories, as indicated by the black dotted lines.

Figure 5.10 Median differences of values of component indicators in 2004, 2014 and 2024 in Hong Kong and Norway based on selected categories of occupational backgrounds, including affiliated organizations (public vs private sectors), job disciplines (risk identification vs risk reduction), and roles of responsibility (management vs technical). Also note the limited independence among categories of occupational backgrounds.

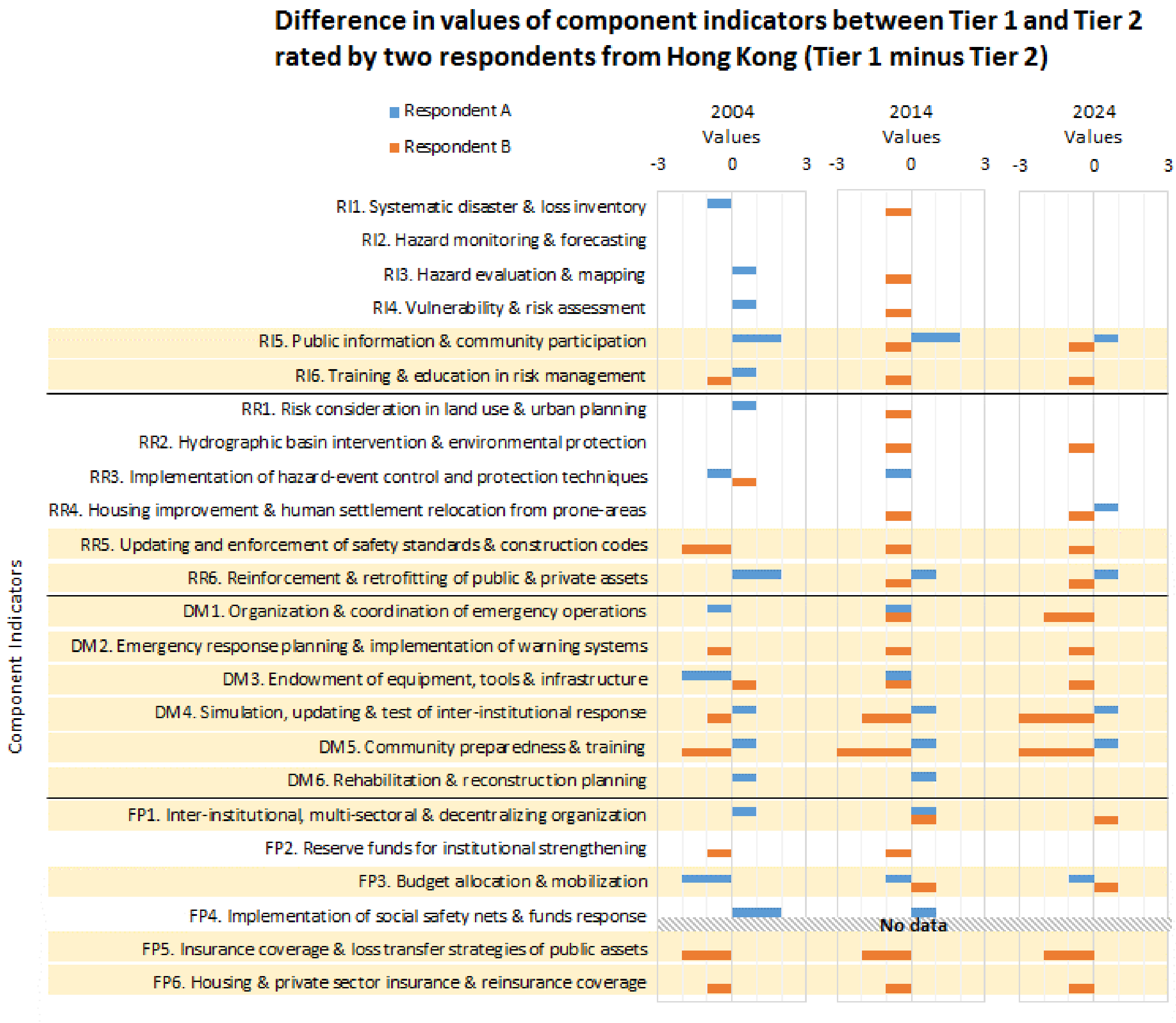


Figure 5.11 Difference in values of component indicators between Tier 1 and Tier 2 by two respondents (A and B) from Hong Kong who have answered both tiers in the questionnaire. The highlighted rows refer to those component indicators that have a consistent direction of discrepancies for both respondents in 2004, 2014 and 2024.

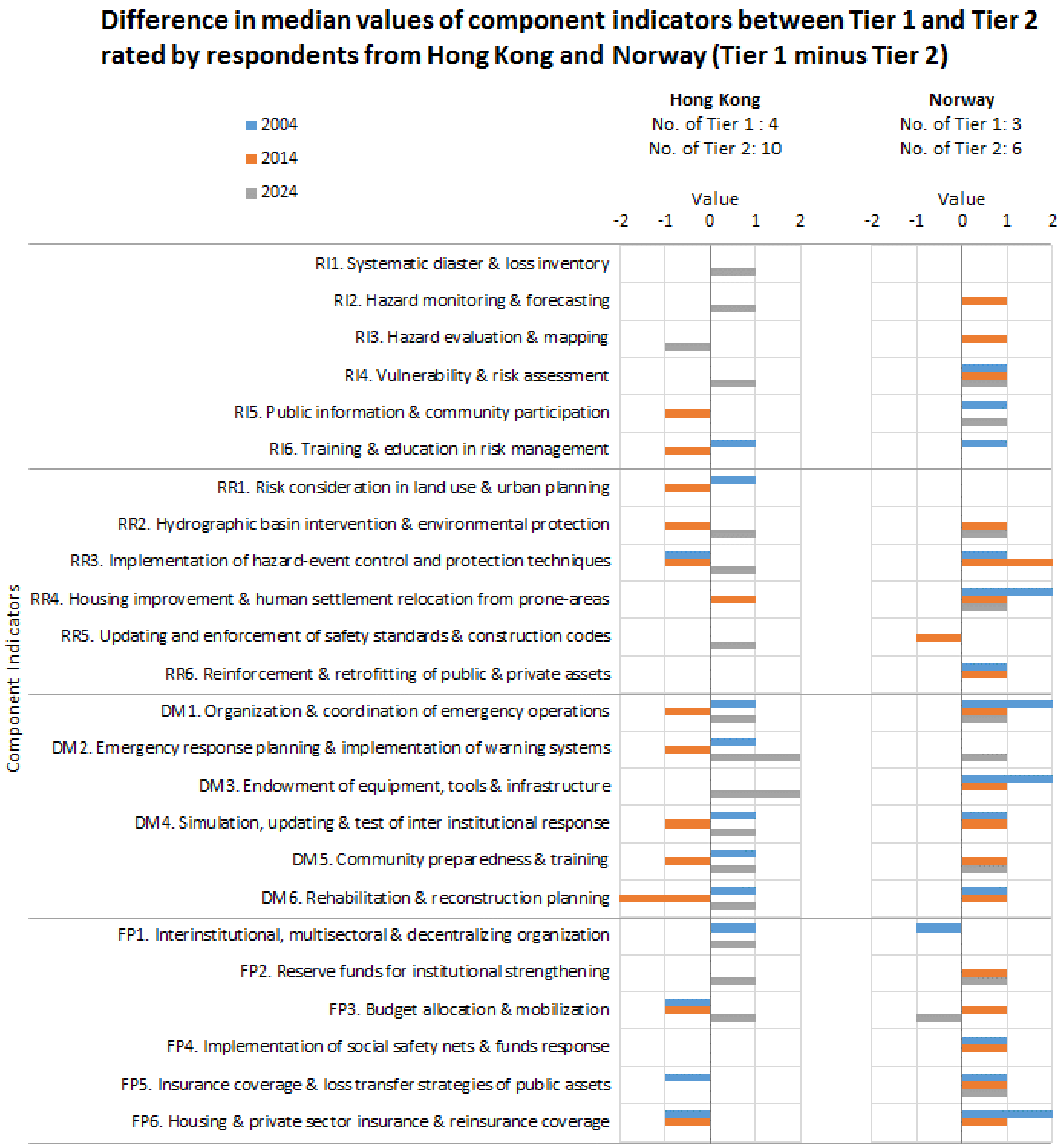


Figure 5.12 Difference in median values of component indicators between Tier 1 and Tier 2. For Hong Kong, 4 and 10 sets of results are obtained for Tier 1 and Tier 2, respectively. Note that two respondents from Hong Kong have answered both tiers (see also Figure 5.11). For Norway, 3 and 6 sets of results are obtained for Tier 1 and Tier 2, respectively.

5.2.3.2 AHP weights

<u>Missing or inconsistent data</u>

Three comparison matrices for Hong Kong in RI, DM and FP from two respondents have missing values in one to two entries. Since these respondents have provided validation of the corresponding component indicators, it is assumed that the entries here are left blank by mistake. Therefore, as suggested, any missing values are replaced by 1, i.e. equal importance between two component indicators.

Four out of 26 and ten out of 28 comparison matrices for Hong Kong and Norway respectively have consistency ratios (CR) greater than 0.1. The original CR of these comparison matrices range from 0.10 to 0.33. These matrices are re-examined and modified based on the graphical method described in section 3.3.2 to an acceptable consistency. Details regarding the modifications of these comparison matrices are found in Appendix L. Table 5.3 summarizes the pairs of component indicators in each public policy that are more commonly inconsistent. Inconsistent entries exist in results concerning all four public policies, particularly for RI and RR public policies for Hong Kong and RR and DM public policies for Norway.

Table 5.3 Pairwise comparisons that are more commonly inconsistent in responses for Hong Kong and Norway. The number of comparison matrices with CR > 0.1 for each territory is also summarized.

<table>
<tr><th rowspan="2">Public policy</th><th rowspan="2" colspan="6">More commonly inconsistent comparison pair</th><th colspan="2">Number of inconsistent comparison matrix</th></tr>
<tr><th>Hong Kong (Total = 26)</th><th>Norway (Total = 28)</th></tr>
<tr><td rowspan="3">RI</td><td rowspan="2">RI1</td><td rowspan="2">Systematic disaster & loss inventory</td><td rowspan="8">vs</td><td>RI5</td><td>Public information & community participation</td><td rowspan="3">2</td><td rowspan="3">2</td></tr>
<tr><td>RI6</td><td>Training & education in risk management</td></tr>
<tr><td>RI3</td><td>Hazard evaluation & mapping</td><td>RI4</td><td>Vulnerability & risk assessment</td></tr>
<tr><td>RR</td><td>RR5</td><td>Updating and enforcement of safety standards & construction codes</td><td>RR6</td><td>Reinforcement & retrofitting of public & private assets</td><td>2</td><td>3</td></tr>
<tr><td rowspan="2">DM</td><td>DM1</td><td>Organization & coordination of emergency operations</td><td>DM2</td><td>Emergency response planning & implementation of warning systems</td><td rowspan="2">1</td><td rowspan="2">3</td></tr>
<tr><td>DM5</td><td>Community preparedness & training</td><td>DM6</td><td>Rehabilitation & reconstruction planning</td></tr>
<tr><td>FP</td><td>FP2</td><td>Reserve funds for institutional strengthening</td><td>FP3</td><td>Budget allocation & mobilization</td><td>1</td><td>1</td></tr>
</table>

Hong Kong and Norway

After correcting the comparison matrices to acceptable consistencies, a representative set of AHP weights for each composite indicator (representing each public policy) is obtained for Hong Kong and Norway, as summarized in Table 5.4 and Figure 5.13. The relative weights of individual component indicators are also compared between Hong Kong and Norway in Figure 5.14.

Both territories have similar distributions of relative weights for RI and RR public policies. For example, both territories put the highest relative weight on *RI3 Hazard evaluation and mapping* and *RR1 Risk consideration in land use and urban planning* (Table 5.4 and Figure 5.13). Similar relative weights are also obtained in many of the component indicators in these two public policies, such as *RI1 Systematic disaster and loss inventory* and *RI6 Training and education in risk management* (Figure 5.14).

The distribution of weights for DM and FP public policies vary the most between Hong Kong and Norway. *DM2 Emergency response planning and implementation of warning systems* and *FP3 Budget allocation and mobilization* in Hong Kong have the highest relative weights in their corresponding public policy, while *DM5 Community preparedness and training* and *FP6 Housing and private sector insurance and reinsurance coverage* in Norway. In particular, FP3, DM5 and FP6 mentioned above depict the greatest differences in relative weights between the territories (Figure 5.14). In addition, respondents from Hong Kong also give a much higher relative weight on FP2 Reserve funds for institutional strengthening than those from Norway (Figure 5.14).

Experts' opinions

Opinions on the relative importance among component indicators are also compared between experts and all respondents. For these two sample groups, comparisons are made by studying the difference in the values (blue bars in Figure 5.15) and the degree of divergence (red boxes in Figure 5.15) between the two sample groups. The comparisons are only available for RI and DM component indicators for Hong Kong and RR component indicators for Norway. This is due to the limited number of experts or non-experts. According to Figure 5.15, the differences in relative weights of component indicators between experts and all respondents are less than 5% without any specific trend. Apart from those, the minimal or negative percentage differences in standard deviations apparently indicate that the experts' opinions are less diverged than all respondents' opinions.

Table 5.4 Weights for sets of component indicators of Hong Kong (left) and Norway (right).

Hong Kong						Norway				
Weight	**RI**	**RR**	**DM**	**FP**		**Weight**	**RI**	**RR**	**DM**	**FP**
w_1	0.12	0.26	0.19	0.12		w_1	0.12	0.29	0.16	0.16
w_2	0.14	0.13	0.23	0.16		w_2	0.15	0.10	0.20	0.08
w_3	0.22	0.20	0.15	0.29		w_3	0.27	0.16	0.10	0.15
w_4	0.20	0.14	0.15	0.14		w_4	0.18	0.17	0.13	0.17
w_5	0.17	0.16	0.17	0.15		w_5	0.13	0.17	0.25	0.18
w_6	0.16	0.11	0.12	0.14		w_6	0.15	0.10	0.16	0.26

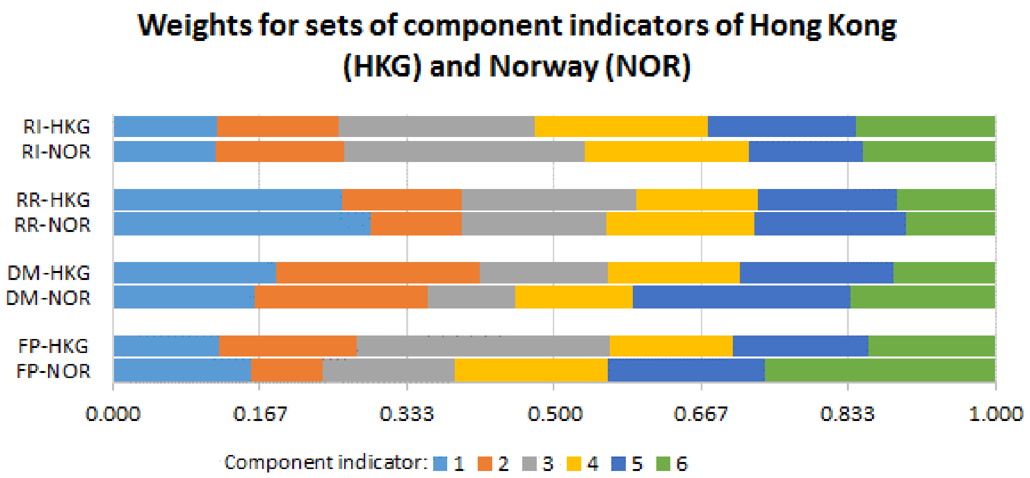


Figure 5.13 Weights for sets of component indicators of Hong Kong and Norway. Note that although all w_1 (same for w_2, w_3, etc.) have the same color, they are not related.

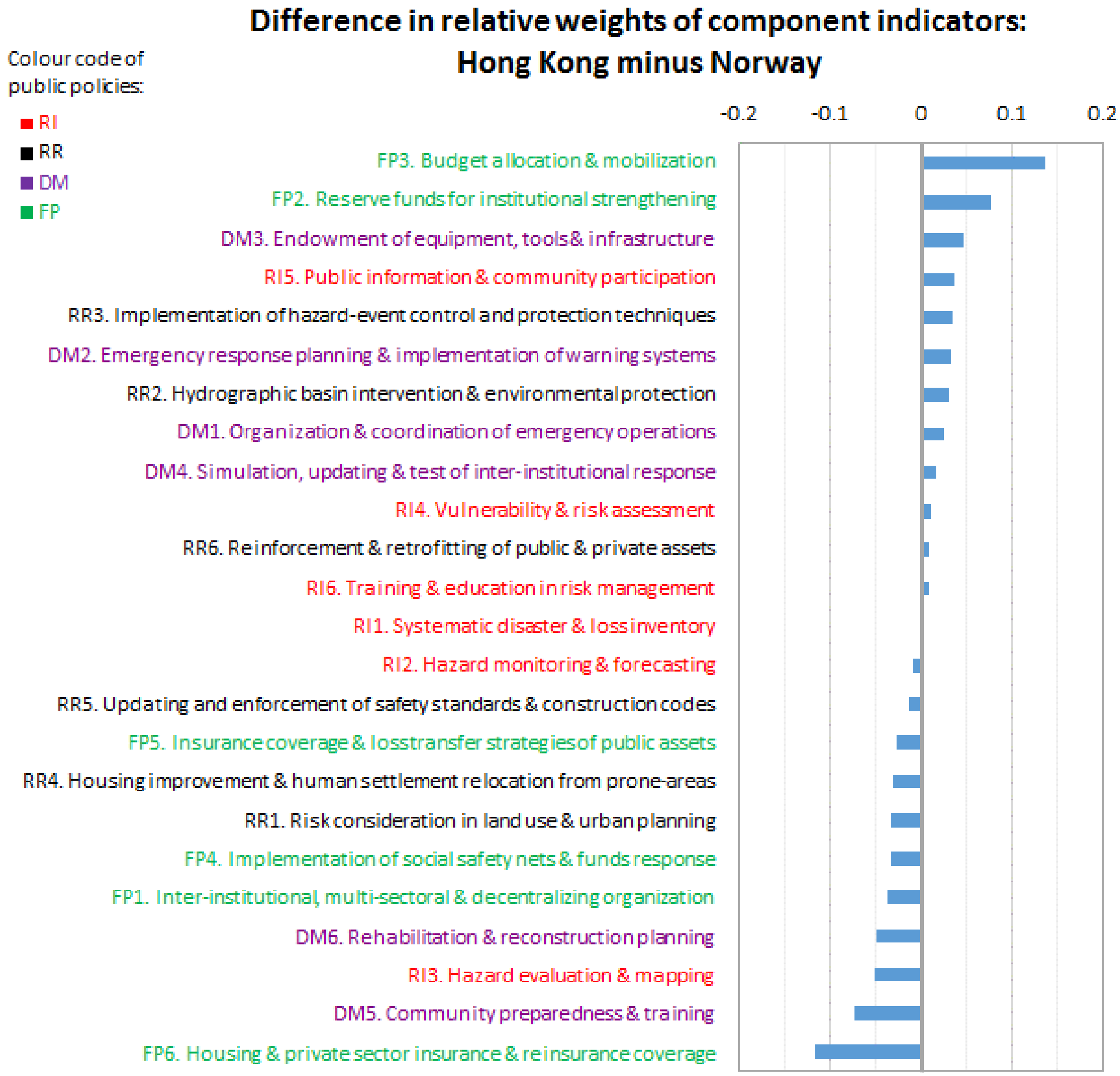


Figure 5.14 Difference in weights of component indicators given by all respondents between Hong Kong and Norway.

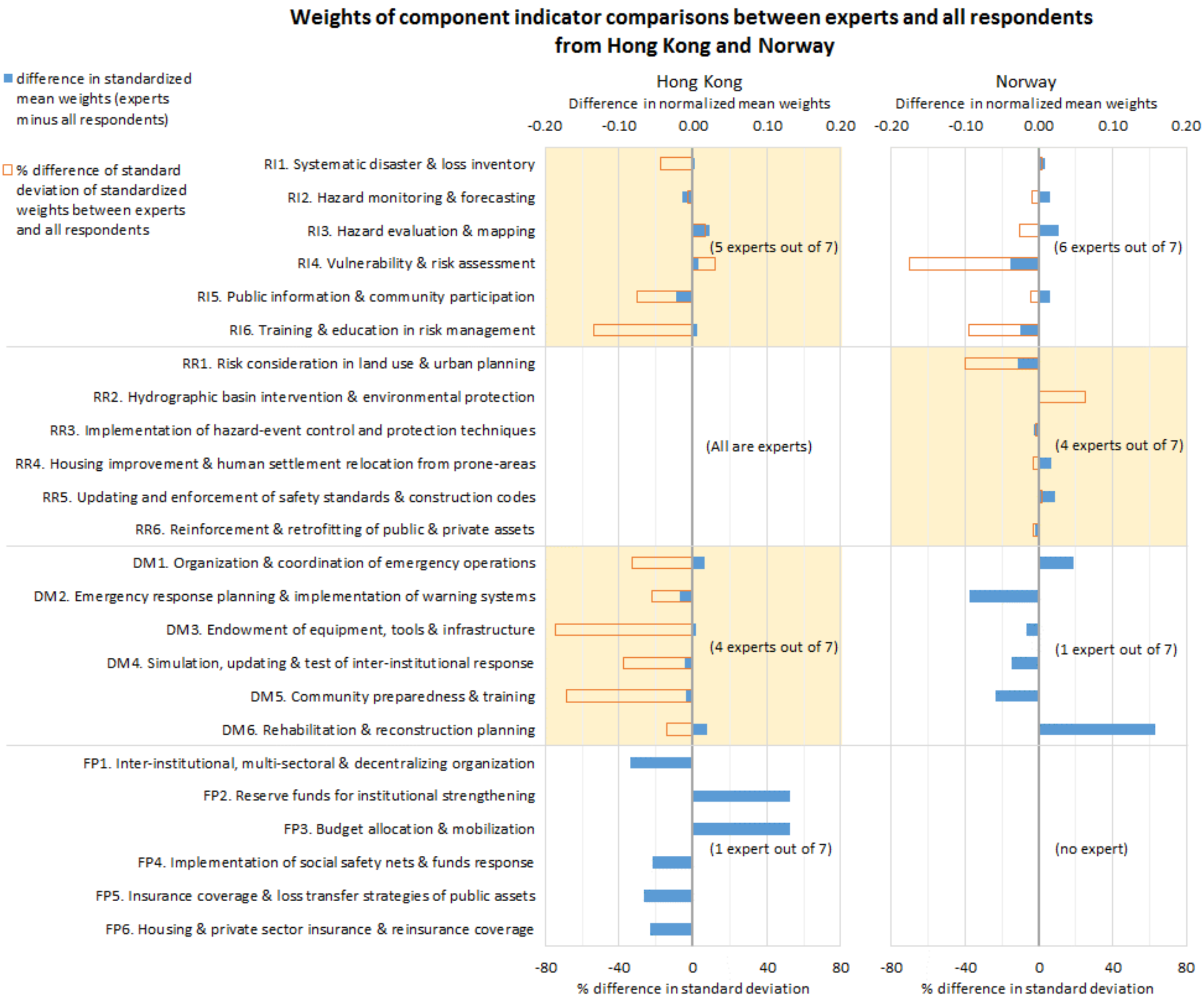


Figure 5.15 Comparisons of weights of component indicators given between experts and all respondents from Hong Kong and Norway. The blue bars (with respect to upper x-axis) represent the difference in normalized mean weights (w) calculated from the data given by experts and all respondents: $w_{expert} - w_{all}$. The red boxes (with respect to lower x-axis) represent the percentage difference of standard deviation of standardized weights (σ) between experts and all respondents: $\frac{\sigma_{expert} - \sigma_{all}}{(\sigma_{expert} + \sigma_{all})/2} \times 100\%$. The percentage difference of standard deviation is used as a tool to measure the degree of divergence in the opinions among each respondent group. Highlighted: such comparison is only valid when there are at least two experts and non-experts in a public policy.

5.2.3.3 RMI results

Considering all survey data, the landslide risk management indices, including RMI_{RI}, RMI_{RR}, RMI_{DM}, RMI_{FP} and RMI from 2004 to 2024 are calculated and summarized in Table 5.5 and Figure 5.16.

Table 5.5 Landslide risk management indices for Hong Kong and Norway in 2004, 2014 and 2024.

<table>
<tr><th></th><th colspan="3">Hong Kong</th><th colspan="3">Norway</th></tr>
<tr><th>Year / Index</th><th>2004</th><th>2014</th><th>2024</th><th>2004</th><th>2014</th><th>2024</th></tr>
<tr><td>RMI_{RI}</td><td>39.96</td><td>62.56</td><td>71.72</td><td>17.26</td><td>45.17</td><td>67.96</td></tr>
<tr><td>RMI_{RR}</td><td>46.86</td><td>66.28</td><td>70.65</td><td>25.68</td><td>48.60</td><td>64.57</td></tr>
<tr><td>RMI_{DM}</td><td>49.52</td><td>57.49</td><td>65.40</td><td>17.26</td><td>47.80</td><td>64.82</td></tr>
<tr><td>RMI_{FP}</td><td>29.47</td><td>29.59</td><td>36.77</td><td>40.70</td><td>45.17</td><td>64.99</td></tr>
<tr><td>Largest difference in above</td><td>20.05</td><td>36.69</td><td>34.95</td><td>23.44</td><td>3.43</td><td>3.39</td></tr>
<tr><td>RMI</td><td>41.45</td><td>53.98</td><td>61.13</td><td>25.23</td><td>46.68</td><td>65.58</td></tr>
<tr><td>Year / Landslide Inventory data</td><td>1995-2004</td><td>2005-2014</td><td rowspan="4">n/a</td><td>1995-2004</td><td>2005-2014</td><td rowspan="4">n/a</td></tr>
<tr><td>Landslide density (Average annual landslides per km^2)</td><td>0.221</td><td>0.228</td><td>0.0026</td><td>0.0046</td></tr>
<tr><td>Total landslide fatalities</td><td>7</td><td>3</td><td>11</td><td>20</td></tr>
<tr><td>Average Population</td><td>6.6 M</td><td>7.0 M</td><td>4.5 M</td><td>4.8 M</td></tr>
</table>

<u>Composite indicators RMI_{RI}, RMI_{RR}, RMI_{DM}, RMI_{FP}</u>

The policy indices for Hong Kong range from 29 to 72 (Figure 5.16). RMI_{RI} and RMI_{RR} are the highest in general throughout the years, whereas RMI_{FP} is constantly significantly lower than the other indices. Improvement for Hong Kong is observed for all public polices from 2004 to

2014, but only relatively little improvement has been evaluated for FP. In addition, the difference between the highest and lowest indices fluctuates between 20 and 37 from 2004 to 2024 (Table 5.5).

The policy indices for Norway range from 17 to 68 (Figure 5.16). Perception of performance in landslide risk management in terms of public policies in Norway has structural changes throughout the decades. In 2004, RMI_{RI} and RMI_{DM} are around 50% lower than RMI_{RR} and RMI_{FP}. In 2014, all indices increase to comparable values. Finally, in 2024, Norway is perceived to improve in all four public policies and sustain its all-round performance. As a result, the largest difference among the indices decreases from about 23 to 3 from 2004 to 2014 and stays at 3 in 2024 (Table 5.5).

RMI

RMI for Hong Kong ranges from 41 to 61, and 25 to 65 for Norway from 2004 to 2024 (Table 5.5 and Figure 5.16). Hong Kong leads Norway in 2004 and 2014, since the risk management indices for RI, RR and DM for Hong Kong are higher in 2004. However, it is perceived that Norway will improve to perform slightly better than Hong Kong by 2024, since it is perceived that Norway will begin to perform significantly better in FP in 2014 and 2024. In addition, both territories are perceived to improve in landslide risk management. A smaller degree of improvement is observed from 2014 to 2024 than from 2004 to 2014 for Hong Kong, whereas improvement is steady from 2014 to 2024 for Norway.

Relationships with existing landslide inventory data

Data of total landslide fatalities and landslide density during 1995-2004 and 2005-2014 for both territories are summarized in Table 5.5 and related to the RMI results in 2004 and 2014, respectively.

During both periods, Hong Kong has a higher landslide density, but lower total fatality than Norway. Also, RMI_{RI} and RMI_{RR} in 2004 and 2014 are higher for Hong Kong than for Norway.

Together with RMI_{RI} and RMI_{RR}, the landslide density for both territories increases with time. On the other hand, total fatalities decrease by 57% across the two 10-year periods in Hong Kong, whereas total fatalities doubled in Norway.

Sensitivity Analysis of experts' opinions

Results of the sensitivity analysis of experts' opinions on the RMI results are included in Appendix M. The key results are presented in Figure 5.17.

According to Figure 5.17c & d, negligible changes are observed with increased weights of experts' opinions in AHP weights.

With increased weights of values of component indicators given by experts, significant changes are resulted in some of the policy indices for both countries. In addition, this can lead to notable changes in RMI (see Table N.1). For instance, the RMI for Hong Kong increases by 5-8% throughout the years due to significant increments in RMI_{RI} (13%) and RMI_{DM} (12-15%) in 2004 and RMI_{FP} in 2014 and 2024 (18% and 24% respectively). The RMI for Norway increases slightly by 1-7% in 2004, but decreases by 3-8% in 2014 and 2024. The increment of RMI in 2004 in Norway is due to the positive change in RMI_{DM} (27-30%), whereas the reduced RMI in 2014 and 2024 is accounted for mainly by the decrease in RMI_{RI} (-6--7%) and RMI_{DM} (-6--26%) in both years. As a result, Figure 5.17e to Figure 5.17h show that the RMI of Hong Kong becomes consistently higher than that of Norway.

Tripling the weights of experts' opinions mostly results in a greater influence on the RMI results than doubling the weights (Table N.1). However, in some cases, the opposite occurs due to the coupling between the relative weights and values of the component indicators.

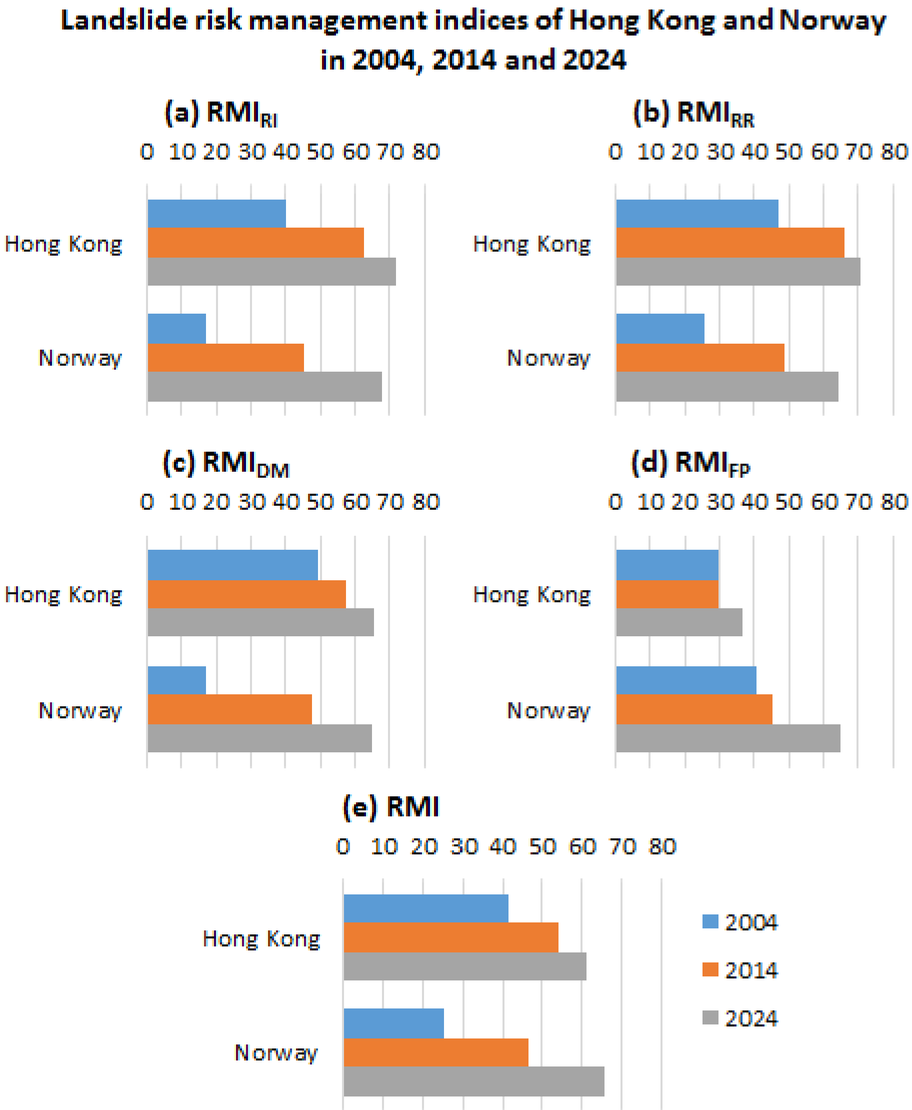


Figure 5.16 Evolution of landslide risk management indices for Hong Kong and Norway.

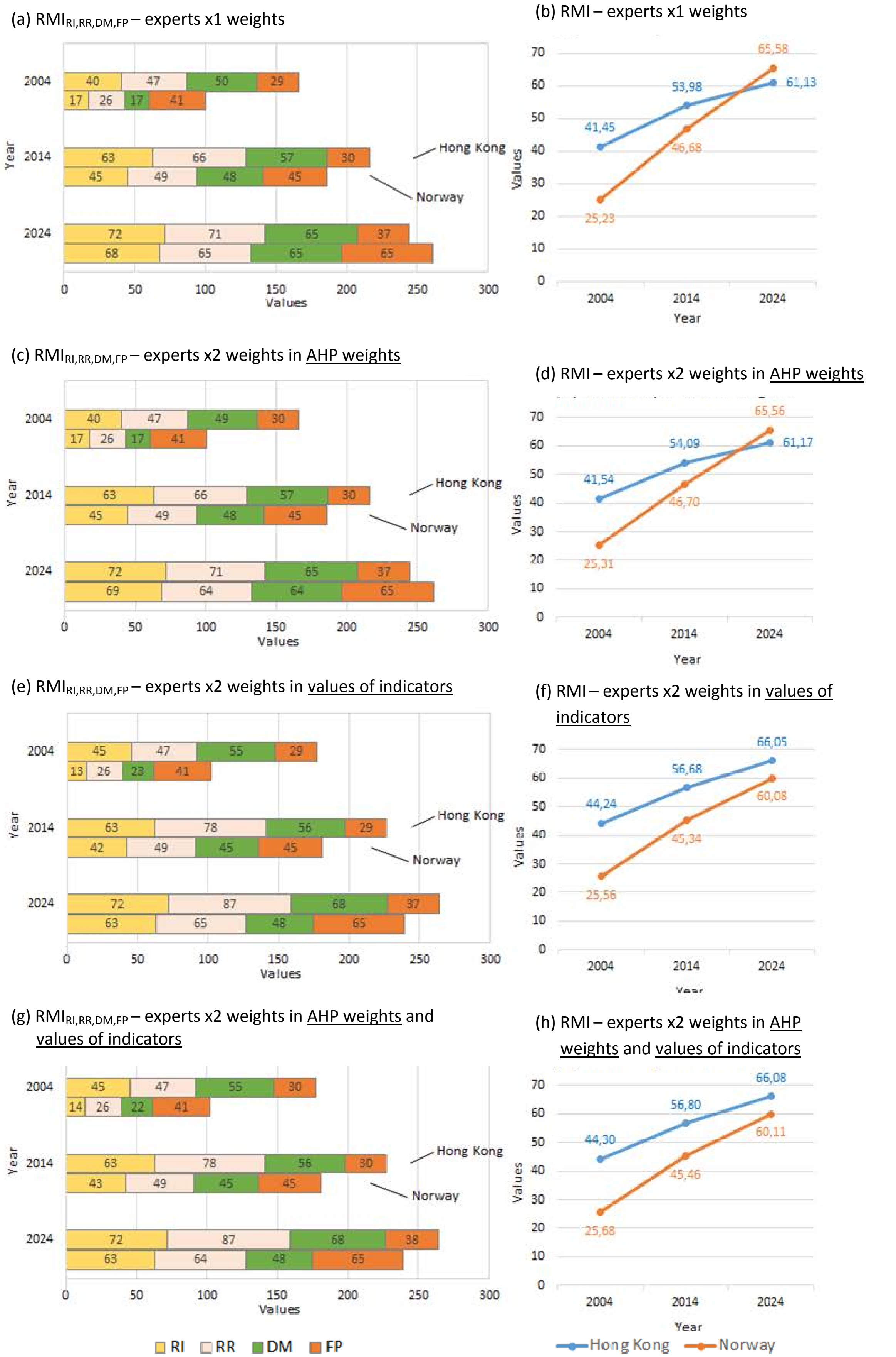


Figure 5.17 Sensitivity analysis of landslide risk management indices from 2004 to 2024 for Hong Kong and Norway based on different relative weights for experts' opinions. (a) & (b): equal weights for each respondent; (c) & (d): double weights for experts' opinions in AHP weights of component indicators; (e) & (f): double weights for experts' opinions in values of component indicators; (g) & (h): double weights for experts' opinions in AHP weights and values of component indicator.

5.2.4 Sub-national level results of Norway

Figure 5.18 shows that six out of eight counties in Norway which are prioritized for collecting survey data receive one to two responses regarding the qualification of component indicators. These counties belong to all the lists except List E in Table 5.2.

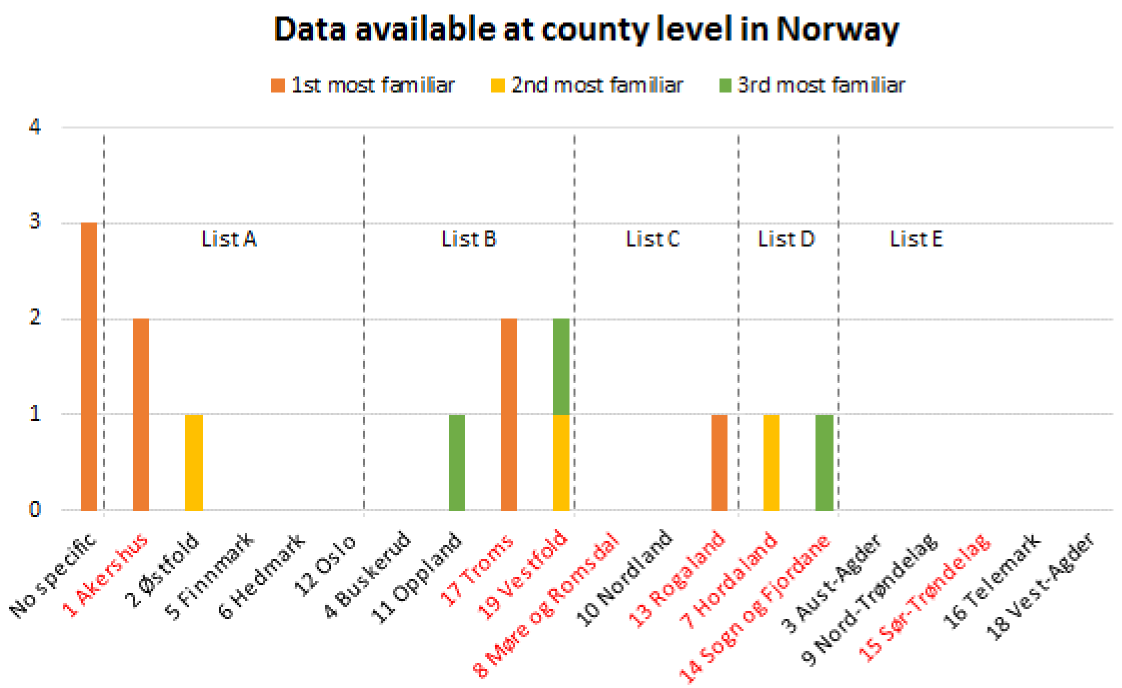


Figure 5.18 County level data available in Norway. The 19 counties of Norway are grouped into five lists (A to E) based on the clustering procedures carried out using extreme values of the GAR2009 landslide hazard data. The counties labelled in red are those at priority in each of the lists for collecting survey data.

5.2.4.1 Values of component indicators

The median values rounded down to the nearest integers of the component indicators of each county and all counties are calculated and summarized in Figure 5.19. These values are compared based on their differences with the median values for all these counties (Figure 5.20). According to Figure 5.20, it is observed that Oppland has the best performance in general with its values of component indicators being generally higher than the counties' medians. Troms is the second best since some of the FP component indicators are not as good as the counties' medians. Median values for Vestfold are comparable to the counties' medians throughout the years. Akershus and Østfold follow. The values for Akershus in RI and RR public policies are lower than the counties' medians mainly only in 2004, but those in DM and FP public policies are perceived to be comparable to the counties' medians. In 2014 and 2024, values of DM and FP public policies for Akershus are occasionally higher than the counties' medians. Østfold has comparable medians in RI and RR public policies, but is deficient in several DM and FP component indicators. The group of counties comprising of Rogaland, Hordaland and Sogn og Fjordane has the poorest performance in general. However, it is worth noting that it has the highest values among all the counties in component indicators including *DM1 Organization and coordination of emergency operations*, *DM4 Simulation, updating and test of inter institutional response* and FP4 *Implementation of social safety nets and funds response*.

5.2.4.2 RMI results

Incorporating the relative importance of component indicators, similar ranking among the counties mentioned above is also observed in the landslide risk management indices. The RMI results obtained for counties in Norway are based on the uncertainty analysis described in Section 3.4.5, for which 2000 random weight samples have been generated. Since only seven sets of AHP weights are obtained from the survey; it is insufficient to visualize any distribution from a histogram (see Appendix O). As a result, the weights here are assumed to be uniformly distributed. The 10th and 90th percentiles of the seven sets of AHP weights for all of Norway (see Appendix I) are used to generate the random weight samples. Results of the uncertainty analysis are presented in Figure 5.21.

1) Oppland, with RMI ranging from 49 to 76, leads the other counties for all the indices in any year.

2) Troms and Vestfold come second and third, with RMI ranging from 33 to 62. Troms leads Vestfold in all the landslide risk management indices, except for RMI_{FP}.

3) Akerhus and Østfold have missing data for qualification of FP component indicators, therefore no RMI_{FP} or RMI are obtained for these counties. Nevertheless, these counties generally have poorer performance than Troms and Vestfold. In particular, Østfold is perceived to perform better in RI and RR then Akershus and vice versa in DM.

4) Rogaland/Hordaland/Sogn og Fjordane has the lowest RMI (27 to 51). This group of counties generally has the lowest RMI_{RI}, RMI_{RR} and RMI_{FP}. Although it has better performance than Østfold and Vestfold in DM in most years, it has the lowest RMI among all the counties.

In addition, there is improvement in all the four public policies in all the counties based on the RMI results from 2004 to 2024. Figure 5.22a shows that the width of confidence bounds classified by public policies are concentrated from around 7 to 9. In addition, the width for FP is generally higher than the other three public policies, thus indicating a larger degree of uncertainty associated with this public policy. The width for the overall RMI is relatively small compared to the other landslide risk management indices. This is probably a result of the averaging procedure. According to Figure 5.22b and c, no appreciable differences in the width of the confidence bounds is observed with respect to years or counties based on the median values. However, the spread of the widths of the confidence bounds is relatively small for year 2014 and Østfold.

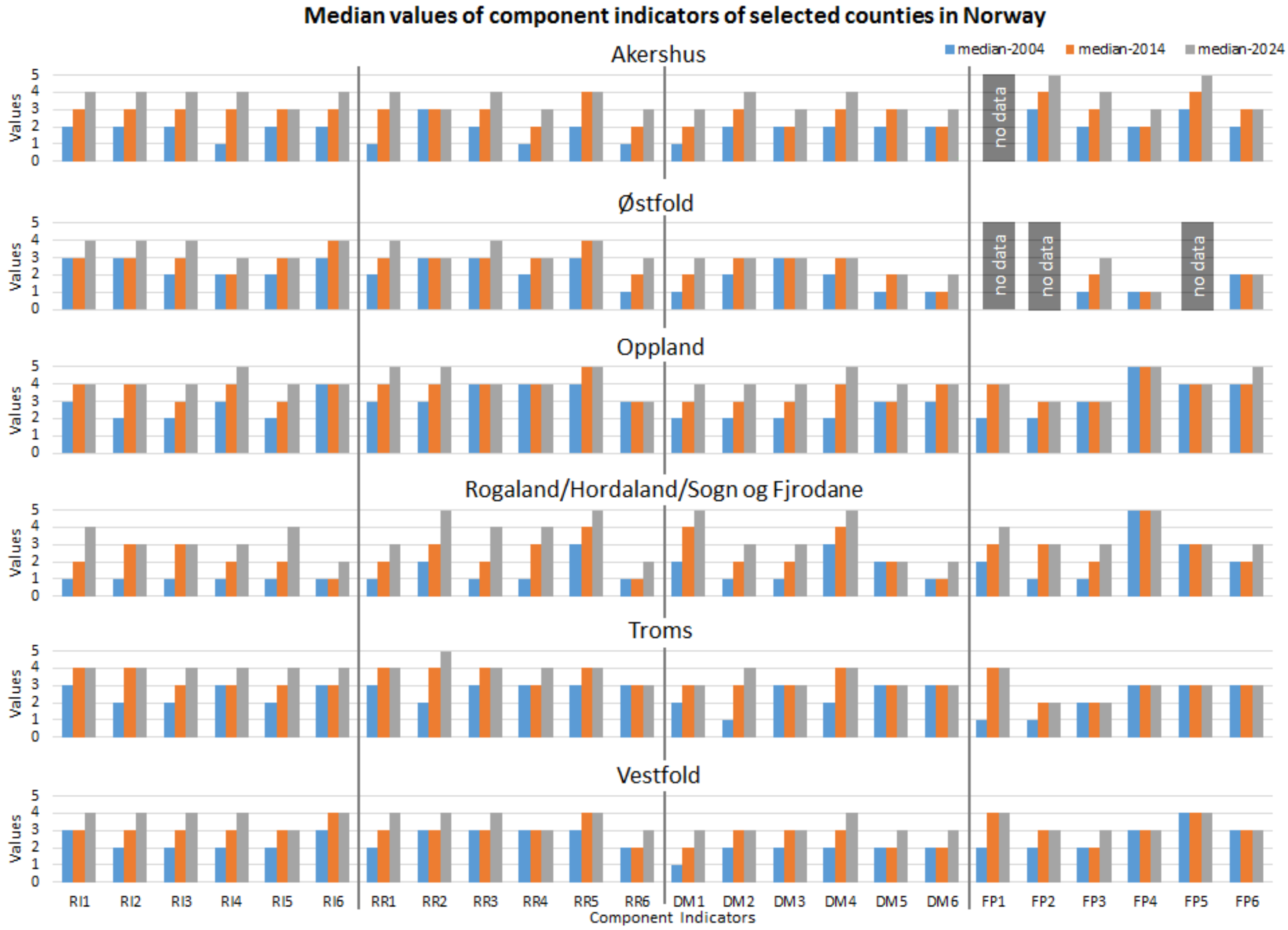


Figure 5.19 Median values of component indicators for selected counties in Norway in 2004, 2014 and 2024. (Performance levels: 1='low', 2='incipient', 3='significant', 4='outstanding', 5='optimal')

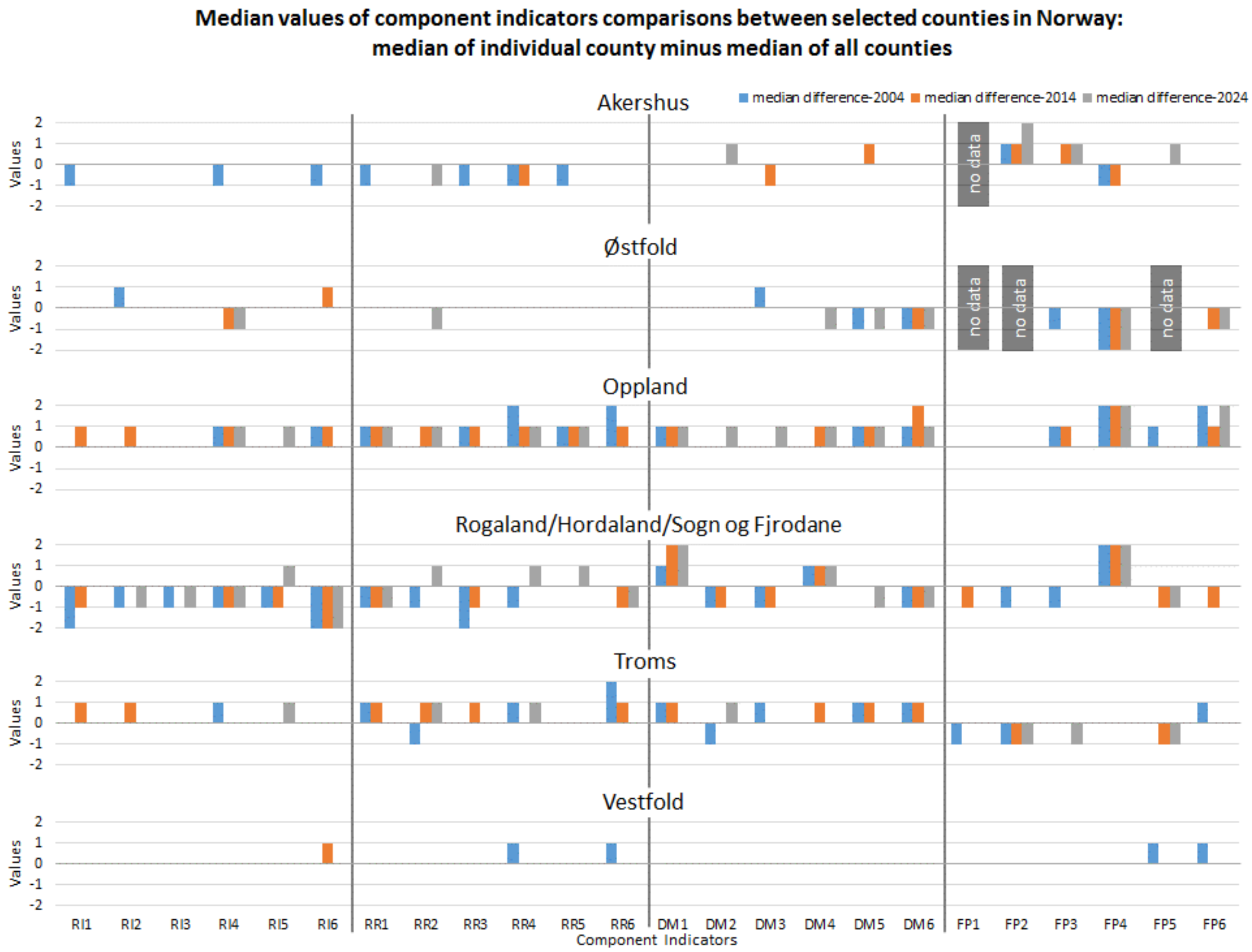


Figure 5.20 Difference of median values of component indicators between individual counties and all the selected counties in Norway in 2004, 2014 and 2024.

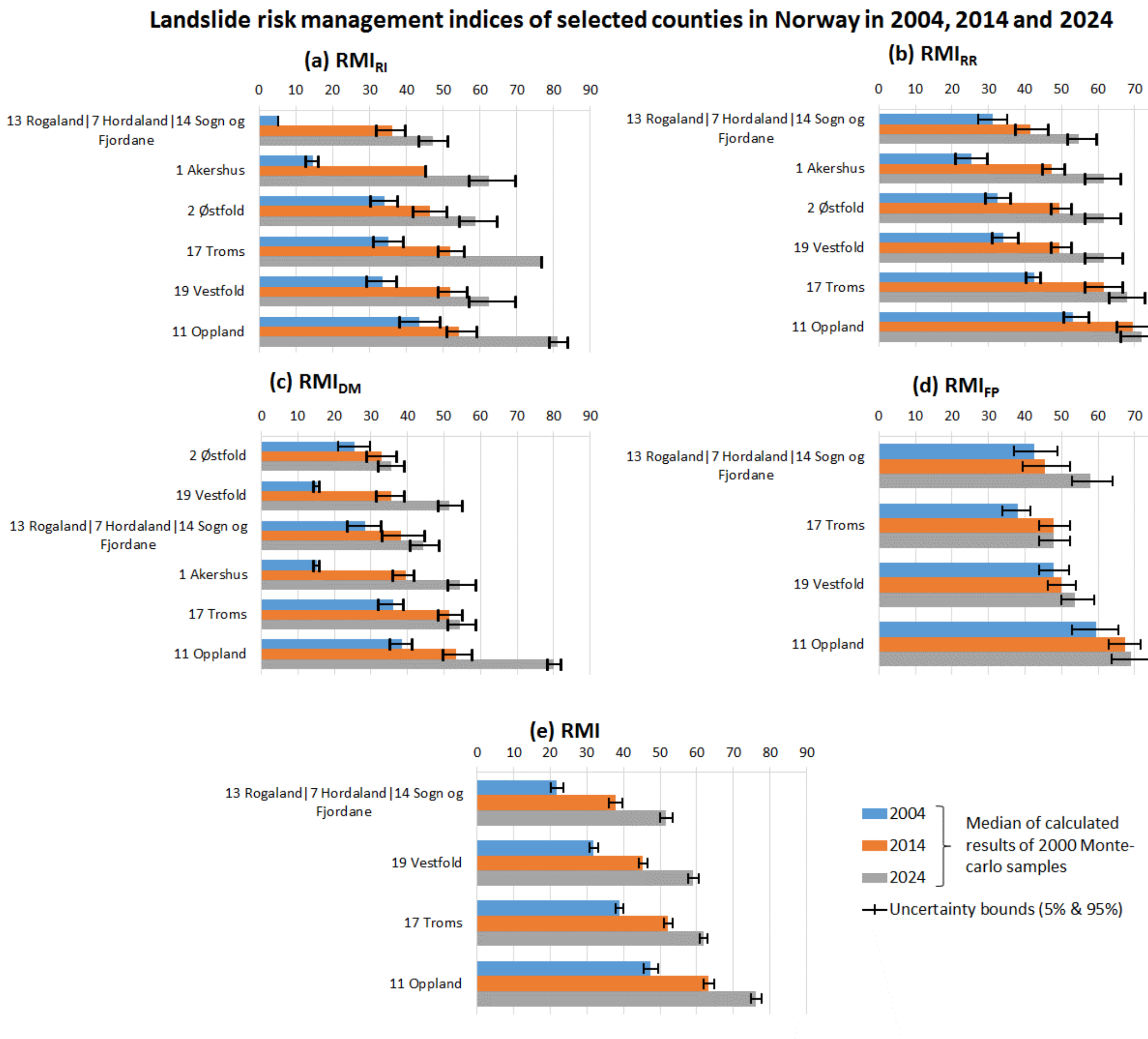


Figure 5.21 Evolution of landslide risk management indices for selected counties in Norway from 2004 to 2024. The counties are arranged in ascending order of the indices in 2014. Akershus and Østfold are not shown in (d) and (e) due to missing data for some FP component indicators.

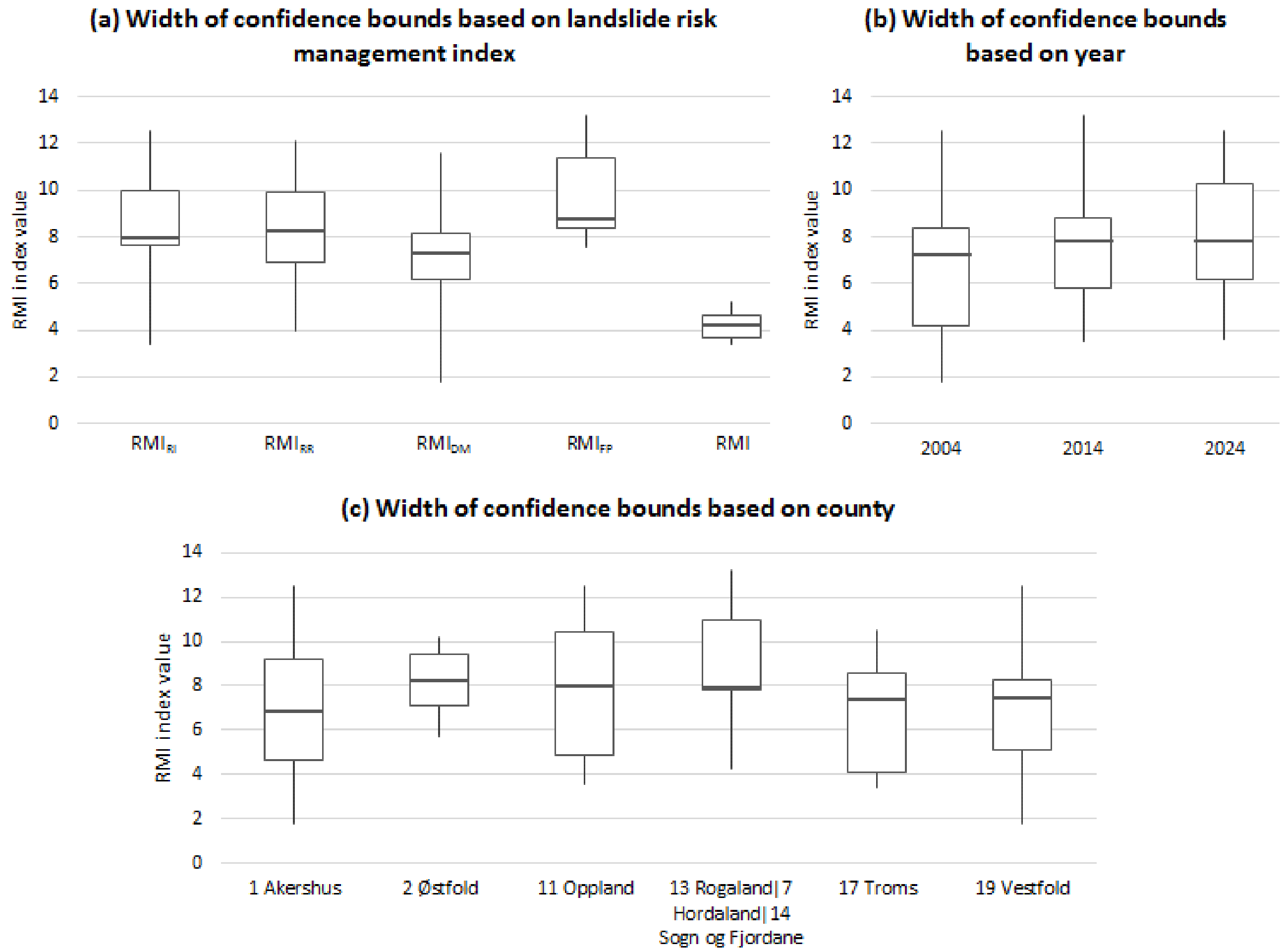


Figure 5.22 Width of confidence bounds based on (a) landslide risk management index, (b) year, and (c) county. The box plots shows the maximum, 75th percentile, median, 25th percentile and minimum of the results.

5.2.4.3 Relationships between RMI results and existing landslide hazards data

For the purpose of studying the relationships between the RMI results and existing landslide hazards data, the RMI results are incorporated into the plots of existing landslide data.

RMI_{RI} and RMI_{RR} in 2004 and 2014 are included in the plots of total fatalities against annual average landslide density during the periods 1995-2004 and 2005-2014, respectively (Figure 5.23). Excluding the inventory data that may be unreliable, it is apparent that both RMI_{RI} and RMI_{RR} decrease with increasing total fatalities and average annual landslide density during the previous 10 years. However, such a trend is neither consistent for Akershus and Rogaland, nor Akershus and Østland for 2014, when considering the policy indices for 2004. On the other hand, comparing the two 10-year periods, even though the total fatalities and landslide densities are generally higher during the latter 10-year period, RMI_{RI} and RMI_{RR} still increase for all the counties from 2004 to 2014.

The RMI results for 2014 are graphed in the plots of landslide hazards data of GAR2009 and Safeland, as shown in Figure 5.24 and Figure 5.25, respectively. Without considering those GAR2009 data that may be underestimated, there exists a general trend of decreasing policy indices and RMI with increasing landslide hazards and risk. Such a trend apparently also exists based on the Safeland data if one considers landslide risk roughly as the product of physical exposure and hazards. However, Østfold does not conform to this trend very well.

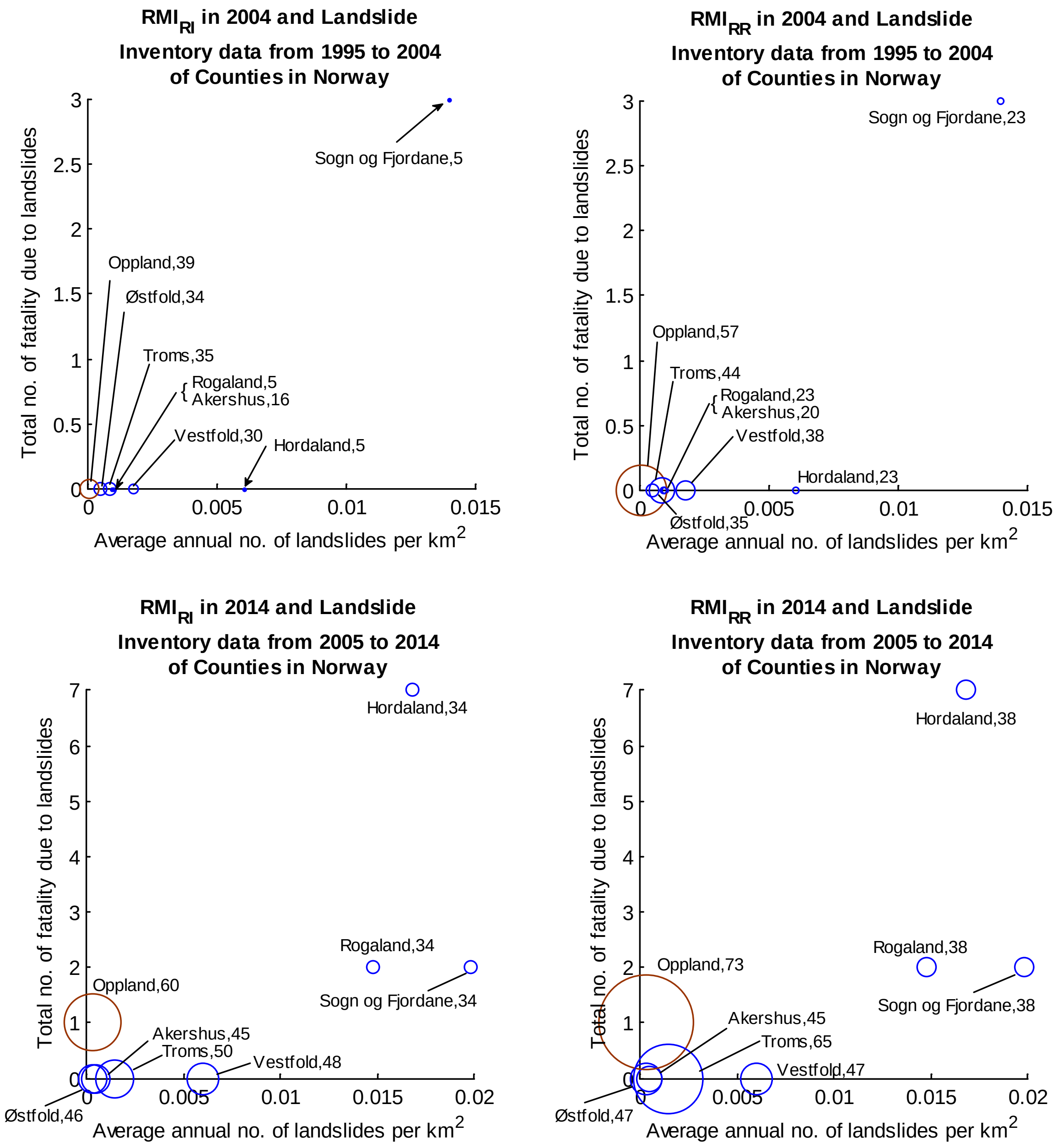
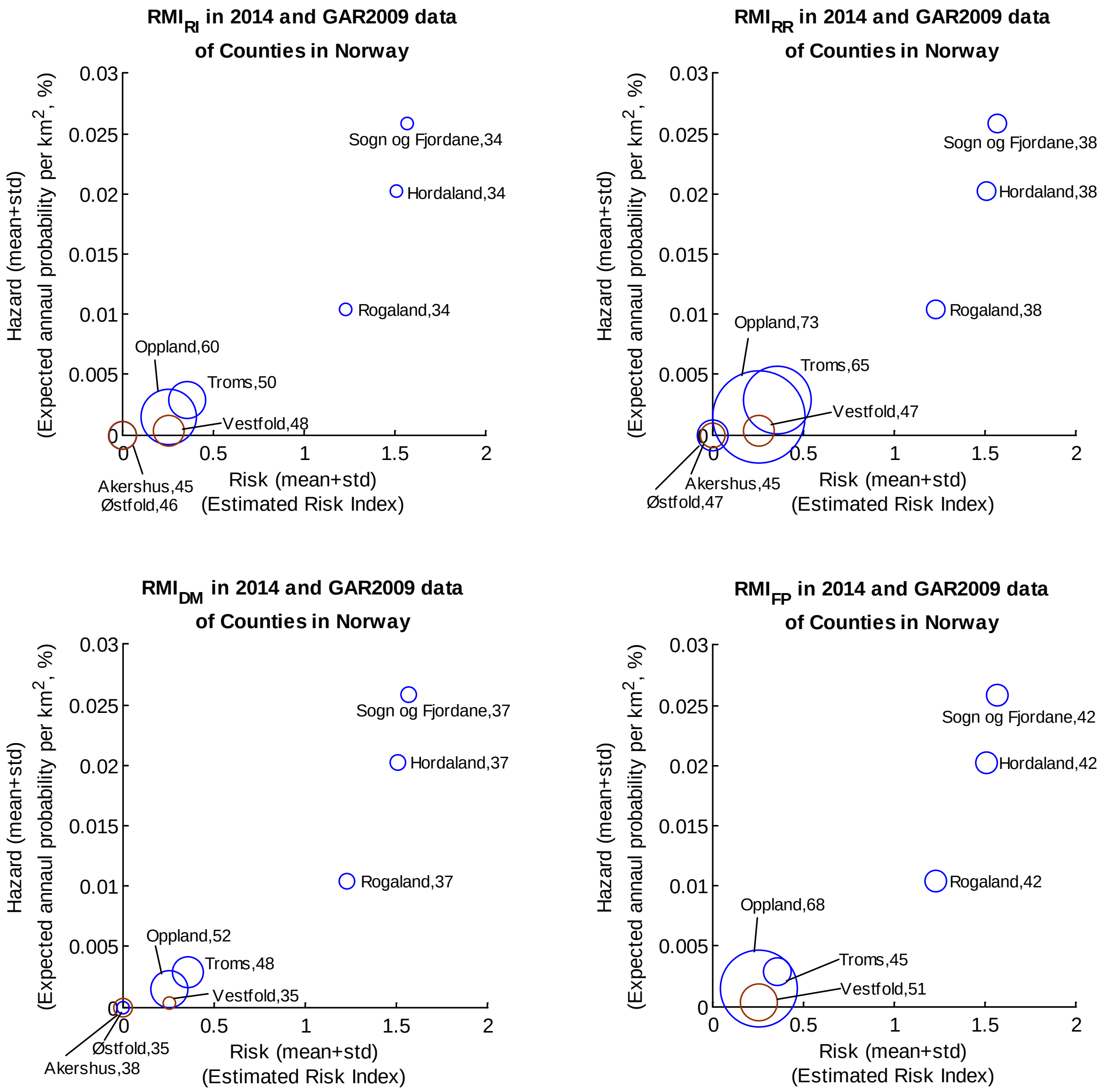


Figure 5.23 RMI_{RI} and RMI_{RR} results in 2004 and 2014; and landslide inventory data of selected counties in Norway from 1995 to2024. The size of the blue circles increases with RMI results (labelled after county's name). Brown indicates Oppland as the records for this county may be incomplete (see Section 4.2.2).



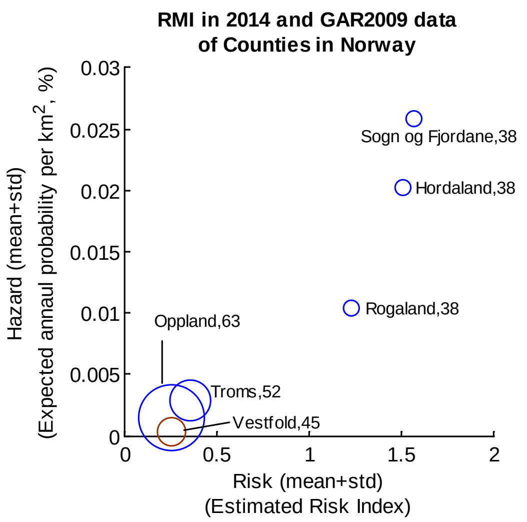
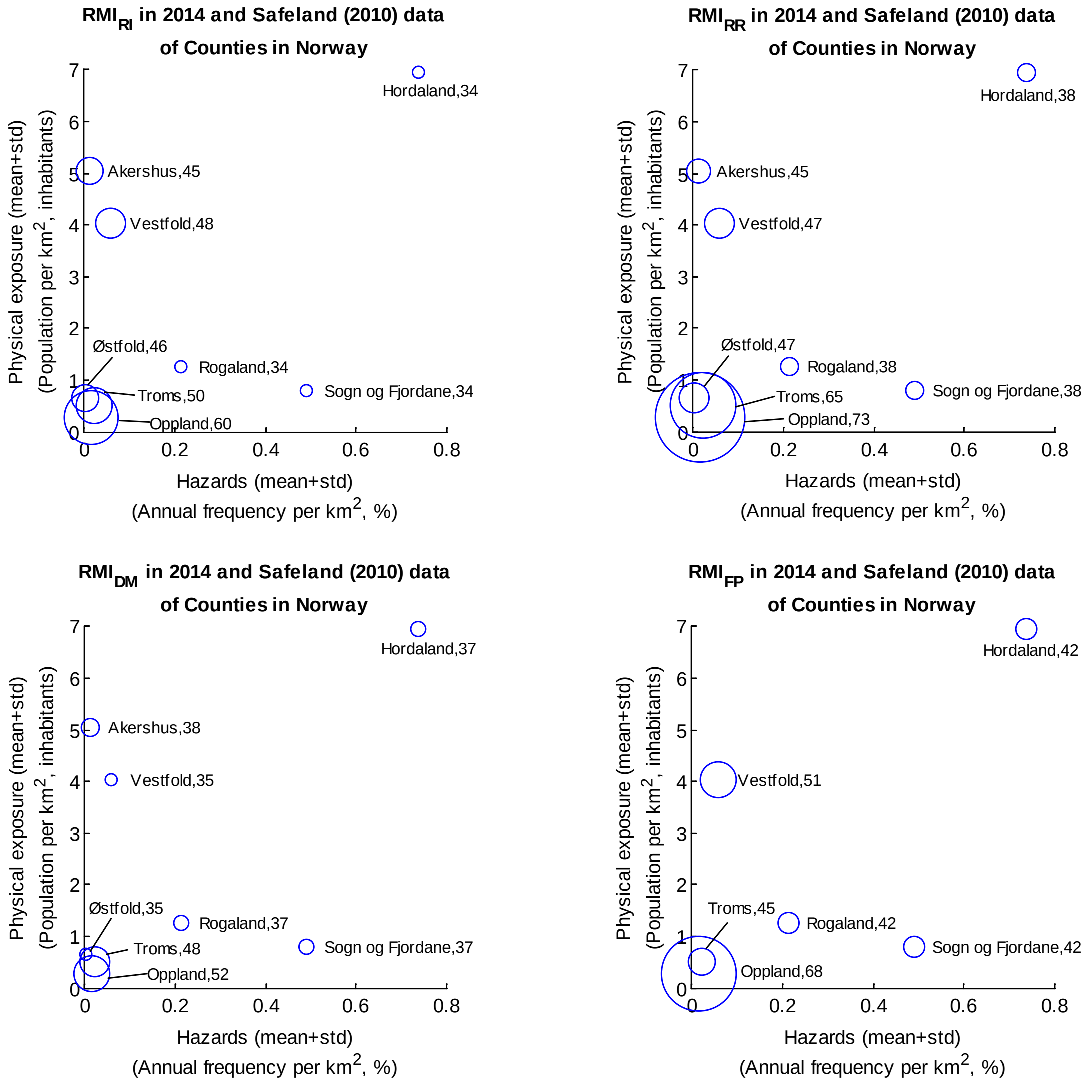


Figure 5.24 RMI results in 2014 and GAR2009 landslide hazard data of selected counties in Norway. The size of the blue circles increases with RMI results (labelled after county's name). Brown indicates Akershus and Vestfold as the GAR2009 data may be underestimated (see Section 5.1.2).



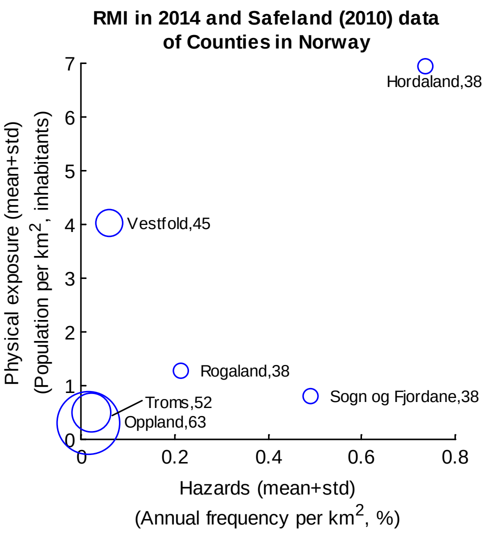


Figure 5.25 RMI results in 2014; and Safeland (2010) landslide hazard data of selected counties in Norway. The size of the blue circles increases with RMI results (labelled after county's name).

5.2.5 Comments regarding the questionnaires

Some comments and notes regarding the questionnaires are also received from the invitees and respondents for the survey. In particular, there are comments regarding the relevance and the design of several component indicators. These comments are summarized in Table 5.6.

In addition, some think that they are not capable of answering because the questions are too complicated. One respondent who has a geotechnical and geology background provided feedback that, in order to answer the questions, it is necessary to have knowledge also on topics such as economy, strategy and the organization of landslide risk management.

Table 5.6 Comments from respondents regarding several component indicators.

Territory	Public policy	Component indicator & Comments from respondents	
Hong Kong	FP	***FP4.***	***Implementation of social safety nets and funds response*** None of the performance levels is appropriate.
Norway	RI	***RI6.***	***Training and education in risk management*** Rating for curriculum adjustments at primary and secondary schools should be higher than curricular reform of higher education. Since individuals cannot be expected to consider landslide risk in their daily lives, it is mainly a concern for decision-makers at a local level, including landslide topics in primary and secondary curriculum would be a big step up.
	RR	***RR4.***	***Housing improvement and human settlement relocation from prone-areas*** Landslide prevention is mainly a local (municipality) responsibility and major landslide risk exists outside the cities, therefore it is not relevant to distinguish landslide prevention measures between major cities and other municipalities.
		RR6.	***Reinforcement and retrofitting of public and private assets*** Irrelevant, since the main priority is to avoid new developments in hazard areas, instead of retrofitting and reinforcement.
	DM	***DM6.***	***Rehabilitation and reconstruction planning*** Landslide disasters in Norway are generally small and do not have lasting impact on the economy at a local level.
	FP	***FP4.***	***Implementation of social safety nets and funds response*** Irrelevant particularly for levels 2 to 5, since there is no specific focus on 'poorest socio-economic groups' or 'poverty reduction' in Norway.
		FP5.	***Insurance coverage and loss transfer strategies of public assets*** Public infrastructure is not insured in Norway

6 Discussion

6.1 Interpretations of results

6.1.1 Reliability of available datasets of landslide hazards

When using modelled landslide data, it is recommended to consider more than one dataset. For instance, some discrepancies exist between the GAR2009 and Safeland data (Section 5.1). The discrepancies between the datasets may be related to the differences in input data and/or modelling method. In particular, the Safeland data is considered more reliable than the GAR2009 data for eastern Norway. Nevertheless, the use of these datasets can achieve the purpose of selecting and prioritizing regions within a territory.

6.1.2 Survey response

Survey response is used as a proxy for evaluating the methodology used in the present study, as well as the feasibility of a similar kind of study.

A response rate of 35-36% was obtained upon survey invitation for both territories, which is considered acceptable in this study (Section 5.2.1). This reflects that the target participants in both territories are quite eager to give their opinions on landslide risk management in their respective territories. This also indicates the feasibility of conducting a similar kind of study with a larger sample in both Hong Kong and Norway.

The rate of response to the survey is rather different between Hong Kong and Norway. In Hong Kong, the majority of those who had agreed to participate in the survey completed the questionnaires. However, only one third did so in Norway and one fourth withdrew because they thought that the survey was too complicated. In particular, it is surprising that no invitees from the road or railway authority in Norway completed the survey. Since these government agencies are on the frontline of tackling landslide problems along transport infrastructures, their perceptions could have been very useful to the present study. The poorer response from Norway is possibly because landslide risk management is a rather new topic. Practitioners in Norway, except for those working at NGI, may be unfamiliar with the concepts and terms adopted in landslide risk management. In addition, it is also possible that people who work at the road or railway authority can only relate risk management to local authorities' responsibilities; therefore they are unable to answer the survey.

The majority of the respondents from both territories completed both questionnaires and the majority of respondents from Norway gave evaluations at both sub-national and national levels. This can be regarded as a positive feedback for the design of the questionnaires since the majority managed to complete the entire survey.

Responses were obtained for the majority of prioritized counties in Norway (Section 5.2.4). This may indicate that the method of selecting and prioritizing regions in the territory is effective. However, each county only received up to 2 responses and no response could be obtained for one of the lists of counties. This might indicate that longer data collection time for the survey is needed.

6.1.3 Comparison of landslide risk management perceptions between Hong Kong and Norway

As a whole, Hong Kong has a better performance in landslide risk management than Norway. This supports our general understanding of landslide risk management of the case study areas (Section 1.3). This is first validated by qualification of the component indicators. More component indicators in Hong Kong have higher ratings than those in Norway (Section 5.2.3.1, Figure 5.9): the majority of the median values of the component indicators for Hong Kong is 'outstanding' to 'optimal', whereas no median values of the component indicators for Norway reach 'optimal' level. The better performance for Hong Kong can be further verified by the RMI results in 2004 and 2014 (Section 5.2.3.3, Figure 5.17a and b). Moreover, Hong Kong has much greater landslide hazards and risk than Norway based on the available landslide hazards data (Section 5.1.1, Figure 5.1) but the fatalities due to landslides in recent years in Hong Kong are fewer than in Norway (Section 5.2.3.3, Table 5.5). This further indicates that landslide risk management in Hong Kong is more effective than Norway.

On the other hand, based on the temporal trend of perceptions against landslide density or fatality for both territories, landslide risk management performance does not decrease with increasing landslide density or fatalities. As a result, it is apparent that the perceptions are not related to the actual occurrence of landslides around a similar period. However, this has to be verified with longer period of data. Nonetheless, it is probable that respondents from both territories have the same impression that landslide risk management in their territory has been improving during the current century, when landslide risk reduction activities have been a global trend.

Looking into details, substantial differences between Hong Kong and Norway are observed in several component indicators in various aspects, especially for those within the FP public policy. The differences in perceptions for FP reveal the key differences in landslide risk management policies between Hong Kong and Norway. In addition, the differences in perceptions for FP have the main influence on the temporal changes observed in the RMI results.

Regarding qualification of component indicators (Section 5.2.3.1), respondents from Hong Kong have more positive perceptions regarding safety standards (RR5), early warning and emergency preparedness (DM2), and emergency operations (DM1) than those from Norway (Figure 5.9). This is reasonable since the GEO of Hong Kong has a comprehensive enforcement of up-to-date geotechnical standards and Hong Kong has a longer experience in landslide warning and emergency preparedness than Norway (Section 2). Norway performs much better in fund response (FP4) as well as insurance coverage and loss transfer strategies (FP5) than Hong Kong. Additionally, FP component indicators for Hong Kong generally have poorer performance than those within the other public policies. Note that evaluation for FP component indicators for either territory may not be sufficiently representative since there is lack of expertise within the FP public policy. Nonetheless, results for Norway are probably reliable as private properties are normally compensated in full under the national insurance scheme for natural disasters (Section 2.2.2). On the contrary, private landowners in Hong Kong bear the responsibility for maintenance of the slopes within their land and apparently also the cost for loss (Section 2.1.2). In addition, policies in financial protection for landslide hazards are barely mentioned by the government agencies that are responsible for landslide risk management. As a result, it may be concluded that there are inadequate policies on the transfer of loss due to landslide disasters in Hong Kong.

Substantial differences in relative weights between Hong Kong and Norway are observed between several component indicators in DM and FP public policies (Section 5.2.3.2) and this again demonstrates the key differences in the landslide risk management strategies between the two territories. Within the DM public policy, Norway focuses much more on community preparedness and training (DM5) than Hong Kong. The larger focus on community activities evaluated for Norway coincides with the assigned responsibility of local authorities (municipalities to prepare emergency plans (Section 2.2.2). For FP public policy, higher relative weights are put on budget allocation and mobilization for vulnerability reduction, as well as environmental protection security (FP3) in Hong Kong, whereas Norway focuses more on insurance and reinsurance coverage for housing and the private sector (FP6). The latter again states the implementation of insurance coverage in Norway for private properties against natural damage. On the other hand, the higher budget allocation perceived by respondents from Hong Kong is understandable since their government spends over 0.2 billion US dollars every year to upgrade and maintain slopes in the entire territory (GEO 2013). On the other hand, local authorities in Norway normally receive funds for mitigation upon identification of significant landslide hazards. In addition, Figure 5.9 shows that the median value of FP3 for Hong Kong is only 'incipient' for all the years, which is substantially lower than that of Norway. The low ratings but high relative weights for FP3 evaluated by respondents from Hong Kong may indicate their inclination towards greater financial support for landslide risk management in the territory.

As mentioned in Section 5.2.3.2, respondents from both territories give contradictory judgements to several pairs of component indicators (Table 5.3). It is not within the scope of the present study to investigate the reasons behind the inconsistent judgements made to these pairs of indicators. However, the component indicators identified here may serve as references for decision-makers to reconsider whether the traditional focus within a public policy can really represent their preferences.

Furthermore, a similar degree of improvement in the qualifications of the component indicators (generally one level up in median values) is observed in both territories, except for the FP component indicators in Hong Kong, which have relatively constant values over the years (Section 5.2.3.1, Figure 5.9). Based on the differential degree of improvement among the indicators, it is foreseeable that RMI for Norway will become greater than that for Hong Kong by 2024 when RMI_{FP} of Norway in 2004, 2014, and 2024 are greater than those of Hong Kong (Section 5.2.3.3, Figure 5.17). This may further imply that in the future scenario, the performance in governance and financial protection will be key to the relative effectiveness in landslide risk management between Hong Kong and Norway.

6.1.4 Landslide risk management perceptions in counties in Norway

Although the survey response for counties in Norway is limited, some important findings can still be obtained, thanks to prioritization of the counties in data collection. In particular, there is an apparent trend that landslide risk management perceptions of a country become more negative with increasing landslide hazards, risk, fatalities, and incidents (Section 5.2.4.3). The observed trend may indicate that more effective landslide risk management is needed in counties with high landslide hazards and risks in Norway. On the other hand, the temporal trend of the perceptions is likely not dependent on the severity and frequency of landslides. This observation also applies to the comparison between Hong Kong and Norway at a national level. This may again imply a general positive impression on the improvement of landslide risk management in Norway at a regional level. However, longer period of RMI is required to verify the observation.

In addition, the county group including Rogaland, Hordaland, and Sogn og Fjordane has relatively high RMI_{DM} and is perceived to perform significantly better than other counties in emergency operations (DM1), simulation of inter-institutional response (DM4), and fund response (FP4) (Section 5.2.4, Figure 5.20). Since these counties have higher landslide hazards than the others, better performance perceived in disaster management and fund response for these counties possibly reflects the risk-based prioritization strategy in emergency preparedness and recovery in Norway, such that counties with higher landslide risk typically have a longer experience and more systematic practices in landslide risk management. However, Figure 5.20 shows that hazard mapping (RI3) has a similar rating for all the counties in any year. The results are rather different from expected since a risk-based prioritized mapping program for counties in Norway has been on-going (Section 2.2.2).

6.2 Reliability of survey results

As mentioned in the beginning of the report, the survey for the case studies was conducted within a limited time (around 1 month). Therefore, the survey response was very limited and may not be sufficiently representative. In spite of this, the degree of reliability of the survey results is assessed and discussed in this section systematically.

Considering experience and education level, all the respondents are considered capable of understanding the questions well in the survey. Since almost all the respondents have postgraduate education and are at least 35 years old, the respondents are assumed to have abundant technical knowledge and experience in their field of expertise (Section 5.2.1).

Considering the rather confined backgrounds of respondents, it is believed that the survey samples cannot represent the population of interest. For instance, the current survey results do not have sufficient experts in the fields of disaster management or financial protection (Section 5.2.1). In addition, around half of the respondents from both territories work in the public sector. Results show that people belonging to different occupation categories may have different tendencies in landslide risk management perceptions. For example, respondents from the public sector of both territories are found to have more negative perceptions than those from the private sector (Section 5.2.3.1, Figure 5.10).

The present study proposes several techniques to justify the reliability of the survey results by examining experts' opinions (Section 5.2.3.3). The assumption is that experts' opinions are more reliable. This assumption is probably also implied in the feedback that participants of the survey should also have knowledge in topics such as economy, strategy and organization of landslide risk management (Section 5.2.5). Result analysis shows that respondents who are experts in a particular public policy give more converged relative weights than when considering all respondents (Section 5.2.3.2, Figure 5.15). This probably supports the aforementioned assumption since it is rational to consider an answer to be accurate if many experts also have similar answers. A sensitivity test is developed to study the influence of the weights of experts' opinions on the RMI results. However, since respondents from both territories are not distributed over all the four public policies, the results obtained for analyzing experts' opinions are not complete and thus are not interpreted in this report.

Reliability of the simplified tier (Tier 1) has been analyzed (Section 5.2.3.1). It is found that there exists discrepancies between the answers between the two tiers. Direction of the discrepancies is generally consistent. For instance, individual respondents from Hong Kong give either higher or lower values for Tier 1 than Tier 2 for a particular component indicator throughout the years (Figure 5.11). Also, Tier 1 response for both territories for all the component indicators appears to be either more positive or negative than Tier 2 in a particular year (Figure 5.12). The consistent directions of discrepancies have two implications: (1) reliability of Tier 1 is doubtful as the performance levels stated in Tier 1 are constantly lower or higher than those in Tier 2; (2) the ranking of the performance levels stated in Tier 2 is logical. Nevertheless, results from Tier 1 are still considered since limited response is obtained for the present study.

Based on certain blank answers and comments from respondents, some results of certain component indicators are considered questionable. For Hong Kong, these component indicators include *RR2 Hydrographic basin intervention and environmental protection* and *FP4 Implementation of social safety net* and funds response (Section 5.2.3.1, Figure 5.8). In particular, one of the respondents from Hong Kong mentioned that none of the performance levels for FP4 is appropriate (Section 5.2.5). Both component indicators also have blank answers in the responses from Norway. A respondent from Norway argues that levels 2 to 5 of FP4 are not relevant since the 'poorest socio-economic groups' or 'poverty reduction' are not considered in Norway. In addition, *FP5 Insurance coverage and loss transfer strategies of public assets* is also considered irrelevant since public infrastructure is not insured. Another respondent also argues that it is not logical to place curriculum adjustments at primary and secondary education at a lower performance level than tertiary education, since teaching landslide topics in primary and secondary schools is considered important through introducing landslide risk to the everyday life of individuals. Irrelevance of FP4 and FP5 for Norway probably suggests that the survey should be improved so that it can be adopted to the socio-economic conditions of each territory. In addition, the irrelevance in some of the component indicators may also imply that different territories may adopt different approaches to tackle landslide risk due to variations in culture, economy, political orientation, etc. Therefore, it is not appropriate to interpret the results based on the indices only, but other factors in the humanities disciplines should also be considered.

According to the above, reliability of the current survey results may be arguable based on the restricted background of the survey samples and the inconsistent results between the two tiers. Besides, the irrelevant component indicators considered by respondents probably indicate that there is not a set of landslide risk management policies that can be ideal or applicable to all territories. Nevertheless, the survey results depict a general picture of landslide risk management performance that is generally consistent with the real situations learnt via studying the related policies of both territories. As a result, the current survey results can provide valuable information regarding the existing problems of landslide risk management and can be a useful reference for decision-makers to evaluate and design policies. This therefore fulfils the genuine aspirations of Cardona et al. (2004) for developing the RMI method.

6.3 Recommended improvements in the survey method

The following includes some suggestions for improving the survey method to obtain more reliable survey results:

1) Longer time for collecting the survey data so that more invitations can be sent out and respondents can have more time to answer. This possibly also allows time to approach individuals in person to take part in the survey.

2) Broaden the spectrum of participants in terms of expertise, experience, occupational backgrounds, and places of work. This enables data collection that is more representative.

3) Ask respondents to answer the years of experience in their fields of expertise instead of their age, so that the actual years of experience can be analyzed.

4) Simplify the questionnaires by using less technical terms and making the sentences more concise to increase the response rate and make the questions more answerable.

5) Add entries of 'not relevant' and 'not able to answer' to the 1st questionnaire, so that respondents can choose not to rate the performance level of the component indicator and state the reason. The reasons are useful for assessing the relevance and design of each of the component indicators that contribute to the RMI.

6) Modify some of the component indicators so that it can be adopted to the conditions of each territory, especially in socio-economic aspect.

7) Use the modified algorithm developed in the present study for calculating RMI, since it is shown to be more reasonable than the one that is possibly used by Cardona et al. (2005).

6.4 Future applications

Based on the survey response and survey results, it is regarded that the methodology developed by the present study is feasible and can be applied to future studies of a similar kind for evaluating the effectiveness of landslide risk management of different territories. Several further techniques and studies related to the present methodology are suggested in this section that may be used and carried out respectively to optimize the method and expand the scope of the application.

1) Apply the method to more territories and conduct the survey on a regular basis (e.g. every 5 or 10 years) or at regular intervals (1-2 years) after a major disaster. This enables collection of sufficient data to study the temporal trend of the RMI so that future scenarios can be modelled. This also allows for studying the change of relative weights of the component indicators over time. The method can also be applied to territories that are threatened by landslides triggered by earthquakes. With modification of the questions, territories of any scale can also be studied.

2) Relative weights between public policies can be introduced. The current RMI is defined as the average of the policy indices, therefore it is used to evaluate an all-round performance. Since policies vary from place to place, the focus of landslide risk management strategies may also vary. Through evaluating the relative weights between public policies, a more realistic RMI can be obtained. This can also allow the understanding of the focus in landslide risk management in a territory at a broader scale. AHP techniques can also be applied to evaluate these relative weights.

3) Conduct peer evaluations, i.e. evaluations of other territories instead of own. Evaluation by external peers are probably more objective. A peer group can comprise neighboring territories, territories that have similar landslide problems, territories that have knowledge exchange, or territories that have corporations in landslide risk management. In addition, members of a peer group can also conduct simple rankings for the group as this is useful in justifying the quantitative results.

7 Conclusions

Surveys on landslide risk management perceptions in Hong Kong and Norway were conducted separately between late January and early March, 2015. A total of twelve and nine responses were received for Hong Kong and Norway, respectively. Respondents for the survey are involved in all stages of landslide risk reduction strategies in their corresponding territories and include technical staff, decision-makers, and stakeholders. The survey is in the form of opinion questionnaires and aims at collecting ratings of performance and relative importance of different component indicators within four public policies, including Risk Identification (RI), Risk Reduction (RR), Disaster Management (DM), and Governance and Financial Protection (FP). Results of the survey are used to obtain the Risk Management Index (RMI) proposed by Cardona et al. (2004), which provides a tool to measure a territory's performance in landslide risk management. Several improvements or techniques are implemented to Cardona et al. (2004)'s RMI method in the present study to enable comparisons between territories and further analysis of the survey results.

Perceptions are given for three time periods: 2004, 2014, and 2024. In addition, respondents from Norway are asked to answer based on both county and national levels. Results show that RMI_{RI} and RMI_{RR} in Hong Kong are the highest in general during all three years, whereas RMI_{FP} is constantly significantly lower than the other policy indices. On the other hand, RMI_{RI} and RMI_{DM} are around 50% lower than RMI_{RR} and RMI_{FP} in Norway in 2004, but all policy indices increase to comparable values in 2014 and 2024. Based on the average of the four policy indices, the RMI for Hong Kong increases from 41 to 61, whereas that for Norway increases from 25 to 65 out of 100 from 2004 to 2024. Hong Kong thus leads Norway in RMI in 2004 and 2014, but Norway is perceived to be better than Hong Kong in 2024.

Survey results between the territories are compared. It is concluded that two key differences in landslide risk management policies between Hong Kong and Norway can be used to explain the important findings of the comparisons. These differences concern budget allocation and financial protection. Firstly, according to the survey results, Hong Kong put higher relative weights on budget allocation and mobilization for vulnerability reduction, as well as environmental protection security. This is reasonable since the government of Hong Kong allocates substantial funds yearly to upgrade and maintain slopes in the entire territory, but local authorities in Norway normally only receive funds upon identification of a significant landslide risk. Secondly, Norway has a higher RMI_{FP} than Hong Kong over all the years. At the same time, Norway focuses more on insurance and reinsurance coverage for housing and private sector than Hong Kong. The survey results are thus consistent with Norway's dual compensation scheme for private properties and possible inadequate policies on loss transfer in Hong Kong.

There are survey responses for eight counties in Norway. Among these counties, Oppland has the highest RMI, which ranges from 49 to 76, in all three years. Rogaland, Hordaland, and Sogn og Fjordane, which are assessed together, have the lowest RMI, ranging from 27 to 51. Although the county data are limited, the obtained results are considered meaningful, thanks to prioritization of counties for data collection. In particular, it is apparent that the higher the landslide hazards, risk, and severity and density of landslide incidents of a county, the more negative the landslide risk management perceptions are. This trend may indicate that more effective landslide risk management is needed in counties with high landslide hazards and risks.

Additionally, the increment of RMI with time at both regional and national levels probably reflects that respondents from both territories have a positive impression on the improvement of landslide risk management in their territory, since landslide risk reduction activities have been a global trend. However, data collection over a longer period of time is necessary to verify this observation.

Based on survey response, diversity of the backgrounds of respondents, and reliability of the simplified tier of the questionnaire, it is concluded that the reliability and representativeness of the survey results may not be sufficient. Apart from that, several component indicators may not be relevant to the study areas; therefore it is suggested to interpret the survey results with consideration of other factors such as culture, economy, political orientation, etc. Nevertheless, the survey results are generally considered consistent with the real situations learnt from the related policies of both territories. As a result, the current survey results can still provide valuable information regarding the effectiveness of landslide risk management of a territory and can be a useful reference for decision-makers to evaluate and design policies. Furthermore, the method and techniques developed for the present study are considered feasible for similar kinds of studies in the future.

To improve and understand better the reliability of the survey, a longer period for data collection is recommended. In addition, approaching target participants in person, broadening the spectrum of the respondents' backgrounds, and asking respondents to state whether the questions are irrelevant or unanswerable may improve survey reliability. It is also suggested to simplify and condense the questions in order to increase the response rate and make the questions more answerable. Some of the component indicators, especially the socio-economic ones, should be modified so that the survey can be adopted to the conditions of each territories. Moreover, the modified algorithm developed in the present study for the calculation of RMI should be used to obtain a reasonable RMI.

Last but not least, the way forward in enhancing the understanding of existing problems and facilitating policy-making in landslide risk management is to quantitatively evaluate, model, and compare the effectiveness of different territories' practices. This can be done by optimizing and expanding the scope of application of the present method. For example, the survey can be conducted for more territories on a regular basis, relative weights between public policies can be introduced, and evaluations of other territories within a peer group can be carried out.

References

Armstrong, K., Carter, M., and Baker, M. (2014). 'Risk of slide ‘unforeseen’? Warnings go back decades'. *The Seattle Times*. 24 March 2014. [online] http://seattletimes.com/html/localnews/2023218573_mudslidewarningsxml.html Accessed: 25 June 2014.

Baum, R.L., Schulz, W.H., Brien, D.L., Burns, W.J., Reid, M.E., and Godt, J.W. (2014). Plenary: progress in regional landslide hazard assessment—examples from the USA. In Sassa, K., Canuti, P., and Yin Y. (Ed) *Landslide Science for a Safer Geoenvironment*, vol. 1. Switzerland: Springer. 493 p.

Cardona, O.D. (2001) *Estimación Holística del Riesgo Sísmico utilizando Sistemas Dinámicos Complejos.* (Spanish) Doctoral Thesis, Technical University of Catalonia, Barcelona. 322p.

Cardona, O.D., Hurtado, J.E., Duque, G., Moreno, A., Chardon, A.C., Velásquez, L.S., and Prieto, S.D. (2004). *Disaster risk and risk management benchmarking: a methodology based on indicators at national level*. IDB/IDEA Program on Indicators for Disaster Risk Management, Universidad Nacional de Colombia, Manizales, http://www.manizales.unal.edu.co/. 101 p.

Cardona, O.D., Hurtado, J.E., Duque, G., Moreno, A., Chardon, A.C., Velásquez, L.S., and Prieto, S.D. (2005). *System of indicators for disaster risk management: program for Latin America and the Caribbean: main technical report*. IDB/IDEA Program on Indicators for Disaster Risk Management, Universidad Nacional de Colombia, Manizales, http://www.manizales.unal.edu.co/. 216 p.

Carreño, M.L. (2001) *Sistema Experto para la Evaluación del Daño Postsísmico en Edificios.* Master thesis, Department of Civil Engineering and Environment, University of Los Andes, Bogota, Colombia.

Carreño, M.L., Cardona, O.D., and Barbat, A.H. (2007). A disaster risk management performance index. *Natural Hazards*, 41, 1-20.

Chan, R.K.S. and Mak, S.H. (2007). Landslide risk management in Hong Kong. *Proceedings of the International Forum on Landslide Disaster Management, Hong Kong,* vol. I, 14-47.

Chan, R.K.S., Mak, S.H., and Au Yeung, Y.S. (2007). Partnering with the community to reduce landslide risk in Hong Kong over the past thirty years. Proceedings of the Seminar on Geotechnical Advancement in Hong Kong since 1970s. *Hong Kong Institution of Engineers*, 183-196.

Chan, R.K.S and Pun, W.K. (2004). Landslip Warning System in Hong Kong. *Geotechnical Instrumentation News for publication, Hong Kong.*

Cheung, P.F.K. and Ko, F.W.Y. (2010). *An updated assessment of landslide risk posed by man-made slopes and natural hillsides in Hong Kong (GEO Report No. 252)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 49 p.

Civil Engineering and Development Department, Hong Kong (CEDD) (2015a). *Slope Information.* [online] http://www.cedd.gov.hk/eng/services/information/ Accessed 26 April 2015.

Civil Engineering and Development Department (CEDD) (2015b). *Natural Terrain in Hong Kong.* [online] http://hkss.cedd.gov.hk/hkss/eng/natural_terrain.aspx Accessed 26 April 2015.

Dai, F.C., Lee, C.F., and Ngai, Y.Y. (2002). Landslide risk assessment and management: an overview. *Engineering Geology*, 64, 65-87.

Devoli, G. (2008). *A study of the distribution, characteristics, behaviour and triggering mechanisms of Nicaraguan landslides*. PHD Thesis. University of Oslo, Norway.

Devoli, G., Cepeda, J., and Kerle, N. (2009). The 1998 Casita volcano flank failure revisited — New insights into geological setting and failure mechanisms. *Engineering Geology*, 105, 65-83.

Drange, H. (2015). *Helge Drange's home page.* [online] http://folk.uib.no/ngfhd/Climate/climate-prec.html Accessed 14 April 2015.

Norwegian Directorate for Civil Protection (DSB) (2013). *National Risk Analysis 2013*. Norwegian Directorate for Civil Protection, Norway.

GADM (undated). *Global Administrative Areas*. [online] http://gadm.org. Accessed 25 June 2014.

Geotechnical Engineering Office (GEO) (2013). *Government Slope Safety Works 2013*. [online] http://hkss.cedd.gov.hk/hkss/eng/geo_pub/Annual%20Report.pdf Accessed 10 May 2015.

Geotechnical Engineering Office (GEO) (2014). *When Hillside Collapses – A Century of Landslides in Hong Kong (2nd Edition).* Civil Engineering and Development Department, HKSAR Government. 274 p.

Geotechnical Engineering Office (GEO) (2015). *Hong Kong Slope Safety Website of Geotechnical Engineering Office (GEO), CEDD*. [online] http://hkss.cedd.gov.hk/hkss/eng/index.aspx Accessed 29 April 2015.

Gregersen, O. (1981). The quick clay landslide in Rissa, Norway. *International Conference on Oil Mechanics and Foundation Engineering*, 10, Stockholm, Vol. 3, 421-426.

Highland, L.M. and Bobrowsky, P. (2008). *The landslide handbook—A guide to understanding landslides*. Reston, Virginia, U.S. Geological Survey Circular 1325. 129 p.

Hong Kong Observatory (HKO) (2015). *Extract of Annual Data*. [online] http://gb.weather.gov.hk/cis/data/annual_record_e.htm Accessed 28 April 2015.

International Strategy for disaster Reduction (ISDR) (2003). *A framework to guide and monitor disaster risk reduction, draft proposal*. www.unisdr.org/dialogue.

Jaedicke, C.J., Sverdrup-Thygeson, K., Smebye, H., Syre, E., Vangelsten, B.V., Nadim, F., and Kalsnes, B. (2010). Identification of landslide hazard and risk “hotspots” in Europe. *Deliverable D2.10, Work Package 2.4, SafeLand Project, 7th Framework Programme.* 132 p.

Kala, C.P. (2014). Deluge, disaster and development in Uttarakhand Himalayan region of India: Challenges and lessons for disaster management. *International Journal of Disaster Risk Reduction*, 8, 143-152.

Lacasse, S. and Nadim, F (2007). Landslide risk management: country report for Norway. *Proceedings of the International Forum on Landslide Disaster Management, Hong Kong,* vol. I, 99-123.

Lo, D.O.K. and Cheung, W.M. (2005). *Assessment of Landslide risk of man-made slopes in Hong Kong (GEO Report No. 177)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 84 p.

Malone, A.W. (1998). Risk management and slope safety in Hong Kong. *Proc. The Hong Kong Institution of Engineers Geotechnical Division Annual Seminar on Slope Engineering in Hong Kong*, vol. 1, 3-17.

Mesta AS (undated). *Road – Mesta Internell (EN)*. [online] http://www.mesta.no/en/business-areas/road Accessed 24 April 2015.

Mileti, D.S., Bolton, P.A., Fernandez, G., and Updike, R.G. (1991). *The eruption of Nevado del Ruiz volcano, Colombia, South America, November 13, 1985*. Committee on Natural Disasters, National Research Council, Natural Disaster Studies, 4. Washington, D.C.: National Academy Press. 109 p.

Ng, K.C., Ho, K.K.S., and Hui, T.H.H. (2010). Natural terrain landslide risk management-experience and practice in Hong Kong. *In* van Westen C.J., Fan, X.M., and Huan, R.Q (Ed.) Examples of international practice in landslide hazard and risk mapping. Assessing the state of art of landslide hazard and risk assessment in the P.R. of China. *Deliverable 2.2a, Work Package 2.1, SafeLand Project, 7th Framework Programme*, 139-198.

NIST/SEMATECH (2013). *e-Handbook of Statistical Methods.* [online] http://www.itl.nist.gov/div898/handbook/ Accessed 7 May 2015.

Norwegian Geotechnical Institute (NGI) (2013). *Landslide Hazard and Risk Assessment in El Salvador*. Background Paper prepared for the 2013 Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDR. 51 p.

Norwegian Meteorological Institute (2015). *eKlima.* [online] http://sharki.oslo.dnmi.no/portal/page?_pageid=73,39035,73_39049&_dad=portal&_schema=PORTAL Accessed 16 May 2015.

Norwegian Water Resources and Energy Directorate (NVE) (2013). *Om jorsdkredvarslingen.* (Norwegian) http://www.varsom.no/Jordskred/Om-jordskredvarslingen/ Accessed 28 April 2015.

Norwegian Water Resources and Energy Directorate (NVE) (2015a). *Overvåking av ustabile fjellparti.* (Norwegian) http://www.nve.no/no/Flom-og-skred/Overvaking-av-ustabile-fjellparti/ Accessed 27 May 2015.

Norwegian Water Resources and Energy Directorate (NVE) (2015b). *Skrednett*. (Norwegian) [online] http://www.skrednett.no/ Accessed 4 April 2015.

Peduzzi, P., Deichmann, U., Maskrey, Nadim, F., A., Dao, H., Chatenoux, B., Herold, C., Debono, A., Giuliani, G., Kluser, S., (2009). *Global disaster risk: patterns, trends and drivers. Global Assessment Report on Disaster Risk Reduction.* Geneva, Switzerland, United Nations. 207 p.

Pelling, M., Bye, L., Zehra Zaidi, R., Scolobig, A., Sharma, U., Mafttei, R., Tudor, E., Mihai, V., Porumbescu, C. and Angignard, M. (2011) The cultures of landslide risk management in Europe and India. *Deliverable 5.5, Work Package 5.2, SafeLand Project, 7th Framework Programme.* 91 p.

Petley, D. (2012). Global patterns of loss of life from landslides, *Geology*, 40, 927-930

Saaty, T.L. (1980). *The analytic hierarchy process*. New York: McGraw-Hill Book Co. 287 p.

Saaty, T.L. (1987). The analytic hierarchy process—what it is and how it is used. *Mathematical Modelling*, 9, 161–176.

Saaty, T.L. and Vargas, L.G. (1991). *Prediction, projection, and forecasting: applications of the analytical hierarchy process in economics, finance, politics, games, and sports*. Boston: Kluwer Academic Publishers. 251 p.

Saisana, M. and Tarantola, S. (2002) *State-of-the-Art Report on Current Methodologies and Practices for Composite Indicator Development.* European Commission, Joint Research Centre, Institute for the Protection and the Security of the Citizen, Technological and Economic Risk Management Unit. 72 p.

Saunders, W.S.A., de Bruin, K., Ruiz Rivera, N., and Lee, H.C. (2015) *A comparative study of natural hazard policy in Taiwan, Mexico, New Zealand and Norway*, GNS Science Report 2015/005. 94 p.

Schuster, R.L. (Ed.) (1991). *The March 5, 1987, Ecuador earthquakes–mass wasting and economic effects*. Committee on Natural Disasters, National Research Council/National Academy of Sciences, Natural Disaster Studies 5, Washington D.C.: National Academy Press. 163 p.

Schuster, R.L. (1995). Landslides and floods triggered by the June 6, 1994, Paez earthquake, southwestern Colombia. *Association of Engineering Geologists, AEG News*, 38 (1), 32-33.

Schuster, R.L. (1996). The 25 most catastrophic landslides of the 20th century. In Chacon, J., Irigaray, C., and Fernandez, T. (Ed.) *Landslides. Proc. Of the 8th International Conf. & Field Trip on Landslides, Granada, Spain, 27-28 Sept*. Rotterdam: Balkema, 53-62.

Scott, K.M., Vallance, J.W., Kerle, N., Macías, J.L., Strauch,W., and Devóli, G. (2005). Catastrophic precipitation-triggered lahar at Casita volcano, Nicaragua: occurrence, bulking and transformation. *Earth Surface Processes and Landforms*, 30 (1), 59–79.

United Nations Environmental Programme / United Nations International Strategy for Disaster Reduction (UNEP/UNISDR) (2013). *Global Risk Data Platform*. [online] http://www.preventionweb.net. Accessed 25 June 2014.

United Nations International Strategy for Disaster Reduction (UNISDR) (2005). *Reducing Disaster Risk: A Challenge for Development*. United Nations Development Programme. Bureau for Crisis Prevention and Recovery. http://www.undp.org/, 146 p.

United Nations International Strategy for Disaster Reduction (UNISDR) (2009). *Global Assessment Report on Disaster Risk Reduction 2009*. United Nations International Strategy for Disaster Reduction Secretariat. 207p.

United States Geological Survey (USGS) (2013). *Catastrophic Landslides of the 20th Century – Worldwide*. [online] http://landslides.usgs.gov/learn/majorls.php/. Accessed 28 August 2014.

van Westen C.J., Alkema, D., Damen, M.C.J., Kerle, K., and Kingma, N.C. (2011). *Multi-hazard risk assessment: Distance Eduction Course Guide Book*. United Nations University – ITC School on Disaster Geoinformation Management. 371 p.

Voight, B. (1990). The Nevado del Ruiz volcano catastrophe; anatomy and retrospection. *Journal of Volcanology and Geothermal Resources*, 44, 349-386.

Wong, H.N. (2009). Rising to the Challenges of Natural Terrain Landslides. Proceedings of the Seminar on Natural Hillsides: Study and Risk Management Measures, *Hong Kong Institution of Engineers*, 15-53.

Appendix A Landslide risk management in Hong Kong

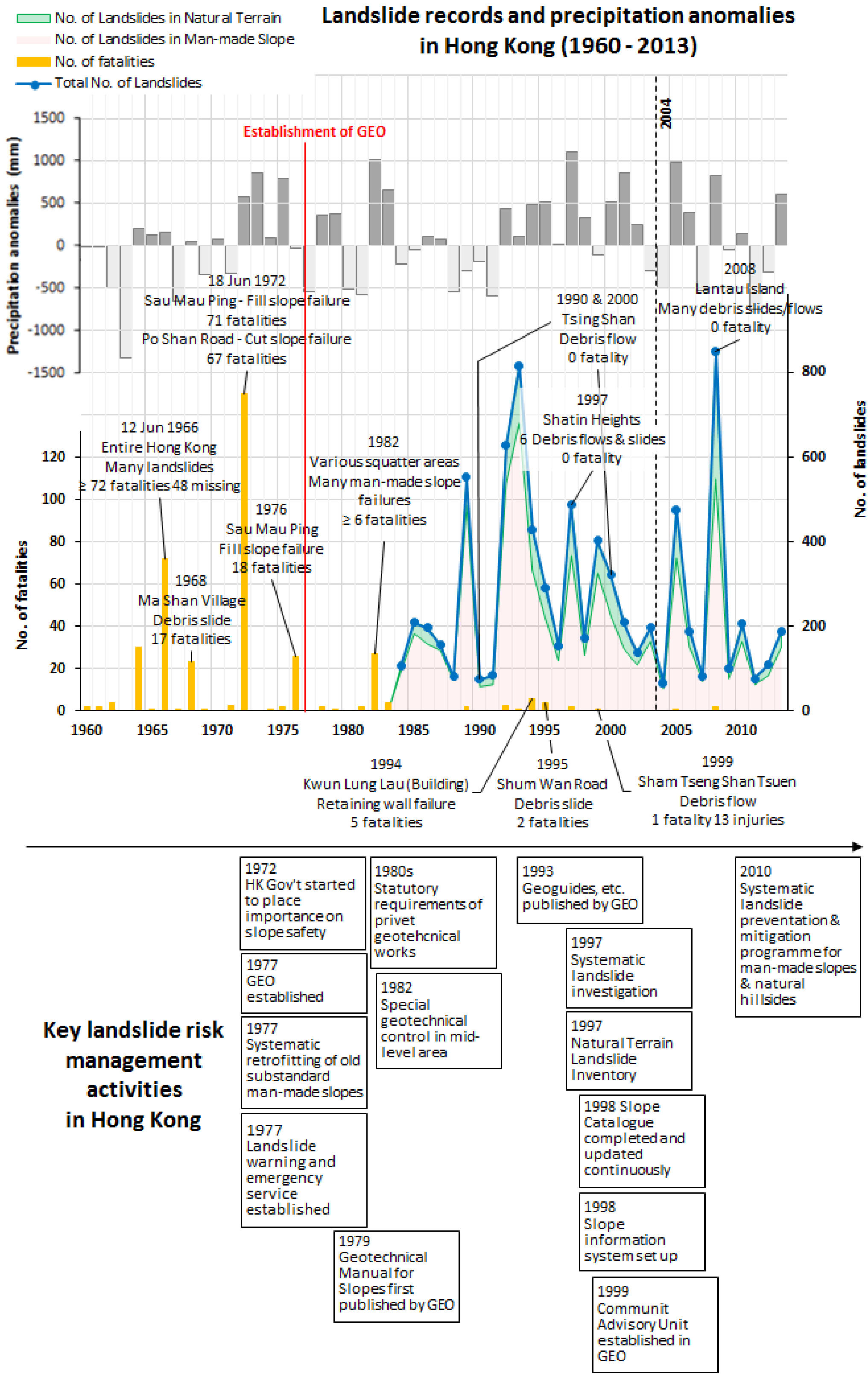


Figure A.1 Landslide records, precipitation anomalies, and timeline of landslide risk management in Hong Kong since 1960s. Precipitation anomalies relative to 1901-2013 mean (=2239mm). Landslide data source: GEO, CEDD (See Appendix C), GEO 2014. Precipitation data source: HKO (2015). Other sources: Chan & Mak 2007, GEO 2015.

Table A.1 Key components of the Slope Safety System of Hong Kong (Based on Malone 1998, Chan & Mak 2007, Ng et al. 2010).

Key Components of Hong Kong's Slope Safety System	Primary Contribution			
	Input for risk identification	Hazard reduction	Consequence reduction	Addressing public attitudes and tolerability of landslide risk
Policing				
• **Cataloguing** *Registration of sizable man-made slopes and mitigation measures, incl. maintenance responsibility.*	✓			
• **Safety-screening studies and recommending statutory repair orders for existing private slopes** *Risk priority order, mandatory maintenance by private owners with government's assistance.*		✓		
• **Checking new slope works** *Public development regulated by Buildings Ordinance, public development controlled under administrative mandates.*		✓		
• **Slope maintenance audits** *Regular engineering inspection and maintenance of registered features, maintenance audit carried out by GEO.*		✓		
• **Recommending safety clearance of vulnerable squatters and unauthorized structure threatened by hillslopes**			✓	
• **Exercising geotechnical control through input to land use planning** *Geotechnical advice at planning stage, avoidance of development in hazardous area, hazard studies and mitigations incorporated in new developments.*			✓	
Works Projects				
• **Retrofitting substandard government man-made slopes** *Risk-based priority system.*		✓		
• **Natural terrain landslide mitigation** *Landslide and catchment inventories, natural terrain hazard studies & risk assessment for existing developments using 'react-to-known' approach, mitigation of risk to 'as low as reasonably practicable (ALARP)' level.*	✓	✓	✓	
Research and safety standards				
• **Systematic investigation of landslides** *To help to improve slope design and construction practice.*	✓			
• **Quantitative Risk Assessment (QRA)** *Global and site-specific landslide studies.*	✓			✓
• **Safety standards** *Standards with up-to-date knowledge on geotechnical works.*		✓	✓	✓
Education and information				
• **Slope maintenance campaigns** *To inform owners of slope maintenance responsibility via public media and street advertisements along with community action.*		✓		✓
• **Risk awareness programmes and personal precautions campaigns** *Public education through community actions, publications, geography curricula in secondary school, education for children, regular publicity activities in various forms, joint force community service to remote villages.*		✓	✓	✓
• **Information services** *A public accessible website managed by GEO with information on slope safety and database of slopes and natural terrain landslides, telephone hotline on slope safety matters and reporting of landslide incidents.*		✓	✓	✓
• **Early warning and emergency preparedness** *Inter-departmental actions to deal with landslide incidents, automatic landslip warning system based on rainfall data, public warnings at slopes prone to failure and vulnerable squatter areas.*			✓	✓

Appendix B Landslide risk management in Norway

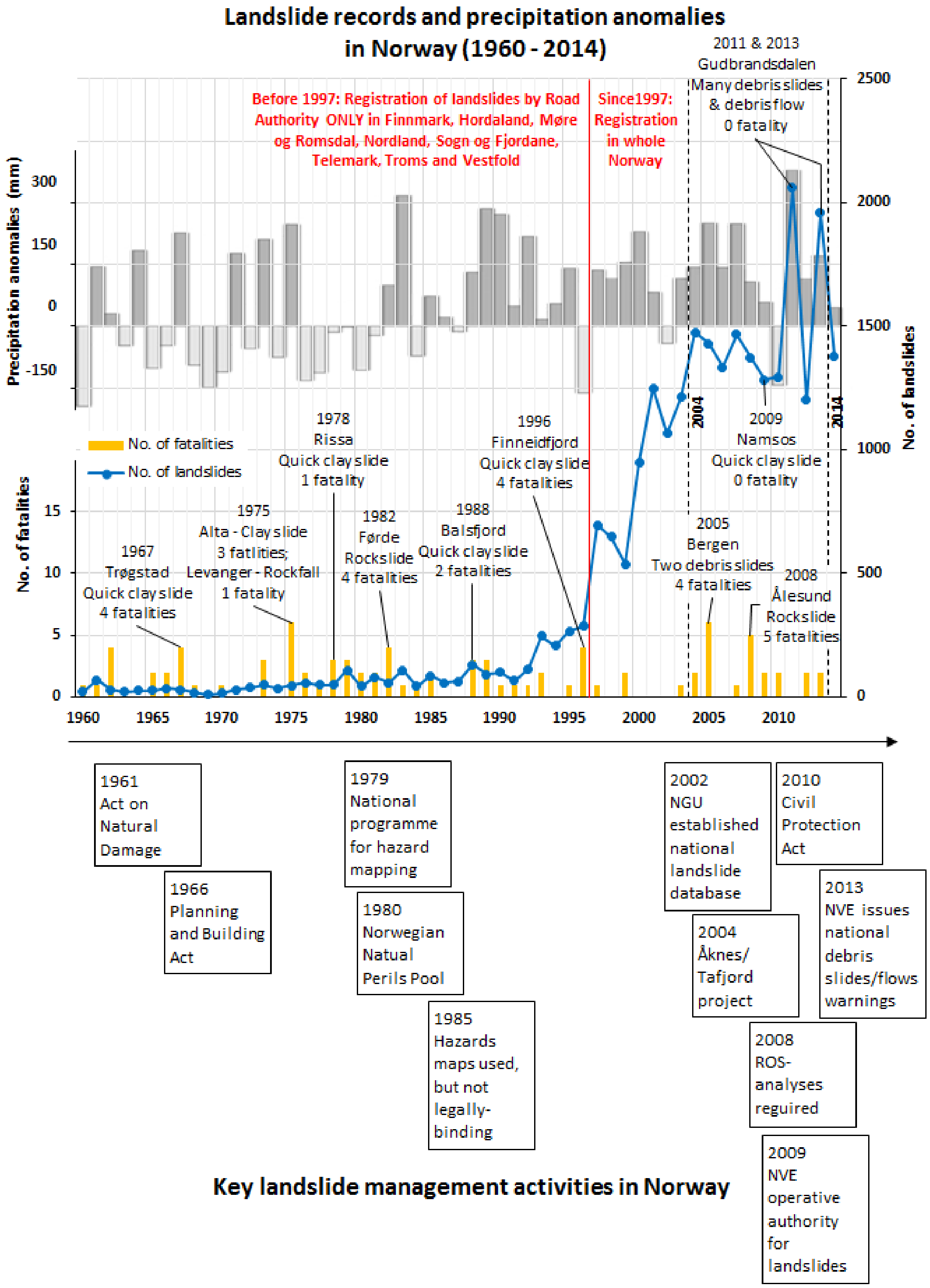


Figure B.1 Landslide records, precipitation anomalies, and timeline of landslide risk management in Norway since 1960s. Precipitation anomalies relative to 1901-2000 mean (=1058mm). Modified from Pelling et al. (2011) and Drange (2015). Landslide data source: skrednett.no (NVE 2015b). Precipitation data source: eKlima of the Norwegian Meteorological Institute (2015).

Table B.1 Key landslide risk management activities of Norway (Based on Lacasse & Nadim 2007, Pelling et al. 2011, Saunders et al. 2015).

Landslide risk management activities of Norway	Primary Contribution: Input for risk identification	Hazard reduction	Consequence reduction	Addressing public attitudes and tolerability of landslide risk
Policing				
• **Planning and Building Act enforced at counties' building council** *Restrictions on building and construction practices, obligatory protective measures against natural hazrds, risk and vulnerability analyses and protective measures to be documented before approval of municipalities'' regulation plans and building requests.*		✓	✓	
• **National programme of hazard mapping** *Detailed hazard plans incl. quick clays and rockslides for planning purpose, w.r.t. the Planning and Building Act.*	✓			
• **Dual compensation insurance scheme for natural disasters** *Full compensations by private natural disaster insurance scheme and public fund.*			✓	
• **Civil Protection Act** *Guided by County Governors, municipalities are responsible for identifying any disruptive events that might occur within their municipalities and preparing emergency plan.*		✓	✓	
Research and safety standards				
• **Risk zonation for quick clay** *'Engineering score' for potential hazard, consequence and risk developed, and corresponding suggested remedial measures.*	✓			
• **Safety class of vairous types of construction** *Based on retuen periods, as stipulated in the Norwegian planning and building law.*			✓	
• **3rd party control for development proejcts in quick clay-prone areas** *To improve control routines and ensure uniform standards in all development projects.*		✓		
• **Åknes/Tafjord project in Møre og Romsdal county** *Inter-municipal and institutional project on rockslides investigations, monitoring, modelling (e.g. modelling of tsunami following rockslides) and implementation of warning systems and evacuation plans.*	✓		✓	✓
• **Run-out estimation of debris flow**	✓			
Education and information				
• **Landslide inventory and registration platform** *NVE manages multiple online platforms which provide the general public access to historical landslide records, meteorological and groundwater information, and a channel to register any nature danger related observations. Until now, there are about 30,000 landslide records dated as early as year 900.*	✓			✓
• **Åknes/Tafjor project** *Civil participation through open dialogues and public meetings also on risk management and technical issues.*			✓	✓
• **Early warning and emergency preparedness** *National landslide warning service by NVE. Emergency preparedness center in Stranda municipality. Early warning system specified by alarm levels and corresponding activities and response established in selected high risk areas in Norddal municipality.*			✓	✓

Appendix C List of annual reports regarding reported landslides in Hong Kong published by GEO and CEDD (in chronological order)

C.1 Annual reports regarding reported landslides in Hong Kong by GEO:

These reports are available at: http://www.cedd.gov.hk/eng/publications/geo_reports/

Premchitt, J. (1991a). *(Hong Kong) Rainfall and landslides in 1984 (GEO Report No. 1)*. Geotechnical Engineering Office, Civil Engineering Department, Hong Kong Government. 91 p. plus 1 drawing.

Premchitt, J. (1991b). *(Hong Kong) Rainfall and landslides in 1985 (GEO Report No. 2)*. Geotechnical Engineering Office, Civil Engineering Department, Hong Kong Government. 108 p. plus 1 drawing.

Premchitt, J. (1991c). *(Hong Kong) Rainfall and landslides in 1986 (GEO Report No. 3)*. Geotechnical Engineering Office, Civil Engineering Department, Hong Kong Government. 113 p. plus 1 drawing.

Premchitt, J. (1991d). *Hong Kong rainfall and landslides in 1987 (GEO Report No. 4)*. Geotechnical Engineering Office, Civil Engineering Department, Hong Kong Government. 101 p. plus 1 drawing.

Premchitt, J. (1991e). *Hong Kong rainfall and landslides in 1988 (GEO Report No. 5)*. Geotechnical Engineering Office, Civil Engineering Department, Hong Kong Government. 64 p. plus 1 drawing.

Siu, K.L. (1991). *Hong Kong rainfall and landslides in 1989 (GEO Report No. 6)*. Geotechnical Engineering Office, Civil Engineering Department, Hong Kong Government. 114 p. plus 1 drawing.

Tang, K.Y. (1992). *Hong Kong rainfall and landslides in 1990 (GEO Report No. 14)*. Geotechnical Engineering Office, Civil Engineering Department, Hong Kong Government. 78 p. plus 1 drawing.

Evans, N.C. (1992). *Hong Kong rainfall and landslides in 1991 (GEO Report No. 20).* Geotechnical Engineering Office, Civil Engineering Department, Hong Kong Government. 76 p. plus 1 drawing.

Chen, P.K.H. (1993). *Hong Kong rainfall and landslides in 1992 (GEO Report No. 35)*. Geotechnical Engineering Office, Civil Engineering Department, Hong Kong Government. 201 p. plus 2 drawings.

Chan, W.L. (1995). *Hong Kong rainfall and landslides in 1993 (GEO Report No. 43)*. Geotechnical Engineering Office, Civil Engineering Department, Hong Kong Government. 214 p. plus 1 drawing.

Chan, W.L. (1996). *Hong Kong rainfall and landslides in 1994 (GEO Report No. 54)*. Geotechnical Engineering Office, Civil Engineering Department, Hong Kong Government. 161 p. plus 1 drawing.

Wong, C.K.L. (1997). *Hong Kong rainfall and landslides in 1995 (GEO Report No. 59).* Geotechnical Engineering Office, Civil Engineering Department, HKSAR Government. 125 p. plus 1 drawing.

Wong, C.K.L. (1998). *Hong Kong rainfall and landslides in 1996 (GEO Report No. 70)*. Geotechnical Engineering Office, Civil Engineering Department, HKSAR Government. 84 p. plus 1 drawing.

Lam, T.W.K. (1999). *Hong Kong rainfall and landslides in 1997 (GEO Report No. 97).* Geotechnical Engineering Office, Civil Engineering Department, HKSAR Government. 271 p. plus 2 drawings.

Lam, T.W.K. (2000). *Hong Kong rainfall and landslides in 1998 (GEO Report No. 105)*. Geotechnical Engineering Office, Civil Engineering Department, HKSAR Government. 96 p. plus 1 drawing.

Ho, K.K.S., Chan, H.W. and Lam, T.M. (2002). *Review of 1999 landslides (GEO Report No. 127)*. Geotechnical Engineering Office, Civil Engineering Department, HKSAR Government. 70 p.

Ho, K.K.S., Sun, H.W., Chan, H.W. and Lam, T.M. (2004). *Review of landslides in 2000 (GEO Report No. 147)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 94 p.

Lam, T.T.M., Sun, H.W. and Ho, K.K.S. (2004). *Review of landslides in 2001 (GEO Report No. 155)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 43 p.

Hui, T.H.H., Lam, T.T.M. and Sun, H.W. (2005). *Review of landslides in 2002 (GEO Report No. 172)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 48 p.

Hui, T.H.H. and Ng, A.F.H. (2006). *Factual Report on Hong Kong Rainfall and Landslides in 2003 (GEO Report No. 186)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 73 p.

Ng, A.F.H., Hui, T.H.H. and Sun, H.W. (2007). *Review of landslides in 2004 (GEO Report No. 202)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 42 p.

Tam, S.M., Lau, T.M.F., Ng, A.F.H. and Kong, H.S.W. (2008). *Review of landslides in 2005 (GEO Report No. 220)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 53 p.

Tam, S.M. and Lau, T.M.F. (2008). *Review of landslides in 2006 (GEO Report No. 237)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 42 p.

Ng, A.F.H., Lau, J.W.C. and Lau, T.M.F. (2010). *Review of landslides in 2007 (GEO Report No. 253)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 42 p.

Li, A.C.O., Lau, J.W.C., Cheung, L.L.K. and Lam, C.L.H. (2012). *Review of landslides in 2008 (GEO Report No. 274)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 60 p.

Li, A.C.O., Lau, J.W.C. and Lam, C.L.H. (2013). *Review of landslides in 2009 (GEO Report No. 290)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 39 p.

Li, A.C.O., Leung, J.W.C. and Lam, H.W.K. (2014). *Review of landslides in 2010 (GEO Report No. 305)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 37 p.

Lam, H.W.K., Leung, J.C.W. and Lo, D.O.K. (2014). *Review of landslides in 2011 (GEO Report No. 306)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government. 34 p.

C.2 Annual reports of CEDD:

These reports are available at:
http://www.cedd.gov.hk/eng/publications/annual_report/index.html

CEDD (2013). *CEDD Annual Report 2012*. Civil Engineering and Development Department, HKSAR Government. 60 p.

CEDD (2014). *CEDD Annual Report 2013*. Civil Engineering and Development Department, HKSAR Government. 76 p.

Appendix D Matlab script for determination of relative weights of component indicators by the Analytic Hierarchy Process (AHP)

```
function [Eigenvalue CI CR Prin_eigenvector Prior_vector] = eigenvector(M)
% This function calculates the Eigenvalue, Consistency Index (CI), and
% Consistency Ratio (CR) of the matrix (Table 13, Carreño et al. 2007) of
% pairwise comparisons for different public policies. It also gives the
% principal eigenvector and normalized priority vector for each indicator
% (Table 14, Carreño et al. 2007)

% created by Jessica K. Y. Chiu in January 2014 at UiO

[V, E]=eig(M);

[Eigenvalue I]=max(E(:));
[max_row max_col]=ind2sub(size(E),I);

Prin_eigenvector = V(:,max_col);

% Consistency Index
CI = (Eigenvalue-length(M))/(length(M)-1);

% Consistency Ratio = CI divided by index of the corresponding random
% matrix. The index is called the random consistency index (RI) and is
derived from Saaty (1980).
if length(M)==3
    CR = CI/0.58;
elseif length(M)==4
    CR = CI/0.90;
elseif length(M)==5
    CR = CI/1.12;
elseif length(M)==6
    CR = CI/1.24;
else
        error
end

% Test CR against acceptable range
if CR>0.1
        CR
%     error('CR exceeds 0.1, elements need to be modified')
else
end

%Pre-allocate output
Prior_vector = zeros(length(M), 1);
V_sum=sum(Prin_eigenvector(:,1));

for i=1:length(M)
    Prior_vector(i,1)=Prin_eigenvector(i,1)/V_sum;
end
end
```

Appendix E Matlab script for calculation of Risk Management Index (RMI)

```
function [ RMI ] = rmi(Prior_vector, Perform)
% This function calculates the RMI index based on the defuzzification
% methodology explained in Cardona  et al. (2005) and Carreño et al. (2007)
% This function mainly makes use of the Fuzzy Logic Toolbox

% created by Jessica K. Y. Chiu in May 2014 at UiO

% defining membership functions
x = 0:0.1:100;
MF=zeros(6,length(x));

MF(1,:) = sigmf(x,[-0.45 8.2]);
          %Fuzzy Logic Toolbox
MF(2,:) = gbellmf(x,[6.9524 1.9812 17]);           %Fuzzy Logic Toolbox
MF(3,:) = gbellmf(x,[14.3417 1.8203 45]);          %Fuzzy Logic Toolbox
MF(4,:) = gbellmf(x,[8.6917 2.0149 76.9]);         %Fuzzy Logic Toolbox
MF(5,:) = sigmf(x,[0.3782 87.92]);
          %Fuzzy Logic Toolbox

WMF=zeros(6,length(x));
area=zeros(6,1);
moment=zeros(6,1);

for i=1:6
    if Perform(i)==1
        WMF(i,:)=Prior_vector(i)*MF(1,:);
%         X=5.0123;
    elseif Perform(i)==2
        WMF(i,:)=Prior_vector(i)*MF(2,:);
%         X=17.2617;
    elseif Perform(i)==3
        WMF(i,:)=Prior_vector(i)*MF(3,:);
%         X=45.1652;
    elseif Perform(i)==4
        WMF(i,:)=Prior_vector(i)*MF(4,:);
%         X=76.6586;
    elseif Perform(i)==5
        WMF(i,:)=Prior_vector(i)*MF(5,:);
%         X=93.0582;
    end
    area(i,1)=trapz(x,WMF(i,:));    % area of the curve
    moment(i,1)=trapz(x,x.*WMF(i,:));  % product of area of curve and the
index
end

RMI = sum(moment)/sum(area);

end
```

Appendix F Verification of Cardona et al. (2005)'s RMI Results

The RMI results for the 11 Latin American and Caribbean countries in Cardona et al. (2005) are calculated using the Matlab script written for the present study. The original data and Cardona et al. (2005)'s RMI results can be obtained from the following:

1) Qualification of the component indicators: Table 4.4.2 to Table 4.4.5 in Cardona et al. (2005)
2) AHP weights of component indicators: Table 4.4.7 in Cardona et al. (2005)
3) RMI results: Table 4.4.1 in Cardona et al. (2005)

During the present study, the Matlab script for calculation of RMI was modified. The former script follows the equation stated in Cardona et al. (2005) which unifies all the membership functions in a fuzzy set before determining the centroid of area (Equation D.1). Using this script, similar results as Cardona et al. (2005) can be produced (Table F.1). Only two results have greater than 10% difference from those calculated by Cardona et al. (2005) (Table F.2):

$$RMI_p = \left[\max\left(w_1 \times \mu_C(C_1), \cdots, w_n \times \mu_C(C_n)\right)\right]_{centroid} \tag{D.1}$$

Table F.1 RMI results calculated using previous script

Year		lnd	Weight	ARG	CHL	COL	CRI	OOM	ECU	SLV	GTM	JAM	MEX	PER
1985	1	Rl	AHP	7.60	10.74	11.40	13.70	5.01	11.60	37.31	11.25	13.63	38.06	11.31
	2	RR	AHP	9.80	29.52	11.84	5.01	5.01	5.01	5.01	5.01	11.62	5.01	5.01
	3	DM	AHP	14.25	24.72	5.01	5.01	5.01	9.68	14.58	11.62	54.68	5.01	9.97
	4	FP	AHP	5.01	31.78	5.01	28.71	5.01	5.01	30.11	6.83	14.41	5.01	5.01
	5	RMI	AHP	9.16	24.19	8.32	13.11	5.01	7.82	21.75	8.68	23.59	13.28	7.83
1990	6	Rl	AHP	9.16	31.44	26.25	13.70	10.24	15.84	33.06	11.25	35.64	38.06	28.87
	7	RR	AHP	26.47	42.33	14.83	29.87	5.01	16.48	5.01	5.01	31.41	15.84	10.47
	8	DM	AHP	38.79	32.53	13.38	16.66	5.01	16.95	14.58	33.33	51.62	13.38	26.54
	9	FP	AHP	5.01	31.78	13.38	33.39	5.01	5.01	39.30	15.53	36.79	5.01	5.01
	10	RMI	AHP	19.86	34.52	16.96	23.41	6.32	13.57	22.99	16.28	38.86	18.07	17.72
1995	11	Rl	AHP	25.62	39.41	32.87	37.75	10.24	33.29	37.31	11.25	40.98	41.12	35.22
	12	RR	AHP	26.47	42.33	40.13	45.43	11.80	16.48	14.59	14.89	31.46	41.53	17.26
	13	DM	AHP	57.29	45.17	13.38	64.59	5.01	16.95	14.58	42.27	55.47	16.63	26.54
	14	FP	AHP	6.92	45.17	31.14	33.39	5.01	5.01	39.30	31.55	38.07	14.91	8.84
	15	RMI	AHP	29.07	43.02	29.38	45.29	8.02	17.93	26.45	24.99	41.50	28.55	21.97
2000	16	Rl	AHP	42.84	45.02	48.43	48.81	12.23	42.28	33.06	32.54	53.08	54.14	51.88
	17	RR	AHP	38.58	42.33	44.21	48.84	29.74	16.71	33.72	17.26	31.46	41.53	35.44
	18	DM	AHP	52.38	66.96	29.71	49.69	14.16	40.21	38.98	64.61	59.68	43.99	44.14
	19	FP	AHP	6.92	62.30	40.51	42.91	13.06	5.01	39.71	32.83	38.07	40.17	17.26
	20	RMI	AHP	35.18	54.15	40.71	47.56	17.30	26.05	36.37	36.81	45.57	44.96	37.18

Table F.2 Percentage difference of RMI results calculated using previous script from Cardona et al. (2005) results

Year		Ind	Weight	ARG	CHL	COL	CRI	OOM	ECU	SLV	GTM	JAM	MEX	PER
	1	**RI**	**AHP**	8.90	8.48	8.16	6.65	9.92	8.06	3.44	8.24	6.99	3.44	8.22
	2	**RR**	**AHP**	8.72	0.69	7.97	9.92	9.92	9.92	9.92	9.92	7.98	9.92	9.92
1985	**3**	**DM**	**AHP**	6.66	0.00	9.92	9.92	9.92	8.76	6.43	8.06	0.44	9.92	8.70
	4	**FP**	**AHP**	9.92	1.14	9.92	5.34	9.92	9.92	4.96	8.91	6.53	9.92	9.92
	5	**RMI**	**AHP**	8.07	1.47	8.58	6.51	9.92	8.83	4.84	8.58	3.13	5.19	8.84
	6	**RI**	**AHP**	8.81	1.10	4.70	11.78	8.62	5.47	3.87	8.24	3.45	3.44	4.29
	7	**RR**	**AHP**	4.94	2.35	6.25	1.97	9.92	4.76	9.92	9.92	3.31	5.45	8.50
1990	**8**	**DM**	**AHP**	3.80	1.18	7.10	4.54	9.92	4.09	6.43	1.31	1.02	7.10	3.64
	9	**FP**	**AHP**	9.92	1.14	7.10	2.26	9.92	9.92	3.70	5.71	3.48	9.92	9.92
	10	**RMI**	**AHP**	5.12	1.50	5.99	3.84	9.34	5.19	4.50	4.09	2.62	4.95	5.06
	11	**RI**	**AHP**	3.19	2.07	1.26	1.73	8.62	1.33	3.44	8.24	2.25	3.36	1.59
	12	**RR**	**AHP**	4.94	2.35	2.17	-0.68	8.05	4.76	6.41	6.20	3.29	3.03	1.54
1995	**13**	**DM**	**AHP**	-0.04	0.37	7.10	-0.77	9.92	4.09	6.43	2.33	-0.30	4.54	3.64
	14	**FP**	**AHP**	8.90	0.37	-1.14	2.26	9.92	9.92	3.70	3.30	3.18	6.13	8.95
	15	**RMI**	**AHP**	2.26	1.24	1.55	0.31	8.77	3.29	4.32	3.82	1.78	3.77	2.88
	16	**RI**	**AHP**	-0.01	-0.24	0.04	-0.24	7.88	2.33	3.87	1.20	0.19	0.90	-1.45
	17	**RR**	**AHP**	18.60	2.35	-0.55	0.03	4.28	4.44	3.59	1.54	3.29	3.03	1.61
2000	**18**	**DM**	**AHP**	0.79	-0.24	3.40	-1.31	6.62	2.98	3.01	-0.35	-0.77	2.32	-0.27
	19	**FP**	**AHP**	8.90	-0.54	2.19	-0.51	7.29	9.92	2.88	2.76	3.18	2.71	1.54
	20	**RMI**	**AHP**	5.24	0.17	1.00	-0.52	5.92	3.27	3.32	0.88	1.01	2.13	-0.05

However, unifying the membership functions in a fuzzy set is not logical since it may hinder the contribution of all the membership functions, as illustrated in Figure F.1.

Instead, the current script considers moments of all the membership functions (Equation 3.6). In this case, all the membership functions will contribute to the RMI results. The results obtained are however substantially different from those in Cardona et al. (2005) (Table F.3). More than 27% of the results exceed 10% difference from Cardona et al. (2005) and some have greater than 30% of difference (Table F.4). This indicates that results in Cardona et al. (2005) should be re-examined.

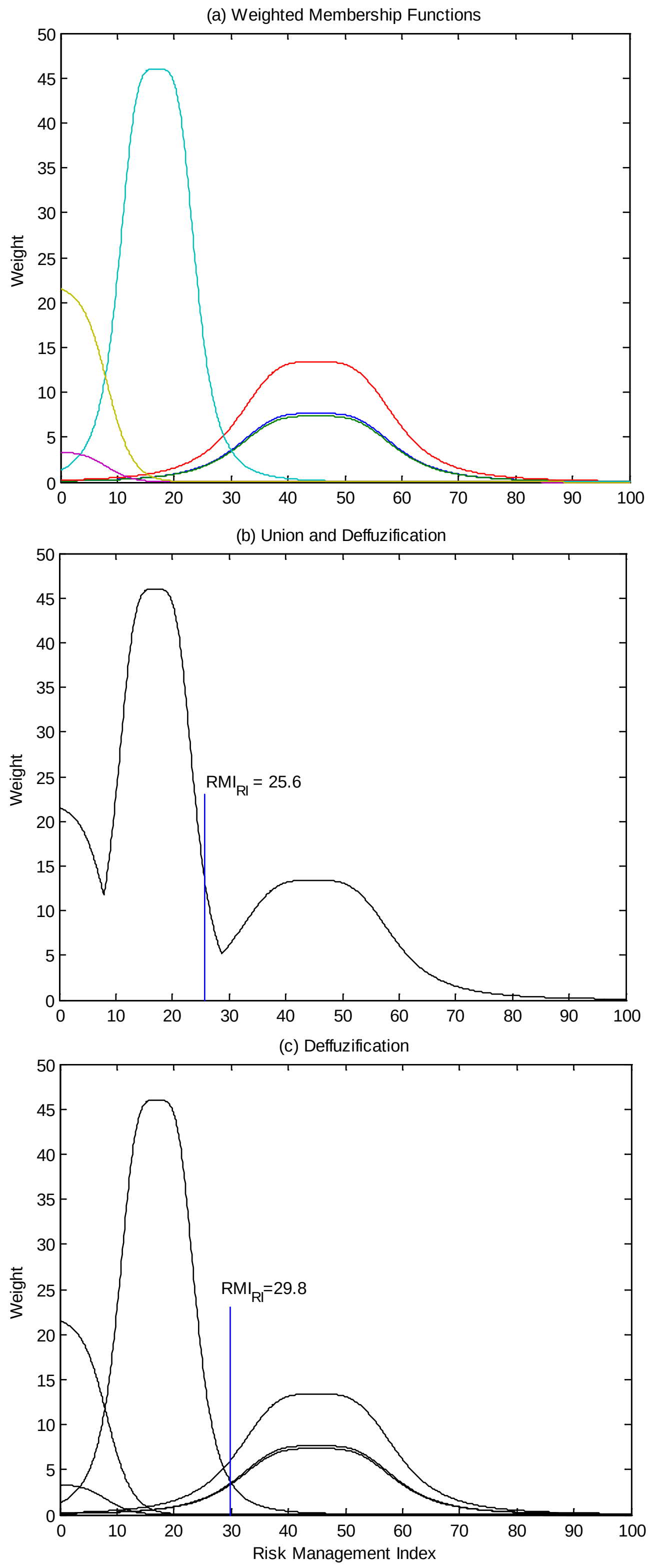


Figure F.1 Calculation of RMI$_{RI}$ for ARG in 1995. The membership functions are shown in (a). (b) After union, two of the membership functions are incorporated into the red membership function. As a result, two component indicators which have qualifications of 3 are eliminated. This will lead to a lower RMI$_{RI}$ than in (c), in which every membership function is considered.

Table F.3 RMI results calculated using current script (Appendix E).

Year		Ind	Weight	ARG	CHL	COL	CRI	OOM	ECU	SLV	GTM	JAM	MEX	PER
	1	RI	AHP	6.64	10.45	10.32	11.78	5.01	11.91	22.60	9.44	13.12	34.17	8.39
	2	RR	AHP	8.14	25.07	8.87	5.01	5.01	5.01	5.01	5.01	9.93	5.01	5.01
1985	3	DM	AHP	12.61	21.66	5.01	5.01	5.01	7.82	12.17	12.77	47.29	5.01	7.37
	4	FP	AHP	5.01	28.86	5.01	22.76	5.01	5.01	21.61	6.06	12.01	5.01	5.01
	5	RMI	AHP	8.10	21.51	7.30	11.14	5.01	7.44	15.35	8.32	20.59	12.30	6.45
	6	RI	AHP	10.21	29.53	21.37	13.82	7.96	16.20	23.39	13.34	30.79	34.17	24.70
	7	RR	AHP	23.03	42.26	15.32	23.20	5.01	16.05	5.01	5.01	29.06	15.36	8.37
1990	8	DM	AHP	35.99	31.38	11.46	16.77	5.01	16.91	12.17	30.46	45.63	10.51	22.03
	9	FP	AHP	5.01	37.14	13.05	27.64	5.01	5.01	37.32	15.08	34.26	5.01	5.01
	10	RMI	AHP	18.56	35.08	15.30	20.36	5.75	13.54	19.47	15.97	34.94	16.26	15.03
	11	RI	AHP	29.78	41.12	40.15	39.87	7.96	33.82	31.54	13.66	41.29	40.19	39.17
	12	RR	AHP	23.03	42.26	38.38	47.25	8.73	16.05	14.41	13.87	34.60	39.66	17.26
1995	13	DM	AHP	55.78	45.17	14.27	57.31	5.01	16.91	12.17	42.99	50.16	16.69	22.32
	14	FP	AHP	6.20	45.17	29.81	27.64	5.01	5.01	37.32	28.45	36.67	14.01	6.71
	15	RMI	AHP	28.70	43.43	30.65	43.02	6.68	17.95	23.86	24.74	40.68	27.64	21.36
	16	RI	AHP	43.62	47.30	47.59	46.81	14.39	42.50	31.55	36.98	57.07	50.42	48.60
	17	RR	AHP	35.70	42.91	41.39	48.86	25.55	16.75	27.00	17.26	34.60	39.66	38.42
2000	18	DM	AHP	51.68	63.66	23.28	52.77	15.85	33.69	38.33	69.41	51.49	44.01	42.90
	19	FP	AHP	6.20	55.72	37.10	44.25	10.54	5.01	38.82	29.69	36.67	33.78	17.26
	20	RMI	AHP	34.30	52.40	37.34	48.17	16.58	24.49	33.92	38.34	44.96	41.97	36.79

Table F.4 Percentage difference of RMI results calculated using current script (Appendix E) from Cardona et al. (2005) results

Year		Ind	Weight	ARG	CHL	COL	CRI	OOM	ECU	SLV	GTM	JAM	MEX	PER
	1	RI	AHP	-4.81	5.60	-2.07	-8.29	9.92	10.99	-37.35	-9.18	3.02	-7.14	-19.68
	2	RR	AHP	-9.66	-14.51	-19.15	9.92	9.92	9.92	9.92	9.92	-7.74	9.92	9.92
1985	3	DM	AHP	-5.64	-12.39	9.92	9.92	9.92	-12.17	-11.19	18.81	-13.13	9.92	-19.62
	4	FP	AHP	9.92	-8.14	9.92	-16.53	9.92	9.92	-24.69	-3.42	-11.24	9.92	9.92
	5	RMI	AHP	-4.47	-9.77	-4.65	-9.50	9.92	3.44	-26.05	4.12	-9.98	-2.52	-10.33
	6	RI	AHP	21.20	-5.04	-14.77	12.74	-15.59	7.86	-26.53	28.44	-10.63	-7.14	-10.77
	7	RR	AHP	-8.69	2.18	9.73	-20.78	9.92	2.03	9.92	9.92	-4.41	2.29	-13.30
1990	8	DM	AHP	-3.68	-2.40	-8.21	5.20	9.92	3.85	-11.19	-7.42	-10.70	-15.85	-13.97
	9	FP	AHP	9.92	18.20	4.49	-15.34	9.92	9.92	-1.54	2.65	-3.63	9.92	9.92
	10	RMI	AHP	-1.75	3.14	-4.38	-9.68	-0.53	4.98	-11.50	2.13	-7.75	-5.55	-10.92
	11	RI	AHP	19.95	6.50	23.69	7.42	-15.59	2.95	-12.55	31.50	3.01	1.02	12.97
	12	RR	AHP	-8.69	2.18	-2.29	3.30	-20.09	2.03	5.13	-1.06	13.58	-1.61	1.54
1995	13	DM	AHP	-2.67	0.37	14.23	-11.96	9.92	3.85	-11.19	4.06	-9.85	4.90	-12.86
	14	FP	AHP	-2.38	0.37	-5.38	-15.34	9.92	9.92	-1.54	-6.83	-0.63	-0.26	-17.28
	15	RMI	AHP	0.94	2.21	5.95	-4.73	-9.39	3.38	-5.88	2.80	-0.23	0.46	0.07
	16	RI	AHP	1.80	4.81	-1.69	-4.34	26.93	2.85	-0.89	15.02	7.73	-6.03	-7.68
	17	RR	AHP	9.76	3.74	-6.89	0.05	-10.43	4.70	-17.05	1.54	13.58	-1.61	10.14
2000	18	DM	AHP	-0.55	-5.16	-18.97	4.80	19.33	-13.74	1.31	7.05	-14.40	2.36	-3.08
	19	FP	AHP	-2.38	-11.04	-6.41	2.59	-13.42	9.92	0.56	-7.07	-0.63	-13.62	1.54
	20	RMI	AHP	2.61	-3.08	-7.36	0.75	1.53	-2.95	-3.62	5.06	-0.36	-4.66	-1.09

Appendix G Survey on Performance of Landslide Risk Management in Hong Kong

Survey on Performance of Landslide Risk Management

Background of study

The current study aims at assessing a territory, e.g. country's risk management performance for landslide risks.

Risk management of a territory takes into account a territory's capability in reducing vulnerability and losses, preparing for crisis and recovering efficiently from disasters. To assess the performance of the territory in risk management, the Risk Management Index[1] (RMI) will be used. The RMI provides a mean to evaluate the achievement levels of risk management. The index is based on indicators grouped into four public policies, including the identification of risk, reduction of risk, disaster management, and governance and financial protection[2].

About the survey

The objective of the survey is to collect data for calculating the RMI of a territory. Analyzed results from the survey can be used to assess the risk management performance of a territory in terms of **time (10 years ago, present, and 10 years later)**. It is expected that participants have certain degree of knowledge on the risk management activities of the place of evaluation, therefore you are invited to answer the survey based on your workplace.

The survey is divided into two tiers. You can choose to complete EITHER ONE. The 1st Tier requires participants to valuate each indicator using five implicit performance levels: low, incipient, significant, outstanding, and optimal; whereas in the 2nd Tier, those performance levels are described explicitly as achievement targets. The estimated lengths of time required for completing the 1st and 2nd Tier of the survey are 10-15 min and 30-45 min respectively.

References:

1. Cardona, O.D., Hurtado, J.E., Duque, G., Moreno, A., Chardon, A.C., Velásquez, L.S., Prieto, S.D. (2003). *The Notion of Disaster Risk: Conceptual framework for integrated management.* IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales.
2. _________. (2005). *System of indicators for disaster risk management: program for Latin America and the Caribbean: main technical report.* IDB/IDEA Program on Indicators for Disaster Risk Management, Universidad Nacional de Colombia, Manizales.

Personal and Occupational Information

Territory: ____________________

Gender:
- ○ M
- ○ F

Age:
- ○ <35
- ○ 35-44
- ○ 44-54
- ○ 55-64
- ○ 65-74
- ○ >74

Education Level:
- ○ Primary education
- ○ Secondary education
- ○ Technical/Vocational training
- ○ Associate degree or equivalent
- ○ Others, please specify: ____________________
- ○ Bachelor or equivalent
- ○ Master or equivalent
- ○ Doctoral or equivalent

Affiliated organization:
- ○ Government
- ○ Industrial research
- ○ Civil society
- ○ Others, please specify: ____________________
- ○ Academia
- ○ Consultant

Discipline in risk management:
- ○ Risk identification
- ○ Emergency response
- ○ Insurance
- ○ Finance
- ○ Others, please specify: ____________________
- ○ Risk reduction
- ○ Training
- ○ Public information and community participation
- ○ Legislation

Role of responsibility:
- ○ Executive
- ○ Technical
- ○ Management
- ○ Others, please specify: ____________________

Which Tier do you want to complete?
- ○ 1st Tier (10-15 min)
- ◉ 2nd Tier (30-45 min) *Recommended

1st Tier

Risk Identification

Select one box for each year

Indicator Degree of …		2004	2014	2024
RI1. Details, completeness, and systematic of inventory of landslide events.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
RI2. Advancement, coverage and maintenance of instrumentation in hazard monitoring and forecasting.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
RI3. Details and adequacy of scales in landslide hazard mapping and evaluation of landslide hazards.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
RI4. Coverage of exposed areas and buildings to landslides hazards for vulnerability analysis and adequacy of factors considered in risk analysis (factors include physical, social, cultural and environmental criteria)	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
RI5. Frequency of promotion of landslide risk management issues at the territory level and scale of participation and support from private sectors and NGOs in promotion activities.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
RI6. Popularization of curricula in landslide hazards and risk management in all stages of education, technical capacity of the territory to generate landslide risk knowledge, and provision of continuous scheme for community training.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			

1st Tier

Risk Reduction

Select one box for each year

Indicator Degree of …		2004	2014	2024
RR1. Extent within the territory with the consideration of landslide risk in territorial organization plans.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
RR2. Intervention in deteriorated/strategic basins and sensitive zones and implementation of environmental protection plan within the territory.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
RR3. Extent of construction of landslide mitigation works for the protection of human settlements and social investment within the territory.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
RR4. Control of landslide risk areas with housing improvement works and implementation of relocation programme of housing in non mitigable risk zones.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
RR5. Enforcement of safety standards and construction codes and updating of them based on local particularities.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
RR6. Obligatory retrofitting of principal public and private buildings and implementation of programs of fiscal incentives for housing rehabilitation lead to lower socio-economic sectors.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			

1st Tier

Disaster Management

Select one box for each year

Indicator				
Degree of …		**2004**	**2014**	**2024**
DM1. Coordination between public, private and community based bodies for response in case of emergencies.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
DM2. Establishment of emergency and contingency plans for all territory levels and the implementation of information and warning systems over the territory.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
DM3. Stable supply of equipments, tools and infrastructure in reserve centers and Emergency Operations Centre for communications, transport and supply facilities during emergency.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
DM4. Frequency of testing of emergency and contingency plans and updating of operational procedures in the majority of the territory.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
DM5. Popularization and frequency of training program on emergency response among the community and in coordination with other organizations and NGOs.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
DM6. Comprehensiveness and details in reconstruction plans dealing with physical damage and social recovery based on risk scenarios over the territory.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			

1st Tier

Governance and Financial Protection (Loss Transfer)

Select one box for each year

Indicator: Degree of …		2004	2014	2024
FP1. Implementation and expertise of risk management system incorporated by interinstitutional, multisectoral and decentralizing organization	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
FP2. Financial autonomy of reserve funds for co-financing institutional risk-management projects and recovering in case of disaster.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
FP3. **National** orientation for allocation of budget to local organizations and implementation of incentives and rates of environmental protection and security.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
FP4. Implementation of support funds and social protection and poverty reduction programs oriented to the reduction of human vulnerability throughout the territory.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
FP5. Insurance coverage for public goods such as buildings, infrastructures and implementation of loss transfer strategies of public assets, such as considering reinsurance groups, risk titles, bonds, etc.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			
FP6. Insurance coverage for housing and private sector insurance, government support of insurance coverage for small businesses and the poorest, and implementation of economic incentive for risk reduction and mass insurance.	1.Low			
	2.Incipient			
	3.Significant			
	4.Outstanding			
	5.Optimal			

2nd Tier

Risk Identification

Select one box for each year

Indicator and Performance levels

RI1. Systematic disaster and loss inventory

		2004	2014	2024
1	Some basic and superficial data on the history of landslide events.	○	○	○
2	Continual registering of current landslide events, incomplete catalogues of the occurrence of some events and limited information on losses and effects.	○	○	○
3	Some complete catalogues of landslide events, systematization of actual events and their economic, social, and environmental effects.	○	○	○
4	Complete inventory and multiple catalogues of landslide events; registry and detailed systematization of effects and losses.	○	○	○
5	Detailed inventory of events and effects for all landslides events and databases.	○	○	○

RI2. Hazard monitoring and forecasting

		2004	2014	2024
1	Minimum and deficient instrumentation.	○	○	○
2	Basic instrumentation networks with problems of updated technology and continuous maintenance.	○	○	○
3	Some networks with advanced technology; improved prognostics and information protocols established.	○	○	○
4	Good and progressive instrumentation, advanced research in the matter on the majority of hazards, and some automatic warning systems working.	○	○	○
5	Wide coverage of station and sensor networks for landslide hazards in all parts of the territory; permanent and opportune analysis of information and automatic early warning systems working continuously in the territory.	○	○	○

RI3. Hazard evaluation and mapping

		2004	2014	2024
1	Superficial evaluation and basic maps covering the influence and susceptibility of landslides.	○	○	○
2	Some descriptive and qualitative studies of susceptibility and hazard of landslides at the territory level and for some specific areas.	○	○	○
3	Some hazard maps based on probabilistic techniques for the territory level and for some regions. Generalized use of GIS for mapping the principle hazards.	○	○	○
4	Evaluation is based on advanced and adequate resolution methodologies for the majority of landslide hazards. Microzonification of some regions based on probabilistic techniques.	○	○	○
5	Detailed studies of landslide hazards throughout the territory. Micro zoning and hazard maps at the territory level.	○	○	○

RI4. Vulnerability and risk assessment

		2004	2014	2024
1	Identification and mapping of the principle elements exposed in prone zones.	○	○	○
2	General studies of physical vulnerability when faced with the most recognized landslide hazards, using GIS.	○	○	○
3	Evaluation of potential damage and loss scenarios for some landslide events. Analysis of the physical vulnerability of some essential buildings.	○	○	○
4	Detailed studies of risk using probabilistic techniques taking into account the economic and social impact of the majority of landslide hazards in some regions. Vulnerability analysis for the majority of essential buildings and life lines.	○	○	○
5	Generalized evaluation of risk, considering physical, social, cultural and environmental factors. Vulnerability analysis also for private buildings and the majority of life lines.	○	○	○

RI5. Public information and community participation

		2004	2014	2024
1	Sporadic information on risk management in normal conditions and more frequently when disaster occur.	○	○	○
2	Press, radio and television coverage oriented towards preparedness in case of emergency. Production of illustrative materials on dangerous phenomena.	○	○	○
3	Frequent opinion programs on risk management issues. Guidelines for vulnerability reduction. Work with communities and NGOs.	○	○	○
4	Generalized diffusion and progressive consciousness; conformation of some social networks for civil protection and NGOs that explicitly promote risk management issues and practice.	○	○	○
5	Widescale participation and support form the private sector for diffusion activities. Consolidation of social networks and notable participation of professionals and NGOs at all levels.	○	○	○

RI6. Training and education in risk management

		2004	2014	2024
1	Incipient incorporation of topics about landslides in formal education and programs for community participation.	○	○	○
2	Some curricular adjustments at the primary and secondary levels. Production of teaching guides for teachers and community leaders in some places.	○	○	○
3	Progressive incorporation of landslide risk management in curricula. Considerable production of teaching materials and undertaking of frequent courses for community training.	○	○	○
4	Widening of curricular reform to higher education programs. Specialization courses offered at various universities. Wide ranging community training at the local level.	○	○	○
5	High technical capacity of the territory to generate landslide risk knowledge. Generalized curricular reform throughout the territory and in all stages of education. Wide ranging production of teaching materials. Permanent schemes for community training.	○	○	○

2nd Tier

Risk Reduction

Select one box for each year

Indicator and Performance levels

	RR1. Risk consideration in land use and urban planning	2004	2014	2024
1	Consideration of some means for identifying risk, and environmental protection in physical planning.	○	○	○
2	Promulgation of some local regulations and legislation that consider landslide hazards as a factor in territorial organization and development planning.	○	○	○
3	Progressive formulation of land use regulations in various cregions that take into account landslide hazards and risks.	○	○	○
4	Wide ranging formulation and updating of territorial organization plans with a preventive approach in the majority area of the territory.	○	○	○
5	Generalized approval and control of implementation of territorial organization plans that include landslide risk as a major factor.	○	○	○

	RR2. Hydrographic basin intervention and environmental protection	2004	2014	2024
1	Inventory of basins and areas of severe environmental deterioration or those considered to be most fragile	○	○	○
2	Promulgation of territory level legal dispositions and some local ones that establish the obligatory nature of reforestation, environmental protection and river basin planning.	○	○	○
3	Formulation of some plans for organization and intervention in strategic water basins and sensitive zones taking into account landslide risk and vulnerability aspects.	○	○	○
4	Appreciable number of regions and water basins with environmental protection plans, impact studies and ordering of agricultural areas and that consider landslide risk a factor in determining investment divisions.	○	○	○
5	Intervention in a considerable number of deteriorated basins, sensitive zones and strategic ecosystems. Majorities regions have environmental intervention and protection plans.	○	○	○

	RR3. Implementation of hazard-event control and protection techniques	2004	2014	2024
1	Some structural control and stabilization measures in some more dangerous places.	○	○	○
2	Channeling works in most major regions all constructed following security norms.	○	○	○
3	Establishment of measures and regulations for the design and construction of hazard control and protection works in harmony with territorial organization dictates.	○	○	○
4	Wide scale intervention in mitigable risk zones using protection and control measures in principal regions.	○	○	○
5	Adequate design and construction of stabilizing, dissipation and control works in the majority of territory in order to protect human settlements and social investment.	○	○	○

	RR4. Housing improvement and human settlement relocation from prone-areas	2004	2014	2024
1	Identification and inventory of marginal human settlements located in landslide hazard prone areas.	○	○	○
2	Promulgation of legislation establishing the priority of dealing with deteriorated urban areas at risk of landslides.	○	○	○
3	Programs for upgrading the surroundings, existing housing, and relocation from landslide risk areas in principal regions.	○	○	○
4	Progressive intervention of human settlements at risk of landslide hazards in the majority of regions and adequate treatment of cleared areas.	○	○	○
5	Notable control of landslide risk areas in the territory and relocation of the majority of housing constructed in non mitigable risk zones.	○	○	○

	RR5. Updating and enforcement of safety standards and construction codes	2004	2014	2024
1	Voluntary use of norms and codes from other countries without major adjustments	○	○	○
2	Adaptation of some requirements and specifications according to some national and local criteria and particularities.	○	○	○
3	Promulgation and updating of obligatory norms based on international norms that have been adjusted according to the hazard evaluations made in the territory.	○	○	○
4	Technological updating of the majority of security and construction code norms for new and existing buildings with special requirements for special buildings and life lines.	○	○	○
5	Permanent updating of codes and security norms: establishment of local regulations for construction.	○	○	○

	RR6. Reinforcement and retrofitting of public and private assets	2004	2014	2024
1	Retrofitting and sporadic adjustments to buildings and life lines; remodeling, changes of use or modifications.	○	○	○
2	Promulgation of intervention norms as regards the vulnerability of existing buildings. Strengthening of essential buildings such as hospitals or those considered indispensable.	○	○	○
3	Some mass programs for evaluating vulnerability, rehabilitation and retrofitting of hospitals, schools, and the central offices of life line facilities. Obligatory nature of retrofitting.	○	○	○
4	Progressive number of buildings retrofitted, life lines intervened, some buildings of the private sector retrofitted autonomously or due to fiscal incentives given by government.	○	○	○
5	Massive retrofitting of principal public and private buildings. Permanent programs of incentives for housing rehabilitation lead to lower socio-economic sectors.	○	○	○

2nd Tier

Disaster Management

Select one box for each year

Indicator and Performance levels

DM1. Organization and coordination of emergency operations

		2004	2014	2024
1	Different organizations attend emergencies but lack resources and various operate only with voluntary personnel.	○	○	○
2	Specific legislation defines an institutional structure, roles for operational entities and coordination of emergency commissions throughout the territory.	○	○	○
3	Considerable coordination exists in some localities or districts, between organizations in preparedness, communications, search and rescue, emergency networks, and management of temporary shelters.	○	○	○
4	Permanent coordination for response between operational organizations, public services, local authorities and civil society organizations.	○	○	○
5	Advanced levels of interinstitutional organization between public, private and community based bodies. Adequate protocols exist for horizontal and vertical coordination throughtout the territory.	○	○	○

DM2. Emergency response planning and implementation of warning systems

		2004	2014	2024
1	Basic emergency and contingency plans exist with check lists and information on available personnel.	○	○	○
2	Legal regulations and exist that establish the obligatory nature of emergency plans. Some reigons have operational plans and articulation exists with technical information providers at the territory level.	○	○	○
3	Protocols and operational procedures are well defined in the territory. Various prognosis and warning centers operate continuously.	○	○	○
4	Emergency and contingency plans are complete and associated with information and warning systems in the territory.	○	○	○
5	Response preparedness based on probable scenarios in all localities or districts. Use of information technology to activate automatic response procedures / Response preparedness based on analysis.	○	○	○

DM3. Endowment of equipments, tools and infrastructure

		2004	2014	2024
1	Basic supply and inventory of resources only in the operational organizations and emergency commissions.	○	○	○
2	Centre with reserves and specialized equipment for emergencies. Inventory of resources in other public and private organizations.	○	○	○
3	Emergency Operations Centre (EOC) which is well stocked with communication equipment and adequate registry systems. Specialized equipment and reserve centers exist.	○	○	○
4	EOCs are well equipped and systematized. Progressive complimentary stocking of operational organizations.	○	○	○
5	Interinstitutional support networks between reserve centers and EOCs are working permanently. Wide ranging communications, transport and supply facilities exist in case of emergency.	○	○	○

DM4. Simulation, updating and test of inter institutional response

		2004	2014	2024
1	Some internal and joint institutional simulations between operational organizations exist.	○	○	○
2	Sporadic simulation exercises for emergency situations and institutional response exist with all operational organizations.	○	○	○
3	Desk and operational simulations with the additional participation of public service entities and local administrations.	○	○	○
4	Coordination of simulations with community, private sector and media at the territory level.	○	○	○
5	Testing of emergency and contingency plans and updating of operational procedures based on frequent simulation exercises.	○	○	○

DM5. Community preparedness and training

		2004	2014	2024
1	Informative meetings with community in order to illustrate emergency procedures during disasters.	○	○	○
2	Sporadic training courses with civil society organizations dealing with disaster related themes.	○	○	○
3	Community training activities are regularly programmed on emergency response in coordination with community development organizations and NGOs.	○	○	○
4	Courses are run frequently with communities on preparedness, prevention and reduction of risk.	○	○	○
5	Permanent prevention and disaster response courses in the entire territory within the framework of a training program in community development and in coordination with other organizations and NGOs.	○	○	○

DM6. Rehabilitation and reconstruction planning

		2004	2014	2024
1	Design and implementation of rehabilitation and reconstruction plans only after important disasters.	○	○	○
2	Planning of some provisional recovery measures by public service institutions and those responsible for damage evaluation.	○	○	○
3	Diagnostic procedures, reestablishment and repairing of infrastructure and production projects for community recovery are available.	○	○	○
4	Ex ante undertaking of recovery plans and programs to support social recovery, sources of employment and productive means for communities.	○	○	○
5	Generalized development of detailed reconstruction plans dealing with physical damage and social recovery based on risk scenarios. Specific legislation exists and anticipated measures for reactivation.	○	○	○

2nd Tier

Governance and Financial Protection (Loss Transfer)

Select one box for each year

Indicator and Performance levels

	FP1. Interinstitutional, multisectoral and decentralizing organization	2004	2014	2024
1	Basic organizations in commissions, principally with an emergency response approach.	○	○	○
2	Decentralized, Interinstitutional and multisectoral organization for the integral management of risk and formulation of a general risk management plan.	○	○	○
3	Interinstitutional risk management systems active at the local level. Work / Inter-ministerial work in the design of public policies for vulnerability reduction.	○	○	○
4	Continuous implementation of risk management projects associated with programs of adaptation to climate change, environmental protection, energy, sanitation and poverty reduction.	○	○	○
5	Expert personnel with wide experience incorporating risk management in sustainable human development planning. High technology information systems available.	○	○	○

	FP2. Reserve funds for institutional strengthening			
1	Existence of a national disaster fund.	○	○	○
2	Resource management from territory level is established and incipient risk management strengthens. / Regulation of existing reserve funds or creation of new sources to co-finance local level risk management projects.	○	○	○
3	Some occasional funds to co-finance risk management project in an interinstitutional way. / Economic support and search for international funds for institutional development and strengthening of risk management in the whole territory.	○	○	○
4	Reserve funds to co-finance projects, institutional strengthening and recovery in times of disaster are established / are progressively created.	○	○	○
5	Financial engineering for the design of retention and risk transfer instruments. Reserve funds operating.	○	○	○

	FP3. Budget allocation and mobilization			
1	Limited allocation of national budget to competent institutions for emergency response.	○	○	○
2	Legal norms establishing budgetary allocations to territory level organizations with risk management objectives.	○	○	○
3	Legally specified specific allocations for risk management and the frequent undertaking of interadministrative agreements for the execution of prevention projects.	○	○	○
4	Progressive allocation of discretionary expenses for vulnerability reduction, the creation of incentives and rates of environmental protection and security.	○	○	○
5	National orientation and support for loans from multilateral loan organizations.	○	○	○

	FP4. Implementation of social safety nets and funds response			
1	Sporadic subsidies to communities affected by disasters or in critical risk situations.	○	○	○
2	Permanent social investment funds created to support vulnerable communities focusing on the poorest socio-economic groups.	○	○	○
3	Social networks for the self protection of means of subsistence of communities at risk and undertaking of post disaster rehabilitation and reconstruction production projects.	○	○	○
4	Regular micro-credit programs and gender oriented activities oriented to the reduction of human vulnerability.	○	○	○
5	Generalized development of social protection and poverty reduction programs integrated with prevention and mitigation activities throughout the territory.	○	○	○

	FP5. Insurance coverage and loss transfer strategies of public assets			
1	Very few public buildings are insured at the territory level.	○	○	○
2	Obligatory insurance of public goods. Deficient insurance of infrastructure.	○	○	○
3	Progressive insurance of public goods and infrastructure.	○	○	○
4	Design of programs for the collective insurance of buildings and publically rented infrastructure.	○	○	○
5	Analysis and generalized implementation of retention and transfer strategies for losses to public goods, considering reinsurance groups, risk titles, bonds, etc.	○	○	○

	FP6. Housing and private sector insurance and reinsurance coverage			
1	Low percentage of private goods insured. Incipient, economically weak and little regulated insurance industry.	○	○	○
2	Regulation of insurance industry controls over solvency and legislation for insurance of house loan and housing sector.	○	○	○
3	Development of some careful insurance studies based on advanced probabilistic estimates of risk.	○	○	○
4	Design of collective housing insurance programs and for small businesses and insurance companies with automatic coverage for the poorest.	○	○	○
5	Strong support for joint programs between government and insurance companies in order to generate economic incentives for risk reduction and mass insurance.	○	○	○

Appendix H Survey on Performance of Landslide Risk Management in Norway

Survey on Performance of Landslide Risk Management

Background of study

The current study aims at assessing a country's risk management performance for landslide risks.

Landslide here includes various types of landslides which are generally classified in Norway as: '*steinskred*', '*steinsprang*', '*fjellskred*','*løsmasseskred, uspesifisert*', '*jordskred*', '*flomskred*', '*leirskred*', '*kvikkleireskred*',' and '*utglidning*'.

Risk management of a country takes into account a country's capability in reducing vulnerability and losses, preparing for crisis and recovering efficiently from disasters. To assess the performance of the country in risk management, the Risk Management Index[1] (RMI) will be used. The RMI provides a mean to evaluate the achievement levels of risk management. The index is based on indicators grouped into four public policies, including the identification of risk, reduction of risk, disaster management, and governance and financial protection[2].

About the survey

The objective of the survey is to collect data for calculating the RMI of a country. Analyzed results from the survey can be used to assess the risk management performance of a country in terms of **time (10 years ago, present, and 10 years later)** and **different administrative levels (county and national level)**. It is expected that participants have certain degree of knowledge on the risk management activities of the place of evaluation, therefore you are invited to answer the survey based on the county(ies) and country of your workplace.

The survey is divided into two tiers. You can choose to complete EITHER ONE. The 1st Tier requires participants to valuate each indicator using five implicit performance levels: low, incipient, significant, outstanding, and optimal; whereas in the 2nd Tier, those performance levels are described explicitly as achievement targets. The estimated lengths of time required for completing the 1st and 2nd Tier of the survey are 10-15 min and 30-45 min respectively.

References:

1. Cardona, O.D., Hurtado, J.E., Duque, G., Moreno, A., Chardon, A.C., Velásquez, L.S., Prieto, S.D. (2003). *The Notion of Disaster Risk: Conceptual framework for integrated management.* IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales.
2. _________. (2005). *System of indicators for disaster risk management: program for Latin America and the Caribbean: main technical report.* IDB/IDEA Program on Indicators for Disaster Risk Management, Universidad Nacional de Colombia, Manizales.

Personal and Occupational Information

Country: ____________________________

County(ies) most familiar with, ranked from 1 to 3:

Note that you are required to answer the questionnaire based on these counties.

If you are familiar with only one county, select '**N/A**' for both 2. and 3.

1. --Please select-- **2.** --Please select-- **3.** --Please select--

Gender: ○ M ○ F

Age: ○ <35 ○ 35-44 ○ 44-54 ○ 55-64 ○ 65-74 ○ >74

Education Level:
- ○ Primary education
- ○ Secondary education
- ○ Technical/Vocational training
- ○ Associate degree or equivalent
- ○ Others, please specify: ____________________________
- ○ Bachelor or equivalent
- ○ Master or equivalent
- ○ Doctoral or equivalent

Affiliated organization:
- ○ Government
- ○ Industrial research
- ○ Civil society
- ○ Others, please specify: ____________________________
- ○ Academia
- ○ Consultant

Discipline in risk management:
- ○ Risk identification
- ○ Emergency response
- ○ Insurance
- ○ Finance
- ○ Others, please specify: ____________________________
- ○ Risk reduction
- ○ Training
- ○ Public information and community participation
- ○ Legislation

Role of responsibility:
- Executive
- Technical
- ○ Management
- ○ Others, please specify: ____________________________

Which Tier do you want to complete?
- ○ 1st Tier (10-15 min)
- ◉ 2nd Tier (30-45 min) *Recommended

1st Tier

Risk Identification

Select one box for each year and territory level

Indicator	C = County level; N = National level	2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
Degree of …							
RI1. Details, completeness, and systematic of inventory of landslide events.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
RI2. Advancement, coverage and maintenance of instrumentation in hazard monitoring and forecasting.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
RI3. Details and adequacy of scales in landslide hazard mapping and evaluation of landslide hazards.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
RI4. Coverage of exposed areas and buildings to landslides hazards for vulnerability analysis and adequacy of factors considered in risk analysis (factors include physical, social, cultural and environmental criteria)	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
RI5. Frequency of promotion of landslide risk management issues at the territory and local levels and scale of participation and support from private sectors and NGOs in promotion activities.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
RI6. **Popularization of curricula in landslide hazards and risk management in all stages of education^**, technical capacity of the territory to generate landslide risk knowledge, and provision of continuous scheme for community training.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						

^ and bold: only applicable to evaluation at national level

1st Tier

Risk Reduction

Select one box for each year and territory level

Indicator	C = County level; N = National level	2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
Degree of …							
RR1. Extent within the territory with the consideration of landslide risk in territorial organization plans.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
RR2. Intervention in deteriorated/strategic basins and sensitive zones and implementation of environmental protection plan within the territory.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
RR3. Extent of construction of landslide mitigation works for the protection of human settlements and social investment within the territories.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
RR4. Control of landslide risk areas with housing improvement works and implementation of relocation programme of housing in non mitigable risk zones.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
RR5. Enforcement of safety standards and construction codes and updating of them based on local particularities.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
RR6. Obligatory retrofitting of principal public and private buildings and implementation of programs of fiscal incentives for housing rehabilitation lead to lower socio-economic sectors.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						

^ and bold: only applicable to evaluation at national level

1st Tier

Disaster Management

Select one box for each year and territory level

Indicator	C = County level; N = National level						
Degree of …		**2004**		**2014**		**2024**	
		C	**N**	**C**	**N**	**C**	**N**
DM1. Coordination between public, private and community based bodies for response in case of emergencies.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
DM2. Establishment of emergency and contingency plans for all territory levels and the implementation of information and warning systems over the territory.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
DM3. Stable supply of equipment, tools and infrastructure in reserve centers and Emergency Operations Centre for communications, transport and supply facilities during emergency.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
DM4. Frequency of testing of emergency and contingency plans and updating of operational procedures in the majority of the territory.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
DM5. Popularization and frequency of training program on emergency response among the community and in coordination with other organizations and NGOs.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
DM6. Comprehensiveness and details in reconstruction plans dealing with physical damage and social recovery based on risk scenarios over the territory.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						

^ **and bold**: only applicable to evaluation at national level

1st Tier

Governance and Financial Protection (Loss Transfer)

Select one box for each year and territory level

Indicator	C = County level; N = National level						
Degree of …		2004		2014		2024	
		C	N	C	N	C	N
FP1. Implementation and expertise of risk management system incorporated by interinstitutional, multisectoral and decentralizing organization	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
FP2. Financial autonomy of reserve funds for co-financing institutional risk-management projects and recovering in case of disaster in the majorities cities.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
FP3. Local/**National**^ orientation for allocation of budget to local organizations / **sub-national organizations**^ and implementation of incentives and rates of environmental protection and security.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
FP4. Implementation of support funds and social protection and poverty reduction programs oriented to the reduction of human vulnerability throughout the territory.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
FP5. Insurance coverage for public goods such as buildings, infrastructures and implementation of loss transfer strategies of public assets, such as considering reinsurance groups, risk titles, bonds, etc.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						
FP6. Insurance coverage for housing and private sector insurance, government support of insurance coverage for small businesses and the poorest, and implementation of economic incentive for risk reduction and mass insurance.	1.Low						
	2.Incipient						
	3.Significant						
	4.Outstanding						
	5.Optimal						

^ and bold: only applicable to evaluation at national level

2nd Tier

Risk Identification

Select one box for each year and territory level

Indicator and Performance levels

C = County level; N = National level

RI1. Systematic disaster and loss inventory

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Some basic and superficial data on the history of landslide events.	○	○	○	○	○	○
2	Continual registering of current landslide events, incomplete catalogues of the occurrence of some events and limited information on losses and effects.	○	○	○	○	○	○
3	Some complete catalogues of landslide events, systematization of actual events and their economic, social, and environmental effects.	○	○	○	○	○	○
4	Complete inventory and multiple catalogues of landslide events; registry and detailed systematization of effects and losses.	○	○	○	○	○	○
5	Detailed inventory of events and effects for all landslides events and databases at the sub-national and local events.	○	○	○	○	○	○

RI2. Hazard monitoring and forecasting

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Minimum and deficient instrumentation.	○	○	○	○	○	○
2	Basic instrumentation networks with problems of updated technology and continuous maintenance.	○	○	○	○	○	○
3	Some networks with advanced technology; improved prognostics and information protocols established.	○	○	○	○	○	○
4	Good and progressive instrumentation, **advanced research in the matter on the majority of hazards^**, and some automatic warning systems working.	○	○	○	○	○	○
5	Wide coverage of station and sensor networks for landslide hazards in all parts of the territory; permanent and opportune analysis of information and automatic early warning systems working continuously in the territory.	○	○	○	○	○	○

RI3. Hazard evaluation and mapping

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Superficial evaluation and basic maps covering the influence and susceptibility of landslides.	○	○	○	○	○	○
2	Some descriptive and qualitative studies of susceptibility and hazard of landslides at the territory level and for some specific areas.	○	○	○	○	○	○
3	Some hazard maps based on probabilistic techniques for the territory level and for some regions. Generalized use of GIS for mapping the principle hazards.	○	○	○	○	○	○
4	Evaluation is based on advanced and adequate resolution methodologies for the majority of landslide hazards. Microzonification of some regions based on probabilistic techniques.	○	○	○	○	○	○
5	Detailed studies of landslide hazards throughout the territory. Micro zoning of the majority of cities and hazard maps at the territory level/**the sub-national and municipal level^**.	○	○	○	○	○	○

RI4. Vulnerability and risk assessment

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Identification and mapping of the principle elements exposed in prone zones in principal cities.	○	○	○	○	○	○
2	General studies of physical vulnerability when faced with the most recognized landslide hazards, using GIS in some cities.	○	○	○	○	○	○
3	Evaluation of potential damage and loss scenarios for some landslide events in the principal cites. Analysis of the physical vulnerability of some essential buildings.	○	○	○	○	○	○
4	Detailed studies of risk using probabilistic techniques taking into account the economic and social impact of the majority of landslide hazards in some regions. Vulnerability analysis for the majority of essential buildings and life lines.	○	○	○	○	○	○
5	Generalized evaluation of risk, considering physical, social, cultural and environmental factors. Vulnerability analysis also for private buildings and the majority of life lines.	○	○	○	○	○	○

RI5. Public information and community participation

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Sporadic information on risk management in normal conditions and more frequently when disaster occur.	○	○	○	○	○	○
2	Press, radio and television coverage oriented towards preparedness in case of emergency. Production of illustrative materials on dangerous phenomena.	○	○	○	○	○	○
3	Frequent opinion programs on risk management issues at the territory level and local levels. Guidelines for vulnerability reduction. Work with communities and NGOs.	○	○	○	○	○	○
4	Generalized diffusion and progressive consciousness; conformation of some social networks for civil protection and NGOs that explicitly promote risk management issues and practice.	○	○	○	○	○	○
5	Widescale participation and support form the private sector for diffusion activities. Consolidation of social networks and notable participation of professionals and NGOs at all levels.	○	○	○	○	○	○

RI6. Training and education in risk management

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Incipient incorporation of topics about landslides in formal education and programs for community participation.	○	○	○	○	○	○
2	Some curricular adjustments at the primary and secondary levels. Production of teaching guides for teachers and community leaders in some places.	○	○	○	○	○	○
3	Progressive incorporation of landslide risk management in curricula. Considerable production of teaching materials and undertaking of frequent courses for community training.	○	○	○	○	○	○
4	Widening of curricular reform to higher education programs. Specialization courses offered at various universities. Wide ranging community training at the local level.	○	○	○	○	○	○
5	High technical capacity of the territory to generate landslide risk knowledge. **Generalized curricular reform throughout the territory and in all stages of education^**. Wide ranging production of teaching materials. Permanent schemes for community training.	○	○	○	○	○	○

^ and bold: only applicable to evaluation at national level

2nd Tier

Risk Reduction

Select one box for each year and territory level

Indicator and Performance levels		C = County level; N = National level					
		2004		2014		2024	
RR1. Risk consideration in land use and urban planning		C	N	C	N	C	N
1	Consideration of some means for identifying risk, and environmental protection in physical planning.	○	○	○	○	○	○
2	Promulgation of some local regulations and **national legislation^** that consider landslide hazards as a factor in territorial organization and development planning.	○	○	○	○	○	○
3	Progressive formulation of land use regulations in various cities that take into account landslide hazards and risks.	○	○	○	○	○	○
4	Wide ranging formulation and updating of territorial organization plans with a preventive approach in the majority area of the territory.	○	○	○	○	○	○
5	Generalized approval and control of implementation of territorial organization plans that include landslide risk as a major factor.	○	○	○	○	○	○
RR2. Hydrographic basin intervention and environmental protection							
1	Inventory of basins and areas of severe environmental deterioration or those considered to be most fragile	○	○	○	○	○	○
2	Promulgation of territory level legal dispositions and some local ones that establish the obligatory nature of reforestation, environmental protection and river basin planning.	○	○	○	○	○	○
3	Formulation of some plans for organization and intervention in strategic water basins and sensitive zones taking into account landslide risk and vulnerability aspects.	○	○	○	○	○	○
4	Appreciable number of regions and water basins with environmental protection plans, impact studies and ordering of agricultural areas and that consider landslide risk a factor in determining investment divisions.	○	○	○	○	○	○
5	Intervention in a considerable number of deteriorated basins, sensitive zones and strategic ecosystems. Majorities cities have environmental intervention and protection plans.	○	○	○	○	○	○
RR3. Implementation of hazard-event control and protection techniques							
1	Some structural control and stabilization measures in some more dangerous places.	○	○	○	○	○	○
2	Channeling works in most major cities all constructed following security norms.	○	○	○	○	○	○
3	Establishment of measures and regulations for the design and construction of hazard control and protection works in harmony with territorial organization dictates.	○	○	○	○	○	○
4	Wide scale intervention in mitigable risk zones using protection and control measures in principal cities.	○	○	○	○	○	○
5	Adequate design and construction of stabilizing, dissipation and control works in the majority of cities in order to protect human settlements and social investment.	○	○	○	○	○	○
RR4. Housing improvement and human settlement relocation from prone-areas							
1	Identification and inventory of marginal human settlements located in landslide hazard prone areas.	○	○	○	○	○	○
2	Promulgation of legislation establishing the priority of dealing with deteriorated urban areas at risk of landslides in the large cities.	○	○	○	○	○	○
3	Programs for upgrading the surroundings, existing housing, and relocation from landslide risk areas in principal cities.	○	○	○	○	○	○
4	Progressive intervention of human settlements at risk of landslide hazards in the majority of cities and adequate treatment of cleared areas.	○	○	○	○	○	○
5	Notable control of landslide risk areas in the territory and relocation of the majority of housing constructed in non mitigable risk zones.	○	○	○	○	○	○
RR5. Updating and enforcement of safety standards and construction codes							
1	Voluntary use of norms and codes from other countries without major adjustments	○	○	○	○	○	○
2	Adaptation of some requirements and specifications according to some national and local criteria and particularities.	○	○	○	○	○	○
3	Promulgation and updating of obligatory national norms based on international norms that have been adjusted according to the hazard evaluations made in the country.	○	○	○	○	○	○
4	Technological updating of the majority of security and construction code norms for new and existing buildings with special requirements for special buildings and life lines.	○	○	○	○	○	○
5	Permanent updating of codes and security norms: establishment of local regulations for construction in the majorities of cities.	○	○	○	○	○	○
RR6. Reinforcement and retrofitting of public and private assets							
1	Retrofitting and sporadic adjustments to buildings and life lines; remodeling, changes of use or modifications.	○	○	○	○	○	○
2	Promulgation of intervention norms as regards the vulnerability of existing buildings. Strengthening of essential buildings such as hospitals or those considered indispensable.	○	○	○	○	○	○
3	Some mass programs for evaluating vulnerability, rehabilitation and retrofitting of hospitals, schools, and the central offices of life line facilities. Obligatory nature of retrofitting.	○	○	○	○	○	○
4	Progressive number of buildings retrofitted, life lines intervened, some buildings of the private sector retrofitted autonomously or due to fiscal incentives given by government.	○	○	○	○	○	○
5	Massive retrofitting of principal public and private buildings. Permanent programs of incentives for housing rehabilitation lead to lower socio-economic sectors.	○	○	○	○	○	○

^ and bold: only applicable to evaluation at national level

2nd Tier

Disaster Management

Select one box for each year and territory level

Indicator and Performance levels

C = County level;
N = National level

DM1. Organization and coordination of emergency operations

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Different organizations attend emergencies but lack resources and various operate only with voluntary personnel.	○	○	○	○	○	○
2	Specific legislation defines an institutional structure, roles for operational entities and coordination of emergency commissions throughout the territory.	○	○	○	○	○	○
3	Considerable coordination exists in some localities or districts of some cities, between organizations in preparedness, communications, search and rescue, emergency networks, and management of temporary shelters.	○	○	○	○	○	○
4	Permanent coordination for response between operational organizations, public services, local authorities and civil society organizations in the majority of cities.	○	○	○	○	○	○
5	Advanced levels of interinstitutional organization between public, private and community based bodies. Adequate protocols exist for horizontal and vertical coordination at all territorial levels.	○	○	○	○	○	○

DM2. Emergency response planning and implementation of warning systems

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Basic emergency and contingency plans exist with check lists and information on available personnel.	○	○	○	○	○	○
2	Legal regulations and exist that establish the obligatory nature of emergency plans. Some cities have operational plans and articulation exists with technical information providers at the national level.	○	○	○	○	○	○
3	Protocols and operational procedures are well defined in the territory/ **at the national and sub-national levels and in the main cities^**. Various prognosis and warning centers operate continuously.	○	○	○	○	○	○
4	Emergency and contingency plans are complete and associated with information and warning systems in the majority of cities.	○	○	○	○	○	○
5	Response preparedness based on probable scenarios in all localities or districts. Use of information technology to activate automatic response procedures / **Response preparedness based on analysis^**.	○	○	○	○	○	○

DM3. Endowment of equipment, tools and infrastructure

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Basic supply and inventory of resources only in the operational organizations and emergency commissions.	○	○	○	○	○	○
2	Centre with reserves and specialized equipment for emergencies at national level and in some cities. Inventory of resources in other public and private organizations	○	○	○	○	○	○
3	Emergency Operations Centre (EOC) which is well stocked with communication equipment and adequate registry systems. Specialized equipment and reserve centers exist in various cities.	○	○	○	○	○	○
4	EOCs are well equipped and systematized in the majority cities. Progressive complimentary stocking of operational organizations.	○	○	○	○	○	○
5	Interinstitutional support networks between reserve centers and EOCs are working permanently. Wide ranging communications, transport and supply facilities exist in case of emergency.	○	○	○	○	○	○

DM4. Simulation, updating and test of inter institutional response

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Some internal and joint institutional simulations between operational organizations exist in some cities	○	○	○	○	○	○
2	Sporadic simulation exercises for emergency situations and institutional response exist with all operational organizations.	○	○	○	○	○	○
3	Desk and operational simulations with the additional participation of public service entities and local administrations in various cities.	○	○	○	○	○	○
4	Coordination of simulations with community, private sector and media at the national level, and in some cities.	○	○	○	○	○	○
5	Testing of emergency and contingency plans and updating of operational procedures based on frequent simulation exercises in the majority of cities.	○	○	○	○	○	○

DM5. Community preparedness and training

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Informative meetings with community in order to illustrate emergency procedures during disasters.	○	○	○	○	○	○
2	Sporadic training courses with civil society organizations dealing with disaster related themes.	○	○	○	○	○	○
3	Community training activities are regularly programmed on emergency response in coordination with community development organizations and NGOs.	○	○	○	○	○	○
4	Courses are run frequently with communities in the majority citieses on preparedness, prevention and reduction of risk.	○	○	○	○	○	○
5	Permanent prevention and disaster response courses in the entire territory within the framework of a training program in community development and in coordination with other organizations and NGOs.	○	○	○	○	○	○

DM6. Rehabilitation and reconstruction planning

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Design and implementation of rehabilitation and reconstruction plans only after important disasters.	○	○	○	○	○	○
2	Planning of some provisional recovery measures by public service institutions and those responsible for damage evaluation in some cities.	○	○	○	○	○	○
3	Diagnostic procedures, reestablishment and repairing of infrastructure and production projects for community recovery are available **at the national level and in various cities^.**	○	○	○	○	○	○
4	Ex ante undertaking of recovery plans and programs to support social recovery, sources of employment and productive means for communities in the majorities cities.	○	○	○	○	○	○
5	Generalized development of detailed reconstruction plans dealing with physical damage and social recovery based on risk scenarios. Specific legislation exists and anticipated measures for reactivation.	○	○	○	○	○	○

^ and bold: only applicable to evaluation at national level

2nd Tier

Governance and Financial Protection (Loss Transfer)

Select one box for each year and territory level

Indicator and Performance levels		C = County level; N = National level					
		2004		2014		2024	
		C	N	C	N	C	N

FP1. Interinstitutional, multisectoral and decentralizing organization

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Basic organizations **at the national level arranged^** in commissions, principally with an emergency response approach.	○	○	○	○	○	○
2	**Decentralized^**, Interinstitutional and multisectoral organization for the integral management of risk **and formulation of a general risk management plan^.**	○	○	○	○	○	○
3	Interinstitutional risk management systems active at the local level in various cities**.** Work / **Inter-ministerial work at the national level^** in the design of public policies for vulnerability reduction.	○	○	○	○	○	○
4	Continuous implementation of risk management projects associated with programs of adaptation to **climate change^**, environmental protection, energy, sanitation and poverty reduction.	○	○	○	○	○	○
5	Expert personnel with wide experience incorporating risk management in sustainable human development planning in major cit High technology information systems available.	○	○	○	○	○	○

FP2. Reserve funds for institutional strengthening

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Administrative division depends on disaster or calamity funds from the nation. / **Existence of a national disaster fund and some local funds in some cities^.**	○	○	○	○	○	○
2	Resource management from national level is established and incipient risk management strengthens. **/ Regulation of existing reserve funds or creation of new sources to co-finance local level risk management projects^**.	○	○	○	○	○	○
3	Some occasional funds to co-finance risk management project in the administrative division exist in an interinstitutional way. / E**conomic support and search for international funds for institutional development and strengthening of risk management in the whole country**^.	○	○	○	○	○	○
4	Reserve funds to co-finance projects, institutional strengthening and recovery in times of disaster are established in the administrative regions / **are progressively created at municipal level^.**	○	○	○	○	○	○
5	Financial engineering for the design of retention and risk transfer instruments **at the national level^**. Reserve funds operating **in the majority of cities^**.	○	○	○	○	○	○

FP3. Budget allocation and mobilization

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Limited allocation of national budget to competent institutions for emergency response.	○	○	○	○	○	○
2	Legal norms establishing budgetary allocations to territory level organizations with risk management objectives.	○	○	○	○	○	○
3	Legally specified specific allocations for risk management at the local level and the frequent undertaking of interadministrative agreements for the execution of prevention projects.	○	○	○	○	○	○
4	Progressive allocation of discretionary expenses at the national and municipal level for vulnerability reduction, the creation of incentives and rates of environmental protection and security.	○	○	○	○	○	○
5	National orientation and support for loans requested by municipalities and sub national and local organizations from multilateral loan organizations.	○	○	○	○	○	○

FP4. Implementation of social safety nets and funds response

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Sporadic subsidies to communities affected by disasters or in critical risk situations.	○	○	○	○	○	○
2	Permanent social investment funds created to support vulnerable communities focusing on the poorest socio-economic groups.	○	○	○	○	○	○
3	Social networks for the self protection of means of subsistence of communities at risk and undertaking of post disaster rehabilitation and reconstruction production projects.	○	○	○	○	○	○
4	Regular micro-credit programs and gender oriented activities oriented to the reduction of human vulnerability.	○	○	○	○	○	○
5	Generalized development of social protection and poverty reduction programs integrated with prevention and mitigation activities throughout the territory.	○	○	○	○	○	○

FP5. Insurance coverage and loss transfer strategies of public assets

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Very few public buildings are insured **at the national level^** and exceptionally at the local level.	○	○	○	○	○	○
2	Obligatory insurance of public goods. Deficient insurance of infrastructure.	○	○	○	○	○	○
3	Progressive insurance of public goods and infrastructure **at the national level^** and some cities.	○	○	○	○	○	○
4	Design of programs for the collective insurance of buildings and publically rented infrastructure in the majorities cities.	○	○	○	○	○	○
5	Analysis and generalized implementation of retention and transfer strategies for losses to public goods, considering reinsurance groups, risk titles, bonds, etc.	○	○	○	○	○	○

FP6. Housing and private sector insurance and reinsurance coverage

		2004 C	2004 N	2014 C	2014 N	2024 C	2024 N
1	Low percentage of private goods insured. Incipient, economically weak and little regulated insurance industry.	○	○	○	○	○	○
2	Regulation of insurance industry controls over solvency and legislation for insurance of house loan and housing sector.	○	○	○	○	○	○
3	Development of some careful insurance studies based on advanced probabilistic estimates of risk.	○	○	○	○	○	○
4	Design of collective housing insurance programs and for small businesses by the majority of local governments and insurance companies with automatic coverage for the poorest.	○	○	○	○	○	○
5	Strong support for joint programs between government and insurance companies in order to generate economic incentives for risk reduction and mass insurance.	○	○	○	○	○	○

^ and bold: only applicable to evaluation at national level

Appendix I Allocation of relative importance of indicators within each public policy

Allocation of Relative Importance of Indicators within Each Public Policies

In the first questionnaire, you have given ratings on the performance level of landslide risk management with respect to each indicators. In this survey we would like you to give the relative weights between indicators pairwisely.

1.1 Importance Factor Allocation to Indicators of Risk Identification

Which of the indicators is perceived as more important?
(If both are equally important, select either one and select '1' to the right)

In which degree?
('1' = equally important; '9' = the more important indicator is 9 times more importance than the another one)

○	RI1. Systematic disaster and loss inventory	vs	○	RI2. Hazard monitoring and forecasting	1	2	3	4	5	6	7	8	9
○	RI1. Systematic disaster and loss inventory	vs	○	RI3. Hazard evaluation and mapping	1	2	3	4	5	6	7	8	9
○	RI1. Systematic disaster and loss inventory	vs	○	RI4. Vulnerability and risk assessment	1	2	3	4	5	6	7	8	9
○	RI1. Systematic disaster and loss inventory	vs	○	RI5. Public information and community participation	1	2	3	4	5	6	7	8	9
○	RI1. Systematic disaster and loss inventory	vs	○	RI6. Training and education in risk management	1	2	3	4	5	6	7	8	9
○	RI2. Hazard monitoring and forecasting	vs	○	RI3. Hazard evaluation and mapping	1	2	3	4	5	6	7	8	9
○	RI2. Hazard monitoring and forecasting	vs	○	RI4. Vulnerability and risk assessment	1	2	3	4	5	6	7	8	9
○	RI2. Hazard monitoring and forecasting	vs	○	RI5. Public information and community participation	1	2	3	4	5	6	7	8	9
○	RI2. Hazard monitoring and forecasting	vs	○	RI6. Training and education in risk management	1	2	3	4	5	6	7	8	9
○	RI3. Hazard evaluation and mapping	vs	○	RI4. Vulnerability and risk assessment	1	2	3	4	5	6	7	8	9
○	RI3. Hazard evaluation and mapping	vs	○	RI5. Public information and community participation	1	2	3	4	5	6	7	8	9
○	RI3. Hazard evaluation and mapping	vs	○	RI6. Training and education in risk management	1	2	3	4	5	6	7	8	9
○	RI4. Vulnerability and risk assessment	vs	○	RI5. Public information and community participation	1	2	3	4	5	6	7	8	9
○	RI4. Vulnerability and risk assessment	vs	○	RI6. Training and education in risk management	1	2	3	4	5	6	7	8	9
○	RI5. Public information and community participation	vs	○	RI6. Training and education in risk management	1	2	3	4	5	6	7	8	9

1.2 Importance Factor Allocation to Indicators of Risk Reduction

Which of the indicators is perceived as more important?
(If both are equally important, select either one and select '1' to the right)

In which degree?
('1' = equally important; '9' = the more important indicator is 9 times more importance than the another one)

○	RR1. Risk consideration in land use and urban planning	vs	○	RR2. Hydrographic basin intervention and environmental protection	1	2	3	4	5	6	7	8	9
○	RR1. Risk consideration in land use and urban planning	vs	○	RR3. Implementation of hazard-event control and protection techniques	1	2	3	4	5	6	7	8	9
○	RR1. Risk consideration in land use and urban planning	vs	○	RR4. Housing improvement and human settlement relocation from prone-areas	1	2	3	4	5	6	7	8	9
○	RR1. Risk consideration in land use and urban planning	vs	○	RR5. Updating and enforcement of safety standards and construction codes	1	2	3	4	5	6	7	8	9
○	RR1. Risk consideration in land use and urban planning	vs	○	RR6. Reinforcement and retrofitting of public and private assets	1	2	3	4	5	6	7	8	9
○	RR2. Hydrographic basin intervention and environmental protection	vs	○	RR3. Implementation of hazard-event control and protection techniques	1	2	3	4	5	6	7	8	9
○	RR2. Hydrographic basin intervention and environmental protection	vs	○	RR4. Housing improvement and human settlement relocation from prone-areas	1	2	3	4	5	6	7	8	9
○	RR2. Hydrographic basin intervention and environmental protection	vs	○	RR5. Updating and enforcement of safety standards and construction codes	1	2	3	4	5	6	7	8	9
○	RR2. Hydrographic basin intervention and environmental protection	vs	○	RR6. Reinforcement and retrofitting of public and private assets	1	2	3	4	5	6	7	8	9
○	RR3. Implementation of hazard-event control and protection techniques	vs	○	RR4. Housing improvement and human settlement relocation from prone-areas	1	2	3	4	5	6	7	8	9
○	RR3. Implementation of hazard-event control and protection techniques	vs	○	RR5. Updating and enforcement of safety standards and construction codes	1	2	3	4	5	6	7	8	9
○	RR3. Implementation of hazard-event control and protection techniques	vs	○	RR6. Reinforcement and retrofitting of public and private assets	1	2	3	4	5	6	7	8	9
○	RR4. Housing improvement and human settlement relocation from prone-areas	vs	○	RR5. Updating and enforcement of safety standards and construction codes	1	2	3	4	5	6	7	8	9
○	RR4. Housing improvement and human settlement relocation from prone-areas	vs	○	RR6. Reinforcement and retrofitting of public and private assets	1	2	3	4	5	6	7	8	9
○	RR5. Updating and enforcement of safety standards and construction codes	vs	○	RR6. Reinforcement and retrofitting of public and private assets	1	2	3	4	5	6	7	8	9

1.3 Importance Factor Allocation to Indicators of Disaster Management

Which of the indicators is perceived as more important?
(If both are equally important, select either one and select '1' to the right)

In which degree?
('1' = equally important; '9' = the more important indicator is 9 times more importance than the another one)

	Indicator			Indicator									
○	DM1. Organization and coordination of emergency operations	vs	○	DM2. Emergency response planning and implementation of warning systems	1	2	3	4	5	6	7	8	9
○	DM1. Organization and coordination of emergency operations	vs	○	DM3. Endowment of equipment, tools and infrastructure	1	2	3	4	5	6	7	8	9
○	DM1. Organization and coordination of emergency operations	vs	○	DM4. Simulation, updating and test of inter institutional response	1	2	3	4	5	6	7	8	9
○	DM1. Organization and coordination of emergency operations	vs	○	DM5. Community preparedness and training	1	2	3	4	5	6	7	8	9
○	DM1. Organization and coordination of emergency operations	vs	○	DM6. Rehabilitation and reconstruction planning	1	2	3	4	5	6	7	8	9
○	DM2. Emergency response planning and implementation of warning systems	vs	○	DM3. Endowment of equipment, tools and infrastructure	1	2	3	4	5	6	7	8	9
○	DM2. Emergency response planning and implementation of warning systems	vs	○	DM4. Simulation, updating and test of inter institutional response	1	2	3	4	5	6	7	8	9
○	DM2. Emergency response planning and implementation of warning systems	vs	○	DM5. Community preparedness and training	1	2	3	4	5	6	7	8	9
○	DM2. Emergency response planning and implementation of warning systems	vs	○	DM6. Rehabilitation and reconstruction planning	1	2	3	4	5	6	7	8	9
○	DM3. Endowment of equipment, tools and infrastructure	vs	○	DM4. Simulation, updating and test of inter institutional response	1	2	3	4	5	6	7	8	9
○	DM3. Endowment of equipment, tools and infrastructure	vs	○	DM5. Community preparedness and training	1	2	3	4	5	6	7	8	9
○	DM3. Endowment of equipment, tools and infrastructure	vs	○	DM6. Rehabilitation and reconstruction planning	1	2	3	4	5	6	7	8	9
○	DM4. Simulation, updating and test of inter institutional response	vs	○	DM5. Community preparedness and training	1	2	3	4	5	6	7	8	9
○	DM4. Simulation, updating and test of inter institutional response	vs	○	DM6. Rehabilitation and reconstruction planning	1	2	3	4	5	6	7	8	9
○	DM5. Community preparedness and training	vs	○	DM6. Rehabilitation and reconstruction planning	1	2	3	4	5	6	7	8	9

1.4 Importance Factor Allocation to Indicators of Governance and Financial Protection (Loss Transfer)

Which of the indicators is perceived as more important?
(If both are equally important, select either one and select '1' to the right)

In which degree?
('1' = equally important; '9' = the more important indicator is 9 times more importance than the another one)

	Indicator			Indicator									
○	FP1. Interinstitutional, multisectoral and decentralizing organization	vs	○	FP2. Reserve funds for institutional strengthening	1	2	3	4	5	6	7	8	9
○	FP1. Interinstitutional, multisectoral and decentralizing organization	vs	○	FP3. Budget allocation and mobilization	1	2	3	4	5	6	7	8	9
○	FP1. Interinstitutional, multisectoral and decentralizing organization	vs	○	FP4. Implementation of social safety nets and funds response	1	2	3	4	5	6	7	8	9
○	FP1. Interinstitutional, multisectoral and decentralizing organization	vs	○	FP5. Insurance coverage and loss transfer strategies of public assets	1	2	3	4	5	6	7	8	9
○	FP1. Interinstitutional, multisectoral and decentralizing organization	vs	○	FP6. Housing and private sector insurance and reinsurance coverage	1	2	3	4	5	6	7	8	9
○	FP2. Reserve funds for institutional strengthening	vs	○	FP3. Budget allocation and mobilization	1	2	3	4	5	6	7	8	9
○	FP2. Reserve funds for institutional strengthening	vs	○	FP4. Implementation of social safety nets and funds response	1	2	3	4	5	6	7	8	9
○	FP2. Reserve funds for institutional strengthening	vs	○	FP5. Insurance coverage and loss transfer strategies of public assets	1	2	3	4	5	6	7	8	9
○	FP2. Reserve funds for institutional strengthening	vs	○	FP6. Housing and private sector insurance and reinsurance coverage	1	2	3	4	5	6	7	8	9
○	FP3. Budget allocation and mobilization	vs	○	FP4. Implementation of social safety nets and funds response	1	2	3	4	5	6	7	8	9
○	FP3. Budget allocation and mobilization	vs	○	FP5. Insurance coverage and loss transfer strategies of public assets	1	2	3	4	5	6	7	8	9
○	FP3. Budget allocation and mobilization	vs	○	FP6. Housing and private sector insurance and reinsurance coverage	1	2	3	4	5	6	7	8	9
○	FP4. Implementation of social safety nets and funds response	vs	○	FP5. Insurance coverage and loss transfer strategies of public assets	1	2	3	4	5	6	7	8	9
○	FP4. Implementation of social safety nets and funds response	vs	○	FP6. Housing and private sector insurance and reinsurance coverage	1	2	3	4	5	6	7	8	9
○	FP5. Insurance coverage and loss transfer strategies of public assets	vs	○	FP6. Housing and private sector insurance and reinsurance coverage	1	2	3	4	5	6	7	8	9

2. Which public policy(ies) are you most familiar with? (can select more than 1)

- ☐ **Risk Identification**
- ☐ **Risk Reduction**
- ☐ **Disaster Management**
- ☐ **Governance and Financial Protection (Loss Transfer)**

Thank you for your participation!!
- End of survey -

Appendix J GAR2009 and Safeland (2010) data about landslide hazards triggered by precipitation

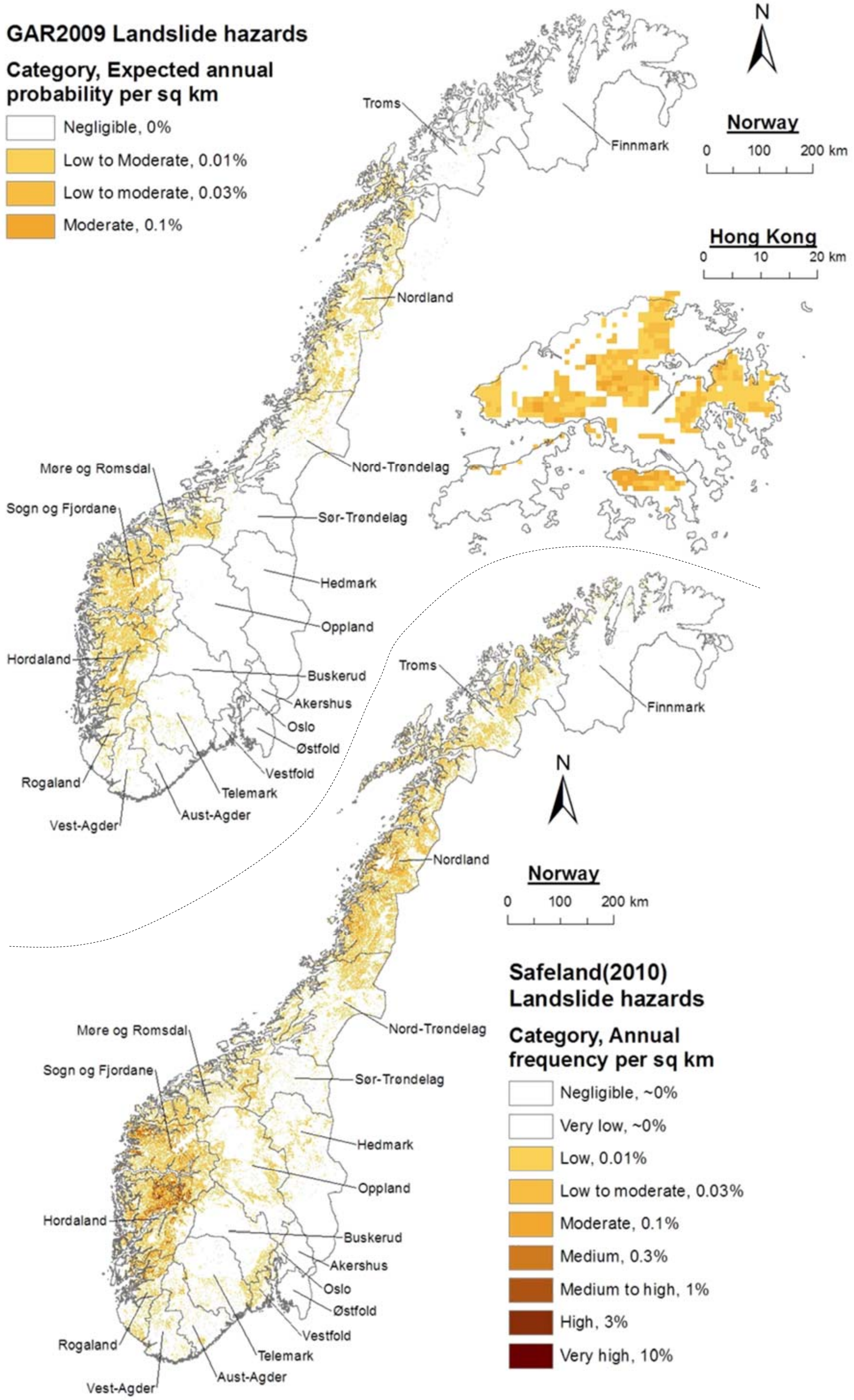


Figure J.1 Landslide hazard map of Norway (GAR2009 and Safeland data) and Hong Kong (GAR2009 data).

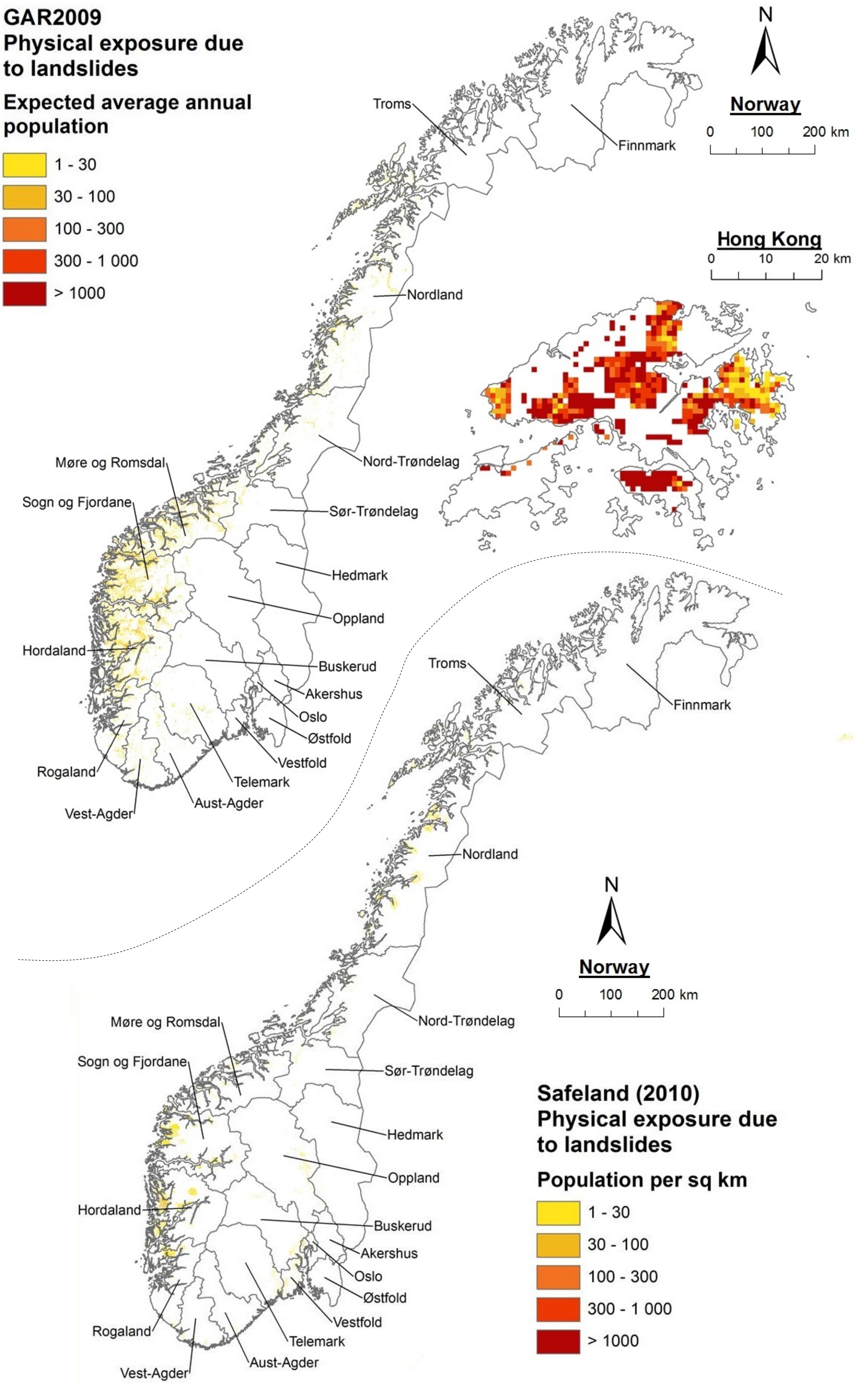


Figure J.2 Landslide physical exposure map of Norway (GAR2009 data and Safeland data) and Hong Kong (GAR2009 data).

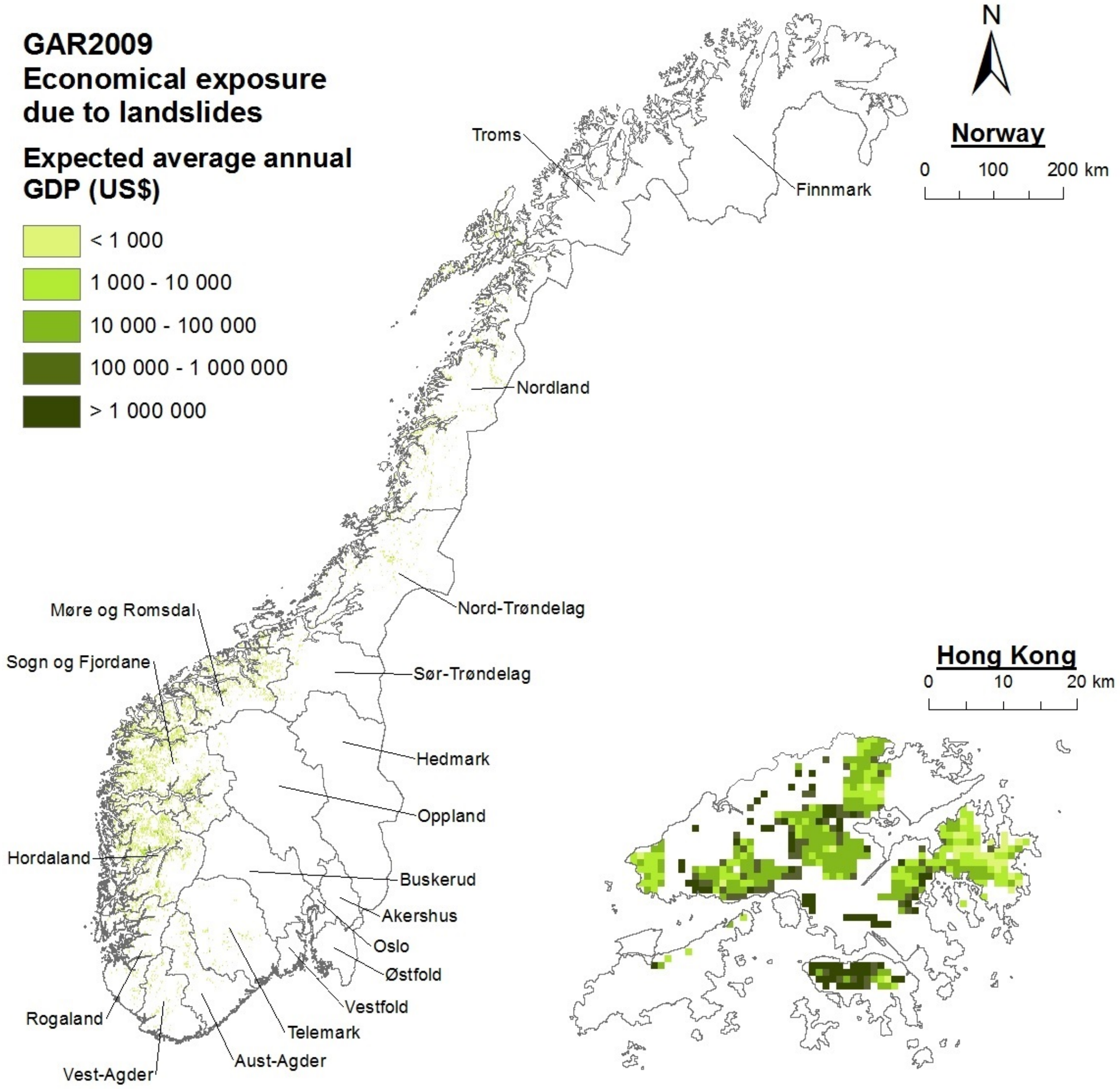


Figure J.3 Landslide economic exposure map of Norway and Hong Kong (GAR2009 data).

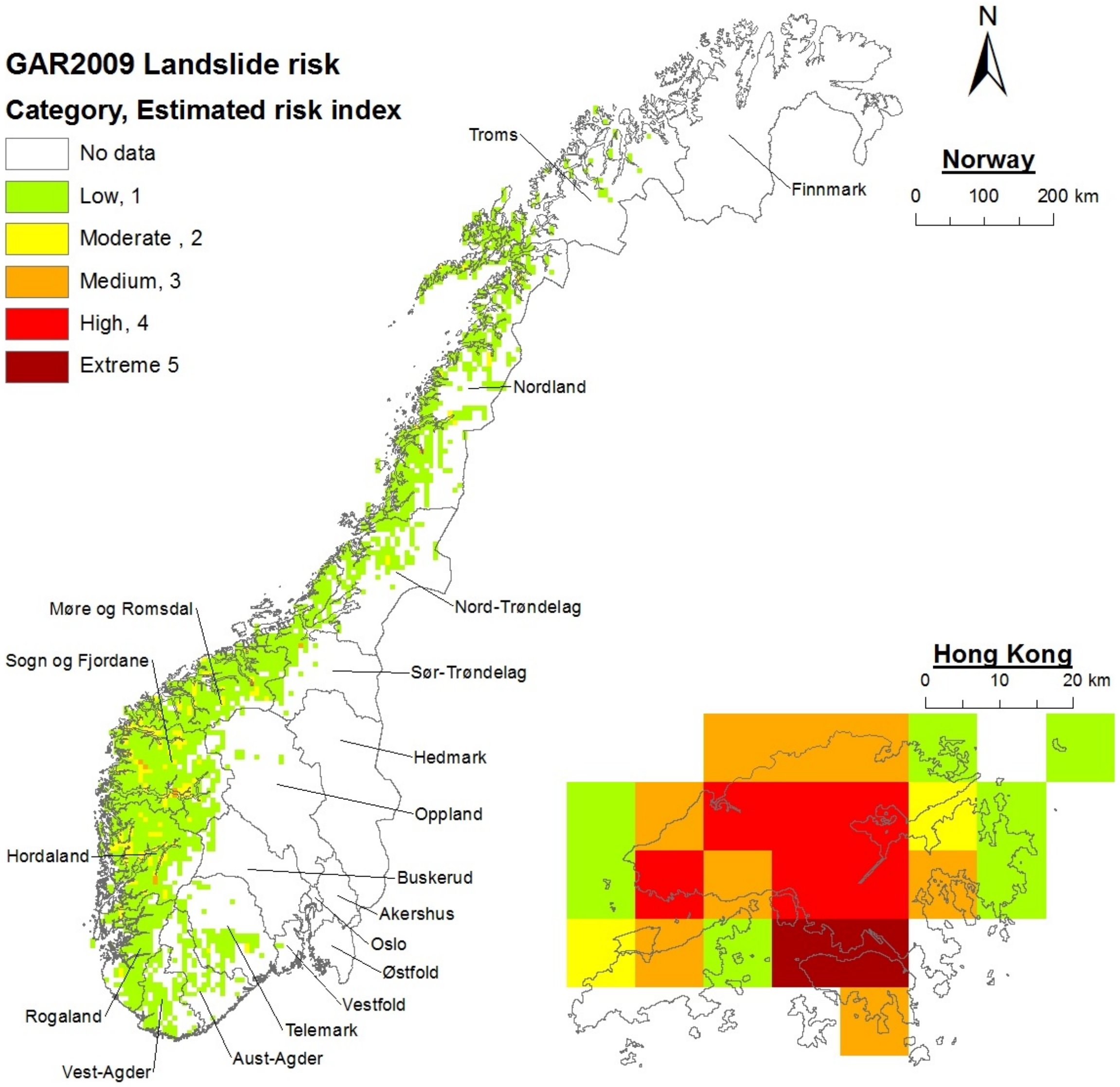


Figure J.4 Landslide risk map of Norway and Hong Kong (GAR2009 data).

Appendix K Survey data

K.1 Hong Kong

Table K.1 Personal and occupational information and expertise of respondents from Hong Kong. The highlighted row is the classification of a respondent's expertise. (to be continued)

	Respondent No.	1	2	3	4	5	6
1st Questionnaire	Country	Hong Kong	Hong Kong	Hong Kong	Hong Kong	Hong Kong	Hong Kong
	Gender	M	M	F	F	M	M
	Age	45-54	Off	35-44	35-44	35-44	35-44
	Education level	Master	Master	Master	Master	Master	Bachelor
	Other education level						
	Affiliated organization	Consultant	Government	Government	Government	Consultant	Consultant
	Other affiliated organization						
	Discipline	Risk identification	Risk reduction	Risk identification	Emergency response	Risk identification	Risk identification
	Other discipline						
	Role of responsibility	Technical	Executive	Executive	Management	Management	Technical
	Other role of responsibility						
2nd Questionn-aire	Public policies most familiar with					RI,RR	
	Expertise	RI	RR	RI	DM	RI,RR	RI

Table K.1 (continued)

	Response No.	7	8	9	10	11	12
1st Questionnaire	**Country**	Hong Kong	Hong Kong	Hong Kong	Hong Kong	Hong Kong	Hong Kong
	Gender	M	M	M	M	M	M
	Age	45-54	45-54	45-54	55-64	55-64	65-74
	Education level	Master	Master	Master	Master	Master	Doctoral
	Other education level						
	Affiliated organization	Government	Government	Government	Government	Consultant	Academia
	Other affiliated organization						
	Discipline	Risk identification	Others	Risk reduction	Risk identification	Risk reduction	Others
	Other discipline		All of these above except insurance				nil
	Role of responsibility	Executive	Others	Executive	Management	Executive	Others
	Other role of responsibility		All three				nil
2nd Questionn-aire	**Public policies most familiar with**	RI,RR,DM	RI,RR,DM	RR	RR	RI,RR,DM	RI,RR,DM,FP
	Expertise	RI,RR,DM	RI,RR,DM	RR	RR	RI,RR,DM	RI,RR,DM,FP

Table K.2 Answers to 1st questionnaire by respondents from Hong Kong. (to be continued)

Respondent No.	1	2	3	4	5	6	7	8	8	9	10	11	11	12
Tier	1	1	2	2	2	2	2	2	1	2	2	2	1	2
RI1_2004	3	5	3	4	2	5	3	5	4	4	1	3	3	4
RI1_2014	4	4	3	4	2	5	4	5	5	4	3	5	4	4
RI1_2024	5	4	3	5	2	5	5	5	5	4	4	5	5	5
RI2_2004	2	5	1	3	5	4	2	3	3	2	2	3	3	5
RI2_2014	3	5	1	4	5	4	3	4	4	2	3	4	4	5
RI2_2024	3	5	2	5	5	4	4	5	5	3	4	5	5	5
RI3_2004	3	4	2	2	2	3	3	2	3	2	3	3	3	5
RI3_2014	4	4	5	3	4	4	4	4	4	2	4	5	4	5
RI3_2024	4	4	5	4	5	5	5	4	4	2	5	5	5	5
RI4_2004	3	5	5	2	2	3	3	2	3	2	3	3	3	5
RI4_2014	4	5	5	3	4	4	3	3	3	2	4	5	4	5
RI4_2024	4	5	5	4	5	4	4	4	4	3	5	5	5	5
RI5_2004	3	5	1	1	4	3	2	2	4	2	2	3	3	5
RI5_2014	3	5	2	2	4	5	3	3	5	2	4	5	4	5
RI5_2024	3	5	5	3	4	5	4	4	5	2	5	5	4	5
RI6_2004	2	5	2	1	5	3	1	3	4	2	2	4	3	3
RI6_2014	2	5	2	3	5	4	2	4	4	2	3	5	4	3
RI6_2024	2	5	2	3	5	5	3	5	5	2	4	5	4	3
RR1_2004	3	4	3	4	4	5	2	3	4	2	3	4	4	5
RR1_2014	3	4	3	5	5	5	2	4	4	2	4	5	4	5
RR1_2024	3	4	3	5	5	5	3	5	5	2	5	5	5	5
RR2_2004	3	5	1	3	4	5	Off	3	3	Off	1	3	3	3
RR2_2014	3	5	1	4	4	5	Off	4	4	Off	2	4	3	4
RR2_2024	3	5	1	5	5	5	Off	5	5	Off	3	4	3	5
RR3_2004	2	5	3	3	3	4	4	4	3	1	3	3	4	3
RR3_2014	3	5	4	4	4	5	4	5	4	3	4	4	4	4
RR3_2024	3	5	5	4	5	5	5	5	5	4	5	5	5	5
RR4_2004	3	3	1	3	5	5	3	3	3	3	3	3	3	5
RR4_2014	3	3	1	3	5	5	3	4	4	3	4	4	3	5
RR4_2024	3	3	1	3	5	5	3	4	5	3	5	4	3	5
RR5_2004	3	4	5	3	5	5	4	4	4	3	3	5	3	5
RR5_2014	3	4	5	3	5	5	5	5	5	3	4	5	4	5
RR5_2024	3	4	5	4	5	5	5	5	5	3	5	5	4	5
RR6_2004	1	5	1	1	2	5	2	1	3	1	3	3	3	5
RR6_2014	1	5	1	1	4	5	2	2	3	1	4	4	3	5
RR6_2024	1	5	1	3	4	5	2	2	3	1	5	4	3	5

Table K.2 (continued)

DM1_2004	3	5	1	3	4	4	5	4	3	4	4	3	3	5
DM1_2014	3	5	1	3	4	4	5	5	4	4	4	4	3	5
DM1_2024	3	5	1	4	4	4	5	5	5	4	5	5	3	5
DM2_2004	3	4	1	4	3	4	4	4	4	4	4	4	3	5
DM2_2014	3	4	1	4	3	4	4	4	4	4	4	4	3	5
DM2_2024	3	4	5	5	3	5	4	5	5	5	5	4	3	5
DM3_2004	3	5	1	1	4	4	5	5	3	2	3	3	4	5
DM3_2014	3	5	1	2	4	4	5	5	4	2	4	5	4	5
DM3_2024	3	5	5	3	4	4	5	5	5	3	5	5	4	5
DM4_2004	2	5	1	2	2	4	5	2	3	1	1	3	2	5
DM4_2014	2	5	1	3	2	4	5	3	4	1	3	4	2	5
DM4_2024	2	5	5	4	2	4	5	4	5	2	5	5	2	5
DM5_2004	2	2	1	1	1	1	1	2	3	1	1	4	2	3
DM5_2014	2	2	1	1	1	1	1	3	4	1	3	5	2	3
DM5_2024	2	3	3	3	1	2	1	4	5	1	5	5	2	3
DM6_2004	2	2	1	1	2	3	1	2	3	1	2	3	3	1
DM6_2014	2	2	1	2	2	3	1	3	4	1	3	3	3	1
DM6_2024	2	2	3	2	2	3	1	4	4	1	4	3	3	1
FP1_2004	3	5	2	1	5	3	1	3	4	1	3	3	3	3
FP1_2014	4	5	2	2	5	4	2	4	5	1	4	3	4	3
FP1_2024	4	5	4	4	5	5	3	5	5	1	5	4	5	3
FP2_2004	1	5	1	2	3	4	2	3	3	3	2	4	3	4
FP2_2014	1	5	1	2	3	4	2	4	4	3	3	5	4	4
FP2_2024	1	5	1	Off	3	4	2	4	4	3	4	5	5	4
FP3_2004	1	5	1	3	2	4	2	5	3	1	3	3	3	1
FP3_2014	1	5	1	3	2	4	2	5	4	1	4	3	4	1
FP3_2024	1	5	1	3	2	4	2	5	4	1	4	4	5	1
FP4_2004	1	2	1	2	1	5	Off	1	3	1	3	Off	2	1
FP4_2014	1	2	1	2	1	5	Off	2	3	1	4	Off	2	1
FP4_2024	1	2	1	2	1	5	Off	3	3	1	5	Off	2	1
FP5_2004	3	2	1	1	3	4	Off	1	1	1	1	5	3	1
FP5_2014	3	2	1	1	3	4	Off	1	1	1	3	5	3	1
FP5_2024	3	2	1	1	3	4	Off	1	1	1	4	5	3	1
FP6_2004	3	2	1	1	2	2	Off	1	1	2	2	3	2	3
FP6_2014	3	2	1	1	2	2	Off	1	1	2	3	3	2	3
FP6_2024	3	2	1	1	2	2	Off	1	1	2	4	3	2	3

Table K.3 Answers to 2nd questionnaire by respondents from Hong Kong. (to be continued)

Respondent No.	5	7	8	9	10	11	12	Respondent No.	5	7	8	9	10	11	12
Which one is more important?								**In which degree?**							
1_2.RI	2	1	2	1	2	2	2	**1_2_v.RI**	3	2	1	1	3	1	1
1_3.RI	2	2	2	1	2	2	2	**1_3_v.RI**	3	2	1	1	3	3	1
1_4.RI	2	2	2	1	2	2	2	**1_4_v.RI**	3	2	1	1	3	3	1
1_5.RI	1	1	2	1	2	2	2	**1_5_v.RI**	5	1	1	1	5	2	1
1_6.RI	2	1	2	1	2	2	2	**1_6_v.RI**	7	1	1	2	5	4	1
2_3.RI	2	2	2	1	1	2	2	**2_3_v.RI**	8	4	1	1	1	3	1
2_4.RI	2	2	2	1	2	2	2	**2_4_v.RI**	1	4	1	1	2	3	1
2_5.RI	1	2	2	1	2	2	2	**2_5_v.RI**	2	2	1	1	2	3	1
2_6.RI	2	2	2	1	1	2	2	**2_6_v.RI**	2	2	1	2	2	1	1
3_4.RI	1	1	2	1	2	2	2	**3_4_v.RI**	2	1	1	1	3	1	1
3_5.RI	1	1	2	1	2	2	2	**3_5_v.RI**	5	2	1	1	Off	1	1
3_6.RI	1	1	2	1	2	2	2	**3_6_v.RI**	3	2	1	2	Off	1	1
4_5.RI	1	1	2	1	2	1	2	**4_5_v.RI**	2	2	1	1	2	2	1
4_6.RI	1	1	2	1	2	2	2	**4_6_v.RI**	2	2	1	2	3	1	1
5_6.RI	2	1	2	1	1	2	2	**5_6_v.RI**	1	1	1	2	2	1	1
1_2.RR	1	Off	2	1	1	2	1	**1_2_v.RR**	6	Off	1	4	2	1	5
1_3.RR	1	2	2	1	2	2	1	**1_3_v.RR**	4	2	1	3	1	1	5
1_4.RR	1	1	1	1	2	1	1	**1_4_v.RR**	1	1	9	2	1	3	1
1_5.RR	2	2	2	1	1	1	1	**1_5_v.RR**	2	2	1	3	3	3	1
1_6.RR	1	1	2	1	1	2	1	**1_6_v.RR**	2	1	1	4	2	1	1
2_3.RR	2	Off	2	2	2	2	2	**2_3_v.RR**	4	Off	1	2	3	1	1
2_4.RR	2	Off	1	2	2	1	2	**2_4_v.RR**	2	Off	9	3	2	3	1
2_5.RR	2	Off	2	2	1	2	2	**2_5_v.RR**	2	Off	1	2	4	1	1
2_6.RR	2	Off	1	2	2	1	2	**2_6_v.RR**	2	Off	5	1	2	3	1
3_4.RR	1	1	1	2	1	1	2	**3_4_v.RR**	2	2	9	2	3	3	1
3_5.RR	2	1	1	1	1	2	2	**3_5_v.RR**	1	1	1	1	3	1	1
3_6.RR	1	1	1	1	2	1	2	**3_6_v.RR**	3	2	9	2	1	3	1
4_5.RR	1	2	2	1	1	2	2	**4_5_v.RR**	2	2	5	2	2	3	1
4_6.RR	1	1	2	1	2	1	2	**4_6_v.RR**	2	1	1	3	3	2	1
5_6.RR	1	1	1	1	1	1	2	**5_6_v.RR**	2	2	5	2	3	2	1
1_2.DM	2	1	2	1	2	2	2	**1_2_v.DM**	2	1	1	1	2	3	1
1_3.DM	1	1	2	1	2	1	2	**1_3_v.DM**	2	2	1	1	1	2	1
1_4.DM	1	1	2	1	2	2	2	**1_4_v.DM**	1	2	1	2	2	1	1
1_5.DM	1	1	2	1	2	2	2	**1_5_v.DM**	2	2	1	1	5	1	1
1_6.DM	1	1	1	1	1	1	2	**1_6_v.DM**	2	2	5	3	2	2	1
2_3.DM	1	1	2	1	1	1	2	**2_3_v.DM**	2	2	1	1	3	2	1
2_4.DM	1	1	2	1	1	1	2	**2_4_v.DM**	2	2	1	2	2	2	1
2_5.DM	1	1	2	1	1	2	2	**2_5_v.DM**	2	2	1	1	1	1	1

Table K.3 (continued)

2_6.DM	1	1	1	1	1	Off	2	**2_6_v.DM**	2	2	5	3	5	Off	1
3_4.DM	2	1	2	1	2	1	2	**3_4_v.DM**	2	1	1	2	2	2	1
3_5.DM	1	1	2	1	2	2	2	**3_5_v.DM**	3	1	1	1	3	2	1
3_6.DM	2	1	2	1	1	1	2	**3_6_v.DM**	2	1	1	3	2	2	1
4_5.DM	1	1	2	2	2	2	2	**4_5_v.DM**	2	1	1	2	1	1	1
4_6.DM	1	1	2	1	1	2	2	**4_6_v.DM**	2	1	1	2	3	2	1
5_6.DM	2	1	1	1	1	2	2	**5_6_v.DM**	2	1	5	2	3	2	1
1_2.FP	2	1	2	1	1	2	2	**1_2_v.FP**	4	1	1	1	2	2	5
1_3.FP	2	1	2	1	1	2	2	**1_3_v.FP**	4	1	1	1	1	2	5
1_4.FP	2	Off	2	1	1	2	2	**1_4_v.FP**	3	Off	1	1	2	2	5
1_5.FP	2	Off	1	1	2	2	2	**1_5_v.FP**	3	Off	5	1	2	2	5
1_6.FP	2	Off	1	1	2	2	2	**1_6_v.FP**	2	Off	5	1	3	3	5
2_3.FP	2	1	2	1	2	2	2	**2_3_v.FP**	4	1	9	1	2	1	5
2_4.FP	1	Off	2	1	2	2	1	**2_4_v.FP**	2	Off	5	1	3	1	5
2_5.FP	2	Off	2	1	2	2	1	**2_5_v.FP**	2	Off	1	1	2	1	5
2_6.FP	1	Off	2	1	2	2	1	**2_6_v.FP**	2	Off	1	1	2	1	5
3_4.FP	1	Off	1	1	1	2	1	**3_4_v.FP**	3	Off	3	1	2	1	5
3_5.FP	1	Off	1	1	2	2	1	**3_5_v.FP**	3	Off	5	1	Off	2	5
3_6.FP	1	Off	1	1	1	1	1	**3_6_v.FP**	3	Off	5	1	Off	2	5
4_5.FP	2	Off	1	1	1	2	2	**4_5_v.FP**	2	Off	2	1	3	3	1
4_6.FP	2	Off	1	1	2	2	2	**4_6_v.FP**	2	Off	2	1	2	1	1
5_6.FP	1	Off	1	1	2	1	2	**5_6_v.FP**	2	Off	1	1	2	2	1

K.2 Norway

Table K.4 Personal and occupational information and expertise of respondents from Norway. The highlighted row is the classification of a respondent's expertise. County code can be referred to Figure 5.3. (to be continued)

	Respondent No.	**1**	**2**	**3**	**4**	**5**	**6**
1st Questionnaire	**Country**	Norway	Norway	Norway	Norway	Norway	Norway
	County 1st most familiar	15	17	Off	1	Off	17
	County 2nd most familiar	8	19	Off	Off	Off	Off
	County 3rd most familiar	14	11	Off	Off	Off	Off
	Gender	M	M	M	M	M	M
	Age	55-64	44-54	55-64	35-44	44-54	44-54
	Education level	Doctoral	Master	Master	Master	Master	Master
	Other education level						
	Affiliated organization	Academia	Government	Consultant	Consultant	Consultant	Government
	Other affiliated organization						
	Discipline	Risk identification	Risk reduction	Risk identification	Risk identification	Risk identification and risk reduction	Legislation
	Other discipline						
	Role of responsibility	Management	Management	Technical		Technical	Management
	Other role of responsibility				Geologist		
2nd Questionn-aire	**Public policies most familiar with**	RI	RR	RI		RI	
	Expertise	RI	RR	RI	RI	RI	

Table K.4 (continued)

	Respondent No.	7	8	9	10
1st Questionnaire	Country	Norway	Norway	Norway	
	County 1st most familiar	1	13	Off	
	County 2nd most familiar	2	7	Off	
	County 3rd most familiar	19	14	Off	
	Gender	M	F	M	
	Age	44-54	35-44	44-54	
	Education level	Master	Master	Master	
	Other education level				
	Affiliated organization	Research institute	Government	Government	
	Other affiliated organization				
	Discipline	Risk identification, risk reduction and emergency response	Risk identification	Risk reduction	
	Other discipline				
	Role of responsibility	Technical	Others	Management	
	Other role of responsibility				
2nd Questionn-aire	Public policies most familiar with	RI,RR,DM		RI,RR	RI,RR
	Expertise	RI,RR,DM	RI	RI,RR	RI,RR

Table K.5 Answers to 1st questionnaire at national level by respondents from Norway. (to be continued)

Respondent No.	1	2	3	4	5	6	7	8	9
Tier	1	2	1	2	2	1	2	2	2
RI1_2004	1	2	2	2	2	2	3	1	1
RI1_2014	3	3	3	4	3	3	3	2	2
RI1_2024	4	4	4	5	4	3	4	4	3
RI2_2004	2	2	1	2	2	3	3	1	1
RI2_2014	4	3	4	3	3	4	3	3	3
RI2_2024	5	4	4	4	4	4	4	3	4
RI3_2004	2	2	3	2	2	2	2	1	1
RI3_2014	4	3	4	4	3	4	3	3	2
RI3_2024	5	4	4	5	4	4	4	3	3
RI4_2004	2	3	1	2	1	3	2	1	1
RI4_2014	3	4	2	4	3	3	2	2	2
RI4_2024	4	5	3	5	3	4	3	3	3
RI5_2004	2	2	1	2	1	3	2	1	1
RI5_2014	3	3	2	3	3	4	3	2	2
RI5_2024	4	4	3	4	3	4	3	4	3
RI6_2004	2	4	2	1	1	2	3	1	1
RI6_2014	3	4	3	3	2	3	4	1	3
RI6_2024	4	4	3	4	2	4	4	2	4
RR1_2004	2	3	2	2	3	3	2	1	1
RR1_2014	3	4	3	3	3	4	3	2	3
RR1_2024	4	5	3	4	3	4	4	3	4
RR2_2004	3	3	1	Off	2	2	3	2	1
RR2_2014	4	4	2	Off	2	4	3	4	3
RR2_2024	5	5	3	Off	3	5	3	5	4
RR3_2004	2	4	3	2	2	3	3	1	1
RR3_2014	3	4	4	3	2	4	3	2	1
RR3_2024	4	4	4	4	3	4	4	4	2
RR4_2004	3	4	2	1	2	3	2	1	1
RR4_2014	4	4	2	2	2	3	3	3	1
RR4_2024	4	4	3	3	3	4	3	4	2
RR5_2004	2	4	3	2	3	3	3	3	1
RR5_2014	3	5	4	4	3	3	4	4	3
RR5_2024	4	5	4	5	3	3	4	5	4
RR6_2004	2	3	Off	2	2	3	1	1	1
RR6_2014	3	3	Off	3	3	3	2	1	2
RR6_2024	4	3	Off	4	3	3	3	2	2

Table K.5 (continued)

DM1_2004	3	2	3	1	2	3	1	2	1
DM1_2014	4	3	3	2	2	3	2	4	5
DM1_2024	4	4	4	3	3	3	3	5	5
DM2_2004	3	2	2	3	2	2	2	1	1
DM2_2014	4	3	3	4	2	3	3	2	3
DM2_2024	4	4	4	5	3	4	3	3	3
DM3_2004	3	2	Off	1	3	4	3	1	1
DM3_2014	4	3	Off	2	4	3	3	2	2
DM3_2024	4	4	Off	3	4	3	3	3	5
DM4_2004	2	2	3	3	2	3	2	3	1
DM4_2014	4	4	3	4	3	4	3	4	2
DM4_2024	4	5	3	5	4	5	3	5	4
DM5_2004	2	3	2	3	2	4	1	2	2
DM5_2014	3	3	3	4	2	3	2	2	3
DM5_2024	4	4	4	5	2	3	2	2	4
DM6_2004	2	3	Off	3	2	3	1	1	1
DM6_2014	3	4	Off	4	2	3	1	1	3
DM6_2024	4	4	Off	5	3	3	2	2	5
FP1_2004	1	2	1	Off	2	1	5	2	1
FP1_2014	3	4	1	Off	2	4	5	3	2
FP1_2024	4	4	3	Off	3	5	5	4	4
FP2_2004	2	3	3	3	3	3	3	1	1
FP2_2014	3	3	4	4	3	4	3	3	2
FP2_2024	3	4	4	5	3	4	3	3	2
FP3_2004	2	3	2	3	3	3	1	1	1
FP3_2014	3	3	3	4	3	3	2	2	1
FP3_2024	4	4	3	5	4	3	3	3	4
FP4_2004	5	5	Off	3	3	3	1	5	1
FP4_2014	5	5	Off	4	3	3	1	5	1
FP4_2024	5	5	Off	5	3	3	1	5	2
FP5_2004	4	4	2	3	3	4	1	3	2
FP5_2014	4	4	2	4	3	4	1	3	2
FP5_2024	5	4	2	5	3	4	1	3	2
FP6_2004	3	4	4	3	3	4	2	2	2
FP6_2014	3	4	4	4	3	4	2	2	3
FP6_2024	4	5	4	5	3	4	2	3	5

Table K.6 Answers to 1st questionnaire at county level by respondents from Norway.

Respondent No.	2	4	6	7	8	9
Tier	2	2	1	2	2	2
RI1_2004	2	2	3	3	1	Off
RI1_2014	3	4	4	3	2	Off
RI1_2024	4	4	4	4	4	Off
RI2_2004	2	1	3	3	1	1
RI2_2014	3	3	4	3	3	Off
RI2_2024	4	4	4	4	3	Off
RI3_2004	2	2	2	2	1	1
RI3_2014	3	4	4	3	3	Off
RI3_2024	4	5	4	4	3	Off
RI4_2004	3	1	3	2	1	Off
RI4_2014	4	4	3	2	2	Off
RI4_2024	5	5	4	3	3	Off
RI5_2004	2	2	3	2	1	Off
RI5_2014	3	3	4	3	2	Off
RI5_2024	4	4	4	3	4	Off
RI6_2004	4	1	2	3	1	Off
RI6_2014	4	3	3	4	1	Off
RI6_2024	4	4	4	4	2	Off
RR1_2004	3	1	3	2	1	Off
RR1_2014	4	3	4	3	2	Off
RR1_2024	5	4	4	4	3	Off
RR2_2004	3	Off	2	3	2	Off
RR2_2014	4	Off	4	3	3	Off
RR2_2024	5	Off	5	3	5	Off
RR3_2004	4	2	3	3	1	Off
RR3_2014	4	3	4	3	2	Off
RR3_2024	4	4	4	4	4	Off
RR4_2004	4	1	3	2	1	Off
RR4_2014	4	2	3	3	3	Off
RR4_2024	4	3	4	3	4	Off
RR5_2004	4	2	3	3	3	Off
RR5_2014	5	4	3	4	4	Off
RR5_2024	5	5	3	4	5	Off
RR6_2004	3	2	3	1	1	Off
RR6_2014	3	3	3	2	1	Off
RR6_2024	3	4	3	3	2	Off

Respondent No.	2	4	6	7	8	9
Tier	2	2	1	2	2	2
RI1_2004	2	1	3	1	2	Off
RI1_2014	3	2	3	2	4	Off
RI1_2024	4	3	3	3	5	Off
RI2_2004	2	3	1	2	1	Off
RI2_2014	3	4	3	3	2	Off
RI2_2024	4	5	4	3	3	Off
RI3_2004	2	1	4	3	1	Off
RI3_2014	3	2	3	3	2	Off
RI3_2024	4	3	3	3	3	Off
RI4_2004	2	3	3	2	3	Off
RI4_2014	4	4	4	3	4	Off
RI4_2024	5	5	4	3	5	Off
RI5_2004	3	3	4	1	2	Off
RI5_2014	3	4	3	2	2	Off
RI5_2024	4	5	3	2	2	Off
RI6_2004	3	3	3	1	1	Off
RI6_2014	4	4	3	1	1	Off
RI6_2024	4	5	3	2	2	Off
RR1_2004	2	Off	1	Off	2	Off
RR1_2014	4	Off	4	Off	3	Off
RR1_2024	4	Off	4	Off	4	Off
RR2_2004	2	3	1	Off	1	Off
RR2_2014	3	4	1	Off	3	Off
RR2_2024	3	5	1	Off	3	Off
RR3_2004	3	3	1	1	1	Off
RR3_2014	3	4	1	2	2	Off
RR3_2024	3	5	1	3	3	Off
RR4_2004	5	3	1	1	5	Off
RR4_2014	5	4	1	1	5	Off
RR4_2024	5	5	1	1	5	Off
RR5_2004	4	3	3	Off	3	Off
RR5_2014	4	4	3	Off	3	Off
RR5_2024	4	5	3	Off	3	Off
RR6_2004	4	3	2	2	2	Off
RR6_2014	4	4	2	2	2	Off
RR6_2024	5	5	2	2	3	Off

Table K.7 Answers to 2nd questionnaire by respondents from Norway. (to be continued)

Respondent No.	1	2	3	5	7	9	10	Respondent No.	1	2	3	5	7	9	10
Which one is more important?								**In which degree?**							
1_2.RI	2	1	1	2	1	2	2	**1_2_v.RI**	3	4	5	2	3	1	3
1_3.RI	2	2	2	2	2	2	2	**1_3_v.RI**	3	7	6	2	3	1	9
1_4.RI	2	2	1	2	2	2	2	**1_4_v.RI**	3	9	5	2	1	1	2
1_5.RI	2	1	1	2	2	2	1	**1_5_v.RI**	3	4	6	2	5	1	3
1_6.RI	2	2	1	1	2	2	2	**1_6_v.RI**	3	8	2	2	1	1	6
2_3.RI	2	2	2	2	2	2	2	**2_3_v.RI**	2	7	7	1	9	1	2
2_4.RI	1	2	1	2	2	2	1	**2_4_v.RI**	4	9	5	1	9	1	2
2_5.RI	1	1	1	2	2	2	1	**2_5_v.RI**	4	7	2	2	4	1	3
2_6.RI	1	2	1	1	2	2	2	**2_6_v.RI**	3	8	4	2	3	1	1
3_4.RI	1	2	1	2	2	2	1	**3_4_v.RI**	3	9	7	1	1	1	3
3_5.RI	1	1	1	2	1	2	1	**3_5_v.RI**	3	7	5	2	2	1	5
3_6.RI	1	2	1	1	1	2	1	**3_6_v.RI**	3	7	5	2	2	1	2
4_5.RI	1	1	1	2	2	2	1	**4_5_v.RI**	1	9	2	1	1	1	3
4_6.RI	1	1	1	1	1	2	2	**4_6_v.RI**	1	9	3	2	2	1	2
5_6.RI	1	2	1	2	1	2	2	**5_6_v.RI**	1	7	3	1	2	1	3
1_2.RR	1	1	1	1	1	2	1	**1_2_v.RR**	1	6	8	3	2	1	7
1_3.RR	1	1	1	1	1	2	1	**1_3_v.RR**	1	7	7	3	1	1	3
1_4.RR	1	1	1	1	1	2	1	**1_4_v.RR**	1	6	6	2	1	1	2
1_5.RR	1	2	1	2	1	2	1	**1_5_v.RR**	1	2	6	1	3	1	1
1_6.RR	1	1	1	1	1	2	1	**1_6_v.RR**	1	9	6	2	1	1	2
2_3.RR	2	2	1	2	2	2	1	**2_3_v.RR**	2	7	2	2	2	1	1
2_4.RR	2	2	1	2	2	2	1	**2_4_v.RR**	2	6	2	2	2	1	2
2_5.RR	2	2	1	2	1	2	2	**2_5_v.RR**	2	5	1	3	3	1	5
2_6.RR	2	2	1	2	1	2	2	**2_6_v.RR**	2	4	2	1	2	1	2
3_4.RR	1	2	1	2	2	2	1	**3_4_v.RR**	2	6	3	2	2	1	2
3_5.RR	1	2	1	2	1	2	2	**3_5_v.RR**	2	3	3	1	4	1	3
3_6.RR	1	1	1	2	1	2	1	**3_6_v.RR**	2	2	3	1	6	1	3
4_5.RR	2	1	2	1	2	2	2	**4_5_v.RR**	1	3	2	2	3	1	2
4_6.RR	2	1	1	1	1	2	2	**4_6_v.RR**	1	5	2	2	2	1	1
5_6.RR	2	1	1	2	1	2	1	**5_6_v.RR**	1	3	5	1	2	1	2
1_2.DM	1	2	2	2	1	2	2	**1_2_v.DM**	2	7	6	1	3	1	1
1_3.DM	1	1	1	1	1	2	1	**1_3_v.DM**	2	4	4	2	3	1	2
1_4.DM	2	1	1	1	1	2	2	**1_4_v.DM**	2	4	4	2	3	1	2
1_5.DM	2	2	2	2	2	2	2	**1_5_v.DM**	1	9	1	3	1	1	1
1_6.DM	1	2	1	2	2	2	1	**1_6_v.DM**	1	5	3	2	3	1	2
2_3.DM	2	1	1	1	1	2	1	**2_3_v.DM**	2	6	5	2	3	1	2
2_4.DM	1	1	1	1	2	2	2	**2_4_v.DM**	2	6	6	2	2	1	1
2_5.DM	2	2	1	2	2	2	2	**2_5_v.DM**	2	9	5	3	2	1	1

Table K.7 (continued)

2_6.DM	1	2	1	2	2	2	1	**2_6_v.DM**	2	7	4	1	3	1	3
3_4.DM	2	2	2	2	2	2	2	**3_4_v.DM**	2	7	2	1	1	1	2
3_5.DM	1	2	2	2	2	2	2	**3_5_v.DM**	1	9	3	3	2	1	3
3_6.DM	2	2	1	2	2	2	1	**3_6_v.DM**	1	8	4	2	2	1	4
4_5.DM	1	2	2	2	2	2	2	**4_5_v.DM**	2	9	2	3	3	1	3
4_6.DM	1	2	1	2	2	2	1	**4_6_v.DM**	2	7	4	2	3	1	3
5_6.DM	1	2	1	1	2	2	1	**5_6_v.DM**	2	2	3	3	2	1	4
1_2.FP	1	1	1	1	1	2	1	**1_2_v.FP**	1	6	3	2	2	1	5
1_3.FP	2	2	1	1	2	2	1	**1_3_v.FP**	1	4	2	2	3	1	2
1_4.FP	2	2	2	1	2	2	2	**1_4_v.FP**	1	2	3	2	4	1	1
1_5.FP	2	1	2	1	2	2	2	**1_5_v.FP**	1	5	4	2	9	1	1
1_6.FP	2	1	2	1	2	2	2	**1_6_v.FP**	1	5	6	2	9	1	5
2_3.FP	2	2	1	2	2	2	2	**2_3_v.FP**	2	2	1	1	5	1	6
2_4.FP	2	2	2	2	2	2	2	**2_4_v.FP**	2	3	2	2	4	1	7
2_5.FP	2	2	2	2	2	2	2	**2_5_v.FP**	2	2	1	2	9	1	6
2_6.FP	2	2	2	2	2	2	2	**2_6_v.FP**	2	2	6	2	9	1	9
3_4.FP	2	2	1	2	2	2	2	**3_4_v.FP**	2	2	2	1	3	1	2
3_5.FP	1	1	1	1	2	2	2	**3_5_v.FP**	3	2	2	2	5	1	3
3_6.FP	1	2	2	1	2	2	2	**3_6_v.FP**	2	1	6	2	5	1	5
4_5.FP	1	1	1	2	2	2	2	**4_5_v.FP**	2	3	2	1	5	1	5
4_6.FP	1	1	2	2	2	2	2	**4_6_v.FP**	3	3	6	1	5	1	5
5_6.FP	1	1	2	2	2	2	2	**5_6_v.FP**	2	2	6	1	1	1	2

Appendix L Corrections of inconsistent weights

L.1 How CR changes

Table L.1 and Figure L.1 show examples of how CR changes with difference values in an entry in a comparison matrix. In Case 1 (Table L.1a), since both Indicators 2 and 3 are two times more important than Indicator 1, Indicators 2 and 3 should be equally important to maintain consistent perceptions. Hence, CR = 0 if $x = 1$. With increasing distance from a consistent set of values of relative importance between indicators, CR increases. Figure L.1 shows that CR exceeds 0.1 when Indicator 2 is more than two times more or less important than indicator 3. In Case 2 (Table L.1b), Indicator 2 is expected to be two times more important than Indicator 3 since Indicator 1 is two and four times more important than Indicators 2 and 3 respectively. According to Figure L.1, the increment of CR is not symmetrical: CR is still within the acceptable range (i.e. ≤ 1) even if Indicator 2 is regarded as 5 times more important than Indicator 3, however, CR increases more abruptly and exceeds 0.1 right away if indicator 2 appears not to be as important as indicator 3. The difference in gradients of increment of CR thus demonstrates that the tolerance for inconsistency is small if the relative importance between two indicators deviates from what is expected.

Table L.1 Examples of a 3×3 comparison matrix

(a) Case 1	Indicator 1	Indicator 2	Indicator 3
Indicator 1	1	2	2
Indicator 2	1/2	1	x
Indicator 3	1/2	$1/x$	1

(b) Case 2	Indicator 1	Indicator 2	Indicator 3
Indicator 1	1	2	4
Indicator 2	1/2	1	y
Indicator 3	1/4	$1/y$	1

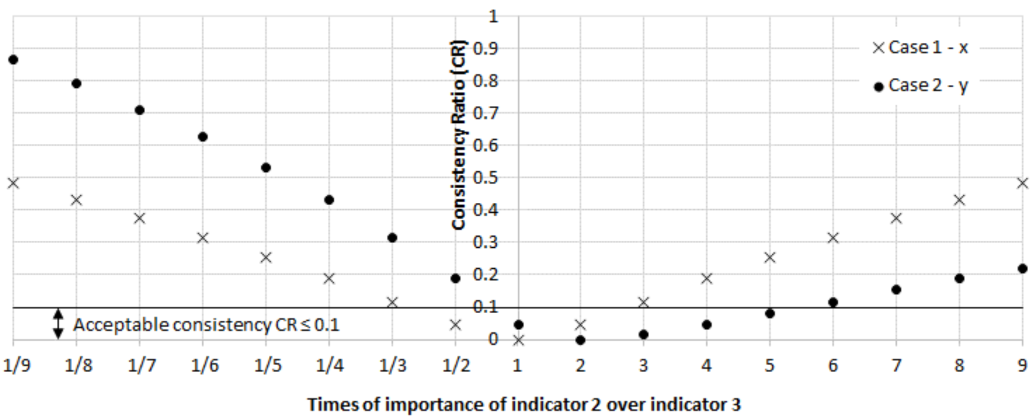


Figure L.1 Changes of Consistency Ratio (CR) with changing values in an entry in the 3×3 comparison matrices in Table L.1.

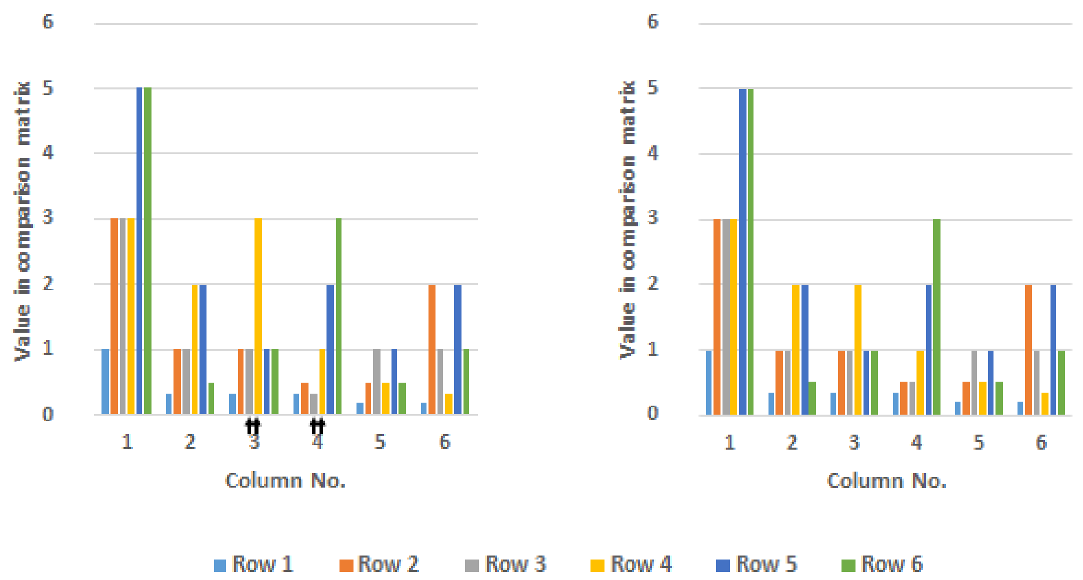
L.2 Manual corrections made in survey data

The following presents all the corrections that have been made for those comparison matrices with CR greater than 0.1. Selection of the entries in a comparison matrix for correction is based on the graphical method developed in the present study. The principle of the method is described in Section 3.3.2. The arrows in the clustered column plots indicate those columns that have a major contribution to the inconsistent pattern in the plots.

Hong Kong: RI - Respondent No. 10

Original: assuming missing data = 1 (blue highlighted)							**Corrected:** (Red highlighted)						
	RI1	RI2	RI3	RI4	RI5	RI6		RI1	RI2	RI3	RI4	RI5	RI6
RI1	1	1/3	1/3	1/3	1/5	1/5	RI1	1	1/3	1/3	1/3	1/5	1/5
RI2	3	1	1	1/2	1/2	2	RI2	3	1	1	1/2	1/2	2
RI3	3	1	1	1/3	1	1	RI3	3	1	1	1/2	1	1
RI4	3	2	3	1	1/2	1/3	RI4	3	2	2	1	1/2	1/3
RI5	5	2	1	2	1	2	RI5	5	2	1	2	1	2
RI6	5	1/2	1	3	1/2	1	RI6	5	1/2	1	3	1/2	1

CR = 0.1115 | CR = 0.0916



Hong Kong: RI - Respondent No. 5

Original:

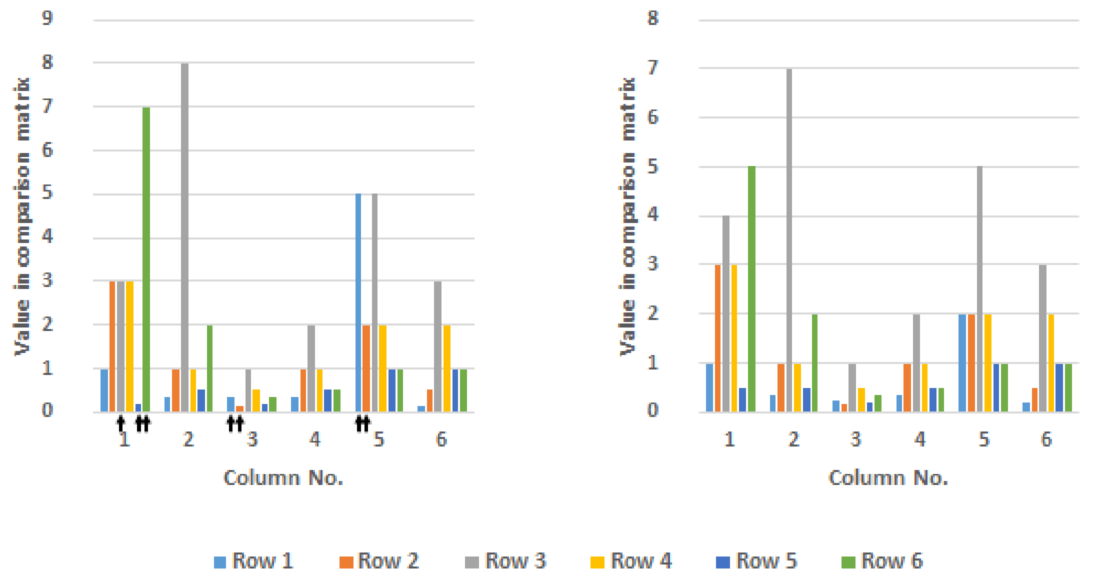
	RI1	RI2	RI3	RI4	RI5	RI6
RI1	1	1/3	1/3	1/3	5	1/7
RI2	3	1	1/8	1	2	1/2
RI3	3	8	1	2	5	3
RI4	3	1	1/2	1	2	2
RI5	1/5	1/2	1/5	1/2	1	1
RI6	7	2	1/3	1/2	1	1

CR = 0.2114

Corrected: (Red highlighted)

	RI1	RI2	RI3	RI4	RI5	RI6
RI1	1	1/3	1/4	1/3	2	1/5
RI2	3	1	1/7	1	2	1/2
RI3	4	7	1	2	5	3
RI4	3	1	1/2	1	2	2
RI5	1/2	1/2	1/5	1/2	1	1
RI6	5	2	1/3	1/2	1	1

CR = 0.0987



Hong Kong: RR - Respondent No. 10

Original:

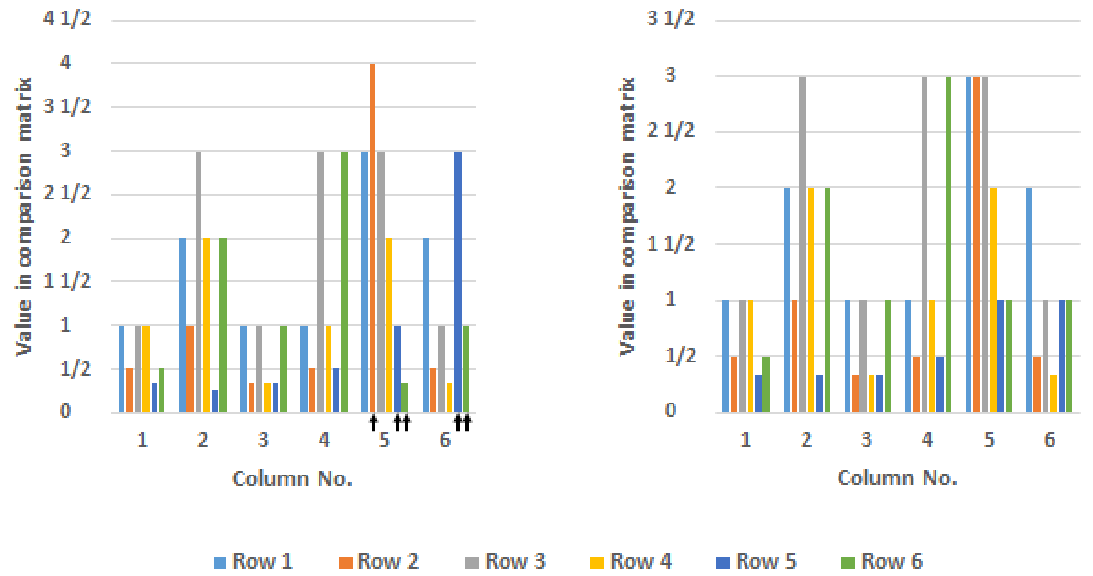
	RR1	RR2	RR3	RR4	RR5	RR6
RR1	1	2	1	1	3	2
RR2	1/2	1	1/3	1/2	4	1/2
RR3	1	3	1	3	3	1
RR4	1	2	1/3	1	2	1/3
RR5	1/3	1/4	1/3	1/2	1	3
RR6	1/2	2	1	3	1/3	1

CR = 0.2085

Corrected: (Red highlighted)

	RR1	RR2	RR3	RR4	RR5	RR6
RR1	1	2	1	1	3	2
RR2	1/2	1	1/3	1/2	3	1/2
RR3	1	3	1	3	3	1
RR4	1	2	1/3	1	2	1/3
RR5	1/3	1/3	1/3	1/2	1	1
RR6	1/2	2	1	3	1	1

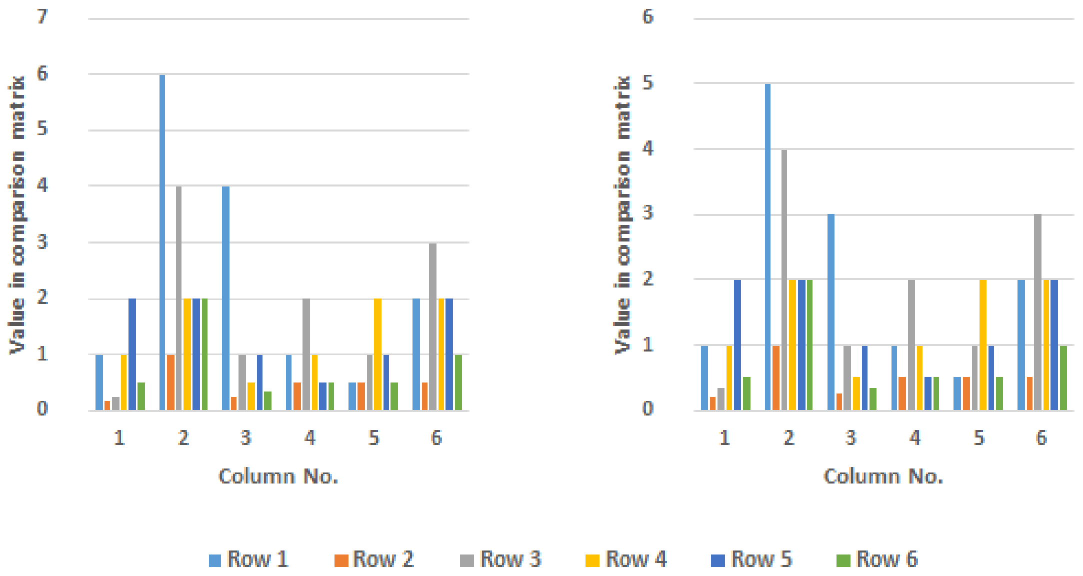
CR = 0.0888



Hong Kong: RR - Respondent No. 5

Original:							**Corrected:** (Red highlighted: 'contrast' reduced)						
	RR1	RR2	RR3	RR4	RR5	RR6		RR1	RR2	RR3	RR4	RR5	RR6
RR1	1	6	4	1	1/2	2	RR1	1	5	3	1	1/2	2
RR2	1/6	1	1/4	1/2	1/2	1/2	RR2	1/5	1	1/4	1/2	1/2	1/2
RR3	1/4	4	1	2	1	3	RR3	1/3	4	1	2	1	3
RR4	1	2	1/2	1	2	2	RR4	1	2	1/2	1	2	2
RR5	2	2	1	1/2	1	2	RR5	2	2	1	1/2	1	2
RR6	1/2	2	1/3	1/2	1/2	1	RR6	1/2	2	1/3	1/2	1/2	1

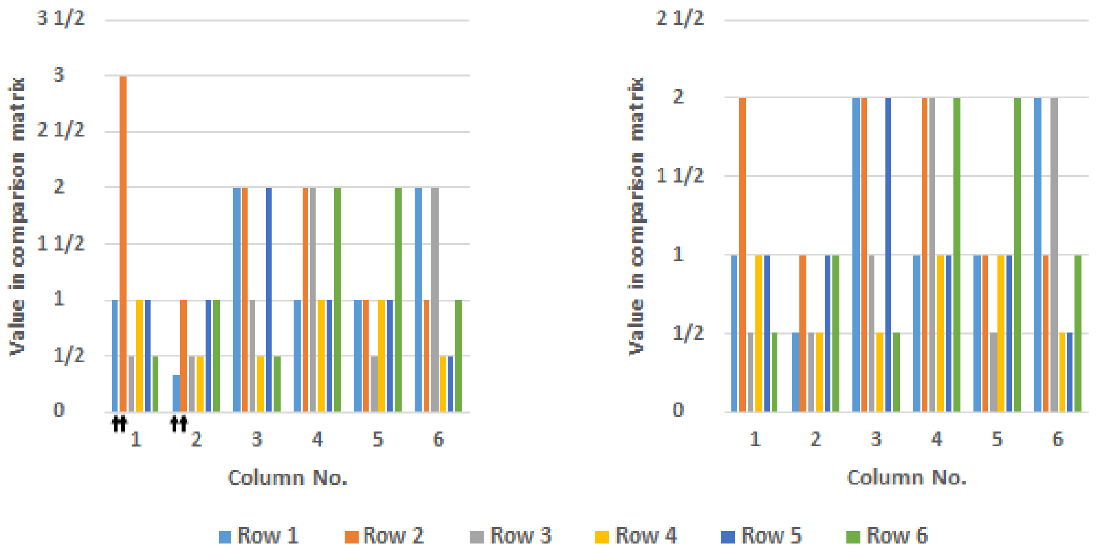
CR = 0.1213 | CR = 0.0971



Hong Kong: DM - Respondent No. 11

Original: assuming missing data = 1 (blue highlighted)							**Corrected:** (Red highlighted)						
	DM1	DM2	DM3	DM4	DM5	DM6		DM1	DM2	DM3	DM4	DM5	DM6
DM1	1	1/3	2	1	1	2	DM1	1	1/2	2	1	1	2
DM2	3	1	2	2	1	1	DM2	2	1	2	2	1	1
DM3	1/2	1/2	1	2	1/2	2	DM3	1/2	1/2	1	2	1/2	2
DM4	1	1/2	1/2	1	1	1/2	DM4	1	1/2	1/2	1	1	1/2
DM5	1	1	2	1	1	1/2	DM5	1	1	2	1	1	1/2
DM6	1/2	1	1/2	2	2	1	DM6	1/2	1	1/2	2	2	1

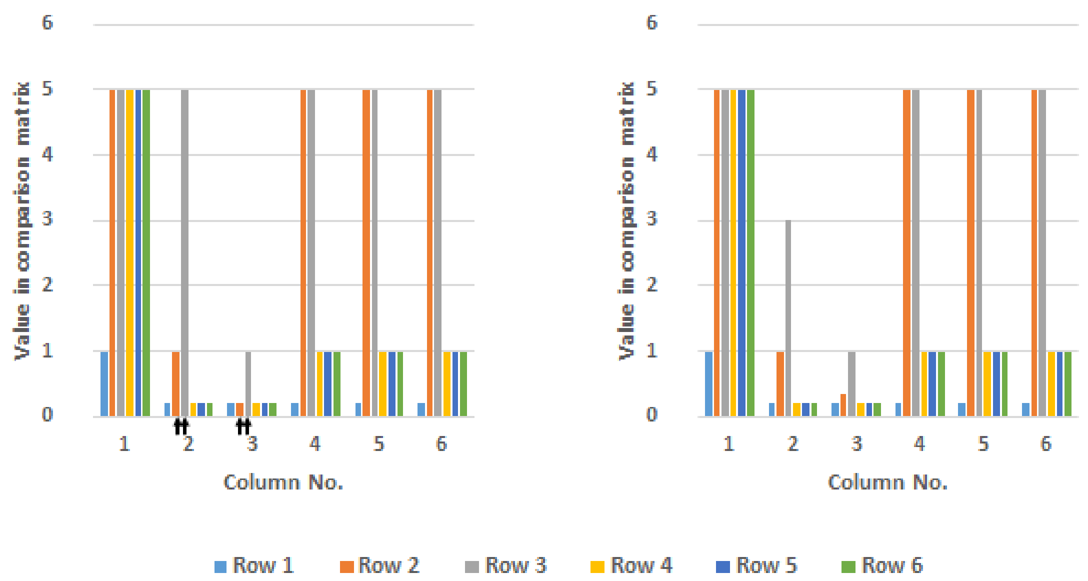
CR = 0.1034 | CR = 0.0897



Hong Kong: FP - Respondent No. 12

Original:							**Corrected:** (Red highlighted)						
	FP1	FP2	FP3	FP4	FP5	FP6		FP1	FP2	FP3	FP4	FP5	FP6
FP1	1	1/5	1/5	1/5	1/5	1/5	FP1	1	1/5	1/5	1/5	1/5	1/5
FP2	5	1	1/5	5	5	5	FP2	5	1	1/3	5	5	5
FP3	5	5	1	5	5	5	FP3	5	3	1	5	5	5
FP4	5	1/5	1/5	1	1	1	FP4	5	1/5	1/5	1	1	1
FP5	5	1/5	1/5	1	1	1	FP5	5	1/5	1/5	1	1	1
FP6	5	1/5	1/5	1	1	1	FP6	5	1/5	1/5	1	1	1

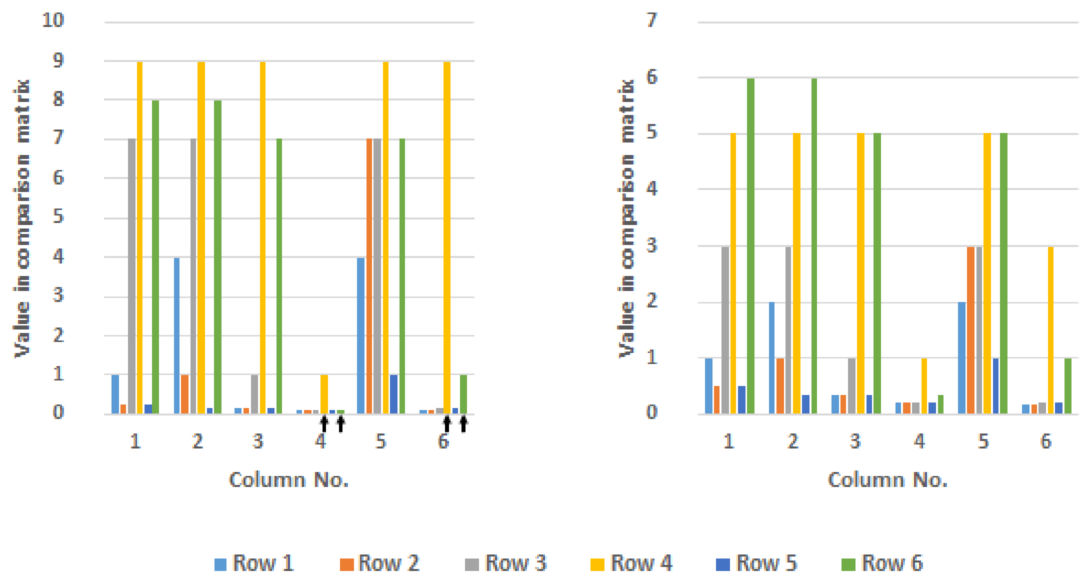
CR = 0.1277 | CR = 0.0978



Norway: RI - Respondent No. 2

Original:							**Corrected:** (Red highlighted) + 'contrast' generally reduced						
	RI1	RI2	RI3	RI4	RI5	RI6		RI1	RI2	RI3	RI4	RI5	RI6
RI1	1	4	1/7	1/9	4	1/8	RI1	1	2	1/3	1/5	2	1/6
RI2	1/4	1	1/7	1/9	7	1/8	RI2	1/2	1	1/3	1/5	3	1/6
RI3	7	7	1	1/9	7	1/7	RI3	3	3	1	1/5	3	1/5
RI4	9	9	9	1	9	9	RI4	5	5	5	1	5	3
RI5	1/4	1/7	1/7	1/9	1	1/7	RI5	1/2	1/3	1/3	1/5	1	1/5
RI6	8	8	7	1/9	7	1	RI6	6	6	5	1/3	5	1

CR = 0.3276 | CR = 0.0958



Norway: RI - Respondent No. 3

Original:

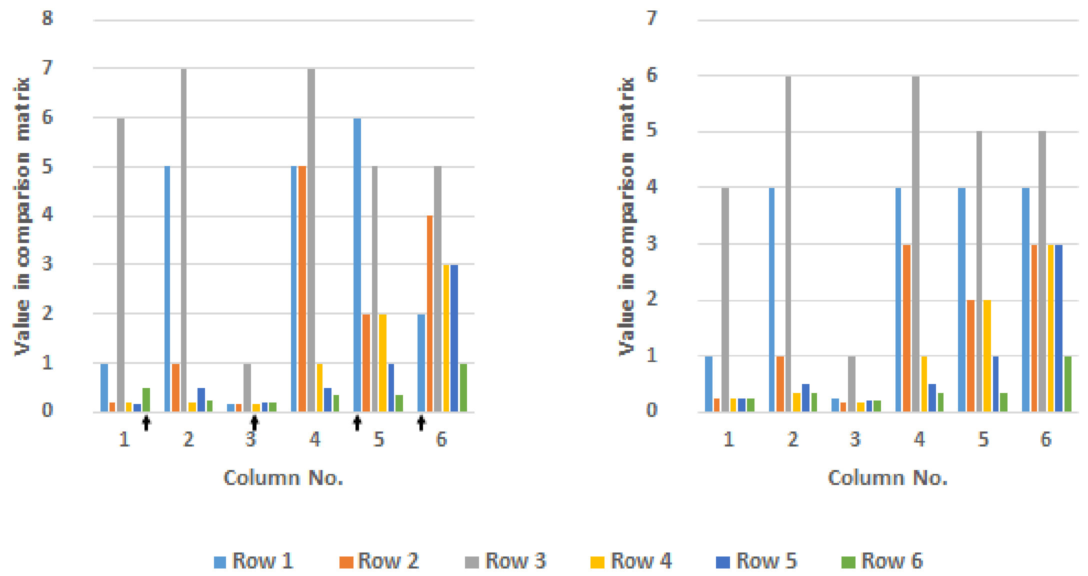
	RI1	RI2	RI3	RI4	RI5	RI6
RI1	1	5	1/6	5	6	2
RI2	1/5	1	1/7	5	2	4
RI3	6	7	1	7	5	5
RI4	1/5	1/5	1/7	1	2	3
RI5	1/6	1/2	1/5	1/2	1	3
RI6	1/2	1/4	1/5	1/3	1/3	1

CR = 0.2020

Corrected: (Red highlighted)

	RI1	RI2	RI3	RI4	RI5	RI6
RI1	1	4	1/4	4	4	4
RI2	1/4	1	1/6	3	2	3
RI3	4	6	1	6	5	5
RI4	1/4	1/3	1/6	1	2	3
RI5	1/4	1/2	1/5	1/2	1	3
RI6	1/4	1/3	1/5	1/3	1/3	1

CR = 0.0977



Norway: RR - Respondent No. 2

Original:

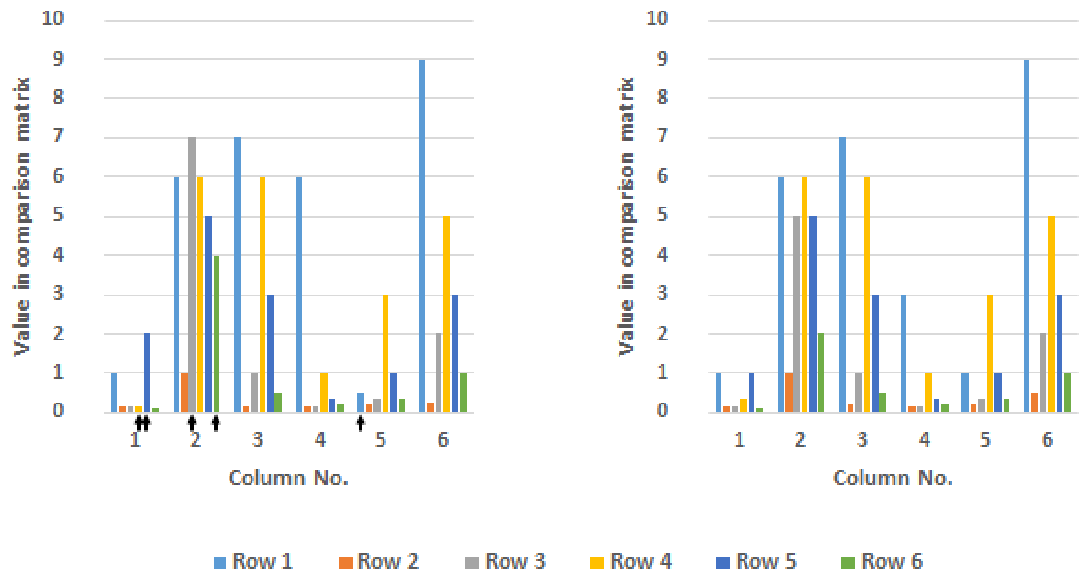
	RR1	RR2	RR3	RR4	RR5	RR6
RR1	1	6	7	6	1/2	9
RR2	1/6	1	1/7	1/6	1/5	1/4
RR3	1/7	7	1	1/6	1/3	2
RR4	1/6	6	6	1	3	5
RR5	2	5	3	1/3	1	3
RR6	1/9	4	1/2	1/5	1/3	1

CR = 0.2314

Corrected: (Red highlighted)

	RR1	RR2	RR3	RR4	RR5	RR6
RR1	1	6	7	3	1	9
RR2	1/6	1	1/5	1/6	1/5	1/2
RR3	1/7	5	1	1/6	1/3	2
RR4	1/3	6	6	1	3	5
RR5	1	5	3	1/3	1	3
RR6	1/9	2	1/2	1/5	1/3	1

CR = 0.0962



Norway: RR - Respondent No. 3

Original:

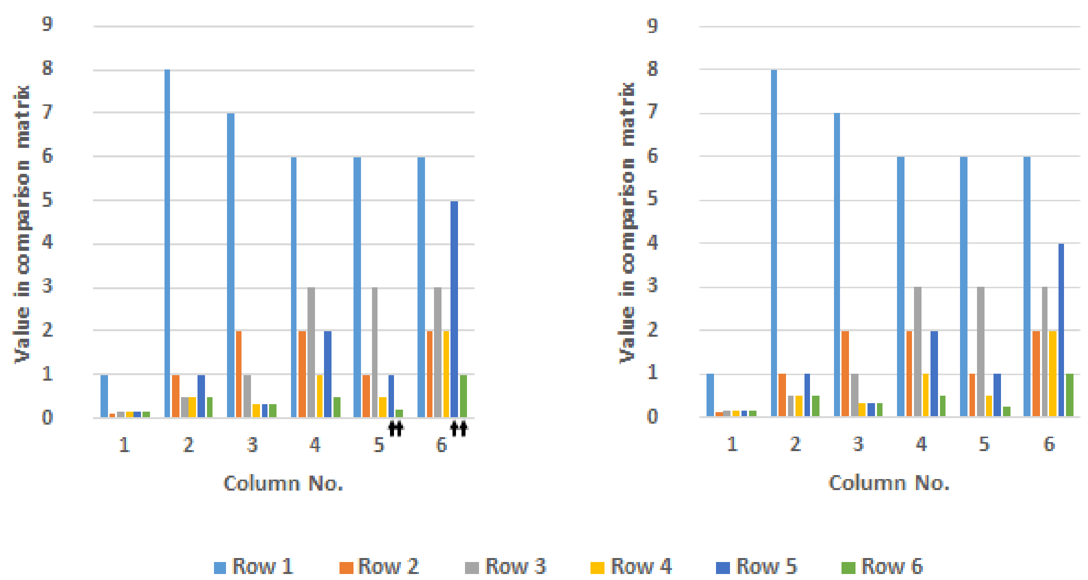
	RR1	RR2	RR3	RR4	RR5	RR6
RR1	1	8	7	6	6	6
RR2	1/8	1	2	2	1	2
RR3	1/7	1/2	1	3	3	3
RR4	1/6	1/2	1/3	1	1/2	2
RR5	1/6	1	1/3	2	1	5
RR6	1/6	1/2	1/3	1/2	1/5	1

CR = 0.1016

Corrected: (Red highlighted)

	RR1	RR2	RR3	RR4	RR5	RR6
RR1	1	8	7	6	6	6
RR2	1/8	1	2	2	1	2
RR3	1/7	1/2	1	3	3	3
RR4	1/6	1/2	1/3	1	1/2	2
RR5	1/6	1	1/3	2	1	4
RR6	1/6	1/2	1/3	1/2	1/4	1

CR = 0.0928



Norway: RR - Respondent No. 7

Original:

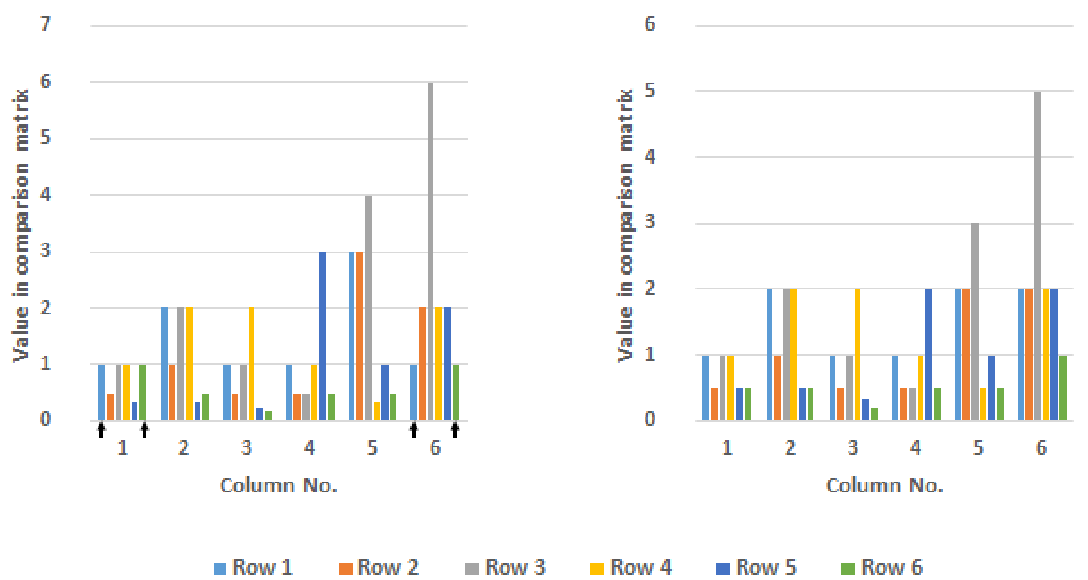
	RR1	RR2	RR3	RR4	RR5	RR6
RR1	1	2	1	1	3	1
RR2	1/2	1	1/2	1/2	3	2
RR3	1	2	1	1/2	4	6
RR4	1	2	2	1	1/3	2
RR5	1/3	1/3	1/4	3	1	2
RR6	1	1/2	1/6	1/2	1/2	1

CR = 0.2076

Corrected: (Red highlighted) + 'contrast' generally reduced

	RR1	RR2	RR3	RR4	RR5	RR6
RR1	1	2	1	1	2	2
RR2	1/2	1	1/2	1/2	2	2
RR3	1	2	1	1/2	3	5
RR4	1	2	2	1	1/2	2
RR5	1/2	1/2	1/3	2	1	2
RR6	1/2	1/2	1/5	1/2	1/2	1

CR = 0.0992



Norway: DM - Respondent No. 1

Original:

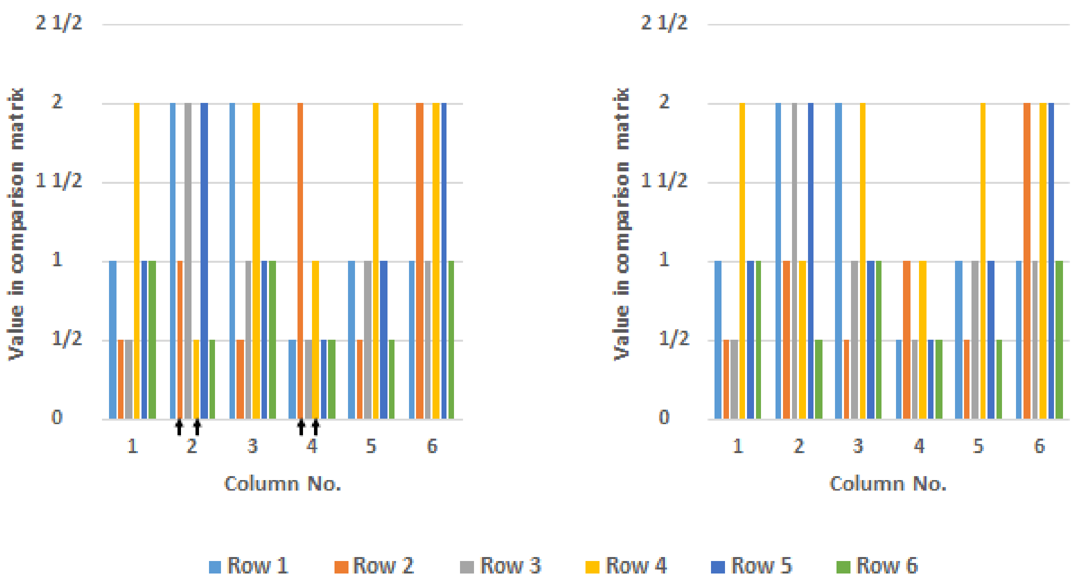
	DM1	DM2	DM3	DM4	DM5	DM6
DM1	1	2	2	1/2	1	1
DM2	1/2	1	1/2	2	1/2	2
DM3	1/2	2	1	1/2	1	1
DM4	2	1/2	2	1	2	2
DM5	1	2	1	1/2	1	2
DM6	1	1/2	1	1/2	1/2	1

CR = 0.1030

Corrected: (Red highlighted)

	DM1	DM2	DM3	DM4	DM5	DM6
DM1	1	2	2	1/2	1	1
DM2	1/2	1	1/2	1	1/2	2
DM3	1/2	2	1	1/2	1	1
DM4	2	1	2	1	2	2
DM5	1	2	1	1/2	1	2
DM6	1	1/2	1	1/2	1/2	1

CR = 0.0622



Norway: DM - Respondent No. 2

Original:

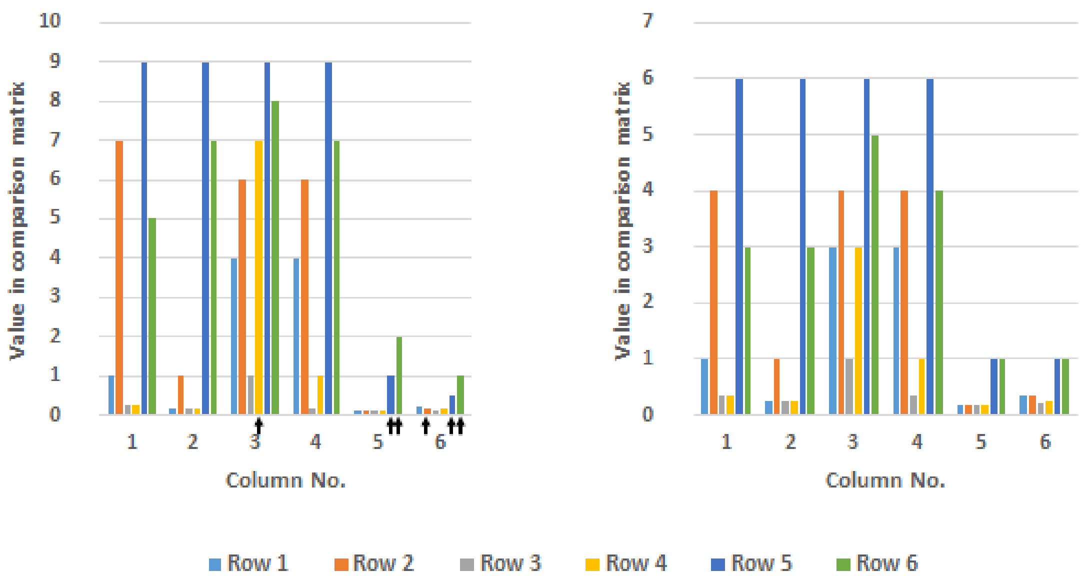
	DM1	DM2	DM3	DM4	DM5	DM6
DM1	1	1/7	4	4	1/9	1/5
DM2	7	1	6	6	1/9	1/7
DM3	1/4	1/6	1	1/7	1/9	1/8
DM4	1/4	1/6	7	1	1/9	1/7
DM5	9	9	9	9	1	1/2
DM6	5	7	8	7	2	1

CR = 0.2488

Corrected: (Red highlighted) + 'contrast' generally reduced

	DM1	DM2	DM3	DM4	DM5	DM6
DM1	1	1/4	3	3	1/6	1/3
DM2	4	1	4	4	1/6	1/3
DM3	1/3	1/4	1	1/3	1/6	1/5
DM4	1/3	1/4	3	1	1/6	1/4
DM5	6	6	6	6	1	1
DM6	3	3	5	4	1	1

CR = 0.0986



Norway: DM - Respondent No. 3

Original:

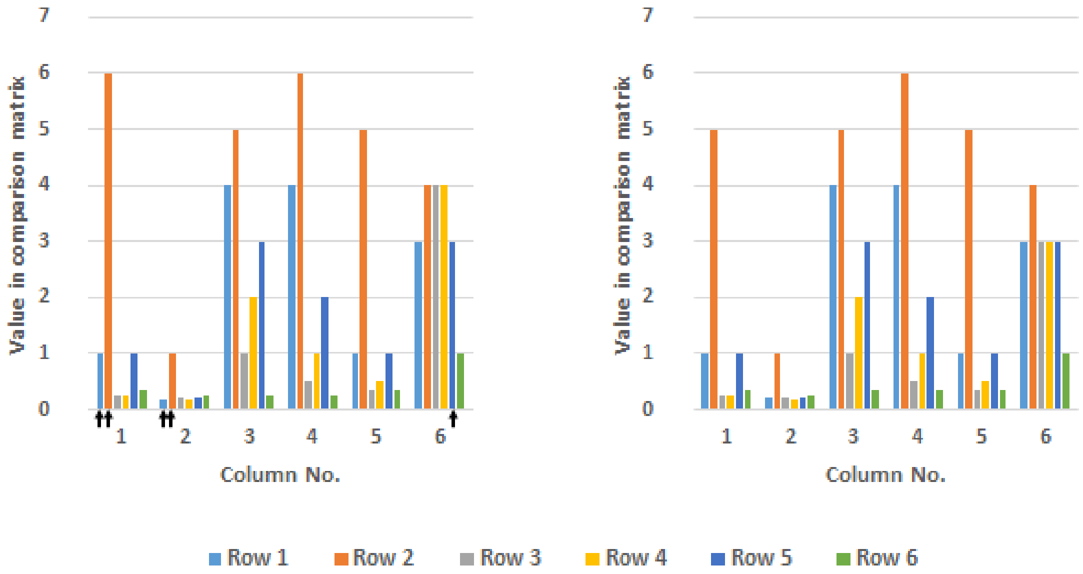
	DM1	DM2	DM3	DM4	DM5	DM6
DM1	1	1/6	4	4	1	3
DM2	6	1	5	6	5	4
DM3	1/4	1/5	1	1/2	1/3	4
DM4	1/4	1/6	2	1	1/2	4
DM5	1	1/5	3	2	1	3
DM6	1/3	1/4	1/4	1/4	1/3	1

CR = 0.1277

Corrected: (Red highlighted)

	DM1	DM2	DM3	DM4	DM5	DM6
DM1	1	1/5	4	4	1	3
DM2	5	1	5	6	5	4
DM3	1/4	1/5	1	1/2	1/3	3
DM4	1/4	1/6	2	1	1/2	3
DM5	1	1/5	3	2	1	3
DM6	1/3	1/4	1/3	1/3	1/3	1

CR = 0.0955



Norway: FP - Respondent No. 2

Original:

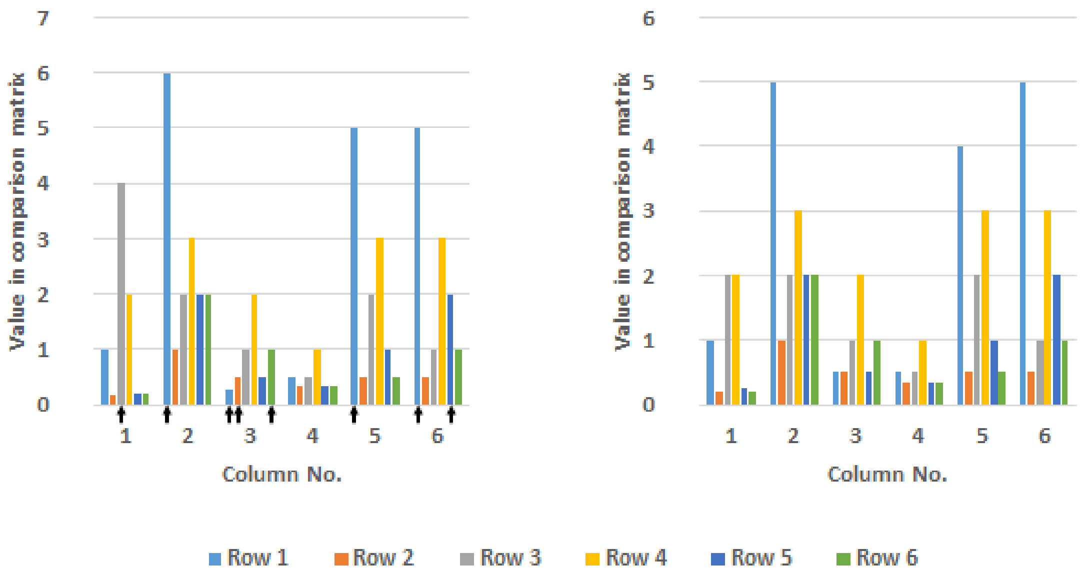
	FP1	FP2	FP3	FP4	FP5	FP6
FP1	1	6	1/4	1/2	5	5
FP2	1/6	1	1/2	1/3	1/2	1/2
FP3	4	2	1	1/2	2	1
FP4	2	3	2	1	3	3
FP5	1/5	2	1/2	1/3	1	2
FP6	1/5	2	1	1/3	1/2	1

CR = 0.1714

Corrected: (Red highlighted)

	FP1	FP2	FP3	FP4	FP5	FP6
FP1	1	5	1/2	1/2	4	5
FP2	1/5	1	1/2	1/3	1/2	1/2
FP3	2	2	1	1/2	2	1
FP4	2	3	2	1	3	3
FP5	1/4	2	1/2	1/3	1	2
FP6	1/5	2	1	1/3	1/2	1

CR = 0.0943



Appendix M Results of AHP weights

M.1 Hong Kong

Table M.1 Results of AHP weights for Hong Kong. (to be continued)

Respondent No.	Indicator	5	7	8	9	10	11	12
Eigenvalue	RI	6.6122	6.0000	6.0000	6.0000	6.5677	6.2332	6.0000
CI		0.122	0.000	0.000	0.000	0.114	0.047	0.000
CR		0.099	0.000	0.000	0.000	0.092	0.038	0.000
Principal eigenvector	RI1	0.1366	-0.2981	0.4082	-0.4364	0.1051	-0.1685	0.4082
	RI2	0.2387	-0.1491	0.4082	-0.4364	0.3737	-0.2113	0.4082
	RI3	0.8231	-0.5963	0.4082	-0.4364	0.3494	-0.4899	0.4082
	RI4	0.3544	-0.5963	0.4082	-0.4364	0.3976	-0.5570	0.4082
	RI5	0.1503	-0.2981	0.4082	-0.4364	0.5990	-0.4182	0.4082
	RI6	0.3140	-0.2981	0.4082	-0.2182	0.4587	-0.4491	0.4082
Priority vector	RI1	0.07	0.13	0.17	0.18	0.05	0.07	0.17
	RI2	0.12	0.07	0.17	0.18	0.16	0.09	0.17
	RI3	0.41	0.27	0.17	0.18	0.15	0.21	0.17
	RI4	0.18	0.27	0.17	0.18	0.17	0.24	0.17
	RI5	0.07	0.13	0.17	0.18	0.26	0.18	0.17
	RI6	0.16	0.13	0.17	0.09	0.20	0.20	0.17
Remarks		corrected				missing value = 1, corrected		

Respondent No.	Indicator	5	7	8	9	10	11	12
Eigenvalue	RR	6.6020		6.5349	6.0414	6.5505	6.4538	6.4601
CI		0.120		0.107	0.008	0.110	0.091	0.092
CR		0.097		0.086	0.007	0.089	0.073	0.074
Principal eigenvector	RR1	0.5696		0.4187	-0.7591	-0.5152	0.5407	-0.6896
	RR2	0.1385		0.5012	-0.1540	-0.2522	0.4840	-0.2699
	RR3	0.4769		0.5838	-0.2739	-0.5814	0.4840	-0.2699
	RR4	0.4283		0.0711	-0.4758	-0.3137	0.1942	-0.3553
	RR5	0.4501		0.4577	-0.2739	-0.1896	0.3953	-0.3553
	RR6	0.2071		0.1349	-0.1540	-0.4457	0.2124	-0.3553
Priority vector	RR1	0.25		0.19	0.36	0.22	0.23	0.30
	RR2	0.06		0.23	0.07	0.11	0.21	0.12
	RR3	0.21		0.27	0.13	0.25	0.21	0.12
	RR4	0.19		0.03	0.23	0.14	0.08	0.15
	RR5	0.20		0.21	0.13	0.08	0.17	0.15
	RR6	0.09		0.06	0.07	0.19	0.09	0.15
Remarks		corrected				corrected		

Table M.1 (continued)

Respondent No.	Indicator	5	7	8	9	10	11	12
Eigenvalue	DM	6.3038	6.0000	6.4601	6.0343	6.1650	6.5564	6.0000
CI		0.061	0.000	0.092	0.007	0.033	0.111	0.000
CR		0.049	0.000	0.074	0.006	0.027	0.090	0.000
Principal eigenvector	DM1	-0.4400	-0.5774	-0.4820	0.4830	-0.2122	0.4435	0.4082
	DM2	-0.6295	-0.5774	-0.4820	0.4830	-0.6046	0.5305	0.4082
	DM3	-0.2799	-0.2887	-0.3661	0.4830	-0.2088	0.3649	0.4082
	DM4	-0.4400	-0.2887	-0.3661	0.2553	-0.4127	0.2673	0.4082
	DM5	-0.1900	-0.2887	-0.4820	0.4554	-0.5989	0.3912	0.4082
	DM6	-0.3195	-0.2887	-0.1871	0.1665	-0.1295	0.4052	0.4082
Priority vector	DM1	0.19	0.25	0.20	0.21	0.10	0.18	0.17
	DM2	0.27	0.25	0.20	0.21	0.28	0.22	0.17
	DM3	0.12	0.13	0.15	0.21	0.10	0.15	0.17
	DM4	0.19	0.13	0.15	0.11	0.19	0.11	0.17
	DM5	0.08	0.13	0.20	0.20	0.28	0.16	0.17
	DM6	0.14	0.13	0.08	0.07	0.06	0.17	0.17
Remarks							missing value = 1, corrected	

Respondent No.	Indicator	5	7	8	9	10	11	12
Eigenvalue	FP	6.3332		6.5584	6.0000	6.5970	6.2377	6.6065
CI		0.067		0.112	0.000	0.119	0.048	0.121
CR		0.054		0.090	0.000	0.096	0.038	0.098
Principal eigenvector	FP1	0.1117		-0.4648	0.4082	0.3444	0.1920	0.0650
	FP2	0.3219		-0.1586	0.4082	0.1776	0.4028	0.5434
	FP3	0.7941		-0.7695	0.4082	0.4304	0.4083	0.7873
	FP4	0.2019		-0.3652	0.4082	0.3864	0.3352	0.1639
	FP5	0.3969		-0.1290	0.4082	0.3060	0.6318	0.1639
	FP6	0.2346		-0.1290	0.4082	0.6493	0.3502	0.1639
Priority vector	FP1	0.05		0.23	0.17	0.15	0.08	0.03
	FP2	0.16		0.08	0.17	0.08	0.17	0.29
	FP3	0.39		0.38	0.17	0.19	0.18	0.42
	FP4	0.10		0.18	0.17	0.17	0.14	0.09
	FP5	0.19		0.06	0.17	0.13	0.27	0.09
	FP6	0.11		0.06	0.17	0.28	0.15	0.09
Remarks						Missing value = 1		corrected

M.2 Norway

Table M.2 Results of AHP weights for Norway. (to be continued)

Respondent No.	Indicator	1	2	3	5	7	9	10	10th %tile	90th %tile
Eigenvalue	RI	6.3382	6.5942	6.6058	6.2818	6.3485	6.0000	6.3088		
CI		0.068	0.119	0.121	0.056	0.070	0.000	0.062		
CR		0.055	0.096	0.098	0.045	0.056	0.000	0.050		
Principal eigenvector	RI1	-0.1231	0.1251	-0.4287	0.2703	0.2342	0.4082	-0.1336		
	RI2	-0.6034	0.1107	-0.2056	0.4161	0.0763	0.4082	-0.3763		
	RI3	-0.6810	0.2164	-0.8561	0.4161	0.6288	0.4082	-0.7629		
	RI4	-0.2261	0.7761	-0.1419	0.4601	0.4743	0.4082	-0.2333		
	RI5	-0.2261	0.0785	-0.1222	0.5524	0.5123	0.4082	-0.1030		
	RI6	-0.2341	0.5628	-0.0776	0.2525	0.2376	0.4082	-0.4399		
Priority vector	RI1	0.06	0.07	0.23	0.11	0.11	0.17	0.07	0.06	0.19
	RI2	0.29	0.06	0.11	0.18	0.04	0.17	0.18	0.05	0.23
	RI3	0.33	0.12	0.47	0.18	0.29	0.17	0.37	0.15	0.41
	RI4	0.11	0.42	0.08	0.19	0.22	0.17	0.11	0.10	0.30
	RI5	0.11	0.04	0.07	0.23	0.24	0.17	0.05	0.05	0.23
	RI6	0.11	0.30	0.04	0.11	0.11	0.17	0.21	0.08	0.25
Remarks			corrected	corrected						

Respondent No.	Indicator	1	2	3	5	7	9	10	10th %tile	90th %tile
Eigenvalue	RR	6.1360	6.5967	6.5753	6.2436	6.6148	6.0000	6.5817		
CI		0.027	0.119	0.115	0.049	0.123	0.000	0.116		
CR		0.022	0.096	0.093	0.039	0.099	0.000	0.094		
Principal eigenvector	RR1	0.3851	-0.7461	0.9315	0.6411	-0.4719	0.4082	0.6529		
	RR2	0.2438	-0.0640	0.1948	0.1921	-0.3107	0.4082	0.1835		
	RR3	0.6082	-0.1453	0.2256	0.2871	-0.5592	0.4082	0.3023		
	RR4	0.3752	-0.5368	0.1007	0.4956	-0.4812	0.4082	0.1969		
	RR5	0.3752	-0.3489	0.1664	0.3863	-0.3320	0.4082	0.5971		
	RR6	0.3752	-0.0906	0.0753	0.2735	-0.1620	0.4082	0.2310		
Priority vector	RR1	0.16	0.39	0.55	0.28	0.20	0.17	0.30	0.17	0.45
	RR2	0.10	0.03	0.11	0.08	0.13	0.17	0.08	0.06	0.15
	RR3	0.26	0.08	0.13	0.13	0.24	0.17	0.14	0.11	0.25
	RR4	0.16	0.28	0.06	0.22	0.21	0.17	0.09	0.08	0.24
	RR5	0.16	0.18	0.10	0.17	0.14	0.17	0.28	0.13	0.22
	RR6	0.16	0.05	0.04	0.12	0.07	0.17	0.11	0.05	0.16
Remarks			corrected	corrected		corrected				

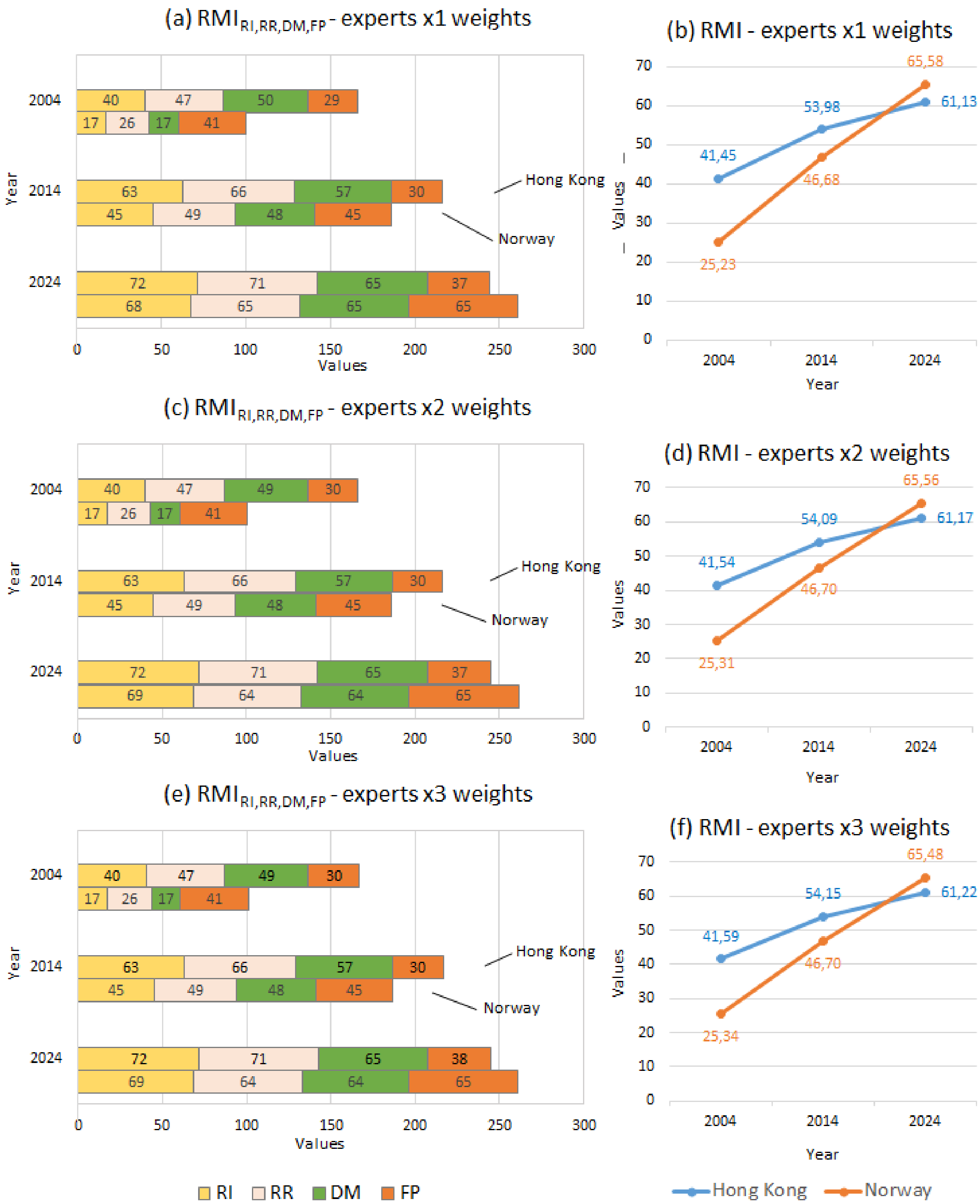
Table M.2 (continued)

Respondent No.	Indicator	1	2	3	5	7	9	10	10th %tile	90th %tile
Eigenvalue	DM	6.3859	6.6111	6.5923	6.1353	6.4884	6.0000	6.3667		
CI		0.077	0.122	0.118	0.027	0.098	0.000	0.073		
CR		0.062	0.099	0.096	0.022	0.079	0.000	0.059		
Principal eigenvector	DM1	0.4269	0.1621	0.3306	0.2901	-0.4556	0.4082	0.3817		
	DM2	0.3195	0.2961	0.8787	0.3200	-0.2262	0.4082	0.4360		
	DM3	0.3402	0.0707	0.1252	0.1813	-0.1814	0.4082	0.2527		
	DM4	0.5972	0.1068	0.1585	0.1813	-0.2108	0.4082	0.4299		
	DM5	0.4153	0.7728	0.2635	0.7828	-0.4108	0.4082	0.6312		
	DM6	0.2661	0.5219	0.0916	0.3673	-0.7037	0.4082	0.1305		
Priority vector	DM1	0.18	0.08	0.18	0.14	0.21	0.17	0.17	0.12	0.19
	DM2	0.14	0.15	0.48	0.15	0.10	0.17	0.19	0.12	0.31
	DM3	0.14	0.04	0.07	0.09	0.08	0.17	0.11	0.06	0.15
	DM4	0.25	0.06	0.09	0.09	0.10	0.17	0.19	0.07	0.22
	DM5	0.18	0.40	0.14	0.37	0.19	0.17	0.28	0.16	0.38
	DM6	0.11	0.27	0.05	0.17	0.32	0.17	0.06	0.05	0.29
Remarks		corrected	corrected	corrected						

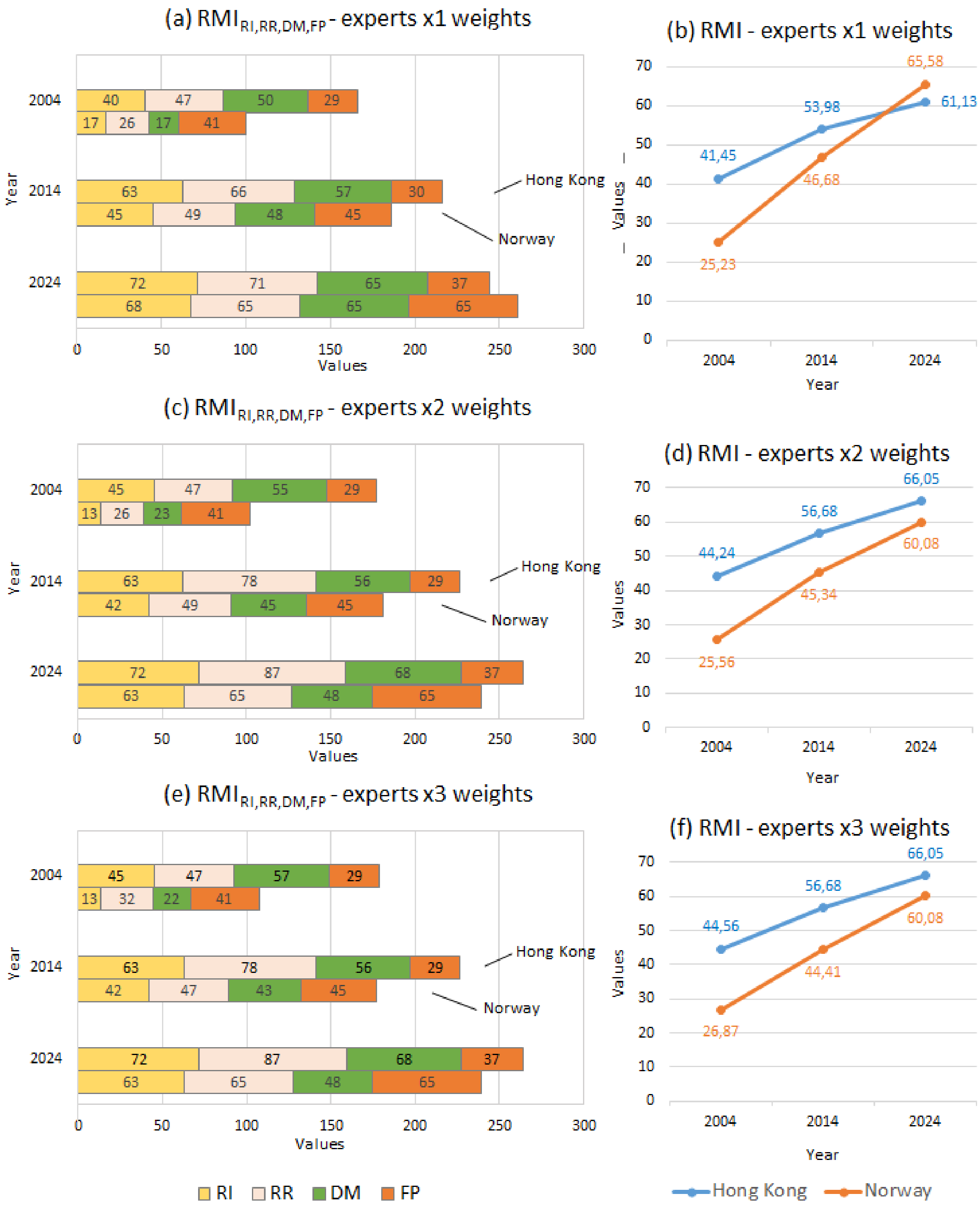
Respondent No.	Indicator	1	2	3	5	7	9	10	10th %tile	90th %tile
Eigenvalue	FP	6.3748	6.5846	6.5179	6.2200	6.3285	6.0000	6.4769		
CI		0.075	0.117	0.104	0.044	0.066	0.000	0.095		
CR		0.060	0.094	0.084	0.035	0.053	0.000	0.077		
Principal eigenvector	FP1	0.3632	0.5514	-0.1444	-0.6447	-0.0673	0.4082	0.2528		
	FP2	0.2279	0.1332	-0.1428	-0.2408	-0.0508	0.4082	0.0497		
	FP3	0.4997	0.4176	-0.2082	-0.4274	-0.1504	0.4082	0.1541		
	FP4	0.6150	0.6444	-0.1859	-0.3610	-0.2242	0.4082	0.2122		
	FP5	0.3406	0.2200	-0.1680	-0.3267	-0.6782	0.4082	0.4529		
	FP6	0.2687	0.2004	-0.9234	-0.3267	-0.6782	0.4082	0.8122		
Priority vector	FP1	0.16	0.25	0.08	0.28	0.04	0.17	0.13	0.06	0.26
	FP2	0.10	0.06	0.08	0.10	0.03	0.17	0.03	0.03	0.13
	FP3	0.22	0.19	0.12	0.18	0.08	0.17	0.08	0.08	0.20
	FP4	0.27	0.30	0.10	0.16	0.12	0.17	0.11	0.11	0.28
	FP5	0.15	0.10	0.09	0.14	0.37	0.17	0.23	0.10	0.29
	FP6	0.12	0.09	0.52	0.14	0.37	0.17	0.42	0.11	0.46
Remarks		corrected								

Appendix N Sensitivity Analysis of Experts' opinions

Landslide risk management indices for Hong Kong and Norway in 2004, 2014 and 2024: Varied <u>relative weights</u> of component indicators with respect to experts' opinions



Landslide risk management indices for Hong Kong and Norway in 2004, 2014 and 2024: Varied values of component indicators with respect to experts' opinions



**Landslide risk management indices for Hong Kong and Norway in 2004, 2014 and 2024:
Varied relative weights and values of component indicators with respect to experts' opinions**

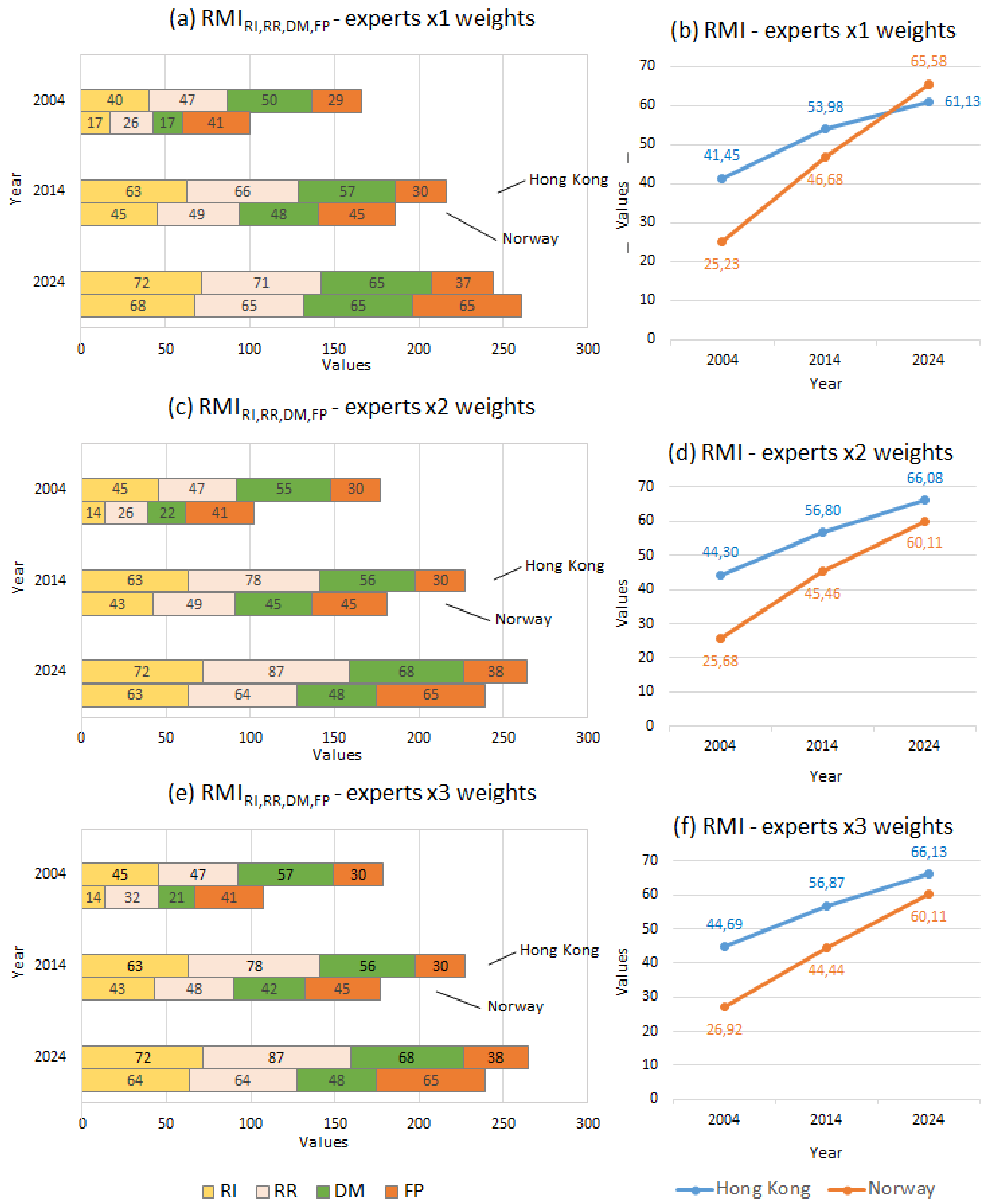


Table N.1 Percentage change of landslide risk management indices with different weights of experts' opinions in relative weights and values of component indicators (Hyphen '-' represents no change; negative values are in brackets).

(a) Hong Kong

Year		**2004**			**2014**			**2024**		
Weights of experts		Relative weights	Values	Relative weights & Values	Relative weights	Values	Relative weights & Values	Relative weights	Values	Relative weights & Values
		(in %)								
RMI_{RI}	×2	0.34	13.04	13.04	0.40	-	0.40	(-0.03)	-	(-0.03)
	×3	0.48	13.04	13.04	0.57	-	0.57	(-0.04)	-	(-0.04)
RMI_{RR}	×2	-	-	-	-	18.28	18.28	-	23.75	23.75
	×3	-	-	-	-	18.28	18.28	-	23.75	23.75
RMI_{DM}	×2	(-0.13)	12.00	11.93	(-0.13)	(-2.05)	(-2.13)	(-0.38)	3.84	3.43
	×3	(-0.19)	14.55	14.69	(-0.19)	(-2.05)	(-2.17)	(-0.56)	3.84	3.24
RMI_{FP}	×2	0.89	-	0.89	0.82	(-0.40)	0.49	1.17	1.07	2.25
	×3	1.55	-	1.55	1.42	(-0.40)	1.14	2.04	1.07	3.12
RMI	×2	0.20	6.73	6.87	0.19	5.01	5.23	0.07	8.05	8.11
	×3	0.33	7.49	7.80	0.31	5.01	5.36	0.15	8.05	8.18

(b) Norway

Year		**2004**			**2014**			**2024**		
Weights of experts		Relative weights	Values	Relative weights & Values	Relative weights	Values	Relative weights & Values	Relative weights	Values	Relative weights & Values
		(in %)								
RMI_{RI}	×2	-	(-22.56)	-	-	(-6.02)	(-5.39)	1.10	(-7.36)	(-6.77)
	×3	-	(-22.56)	-	-	(-6.02)	(-5.16)	1.51	(-7.36)	(-6.56)
RMI_{RR}	×2	1.24	-	1.24	0.34	-	0.34	(-0.27)	-	(-0.27)
	×3	1.81	22.89	23.84	0.50	(-2.75)	(-2.16)	(-0.40)	-	(-0.40)
RMI_{DM}	×2	-	30.38	29.82	(-0.20)	(-5.51)	(-5.51)	(-1.02)	(-26.25)	(-26.40)
	×3	-	26.54	24.53	(-0.36)	(-10.52)	(-11.70)	(-1.80)	(-26.25)	(-26.52)
RMI_{FP}	×2	-	-	-	-	-	-	-	-	-
	×3	-	-	-	-	-	-	-	-	-
RMI	×2	0.31	1.34	1.79	0.04	(-2.87)	(-2.63)	(-0.04)	(-8.39)	(-8.35)
	×3	0.46	6.51	6.72	0.04	(-4.86)	(-4.81)	(-0.15)	(-8.39)	(-8.35)

Appendix O Histograms of AHP weights of component indicators for Norway

Figure O.1 Histograms of AHP weights for each component indicator given by seven respondents from Norway. The interval size for the histograms is 0.063. The amount of the survey data is insufficient to show any distribution of the data.