Disaster risk management and climate change adaptation in urban contexts:

Integration and challenges

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Abstract

The purpose of the thesis is to better understand the challenges and processes of integrating climate change adaptation (CCA) into disaster riks managament (DRM), and propose ways to investigate these challenges. It focuses on the integration of CCA into DRM, with a particular emphasis on urban contexts. Taking Nicaragua as a case study, it explores the current extent of CCA integration into DRM, and identifies challenges to further progress. The initial analysis was based on an examination of integration into policies, regulatory instruments, perceptions and practice in the fields of DRM, urban planning (UP) and environment. However, as it became clear that some challenges are difficult to detect solely through an analysis of policy and practice, a theoretical model of the functioning of DRM systems and related CCA integration was developed. This was applied to the Nicaraguan and Swedish DRM systems, to evaluate and compare them, and investigate challenges in greater depth.

The results indicated that although there has been some progress in CCA integration in Nicaragua, further advances depend on up-to-date, comprehensive policies and regulatory instruments. Also, stakeholder's lack of understanding of CCA was identified as an obstacle that limits its integration into practice. The theoretical model highlighted that key processes within the Nicaraguan DRM system are fragmented: two of which are relevant here. The first concerns the difficulty of incorporating scientific and non-technical information between administrative levels in ways that are useful for decision-making. The second is that municipalities rely on local information from community members regarding risks and vulnerabilities, and lack more technically-advanced information (which may include CCA considerations) from higher-level authorities. Both of these challenges influence the integration of CCA into DRM, as it becomes difficult to analyse and communicate the potential benefits of integrated approaches and measures. These findings led to the development of assumptions regarding the usefulness of risk descriptions for decision-making, which were empirically tested.

The results showed that the presentation of the risk assessment influenced its usefulness in decision-making. Taken together, the results provide a way forward to foster CCA-DRM integration and support sustainable urban development and planning.

Key words: Climate change adaptation, disaster risk management, disaster risk reduction, mainstreaming, Nicaragua, risk governance, Sweden, urban planning

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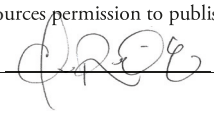
Signature  Date 2015-12-14

Disaster risk management and climate change adaptation in urban contexts:

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Abstract

An increasing number of disasters continue to affect urban populations and housing infrastructure. The overwhelming majority of them have been caused by climate-related events. This situation has made the creation of synergies between climate change adaptation (CCA) and disaster risk management (DRM) urgent. Despite the recognised need to unite CCA and DRM efforts, the fields remain separate. Furthermore, it has been difficult to reach a consensus on how to merge approaches in ways that avoid duplication of actions and reduce risk in a comprehensive way.

The integration of CCA into DRM systems, which is promoted at international, national and regional levels, relies on collaboration between multiple stakeholders with different interests and objectives. While much effort has been put into understanding the barriers to integration in other fields such as development, little attention has been paid to understanding the difficulties encountered when attempts are made to integrate CCA into DRM.

This thesis contributes to our understanding of the issue. It provides new knowledge about ways to evaluate and compare DRM systems in order to investigate challenges to integration. Taking Nicaragua as a case study, it explores the current extent of CCA integration into DRM, and identifies challenges to further progress. The initial analysis was based on an examination of integration into policies, regulatory instruments, perceptions and practice in the fields of DRM, urban planning and environment. However, as it became clear that some challenges are difficult to detect solely through an analysis of policy and practice, a theoretical model of the functioning of DRM systems and related CCA integration was developed. This was applied to the Nicaraguan and Swedish DRM systems, to evaluate and compare them, and investigate challenges in greater depth. It helped to draw conclusions about system behaviour and identify differences in how they attempt to achieve the same goal.

The initial results indicated that although there has been some progress in CCA integration in Nicaragua, further advances depend on up-to-date, comprehensive policies and regulatory instruments. Finally, stakeholder's lack of understanding of CCA was identified as an obstacle that limits its integration into practice.

Consequently, with the application of the model it was possible to identify challenges in the Nicaraguan DRM system. It highlighted that key processes within the system are fragmented: two of which are relevant here. The first concerns the difficulty of incorporating scientific and non-technical information between administrative levels

(national, regional and local) in ways that are useful for decision-making. The second is that municipalities rely on local information from community members regarding risks and vulnerabilities, and lack more technically-advanced information (which may include CCA considerations) from higher-level authorities. Both of these challenges influence the integration of CCA into DRM, as it becomes difficult to analyse and communicate the potential benefits of integrated approaches and measures. Consequently, progress (in terms of policies and regulation) has not been reflected in the implementation of measures at the local level.

These findings led to the development of assumptions regarding the usefulness of risk descriptions for decision-making, which were empirically tested. The results showed that the presentation of the risk assessment influenced its usefulness in decision-making. Taken together, the results provide a way forward to foster CCA-DRM integration and support sustainable urban development and planning.

Sammanfattning (in Swedish)

Ett ökande antal katastrofer fortsätter att drabba världen och de intensifieras av extrema väderhändelser orsakade av klimatförändringar. Denna situation har gjort behovet av att skapa synergier mellan klimatanpassning och katastrofriskhantering akut. Trots ett erkänt behov av att förena arbetet inom dessa två fält har det i praktiken varit svårt att åstadkomma. Dessutom har det varit svårt att nå konsensus om hur tillvägagångssätt ska förenas på ett sätt som undviker duplicering av riskreducerande åtgärder.

Integrering av klimatanpassning i katastrofriskhanteringssystemen är beroende av samarbete mellan många aktörer med olika intressen och mål. Denna komplexa miljö ger upphov till utmaningar som har sin grund i interaktionen mellan aktörerna. Medan mycket arbete har lagts ner på att förstå barriärerna för integrering har lite uppmärksamhet ägnats åt att förstå de utmaningar som uppstått vid försök att integrera klimatanpassning i katastrofriskhantering.

Denna avhandling bidrar med förståelse för detta problem. Den ger ny kunskap om tillvägagångssätt för att utvärdera och jämföra katastrofriskhanteringssystemen och hur utmaningar med integrering kan undersökas. Med Nicaragua som fallstudie utforskar avhandlingen den nuvarande graden av klimatanpassning i katastrofriskhantering och identifierar utmaningar för fortsatta framsteg. Den inledande analysen baserades på en undersökning av lagar, regler, mm. samt på uppfattningar från olika professionella med avseende på katastrofriskhantering, klimatanpassning och stadsplanering. Allt eftersom det stod klart att vissa utmaningar var svåra att identifiera enbart genom en analys av lagar, regler, samt de professionellas uppfattningar utvecklades en teoretisk modell. Denna användes för de nicaraguanska och svenska katastrofriskhanteringssystemen med syftet att utvärdera och jämföra dessa, samt att mer ingående undersöka utmaningar. Modellen var användbar för att dra slutsatser om hur väl arbetet med katastrofriskreducering i de två länderna fungerar, och för att identifiera skillnader i hur målen uppnås.

De inledande resultaten indikerade att även om det har skett vissa framsteg i integreringen av klimatanpassning i Nicaragua så uppdateras lagar och regler inom området inte lika ofta som inom jämförbara områden. Dessutom framgick att många professionella som arbetar inom de aktuella områdena i Nicaragua har en bristande förståelse för vad klimatanpassning innebär, vilket utgör ett hinder för att åstadkomma integrering mellan katastrofriskhantering och klimatanpassning i praktiken.

Användandet av den utvecklade modellen möjliggjorde därefter en mer detaljerad identifiering av utmaningar i det nicaraguanska katastrofriskhanteringssystemet. En fragmentering av processer inom systemet uppmärksammades, och särskilt två sådana är relevanta i detta sammanhang. Den första handlar om svårigheten att integrera vetenskaplig och icketeknisk information mellan administrativa nivåer (nationell, regional och lokal) på sätt som är användbara för beslutsfattande. Den andra handlar om att arbetet med katastrofriskhantering på den lokala nivån (kommuner) i viss mån sker isolerat från den regionala och nationella nivån. I praktiken innebär det att kommunerna i hög grad får förlita sig på lokala resurser och saknar mer tekniskt avancerat stöd för beslut som skulle kunna ges av aktörer på den nationella nivån. Båda dessa utmaningar påverkar integreringen av klimatanpassning i katastrofriskhantering eftersom de ger upphov till svårigheter att analysera och kommunicera de potentiella fördelarna med klimatanpassningsåtgärder. Det är tydligt att framsteg (i termer av policys och lagstiftning) inte speglas i implementeringen av åtgärder på den lokala nivån.

Ett viktigt antagande för analysen av utmaningarna i det nicaraguanska katastrofriskhanteringssystemet var att det sätt man presenterar och kommunicerar risk på inom systemet i hög grad påverkar möjligheten att fatta beslut rörande åtgärder för riskreduktion. Mer precist antogs att om beskrivningarna av risk innehöll scenariobeskrivningar, beskrivningar av hur troligt det bedöms vara att ett specifikt scenario inträffar, samt en beskrivning av scenariers konsekvenser, skulle beskrivningen vara mer användbar som stöd för beslutsfattande än om dessa komponenter saknades. Detta antagande testades empiriskt i en experimentstudie. Resultatet visade att det sätt som risk presenteras på påverkar beskrivningens användbarhet för beslutsfattande i enlighet med de antaganden som gjordes.

Slutligen visar avhandlingen att katastrofriskhanteringssystemet kan utvärderas och jämföras i termer av det som produceras inom systemet (t.ex. katastrofriskhanteringsplaner) och att integrering av klimatanpassning inte endast handlar om att lägga till denna del till katastrofriskhantering, utan även att förbättring av katastrofriskhanteringssystemet i sig är centralt.

Preface

Now that I am at the end of this journey, it is time to reflect on my personal motivation for conducting this research. My first degree was in architecture, and later I obtained a Master's degree in Risk Assessment and Disaster Risk Reduction from the National Autonomous University of Nicaragua (UNAN-Managua). During that time, I developed an interest in creating better synergies between risk assessment and urban planning. This was reflected in my Master's thesis, which focused on integrating the results of risk assessments into urban planning processes.

Beginning in 2005, I have been gaining experience in the field of disaster risk management and I had the opportunity to conduct fieldwork in areas devastated by Hurricane Mitch and Felix in Nicaragua. Although several years had passed since Hurricane Mitch hit the country in 1998, it was striking to see the traces of its impact in the affected areas and how it had remained in the memories of survivors. Hurricane Felix struck indigenous communities on the Atlantic Coast in 2007, and I was involved in a subsequent study with Oxfam-Spain. Both places have a high level of poverty and limited infrastructure. I had the opportunity to conduct interviews and focus groups with local actors. These experiences brought me closer to the reality of people affected by disasters, many of whom lost part or all of their family, or an entire community.

Therefore, the motivation for my research was to help to find solutions to an issue of paramount concern: increasing the effectiveness of risk management and more specifically, risks related to climate change. I hope that both Nicaragua and other similar countries may be able to use this modest contribution to increase their knowledge of how to deal with hazards and disasters.

Finally, I wanted to experience the 'research adventure', and to be involved in higher education in a very different context (Sweden). I started this journey with high expectations and a list of ideas about what I wanted to achieve during the process, but with little idea of how. The first lesson I learnt was that a PhD programme does not come with a manual. So, the first challenge was to set feasible goals, and the real challenge is not about finding the 'tracks', but finding out how to create them. This leads me to the second, but not last, lesson I learnt, which is that a manual for this academic adventure would decrease the authenticity and freedom of the research process, and the satisfaction of knowing how much you have grown-up during the journey.

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Lund, November 2015

Claudia Marina Rivera Escorcia

Appended publications

1. Integrating climate change adaptation, disaster risk reduction and urban planning: A review of Nicaraguan policies and regulations
   Claudia Rivera, Christine Wamsler. 2014.
   International Journal of Disaster Risk Reduction, 7(0), pages 78–90.
   doi:10.1016/j.ijdrr.2013.12.008

2. Integrating climate change adaptation into disaster risk reduction in urban contexts: Perceptions and practice
   Claudia Rivera. 2014.
   PLOS Currents Disasters, online :
   http://currents.plos.org/disasters/article/integrating-climate-change-adaptation-into-disaster-risk-reduction-in-urban-contexts-perceptions-and-practice/
   doi: 10.1371/currents.dis.7bfa59d37f7f59abc238462d53fbb41f

3. Evaluating the performance of disaster risk management systems: Is it possible?
   Claudia Rivera, Henrik Tehler, Christine Wamsler. 2016.
   Chapter IV in Handbook of Disaster Risk Reduction & Management.
   Madu, C.N; Chu-hua, K. World Scientific Press & Imperial College Press, London.

4. Fragmentation in disaster risk management systems: A barrier for integrated planning
   Claudia Rivera, Henrik Tehler, Christine Wamsler. 2015.
   International Journal of Disaster Risk Reduction, 14 (4), pages 445-456.
   doi: 10.1016/j.ijdrr.2015.09.009

5. Communicating risk in disaster risk management systems: Experimental evidence on the perceived usefulness of risk descriptions
   Lexin Lin, Claudia Rivera, Marcus Abrahamsson, Henrik Tehler
   Submitted to an international scientific journal.

Related publications

1. Planning for climate change in urban areas: From theory to practice
   Christine Wamsler, Ebba Brink, Claudia Rivera. 2013.
   Journal of Cleaner Production, Special Issue: Advancing sustainable urban transformation, (50), pages: 68–81.
   http://www.lunduniversity.lu.se/lup/publication/3628877
   doi:10.1016/j.jclepro.2012.12.008

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Chapter 1. Introduction

1.1 Background and rationale

Disasters significantly impede progress towards sustainable development (IPCC, 2014a). Although many countries have strengthened their disaster risk management (DRM) capacity (UNISDR, 2015), such events continue to threaten the wellbeing and safety of populations. Their impacts particularly affect developing nations, which report humanitarian emergencies on an ever-increasing scale and frequency (UNISDR, 2009a). Low-income countries are particularly vulnerable, as it is difficult to absorb and recover from disaster impacts (IPCC, 2014a; The World Bank, 2013).

Over the past decade, disasters have been exacerbated by climate change and have affected approximately 1.5 billion people (UN, 2015). In addition, 700 000 human lives have been lost (ibid). The United Nations International Strategy for Disaster Reduction (UNISDR) (2015) recently presented a disaster trends analysis which showed that 91% of disasters that occurred between 1995–2015 were weather-related (from hydrological, meteorological and climatological hazards). Moreover, urban areas are likely to suffer the most adverse impacts (The World Bank, 2008). Cities are fragile systems exposed to rapid change (such as accelerated spatial expansion and an increasing population), which increases their vulnerability to hazards and climate impacts (Pelling, 2003; Wamsler, 2014).

This alarming situation has led govermental and non-governmental organizations, and scholars to search for strategies to increase the effectiveness of DRM systems. In this context, improved integration of DRM and climate change adaptation (CCA) approaches is seen as vital (e.g. Birkmann & von Teichman, 2010; Birkmann & von Teichman, 2009; CCD, 2009; Few et al., 2006; Kelman & Gaillard, 2008; Schipper & Pelling, 2006). Furthermore, coherent DRM and CCA approaches can have a major impact – if they are supported by physical factors such as those found in land use policies and plans (UNISDR, 2013).

Urban planning (UP) may be one of the most important tools in reducing vulnerabilities and risk (UN-Habitat, 2007). It can help cities to significantly increase their resilience in coping with disaster risks and climate change (IFRC, 2010). Its importance relates to its potential to ensure planned adaptation. This consists of developing and investing in urban areas in order to reduce risks from climate-related impacts (and other hazards) and provide better protection for inhabitants, housing, infrastructure and enterprises (Bicknell, Dodman, & Satterthwaite, 2009).

Historically, CCA and DRM have developed separately and have been seen as two independent fields of activty (Kelman & Gaillard, 2010; Sperling & Szekely, 2005). However, their overlapping objectives and the need for integration has become increasingly important, notably since the IPCC-SREX report (IPCC, 2012) published by the Intergovernmental Panel of Climate Change (IPCC). The recent IPCC fifth assessment report (IPCC, 2014b) and the Sendai framework for disaster risk reduction 2015–2030 (UNISDR, 2015) have confirmed this need. The current consensus is that the integration of the two fields is an opportunity to improve the management of present and future hazards and risks (Sperling & Szekely, 2005) and ultimately to achieve sustainable development (Kelman & Gaillard, 2010).

In this thesis, the focus is on the integration of CCA into DRM and not the other way round. This is because DRM systems have become sufficiently well-established to be able to potentially provide a structure for CCA (Schipper & Pelling, 2006), and there has already been progress in terms of the adoption of CCA policies into DRM (Birkmann & von Teichman, 2009). In addition, there is comparably vast experience with DRM at local level (Wamsler, 2014).

Despite the value of integrating the two fields, in practice there have been few achievements (IPCC, 2012). Each domain has its own challenges, and there is a dynamic interplay between a multitude of actors who have different interests, and who operate in different timeframes and policy frameworks (Birkmann & von Teichman, 2010; IPCC, 2012; Schipper, 2009). In addition, there are few tools to guide the analysis of national, regional and local DRM systems in order to conceptualise their disaster reduction capacity and the extent to which CCA is effectively integrated (FAO, 2008; Uittenbroek, Janssen-Jansen, & Runhaar, 2013). Although previous research has provided important insights into the factors that hamper integration, very few studies have been designed to identify and analyse barriers to CCA (Biesbroek et al., 2013). With this in mind, this thesis argues that CCA integration not only involves the incorporation of CCA considerations into DRM systems, but also that DRM itself must be 'done better' to effectively reduce disaster risks.

1.2 Research purpose

The purpose of the thesis is to better understand the challenges and processes of integrating CCA into DRM, and propose ways to investigate these challenges. It focuses on the integration of CCA into DRM, with a particular emphasis on urban contexts.

With this in mind, the thesis underlines the potential role and importance of CCA integration into DRM systems in urban contexts. It investigates challenges to determine how they positively or negatively influence the adoption of CCA.

Specifically, it increases knowledge about CCA integration into DRM policies, regulatory instruments and practice. In addition, it establishes some theoretical foundations for the exploration of the constraints governing CCA integration into DRM systems, and proposes ways to investigate the challenges posed by the interaction of various stakeholders in DRM systems.

1.3 Geographical focus

Nicaragua is the largest country in Central America with a population of 6,080,000 (WHO, 2013). In the ranking of Low-Income Food-Deficit Countries (LIFDC) it is the second-poorest country in the Americas after Haiti (FAO, 2015). It has a history of political, economic and environmental events that have left the country in a precarious developmental position (DiAddario, 1997). Political and environmental events that took place in the past century negatively affected the country, resulting in human and economic losses. These include three decades of dictatorship (1934–1979), the Managua earthquake (1972) and the Sandinista revolution (1979).

Nicaragua was selected as the subject of an in-depth case study due to its long history of disasters and its third-place ranking (according to the Germanwatch Global Climate Risk Index) in the list of countries most affected (in terms of human and economic losses) by extreme weather events between 1992 and 2011 (Harmeling & Eckstein, 2012). Urban risk is high. In most cities there is a lack of infrastructure and poor urban planning (UP) has created informal settlements that are at increased risk. Around 46% of the urban population lives in so-called slums and only 52% have access to improved sanitation (Gencer, 2013; UN-Habitat, 2010; UN, 2012). Cities grow quickly, and every year 3,000 new houses are built in the country's capital Managua in unplanned areas with no technical supervision (IFRC, 2011). Nationally, frequent urban flooding is the consequence of, amongst other things, deforestation, soil erosion, inefficient drainage systems, inadequate waste management, settlements in riverine areas, or inappropriate economic activities (e.g. agriculture and stockbreeding) (DARA, 2011).

Both national and international stakeholders are aware of the importance of addressing disaster risk. The Nicaraguan DRM system[1] is becoming increasingly mature and over the past decade has made significant progress (Lavell, Mansilla, & Smith, 2003; Lavell, 2000; The World Bank & GFDRR, 2010). It is now well-

[1] The term 'DRM system' refers to all actors linked to DRM issues. Although in Nicaragua the national DRM system (SINAPRED) aims to include all actors (from individuals to institutions) in their work, it must be noted that SINAPRED is not the only actor in the case study. More information about the Nicaraguan DRM system is presented in Paper IV.

established, and has more than a decade of experience. This makes Nicaragua a suitable study case for exploring the integration of CCA into the current DRM system.

1.3.1 DRM in Nicaragua

Nicaragua is permanently exposed to natural hazards. It is continuously affected by hurricanes, landslides, volcanic eruptions, earthquakes, droughts, etc., which result in widespread damage and hamper the country´s social and economic progress (The World Bank, 2001). Concerns relate to the wide variety of hazards, their frequency and potential to cause harm (Executive Secretariat SINAPRED, 2005).

In 1998, Hurricane Mitch caused extensive flooding and landslides in the whole of Central America. It was the first reported event to cause damage in the five countries of the region at the same time (CEPAL, 1999). The event was a turning point as it revealed the lack of disaster response and recovery capacity, reflected in delays and failures (The World Bank, 2001). Hurricane Mitch triggered the development of DRM policies in Central America, which were incorporated into the framework of the Central American Integration System (SICA). The implementation of regional DRM policies is the responsibility of the Central American Coordinating Centre for Natural Disaster Prevention (CEPREDENAC) (Lavell, 2002).

In 2000, the government of Nicaragua established the National System for Disaster Management and Prevention (SINAPRED) with international support. The system was established under Law 337: "The creation of the National System for Disaster Management and Prevention" (Executive Secretariat SINAPRED, 2010), which defines how SINAPRED operates. The top-down structure brings together all institutions involved in the coordination and implementation of DRM activities. Its activities are defined by a National Committee led by the President of the Republic and made up of governmental authorities (Moser, et al., 2010).

Together with many other international cooperation agencies, the World Bank had an important role in the creation of a national "Culture of Prevention" (The World Bank, 2001). A project was put in place for the creation of comprehensive capacity building and vulnerability reduction at various levels of the country's administration, with a focus on the local level (The World Bank, 2009)[2]. As a result, SINAPRED brought together non-governmental organizations (NGOs), and private and

[2] Natural Disaster Vulnerability Reduction Project, Nicaragua. The World Bank. Available at:http://documents.worldbank.org/curated/en/2009/08/11091981/nicaragua-natural-disaster-vulnerability-reduction-project

governmental institutions at national, regional and local level. The system is coordinated by an Executive Secretariat, which is a technical body of the National Committee (Executive Secretariat SINAPRED, 2005).

1.3.2 CCA in Nicaragua

Climate change became an issue in Nicaragua after the government accepted the institutional framework of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 (Picado, 2003). At the same time, the government was preparing an environmental strategy and the National Assembly approved the "General Law of environment and natural resources" (Law 217). Moreover, the entity with responsibility for environmental issues was upgraded to a Ministry (the Ministry of Environment and Natural Resources; MARENA). Later in the same decade, Nicaragua approved the Kyoto Protocol (National Assembly of Nicaragua, 1999).

Aspects of CCA first appeared following the publication of a document supported by the United Nations Development Programme (UNDP), namely the Second National Communication for 2005–2009 (MARENA-PNUD, 2009). In addition, one year later the government presented an "Action Plan for the National Environmental Strategy of Climate Change 2010–2015" (MARENA, 2010), which describes CCA as a cross-cutting issue in developmental initiatives.

Like many other Latin American countries, the Nicaraguan government gave responsibility for climate change management exclusively to environmental entities (Lavell, 2011). MARENA's work on climate change is supported by UNDP, and priority is given to water management and agriculture in order to reduce rural poverty and the vulnerability of the agricultural sector (MARENA-PNUD, 2005).

1.3.3 UP in Nicaragua

Urban planning (UP)[3] practice in Nicaragua began in the 1960s in Managua (Chávez, 1987). The city is the administrative and economic centre of the country, and it is also one of the cities most affected by disasters. Records of damage and loss due to earthquakes and floods date back to 1885 (Kates et al., 1973). Another event that had a significant impact on urban development was the 1972 earthquake that hit Managua. This disaster destroyed 75% of housing units, a quarter of heavy industry,

[3] UP is part of the focus of Papers I, II and IV.

and most of the city's commercial and urban infrastructure (Chávez, 1987; Ward, et al., 1974).

Although normative UP and building construction codes were created during the recovery phase after the 1972 earthquake, it was not until 1998 that the city's Master Plan was updated to include partial plans for specific areas. Since then, little progress has been made in the creation of planning instruments (Rodgers, 2008). The consequences of the dramatic social changes that followed the earthquake included: a revolution that ended with the Somoza dictatorship and a subsequent financial crisis; the Sandinista Government (1979–1990) whose social philosophy led to the redistribution of property and land tenure legislation (Darke, 1987); and the re-privatisation of the economy post-1990 with a focus on individual and segregated urban distribution (Rodgers, 2008). Nowadays, Managua can be described as "… a chaotic, energetic place, reflecting decades of civil conflict, the return of exiled capital and business elites, economic and social development efforts, political transitions, and a fundamental change in the city's structure from a central, compact core to a sprawling, suburban-style capital" (Revels, 2014, p. 82).

Most planning instruments were designed for Managua due to its importance as the country's capital and its biggest urban area (approximately a quarter of the total population) (Gordon, 2011). However, all cities have autonomous administrations that were established under Law 40 (National Assembly of Nicaragua, 2012). Each municipality is required to develop a General Municipal Development Plan (PGDM) with technical support from the national government. Like Managua, these cities are constantly affected by natural phenomena and their lack of adequate physical infrastructure increases their vulnerability to climate-related events. For instance, cities such as Matagalpa and Estelí regularly report damage due to flooding that is the result of inadequate management and poor control of urban expansion (Flores, 2014).

1.4 Thesis outline

The Kappa[4] provides a synthesis of the research outcomes and outlines how the study developed in terms of theoretical and methodological considerations. This thesis is composed of six chapters:

Chapter 1: Presents the problem definition, the geographical focus and a description of the evolution of DRM, CCA and UP in Nicaragua.

[4] The term 'Kappa' refers to the synthesis of the dissertation project, which resulted from the studies developed in the appended Papers. 'Thesis' is used to refer to the overall research, including the research articles.

Chapter 2: Describes the theoretical and conceptual background for the research.

Chapter 3: Describes the overall design of the research. It presents the methods used, including how they were selected and applied.

Chapter 4: Contains a description of the results of the appended Papers.

Chapter 5: Presents a discussion of the results and provides some reflections on the quality of the research and future work.

Chapter 6: Summarises the conclusions of the thesis.

1.5 Related work

This section provides a brief outline of previous studies relevant to the research conducted in this thesis. It focuses on the integration of CCA at policy level, planning frameworks that provide practical guidance to stakeholders, and earlier investigations of constraints on CCA integration.

1.5.1 Integrating CCA into policy and practice

There is a large body of literature (academic journals and grey literature) that discusses different aspects of CCA integration. Although they provide important antecedents, their approaches and focuses are quite different from the purposes of this thesis. Also, most explore CCA integration in other sectors, mainly development planning. In the policy arena, the debate is mainly focused on finding more opportunities to integrate CCA into development planning in general (e.g. Biesbroek et al., 2010; Brooks et al., 2011; European Commission, 2009; Klein, Schipper, & Dessai, 2005; Schipper, 2007; Swart & Raes, 2007). Other sectors (such as urban and rural studies) are also becoming interested in integrating CCA considerations into, for instance, poverty reduction policies and strategies (e.g. Matus-Kramer, 2007; Saito, 2013), water management and agriculture (e.g. GIZ, 2012; Urwin & Jordan, 2008). In general, these studies analyse: specific policy domains and the extent to which they include aspects of CCA (e.g. Biesbroek et al., 2010; Matus-Kramer, 2007; Mirza, 2003)[5]; how policies are (or can be) refocused to facilitate integration (e.g. Burton, Diringer, & Smith, 2006; European Commission, 2009); how CCA can be added to

[5] For instance Biesbroek et al. (2010) defined six themes to explore national adaptation strategies: factors that motivate CCA integration; scientific and technical support; communication and awareness; governance; integration and coordination with other policy domains; and implementation and evaluation.

practices (e.g. Scott & Becken, 2010); and case studies where progress in CCA integration into policies is compared and recommendations for further improvements are given (e.g. Biesbroek et al., 2010; Burton et al., 2007; Mirza, 2003; Puppim de Oliveira, 2009; Ranger & Garbett-Shiels, 2012; Scott & Becken, 2010; Tschakert & Dietrich, 2010; van den Berg & Coenen, 2012). One consequence of this interest and pressing need to integrate CCA into planning and practice are debates about the integration process (e.g. Burton et al., 2007; Burton, Malone, & Huq, 2004; Klein, Schipper, & Dessai, 2005; Matus-Kramer, 2007; Ruhl, 2010; Swart & Raes, 2007). Related contributions attempt to guide the process and propose building blocks, steps or action checklists (e.g. AusAID, 2010; Ranger & Garbett-Shiels, 2012).

In addition, there is a growing literature focused on the integration of CCA and DRM (e.g. Becker, Abrahamsson, & Hagelsteen, 2013; Birkmann & von Teichman, 2010; CCD, 2009; Faling, Tempelhoff, & van Niekerk, 2012; Few et al., 2006; Fujikura & Kawanishi, 2010; Kelman & Gaillard, 2010; Khan & Kelman, 2012; Lavell, 2011; Mercer, 2010; O'Brien, et al., 2006; Schipper, 2009). In this context, the IPCC-REX (2012) and the "Implementation of the HFA" report (UNISDR, 2013) outlined the importance of synergies between the two fields and proposed recommendations for increased collaboration. Proposals regarding how to add CCA into practice are found in much of the literature and can be summarized as follows: (a) understanding the political, institutional and governmental contexts for CCA integration; (b) understanding the international and national regulatory and political frameworks related to CCA; (c) the importance of the evaluation of capacity to integrate CCA; (d) the importance of building partnerships between government and non-governmental actors; and (e) the need to monitor and assess progress in CCA integration.

Both the IPCC (2012, 2014a) and the UNISDR (2013) reports recognised the contribution of UP to the integration of CCA and DRM. In the same vein, other authors have investigated potential collaboration between UP, CCA and DRM (e.g. Shah & Ranghieri, 2012; Solecki, Leichenko, & O'Brien, 2011; Uittenbroek, Janssen-Jansen, & Runhaar, 2013; Wamsler, 2014). In general, these studies have investigated the importance and ways to increase synergies between CCA and DRM, but there does not appear to have been any attempt to explore either CCA or DRM as potential structure to facilitate integration.

1.5.2 Obstacles to the integration of CCA

Obstacles have been a central issue in the discussion of how to achieve the efficient incorporation of CCA, leading to several studies that attempted to identify them (see Adger & Barnett, 2009; Biesbroek et al., 2013; Mitchell, Tanner, & Wilkinson, 2006)[6]. In their exploration of barriers, Biesbroek et al. (2013) conducted a literature review of 81 studies. They concluded that although they were able to identify several barriers, the literature focused on individual actors and governance processes aimed at developing and implementing adaptation. Other notable works include how to understand barriers to CCA integration and ways to overcome them (i.e. Birkmann & von Teichman, 2009; Burton et al., 2007; Heinrichs et al., 2011; Puppim de Oliveira, 2009; Ruhl, 2010; Uittenbroek, Janssen-Jansen, & Runhaar, 2013). Finally, a framework for detecting barriers in understanding, planning and management phases was proposed by Moser, Ekstrom & Kasperson (2010)[7]. However, the literature reveals several knowledge gaps. There has been very little investigation of how to detect challenges, and most studies focus on the importance of where and how to add CCA. Furthermore, the focus has been on environmental law (Ruhl, 2010) or governance processes and development planning (e.g. decision-making in Burton et al. (2007). In contrast, this thesis offers a more holistic analysis.

[6] Previous studies have used the term "barrier" to refer to obstacles or constraints on integration (see Biesbroek et al. 2013). Barriers can delay the implementation of adaptation measures or exclude the issue from the policy process (Uittenbroek et al., 2013). Hence, barriers can influence the extent to which climate adaptation is mainstreamed (ibid). In this thesis, the term 'challenge' is synonymous with barrier, obstacle or constraint.

[7] Previous studies of barriers to CCA integration proposed ways to explore and overcome obstacles. However, the literature review revealed that only Moser, Ekstrom & Kasperson (2010) presented a framework to detect them.

Chapter 2. Conceptual framework

A combination of theories and concepts from different fields provided the basis for the research presented here. This chapter starts with a description of the central concepts of DRM, CCA and UP. This is followed by a description of aspects of risk governance that were used in this thesis.

2.1 DRM and CCA

DRM is commonly described as a process that aims at reducing the risk and the negative consequences of so-called disasters (Morgan, 2013; UNISDR, 2009b; Wamsler, 2007)[8]. In the Latin American context, a predominant definition comes from Lavell (2002, p. 5), who defines it as "[…] a relatively complex social process aimed at the reduction of existing disaster risk levels and the prevision and control of future risk in society. This process signifies the implementation of concatenated series of activities that finally lead to the implementation of risk reduction or control strategies, instruments or actions". It includes a broad set of actions such as risk assessment, disaster prevention, mitigation, response and recovery preparedness (including risk financing), and post-disaster response and recovery (Christoplos, Mitchell, & Liljelund, 2001; Wamsler, 2007). Although all of these actions are important, the thesis is focused on the pre-disaster stage. DRM is a dynamic process that it is shaped by the social context. Therefore it is not static and how it unfolds depends on how operational actors understand its theoretical foundations, manifested in operational priorities and programmes (Christoplos, Mitchell & Liljelund, 2001).

DRM includes the intention to deal with future risks, and thus the expected impacts of climate change (Lavell, 2011). Climate change has been defined by the IPCC (2007, p. 30) as "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer". Concerns about climate change are mainly linked to its potential to increase the frequency, intensity and variability of climatic extremes that, in turn, can increase risk. Hazardous events (such as hurricanes, floods, droughts and heavy precipitation) are expected to greatly increase with relatively small increases in average temperature (UNFCCC, 2007).

[8] It should be noted that in this thesis no distinction is made between DRM and disaster risk reduction (DRR). In Papers I and II the term DRR was employed.

Climate change mitigation addresses the causes of climate change, while CCA focuses on reducing its impacts (IPCC, 2012). Although climate change mitigation plays a role in risk reduction, this thesis focuses on adaptation. CCA is defined by the IPCC (2007, 2012) as "the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities". CCA is generally classified into categories such as spontaneous or planned, public or private, and anticipatory or reactive (IPCC, 2001; Smit & Pilifosova, 2003). This thesis examines planned[9] adaptation with a focus on formal DRM and CCA practices in the pre-disaster phase.

Both DRM and CCA have the ultimate goal to increase disaster resilience through incremental and more radical, transformative, changes (IPCC, 2012). Resilience is "The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" (UNISDR, 2009b, p. 24). Although the concepts of resilience and transformation are not explicitly used here, the integration of CCA and DRM is seen as part of efforts to build resilient cities and transform societies.

While CCA and DRM have different starting points, history and conceptual frameworks, they are closely linked, which has increased interest in including them in the sustainable development agenda (Schipper, 2007). They share the aim of reducing the occurrence and impact of climate-related disasters and associated risks; and consequently, the implementation of similar (or the same) measures and strategies at the local level (Wamsler, 2014). In addition, both DRM and CCA have become cross-cutting issues that are a core element for sustainable development and resilience, but must be integrated into the work of different sectors (O'Brien et al., 2006; Wamsler, 2014). Here, sustainable development is defined as "a practical focus on integrating social, economic, and environmental considerations in urban development that considers the impact of today's developments on future generations" (UN-Habitat, 2011).

Used here, the term integration is a synonym for mainstreaming. There is no agreed definition of mainstreaming (Uittenbroek, Janssen-Jansen, & Runhaar, 2013), and only a few studies have examined it (e.g. Wamsler, 2015; Wamsler, Luederitz, & Brink, 2014). In the context of CCA, UNDP-UNEP (2011, p. 3) has defined mainstreaming as "an iterative process of integrating CCA considerations into policy-making, budgeting, implementation and monitoring at national, sector and subnational levels". Mainstreaming CCA into DRM implies that actors at national,

[9] According to (IPCC, 2007), planned adaptation involves activities such as developing infrastructure, and building capacity to adapt in the broader user community and institutions.

regional and local level adopt and improve measures that address disasters and climate risks in plans, policies, strategies, sectors and organizations (Few et al., 2006; IPCC, 2012). More generally, mainstreaming has also been defined as the modification of a specific type of sector work (such as DRM or UP) in order to take into account a new aspect (such as CCA) and to act (indirectly) upon it (Wamsler, 2014). It thus does not mean a complete change in sector-specific aims, core functions or responsibilities, but instead involves viewing them from a different perspective and making any necessary modifications. The focus is on what already exists, and building on structures, mechanisms and procedures (ibid).

Mainstreaming is also focused on opportunities to incorporate CCA at the local level – not only in strategic planning, but more importantly in the implementation of concrete measures at different levels (IPCC, 2012; Uittenbroek, 2014). Measures are defined by the Oxford Dictionary of English (2010) as "plans or courses of actions taken to achieve a particular purpose". Here, measures are actions undertaken at national, regional and local level to reduce disaster and climate risk. They can be classified as 'no regrets' or 'low regrets' if they offer benefits regardless of climate change, and 'climate justified' or 'high regret'[10], if their benefits are justified by climate change projections (OECD, 2009). On-the-ground measures are actions carried out at the local level that have the potential to reduce risks, including the current and future impacts of climate change.

2.2 UP and its links with DRM and CCA

UP is here defined as "the discipline and practical ways of shaping and modifying urban settlements and space" (Almandoz, 2006, p. 83). Comprehensive urban plans form the basis for land use policies, and guide future changes to the living environment in detailed planning (Wang & Hofe, 2007). The role of urban planning in sustainable development is for instance due to the importance of environmental issues in cities, where the populations of the future will live (Bulkeley & Betsill, 2003). Consideration of the long-term impacts of climate change and disasters in UP and development is thus crucial for sustainability (Bulkeley & Betsill, 2003; Shah & Ranghieri, 2012).

The importance of UP for increased CCA and DRM collaboration is based on the approaches and opportunities that the field provides for their effective implementation. Urban planners use collective decision-making processes. Local

[10] The classification of measures varies according to authors and organizations: examples include no-regret, low regret, win-win options, high regret and climate-justified (see OECD, 2009; The Wold Bank, 2010).

stakeholders (e.g. authorities, residents) participate in the development of the built environment (and related comprehensive and detailed planning) which increases their commitment to action (Wang & Hofe, 2007). This suggests that UP could contribute to CCA and DRR integration by providing relevant structures and mechanisms, and ensuring that local knowledge of environmental problems is translated into plans, thus fostering the inclusion of risk-reducing measures and strategies (Bulkeley & Betsill, 2003).

2.3 Risk and risk governance

There are several definitions of risk, and its interpretation remains ambiguous (van Asselt & Renn, 2011). The definition of risk that is best-suited to the research conducted in this thesis was proposed by Aven & Renn (2009, p. 2), who say that "risk refers to uncertainty about and severity of the consequences (or outcomes) of an activity with respect to something that humans value". Using this definition, any activity (and all hazards, including climate-related ones) may produce events and consequences with unknown characteristics that are potential threats to what is considered valuable.

Risk governance describes how the various actors (individuals, and public and private institutions) deal with risks surrounded by uncertainty, complexity, and/or ambiguity (van Asselt & Renn, 2011). It goes beyond risk assessment and analysis, and addresses how actors handle risk in societal structures that are usually very complex and often fragmented (IRGC, 2005).

Risk governance is relevant here as other frameworks (e.g. the ISO 31000 standard for risk management) focus on single actors, while risk governance is focused on collective decisions that are taken and implemented in complex, multi-actor networks and processes (van Asselt & Renn, 2011). The approach provides a point of departure for the study of processes in DRM systems, given the challenges related to collective risk management and sharing mechanisms that involve multiple actors. Its strength is that it focuses on interactions between actors in decision-making processes at various administrative levels in various functional segments (horizontal governance), and the links between these levels (vertical governance) (Lyall & Tait, 2004).

Risk governance also investigates deficits in risk management. To this end, scholars and organizations have developed several conceptual frameworks. One example is the International Risk Governance Council's (IRGC) framework, which defines deficits as "deficiencies (where elements are lacking) or failures (where actions are not taken or prove unsuccessful) in risk governance structures and processes" (IRGC, 2009, p. 5; 2010). The framework focuses on issues related to both risk assessment and management (Aven, 2011; Florin, 2012).

As this Section and Section 1.5.2 show, there are several terms that define barriers to CCA integration, and deficits (deficiencies) in governance processes. Here, they are subsumed into the term 'challenge', which can be defined as 'doing something that one thinks will be difficult'[11]. Challenges in DRM systems can be understood as a set of tasks, made more difficult by barriers or deficits that may impede the achievement of goals, reduce efficiency and slow the adoption of new issues (such as CCA).

Communication challenges are another issue addressed here. Communication is important in risk governance because it enables stakeholders and civil society to understand risks and recognise their role in governance processes. It educates stakeholders about risk assessment decisions so that they can make informed choices (IRGC, 2008).

Finally, here the term 'fragmentation' is used to indicate situations where the collaboration or sharing of information between actors in DRM systems fails. Fragmentation is defined as "situations where the output[12] from one part in the risk governance process cannot be used, or is difficult to use, as input to another part" (Cedergren & Tehler, 2014, p. 90).

[11] Adapted from the Oxford Dictionary of English (2010).

[12] Here, outputs are what the system produces, such as a DRM plan, a risk assessment report, a risk assessment handbook, etc.

Chapter 3. Research design and methodology

3.1 Research questions

This section describes the research questions (RQs) and how they were formulated. As Section 1.2 showed, this thesis investigates CCA integration into DRM systems and the associated challenges. The overall research question was formulated as follows:

> *How is CCA integrated into the DRM system in Nicaragua and what challenges have been encountered during the integration process in urban contexts?*

The question was broken down into five sub-questions that more precisely describe how the research presented here was focused:

> *RQ 1: How is CCA integrated into current policies and regulatory frameworks that promote urban risk reduction planning in Nicaragua?*
>
> *RQ 2: How do disaster risk reduction practitioners in Nicaragua perceive the ongoing integration of CCA into their urban development work?*

At the beginning of the research, RQs 1 and 2 explored the extent to which CCA is integrated into policies, regulatory frameworks, perceptions and the practice of DRM in urban contexts. The answers to both of these questions were descriptive. RQs 1 and 2 were important to identify challenges to CCA integration in specific parts of the DRM system. However, it was clear that the identification of challenges needed a more holistic perspective and a more broad-ranging analysis of the DRM system. In addition, both RQs were developed at the national level, which motivated an exploration of CCA integration at regional and local levels.

The results of RQs 1 and 2 highlighted that not all relevant answers (more precisely, information on challenges) had been obtained from the initial interviews and policies. With this in mind, and given that it was not possible to identify an approach to detect challenges related to CCA integration into DRM systems, the following RQ emerged:

> *How can the integration of CCA into DRM systems and associated challenges be investigated?*

This question suggested the development of approaches to investigate challenges to CCA integration. However, this type of question is problematic as it can broaden,

rather than refine the frame of the research. This is because 'how can' questions are open to multiple answers that explain how 'something' can be done and consequently fail to provide concrete answers. To manage the problem, three criteria were applied, which reduced the number of potential solutions to the problem and made the development process more transparent. These were:

a) Focus on the purpose of the DRM system and relate the identified challenges to it.

b) Identify challenges by studying the dynamics of the DRM system.

c) Consider the influence of multiple stakeholders and their interactions.

These criteria not only helped to frame the answers to the question, but they also served to define which challenges to investigate. Although the definition of a challenge is presented in Section 2.3, its investigation depends on what constitutes a 'challenge'. In this thesis, the investigation of challenges is based on factors that impede DRM systems from achieving their purpose and potentially hamper the adoption of aspects of CCA.

Criterion (a) emphasizes the importance of the purpose of DRM systems as a point of departure for evaluating them (e.g. to reduce disasters)[13]. Unless attention is restricted to those challenges that are related to the system's purpose(s) the number of potential 'challenges' is vast. Even with this restriction, the number is considerable. Nevertheless, the criterion is justified considering the overall purpose of the thesis[14].

The second criterion concerns the behaviour of a DRM system. It emphasises that the attention cannot be limited to structures, resources, rules, guidelines etc., but it also needs to consider the behaviour of actors involved in DRM, i.e. what they do. This criterion is justified given the criterion (a) above and directly links to it. It is necessary to investigate what is going on in DRM systems. For example, in order to lessen both the impact and likelihood of various disastrous events, action is needed and this must be the focus when investigating challenges.

The final criterion emphasizes the importance of extending the investigation to the multitude of different actors involved, rather than limiting attention to one or a few.

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[13] In this thesis, the main purpose of DRM systems is "to lessen the impact, as well as the likelihood, of various events that may damage something that is considered valuable. DRM can be applied at different levels, for example, in a city, a region, or a nation" (see Papers III and IV).

[14] The purpose of the thesis is to better understand challenges encountered in the integration of CCA into DRM systems. The investigation is focused on the challenges that negatively influence the ability of the system to manage risks, and therefore to adopt CCA (see Section 1.2).

In addition to these guiding criteria, the investigation was framed by a theoretical framework (Rojon & Saunders, 2012) (see Chapter 2).

The overall question of identifying a way to investigate challenges to CCA integration into DRM led to RQs 3 and 4. The first focused on the evaluation and comparison of DRM systems:

> *RQ 3: How can disaster risk management systems (and related integration processes) be evaluated and compared?*

This question is important in the study of the challenges related to the purpose of a DRM system as the assessment must include an evaluation of whether a specific factor (e.g. a lack of communication) influences the ability of the system to achieve its purpose. Comparison is an implicit part of the investigation because it makes it possible to establish: (1) the behaviour of the system given the influence of detected challenges, and (2) to predict the behaviour of the system once these challenges are overcome. RQ 3 is focused on the DRM system as it was necessary to first understand the challenges inherent in the system itself, before later investigating their influence on CCA integration.

RQ3 led to the development of a theoretical model that provided a basis for the investigation of challenges to CCA integration. Some of these challenges are hard to detect when studying an individual actor, for example a governmental authority. Instead the investigation must focus on the interactions among multiple actors. In this thesis, these are called 'systemic challenges'. Therefore, RQ 4 was formulated as follows:

> *RQ 4: How can systemic challenges be studied and how do they influence integrated CCA and DRM planning on the ground?*

The theoretical model that was developed to answer RQs 3 and 4 can be used to evaluate and compare DRM systems, and it facilitates the identification of systemic challenges. The model is built on the assumption that the output from a DRM system can be observed and linked to achieving the system's purpose(s). One important output relates to how risk is communicated (risk descriptions) within a DRM system. It was postulated that the way risk descriptions are presented will influence their usefulness as a basis for decision-making concerning risk-reducing measures. The hypothesis needed to be tested. Therefore, RQ 5 was formulated as follows:

> *RQ 5: Do differences in the way risk descriptions are presented influence their perceived usefulness for decision-making?*

The experiment that was developed to answer RQ5 tested the extent to which stakeholders perceived that descriptions were useful for decision-making.

3.2 The research process

The RQs described in Section 3.1 were developed in a process that unfolded over a period of five years. Therefore, this section does not describe an initial plan that was executed, but illustrates the steps that made up the "illumination process" (Rojon & Saunders, 2012). Figure 1 shows the three stages corresponding to the various steps of the research. In Stage I, the context was established. The focus in this Stage was the investigation of the current extent of CCA integration and related challenges in DRM systems in Nicaragua. In Stage II, a theoretical model was developed and applied to detect challenges in DRM systems that influence CCA integration. Finally, Stage III consisted of an empirical study focusing on one of the key assumptions from the previous Stages.

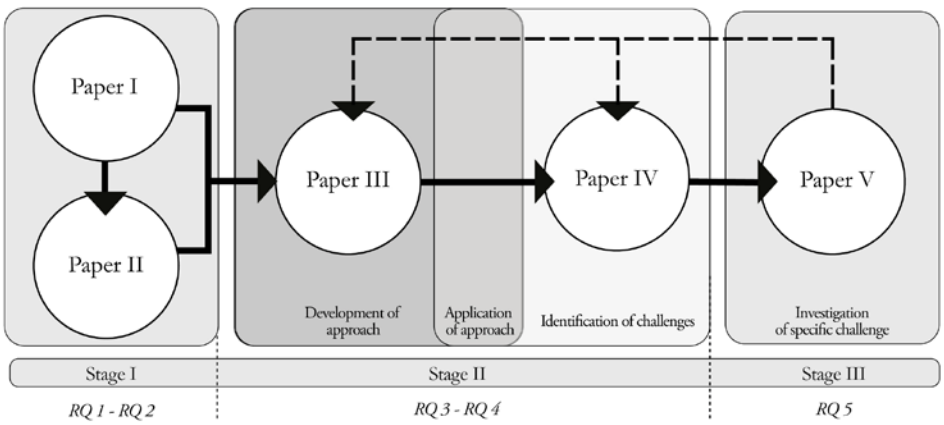

Figure 1. Phases of the research process. Arrows show the relationships between the Papers. Straight lines indicate that the results of one Paper led to the design of the other. Dashed lines indicate that Paper V validated the assumptions developed in the previous Papers.

Stage I:

Papers I and II were developed in this Stage. The two Papers are closely linked as Paper II is the continuation of the study conducted in Paper I. Paper I explored the extent to which CCA is integrated into policies and regulatory frameworks in Nicaragua, while Paper II investigated stakeholder's perceptions of this integration into their practice in urban areas. The results indicated that there had been some important progress at policy level, but also illustrated some challenges.

Stage I also highlighted that the information obtained from interviews and policies was not enough to determine how DRM systems and related CCA integration work. The results motivated the proposal of a method to investigate challenges in DRM systems and how they influence CCA integration. Until this point, the investigation had focused on the so-called blunt end[15] of DRM systems. In order to better understand the challenges it was necessary to extend it to the so-called sharp end.

Stage II:

Figure 1 shows that Papers I and II led to the development of Paper III in Stage II. This Paper[16] presents a theoretical model to evaluate and compare DRM systems (see Section 3.1). The theoretical model presented in Paper III was developed and applied in Paper IV in order to find challenges to CCA integration in the Nicaraguan DRM system.

Stage III:

The results obtained from Stage II formed the basis for Paper V in Stage III. Papers III and IV led to the development of assumptions about the functioning of DRM systems. Specifically, it was assumed that certain types of risk descriptions[17] would be more useful than others for decision-making, and that they would be more effective in meeting the objectives of the DRM system. Paper V reports the results of testing this assumption and illustrates how an output from a DRM system can be empirically analysed and linked to the overall purpose of the system.

[15] 'Blunt' and 'sharp' end are concepts developed by Dekker (2014). 'Sharp end' refers to people who are in direct contact with safety-critical processes. Stakeholders who actually implement measures to reduce risk fall into this category. 'Blunt end' refers to organizations that support and drive sharp end activities. For example, organizations issuing rules and regulations for DRM work.

[16] Although this Paper is not a journal article but a book chapter, it is listed as Paper III in the Kappa.

[17] Risk descriptions refer to how risk information is expressed. They communicate the likelihood of hazards that might trigger risk scenarios and their possible consequences. This information is commonly found in risk assessments, while in the Nicaraguan system it is found in DRM plans for risk and emergency management at the various levels of administration (national, regional and local) (see Papers IV and V).

3.3 Philosophical assumptions and methodology

3.3.1 Philosophical positioning

Explaining the methodology and methods employed in the research process and justifying their selection is crucial (Crotty, 1998). One way to do this is to make explicit the underlying philosophical assumptions and paradigms, which are based upon ontological and epistemological assumptions (Creswell, 2007).

Ideally, the philosophical position would have been established at the beginning of the process; instead decisions were taken based on logic and instinct as the research unfolded. This does not mean that it was irrelevant; on the contrary it was an inherent part of the process (Scotland, 2012) and is reflected in the appended Papers. The philosophical positioning that best describes the ontological (i.e. related to what constitutes reality (Scotland, 2012), and epistemological assumptions (i.e. concerning the nature of systemic inquiry (Mertens, 2012) used in the work presented here is that of critical realism.

In this thesis, reality is perceived to be independent of human beings, and structures in the world can be represented by scientific theories (Alvesson & Sköldberg, 2009). In the context of critical realism, Bhaskar (2013) proposes that reality consists of three domains: real, actual and empirical. The first concerns generative mechanisms, or the way that things act (ibid). Generative mechanisms create events in the domain of the actual that are independent of the observer (Adamides, Papachristos, & Pomonis, 2012). The empirical domain includes what can be observed, i.e. things that happened and exist according to the observer's experience (Alvesson & Sköldberg, 2009).

A simple definition of epistemology says that it is a "way of understanding and explaining how we know what we know" (Crotty, 1998, p. 3). Critical realism is a relatively new approach that describes epistemological assumptions used in the research process. It argues that the world exists independently of our knowledge of it, that it can only be understood using particular descriptions (theory-laden), and that our knowledge is fallible (Easton, 2010; Sayer, 2000). These features place critical realism in a position that lies between the law-finding intention found in the natural sciences and the interpretivist approach of social science (ibid).

Critical realism has been seen as a form of positivism, because both draw upon ontological realism (Maxwell, 2012). The difference is that critical realism uses a wide range of research methods that depend on the nature of the object of the study and the knowledge that is sought (Sayer, 2000). Easton (2010) investigated the advantages of critical realism when used in case study research. Among the characteristics he discusses, two support the use of critical realism in this thesis: (a) it distinguishes

between the real world, actual events created in the real world, and empirical events that can be captured and reported; and (b) it provides building blocks for critical explanations of the real world.

In this thesis, the 'real' domain is the DRM system in question and the environment where it operates. It is independent of the observer. The 'actual' domain is also independent of the observer and corresponds to the events produced by the DRM system. Finally, the 'empirical' domain concerns the researchers who observe the events produced by the DRM system[18] and report them, based on their experience and knowledge. The second characteristic of critical realism implies accepting that knowledge is fallible. It recognises that reality is, to some extent, concept-dependent (but not totally social constructed). Therefore, reality dominates over our interpretations of it, when studying a situation. In line with this perspective, the research carried out in this thesis was driven by a theoretical framework, but it was also necessary to maintain a critical attitude that distinguished between the researcher's frame of reference and the 'real' world (see Section 5.3).

3.3.2 Overall research design

The case study approach (Yin, 2003) is adopted as a general research strategy[19] that is used to gain knowledge of a phenomenon (challenges to CCA integration) by employing a wide variety of quantitative and qualitative methods. It is an approach in which one or multiple bounded systems are explored using multiple sources of information such as interviews, documents and reports (Creswell, 2007). Case studies contribute to our knowledge of individuals and groups, and social, political and related phenomena including organizational and managerial processes (Yin, 2009). The approach is used to study new or emerging process or behaviours, and to understand everyday practices and their meaning for those involved (Hartley, 2004).

The case study requires a comprehensive strategy in which the methods follow a logic of design, data collection techniques and data analysis approaches (Yin, 2003). Methods can be qualitative and quantitative. There is a widespread misunderstanding that the case study is purely a qualitative approach, but in fact this depends on the circumstances and the research problem that is addressed (Simons, 2009).

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[18] Researchers can observe certain events produced by the DRM system (such as procedures and actions). However, it is not possible to observe all of them.

[19] Initially the case study did not guide the process. However, as the research developed it became clear that it was best-suited to the general approach. For this reason, it was not applied in its strict sense, but as a general strategy.

The selection of the research method(s) depends on the research question(s). The formulation of 'how' and 'why' questions is likely to favour the use of case studies, experiments or narrative accounts (Yin, 2009). As Section 3.1 showed, here the RQs attempt to answer 'how' questions, in either a descriptive or normative sense.

The thesis is an example of an embedded study case, where one case (the Nicaragua DRM system) contains multiple units of analysis, i.e., stakeholders from governmental and non-governmental organizations who hold different positions (e.g. operational officers). The case study collects units (or set of units) of information related to the data to be collected or analysed, through a specific form of inquiry such as a survey or experiments (Hammersley & Gomm, 2009). A single-case study requires more information to be collected, as one case is investigated in considerable depth (Hammersley & Gomm, 2009). Yin (2003) distinguishes between holistic and embedded designs in case studies. The difference is related to the number of cases and number of units of analysis (Listou, 2015).

3.3.3 Research methods

Although there is no agreed-upon design for case studies, in general researchers identify problems, pose questions, gather data and analyse them (Creswell, 2007). This research is no exception. Data collection methods included literature review, semi-structured interviews and experiments. Data analysis methods included content analysis, document analysis and a retrospective analysis (Table 1).

Table 1. Research methods and empirical data

PAPER	RESEARCH METHODS AND SAMPLING	EMPIRICAL DATA	GREOGRAPHICAL AREA AND LEVEL
Paper I	Content analysis Snowball sampling	36 documents (13 policies, 12 pieces of legislation, 11 relevant documents)	National Nicaragua
Paper II	Semi-structured interviews Purpuseful sampling Snowball sampling	9 respondents (three operational officers, three academics, three programme managers)	National Nicaragua
Paper III	Document analysis	21 Risk and Vulnerability Assessment reports (Sweden, 2008). 21 Risk and Vulnerability Assessment reports (Sweden, 2010). 16 Disaster Risk Management plans (Nicaragua, 2003–2004)	Regional Nicaragua and Sweden
Paper IV	Semi-structured interviews Document analysis Retrospective analysis Snowball sampling	21 respondents (14 national, 7 local) 54 documents (2 national plans, 16 regional plans, 36 local plans)	National, regional, and local. Nicaragua
Paper V	Experiment Statistical hypothesis testing Purposeful sampling	Experiment 1: 28 participants Experiment 2: 114 participants	Nicaragua and Sweden

3.3.3.1 Purposive and snowball sampling

Purposive sampling involves the selection of individuals, literature and empirical documents that inform the understanding of the research problem and the main phenomena (Creswell, 2007). It is based on a targeted selection of respondents, literature or documents from a segment that is known to have information on the characteristics of interest (Guarte & Barrios, 2006). It provides a systematic way to

identify appropriate actors and documents and makes it possible to map organizations and stakeholders working in relevant fields. The method was applied in all Papers, including the selection of the participants in the experiments described in Paper V (See Table 1).

Snowball sampling can be used to locate potential interviewees identified by respondents in a specific population (Babbie, 2010). Here, it also helped to identify documents that provided information about CCA integration. For instance, references were reviewed and citations that seemed to be relevant were collected in a systematic way. The method also helped to identify important stakeholders (by the interviewees) that had not been identified at the beginning of the selection process.

When applied to interviews it also helped to identify the end point for the interview process. The process ended when respondents suggested potential participants that had already been mentioned by other respondents and when a theoretical saturation point was detected, which happens when there are no major new insights (Cassell & Symon, 2004).

3.3.3.2 Semi-structured interviews

The semi-structured interview is a data collection method used to obtain information from people in the form of a conversation. Questions follow the flow of respondent's answers rather than being imposed by a predetermined list of questions (Sapsford & Jupp, 2006). Although semi-structured interviews use open questions to guide the conversation, there is a degree of control, which makes them 'semi' but 'less' structured than, for instance, highly-structured questionnaires (ibid).

This method was used in Papers II and IV as its flexibility helps to avoid procedural reactivity. Procedural reactivity is a risk in highly-structured interviews, which can influence respondent's responses due to the artificial nature of the situation that can distort or bias their answers. Semi-structured interviews address this problem because respondents are able to provide information about everyday situations, opinions and their beliefs based on natural situations (Sapsford & Jupp, 2006).

All semi-structured interviews were conducted in person, which helped to manage complex questions (Hedrick, Bickman, & Rog, 1993) and get a better understanding of respondent's answers. In addition, visiting respondents in their offices proved to be a good strategy as useful documents could be collected at the same time. The flexibility of semi-structured interviews also helped to identify new aspects of interest and explore the information that respondents provided. All interviews were recorded and transcribed.

Interviews were designed around the research questions. Variables were identified and questions were developed based on these variables. For instance, five aspects (variables) were studied in Paper II: (1) understanding of CCA; (2) links between

CCA and DRM; (3) links between CCA and UP; (4) potential urban adaption measures for climate change; and (5) obstacles, gaps and opportunities to CCA integration. A set of questions was designed to address each aspect and were used to guide the interviews (Appendix 1). The same process was applied in Paper IV.

Although semi-structured interviews enable respondents to talk freely about aspects of interest, the method can lead to misunderstandings, biases and errors. These problems were addressed by guiding the interview with simple questions and through the selection of respondents, both of which helped respondents to provide relevant information (Silverman, 2004). A further potential problem was that less-structured conversations risked losing focus. In order to address this problem, the length of the interview was established in advance.

3.3.3.3 Document analysis

Document analysis is a systematic procedure involving the review and evaluation of documents in order to gain understanding and develop empirical meaning. An analysis follows the document review (Bowen, 2009). Literature (such as reports) provides data about the context in which the participant operates (Mills, Bonner, & Francis, 2008). It is important to note that document analysis and content analysis (Section 3.3.3.4) are different. Document analysis is a qualitative method that involves examination, reading and interpretation to gain understanding and develop empirical knowledge, including elements of content analysis (see Section 3.3.3.4) and thematic analysis, which is a form of pattern recognition within the data (Bowen, 2009).

Papers III and IV used document analysis to investigate and understand specific aspects of DRM. In Paper III, the evaluation and comparison of Nicaraguan and Swedish DRM systems was based on Risk and Vulnerability Assessments (RVA) (Sweden) and DRM plans (Nicaragua). This Paper evaluated how risk descriptions, and assessments of consequences and likelihood were employed at regional level. The analysis of these documents was used to draw conclusions regarding the performance of Swedish and Nicaraguan DRM systems.

Document analysis was also applied in Paper IV. In the Nicaraguan context, DRM plans and other relevant documents at national, regional and local level were investigated in order to identify systemic challenges to CCA integration. Document analysis can be combined with other methods to establish convergence and corroborate information (Bowen, 2009). In Paper IV, interviews helped to confirm the coherence between what was said and what was documented (and vice versa). This helped to limit any potential bias in the analysis.

3.3.3.4 Content analysis

Content analysis is a systematic and quantitative analysis, which organizes information into categories related to the central research question (Bowen, 2009). It uses a set of procedures to make valid inferences from texts (Weber, 1990). The method consists of coding statements found in written and oral communication, for the purpose of description (Druckman, 2005). It was applied in Paper I to examine the content of policies, legislation and regulatory instruments. A set of codes was designed to identify connections between CCA and the fields of DRM, environment and UP. Codes were grouped into six categories. Finally, texts showing connections between CCA and DRM, CCA and UP, and DRM and UP were extracted.

Content analysis was suitable because it provides a comprehensive way to manage documents and facilitates the analysis of their content. It can also be used to address questions such as 'what was said?' (messages in the text), 'who said it?' (the field) and 'to whom it was said' (the type of document) (Druckman, 2005).

Despite these benefits, some problems were identified. Content analysis leads to a data-reduction process in which words and texts are classified into a few content categories, and any ambiguity in the definition of words and categories can decrease the method's reliability (Weber, 1990). In order to overcome this problem, the analysis was not limited to simply counting words and marking texts. As a further check, the keyword-in-context approach was applied. This consists of understanding how the identified words are used in the text (their meaning and usage) (Weber, 1990). Hence, messages containing the codes were extracted and read. It was possible to carry out this exercise as only 36 documents were selected.

3.3.3.5 Retrospective analysis

Retrospective analysis is usually used in medicine (e.g. to trace epidemics) (Cornfield & Haenszel, 1960) or criminal investigations (e.g. to establish the sequence of events) (Sapsford & Jupp, 2006). It helps to establish a relationship between context and outcomes (Cassell & Symon, 2004) as it examine findings from a succession of events at different points in time (Sapsford & Jupp, 2006). This approach was used in Paper IV to trace actions in DRM systems that had resulted in on-the-ground measures (planned or implemented) at local level. This included the identification of preparatory actions (or proposals) such as decision-making, risk analyses and descriptions, information collection, etc.

3.3.3.6 Experiments

Not only can experiments test theories, they can also explore new phenomena even when theories are absent. Here, the approach was based on Baconian methods, where experiments are broadly explanatory prior to theorising (Franklin, 2005). The experiments reported in Paper V did not aim to test existing theories, but provided an

in-depth analysis of how stakeholders perceived the usefulness of different types of risk descriptions.

Specifically, they helped to understand how different ways of describing risk may influence the functioning of a DRM system, and thereby also influence the integration of CCA into DRM. Even if CCA measures are integrated into risk assessments, if the assessments appear to have limited usefulness for decision-making, they may be ignored.

The experiment reported in Paper V employed statistical hypothesis testing. This procedure allows researchers to use sample data to draw inferences about the population of interest (Privitera, 2014). In general, it is applied in four steps: (1) the initial hypotheses[20]; (2) prediction of sample characteristics; (3) determining a random sample from the population; and (4) comparing the results of the experiment with the hypotheses (Gravetter & Wallnau, 2013).

[20] The experiments reported in Paper V tested two hypotheses: (1) changing the risk description scenario does not influence its perceived usefulness; (2) changing the ways in which consequences and likelihood are expressed does influence the perceived usefulness of the description.

Chapter 4. Findings and analysis

4.1 Synthesis and key findings

The chapter presents a description of the appended papers. It includes the aim, design, main findings and how the research questions were addressed in each Paper.

4.1.1 Paper I: Integrating climate change adaptation, disaster risk reduction and urban planning: A review of Nicaraguan policies and regulations

The objective of this Paper was to answer RQ1: *How is CCA integrated into current policies and regulatory frameworks that promote urban risk reduction planning in Nicaragua?* The Paper analyses the integration of CCA into policies and regulatory frameworks in Nicaragua, and explores the extent to which it has been adopted in the two fields of urban DRM and UP. As it quickly became apparent that climate change and CCA were mainly addressed in the national environmental framework, a third field was added to the analysis: environment.

A total of 36 documents were examined. The material was classified into legislation, policies and official documents. Content analysis resulted in the creation of codes (keywords), and text extracts containing these codes were grouped into the following six categories: (A1) CCA: Extract includes CCA codes, (A2) DRR: Extract includes DRR codes, (A3) UP: Extract includes UP codes, (A4) CCA–DRR: Extract includes codes that show links between CCA and DRR, (A5) CCA–UP: Extract includes codes that show links between CCA and UP, (A6) DRR–UP: Extract includes codes that show links between DRR and UP.

Paper I indicated that the extent of CCA integration depends on up-to-date, comprehensive policies and regulatory frameworks. The more effort that had been put into updating policies, frameworks and related instruments in the fields of DRM, environment and UP, the better the chance of CCA integration. The greatest advances were found in relation to the national environmental framework: first because environmental agencies are officially responsible for managing climate change at a national level and second, because the environmental field has the most complete and up-to-date regulatory framework. In contrast, UP has seen less progress due to the fact that the regulatory framework is outdated and there is a lack of related operational instruments and defined responsibilities. These findings show that current policies lack coherence and are in the early stages of providing adequate guidance for CCA integration.

In addition, Paper I demonstrated the influence of international and regional agreements and frameworks, and the country's capacity to address new (mainstreaming) issues for local-level advancements. Policies and regulatory frameworks reflect ongoing changes at international level in the climate change management paradigm, which is moving from a very strict focus on mitigation to comprehensive CCA approaches and its mainstreaming.

4.1.2 Paper II: Integrating climate change adaptation into disaster risk reduction in urban contexts: Perceptions and practice

The findings of Paper I motivated a more extended exploration of CCA integration. Paper II attempted to answer RQ 2: *How do disaster risk reduction practitioners in Nicaragua perceive the ongoing integration of CCA into their urban development work?* To this end, Paper II analysed the perceptions of DRM practitioners with respect to CCA integration at policy level. This is a crucial issue as the effectiveness of risk reduction and adaptation strategies is influenced by social acceptability (Adger, 2003).

Interviews were conducted with operational officers, programme managers and academic staff to explore: (a) understanding of CCA; (b) links between CCA and DRM; (c) links between CCA and UP; (d) potential measures to adapt cities to climate change; and (e) obstacles, gaps and opportunities for linking CCA with DRM and UP[21]. A brief content analysis of transcribed interviews identified messages that contained the target information.

The first finding showed that stakeholders were aware of the importance of CCA, and were keen to improve their knowledge of it. However, they recognised that their understanding of the concepts, and how to implement them in their practice was poor. The second finding showed that all stakeholders were aware that both DRM and CCA addressed climate-related risk. Consequently, they perceived that CCA was (to some extent) already integrated into DRM. The third finding indicated what while they knew that CCA must be integrated into UP, the lack of operational tools and up-to-date instruments made this difficult to achieve.

On the one hand, these results highlighted opportunities identified by stakeholders, namely: (a) CCA was important and was gaining ground on the political agenda; (b) the DRM system was well-established and able to provide a robust structure for CCA; (c) decentralised administration at the municipal level helped to tailor CCA to local

[21] Appendix 1 presents the interview protocol (in Spanish).

needs; and (d) international funding for projects that included CCA[22] had facilitated the creation of strategies and furthered the interests of stakeholders.

On the other hand, the following challenges were identified: (a) the lack of a conceptual and practical understanding of approaches to CCA; (b) the common belief that national-level environmental institutions were solely responsible for CCA; and (c) poor communication between institutions and universities, which had led to a failure to identify topics (e.g. CCA or DRM) to be included in the higher education curricula and consequently a lack of training to expand DRM and CCA capacity.

4.1.3 Paper III: Evaluating the performance of disaster risk management systems: Is it possible?

Consistent with Section 3.1, RQ 3 was formulated as follows: *How can disaster risk management systems (and related integration processes) be evaluated and compared?* Paper III addressed this question by proposing novel ways to detect challenges related to the fulfilment of the purpose(s) of DRM. It took the form of a theoretical discussion of how DRM systems can be evaluated and compared. The paper is in three parts. First, it establishes the theoretical foundations for a model. Second, it discusses methodological challenges that may influence the evaluation of DRM and related CCA integration. Third, a theoretical model is developed and tested by using it to evaluate and compare DRM systems in Nicaragua and Sweden. Finally, it presents some conclusions.

The point of departure for the development of the theoretical model was four difficulties found in evaluating DRM systems. The first relates to biases in judgement stemming from the psychological process of attribute substitution (Kahneman & Frederick, 2002). The second concerns the use of past losses as a basis for evaluation. The third is linked to a focus on resources (including financial) and related aspects, which may overlook the impacts of other contextual factors. The fourth refers to what system behaviours, among the many that are present in DRM systems, should be analysed.

[22] Although there is little guidance on assessing needs and adaptation in urban areas in Nicaragua (Moser et al., 2010), several international agencies are showing increased interest in integrating CCA into different sectors. They include the European Commission, the Swiss Agency for Development and Cooperation (SDC), the German Technical Cooperation Agency (GTZ), the Spanish Agency for International Development Cooperation (AECID in Spanish), and the Inter-American Development Bank (IDB). The websites of these organizations highlight that CCA issues have been included in action priorities.

The theoretical foundations for the model were drawn from design science concepts. DRM systems are seen as artefacts that can be described using three levels of abstraction: purpose, function and form. At the first level, the system is described based on its purpose, i.e. why it exists. In the case of a DRM system, this is most closely linked to the aim of limiting long-term losses. At the second level, function, the system is described based on what it does in order to achieve its overall purpose[23]. The third level, form, focuses on how these functions are performed, and therefore also how the purpose is fulfilled. In the case of a DRM system this could, for example, involve descriptions of documents that are produced and used within the system.

The model was tested using empirical data from Nicaragua and Sweden: 42 Swedish Risk and Vulnerability Assessments (RVA) and 16 Nicaraguan Disaster Risk Management Plans (DRMP). These documents are used to communicate risk on the regional level in the respective DRM systems. Document analysis was used to investigate three aspects: (a) whether they provided descriptions of risk scenarios/ events; (b) how the consequences of the risk scenarios/ events were described; and (c) how assessments of likelihood were described.

On the one hand, this evaluation of the DRM corpuses showed that the Nicaraguan documents often lacked a description of risk scenarios, whereas Swedish documentation often included them. Moreover, Nicaraguan descriptions of the likelihood and consequences of various events were often qualitative. On the other hand, qualitative ordinal scales were most often used in Sweden. This (together with the experiment reported in Paper V) suggested that the Nicaraguan system produces risk descriptions that are less useful for decision-making than their Swedish counterparts. The paper provides a concrete example of how an output from a DRM system (in this case, documentation) can be used to relate its form to its purpose.

[23] In Papers III and IV the actions undertaken by a DRM system are called 'functions'. Four basic functions were used in the theoretical model: (1) Information acquisition: a DRM system must obtain knowledge about the current state of the environment through e.g. monitoring data about affected populations; (2) Orientation/ anticipation: Using the acquired information a DRM system must be able to assess the current state of the environment and interpret the situation (e.g. risk assessment) in order to find possible courses of action; (3) Decision-making: a DRM system must decide a suitable course of action based on its interpretation of the situation (e.g. propose DRM plans or measures); and (4) Implementation: Once the DRM system detects suitable actions, it must intervene in ways that modify or adjust the environment (e.g. building a bridge). Note that the system itself does not 'do' anything; it is the various actors in the system who take action.

4.1.4 Paper IV: Fragmentation in disaster risk management systems: A barrier for integrated planning

Paper IV contributed to the theoretical discussion presented in Paper III and attempted to answer RQ 4: *How can systemic challenges be studied and how do they influence integrated CCA and DRM planning on the ground?* In this Paper, the theoretical model proposed in Paper III was extended and applied to the implementation of on-the-ground measures through a study of systemic challenges. Paper IV highlighted that an overly-narrow focus on a limited number of actors (e.g. governmental agencies) made some challenges difficult to detect. Instead, it was necessary to study several stakeholders and their interactions. Specifically, the connections between stakeholders at the 'sharp end' (i.e. those that implement DRM and CCA measures), and those at the 'blunt end' (e.g. those involved in policy setting) were particularly important.

Using the theoretical model as a point of departure, a retrospective analysis of 52 official documents at regional and local level from the Nicaraguan DRM system identified on-the-ground measures that addressed both CCA and DRM. The analysis was supported by semi-structured interviews with 21 stakeholders. This empirical data made it possible to trace the four functions of DRM systems (proposed in Paper III, see Section 4.1.3). It was then possible to identify systemic challenges, specifically fragmentation, by looking at the connections and disconnections between functions. An example of fragmentation is documents that supposedly describe risk, but lack descriptions of scenarios. This makes them difficult to use as a basis for decision-making.

The findings showed that progress in CCA integration at policy level was not reflected in the on-the-ground measures at local level. The theoretical model helped to detect two critical challenges that not only affected the performance of DRM systems, but also potentially hamper CCA integration. The first relates to the difficulty of integrating risk information about different types of hazards. Detailed risk information was produced by national authorities but it did not reach, and thus was not integrated into, risk descriptions produced at regional and local level. The second challenge related to isolation at the local level. This meant that the progress achieved at national level was not reflected at local level.

4.1.5 Paper V: Communicating risk in disaster risk management systems: Experimental evidence on the perceived usefulness of risk descriptions

Paper V answered RQ 5: *Do differences in the way risk descriptions are presented influence their perceived usefulness for decision-making?*[24] This study tested one of the key assumptions underlying the conclusions of Papers III and IV. It took an experimental approach and examined how the presentation of risk descriptions[25] affected their perceived usefulness. Although the Paper reports two experiments, only one is considered relevant here.

Three groups of subjects were shown the results of a risk assessment for a local municipality. They were then asked to judge how useful the description was as a basis for making decisions about risk reduction measures. The descriptions were intentionally designed to resemble risk assessments commonly found in the Swedish and Nicaraguan DRM systems. The three experimental groups were: (1) professionals with formal training in risk assessment (78 participants); (2) students of UP (31 participants); and (3) professional urban planners (33 participants). Since the risk assessments involved floods, which are a common hazard in urban areas of Nicaragua, it was assumed that the urban planners would be able to understand the assessments even though they may have lacked formal risk training.

Each participant was shown several examples of an assessment. The examples were designed by the researchers and the only difference between them related to how information concerning the likelihood and consequences of a flood was described.

The results showed that: (1) the way risk was described influenced perceived usefulness; (2) descriptions based on semi-quantitative scales and quantitative expressions were perceived as more useful than those that lacked information about likelihood and consequences, and others that described risk in qualitative terms; and (3) similar results were obtained for all groups of participants.

These results indicated that risk assessments that do not include an evaluation of likelihood and consequences are likely to be perceived as less useful. The earlier studies carried out in Nicaragua (see Papers III and IV) had highlighted that in practice many risk assessments either did not contain these evaluations, or used qualitative descriptions. Thus, Paper V provided experimental confirmation for the

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[24] Although the research question in Paper V is normative ("how should"), here it was slightly reformulated as a descriptive question. In this thesis, Paper V tests the assumptions developed in Papers III and IV, therefore, a descriptive question is better suited to this end.

[25] How risk descriptions are presented differs between DRM systems. The more common forms are qualitative descriptions, qualitative ranking scales, semi-quantitative ranking scales and quantitative scales (see Paper V).

claim by practitioners that the output of the Nicaraguan DRM system (risk descriptions) was difficult to use as a support for decision-making. For example, it was very difficult for a local municipality to use the risk information supplied in the regional DRM plan as a basis for decisions concerning risk-reducing measures. Consequently, even if the regional DRM plan included CCA information, it did not necessarily follow that it would be used to inform local decisions.

4.2 Summary

Table 2. Research Questions and summary of findings

RESEARCH QUESTION (RQ)	ANSWERS
RQ 1: How is CCA integrated into current policies and regulatory frameworks that promote urban risk reduction planning in Nicaragua?	The initial focus for integration was climate change mitigation and the protection of natural resources. CCA integration was subsequently integrated to give a more holistic perspective into all sectors. Progress has been different in each field (DRM, UP and environment) and the environmental sector leads DRM and UP. The environmental field has responsibility for climate change issues, and it has up-to-date, comprehensive policies and regulatory instruments which are important in increasing CCA integration. Furthermore, international instruments guide actions in areas where national instruments and policies are lacking.
RQ 2: How do disaster risk reduction practitioners in Nicaragua perceive the ongoing integration of CCA into their urban development work?	Progress in CCA integration at policy level is not reflected in the practice of DRM stakeholders. Although practitioners are aware of the importance of CCA, they lack understanding. Challenges include the perception that CCA is the responsibility of the environmental sector, and a lack of its integration into critical sectors, e.g. land use and UP in general.
RQ 3: How can disaster risk management systems (and related integration processes) be evaluated and compared?	A theoretical model was developed to evaluate and compare DRM systems based on the extent to which they fulfil their purpose. The model looked at four system outputs related to the following questions: (1) How does the DRM system receive information from the environment (information acquisition)?; (2) How does the DRM system produce an understanding of the current state of the environment and what might happen (orientation/ anticipation)?; (3) How does the DRM system decide if risk reduction measures should be implemented (decision-making); and (4) How does the DRM system implement these measures (implementation)? The evaluation of a DRM system can focus on the output associated with one or more of these questions. Elsewhere in this

	thesis, outputs are referred to as 'functions', which can be evaluated according to how well they fulfil the overall purpose of the DRM system. For example, if a system produces risk descriptions (an example of the orientation/ anticipation function) that are not useful for decision-making, then it will perform less well in meeting its overall goals. Therefore, a DRM system can be broken down into parts that are analysed to see how they work together, and how they support the fulfilment of the overall system goal (e.g. to reduce disasters). Factors that impede the system from achieving its goal are defined as challenges. DRM systems can then be compared to see if they contain similar challenges or whether one system performs better than another. This feedback is important to identify suitable interventions for future improvements, including CCA integration.
RQ 4: How can systemic challenges be studied and how do they influence integrated CCA and DRM planning on the ground?	Systemic challenges can be investigated by analysing the interaction between parts of a DRM system. Individual parts can be identified and assessed with a slightly modified version of the theoretical model developed in response to the questions outlined above. Employing the modified model to study the Nicaraguan DRM system resulted in the identification of two systemic challenges likely to seriously affect the integration of CCA into DRM planning on the ground. The first relates to the integration of specific risk information from national authorities into comprehensive risk overviews (a focus on all hazards). The second relates to the inability of the local level to use information from higher levels (such as DRM plans coming from national and regional levels) to support their work.
RQ 5: Do differences in the way risk descriptions are presented influence their perceived usefulness for decision-making?	Differences in how risk descriptions are presented do influence their perceived usefulness for decision-making. The results revealed that semi-quantitative scales and quantitative risk descriptions are perceived to be most useful, which can also influence CCA integration.

Chapter 5. Discussion

This chapter discusses the main contributions of the thesis to knowledge about the integration of CCA into DRM. It begins with a discussion of the current status of CCA integration in Nicaragua and ways to investigate challenges. It continues with a brief discussion of the quality of the research described here, and ends with some ideas for future research.

The research presented here concerns CCA integration into DRM systems in urban contexts. The first part of the investigation studied perceptions of CCA integration into policy, regulatory instruments and practice, while special attention was given to identifying challenges. Based on these results, the second part of the investigation discussed ways to investigate these challenges. A theoretical model was developed and tested through an experimental evaluation and comparison of the performance of two DRM systems.

5.1 Integration of climate change adaptation: policy and practice

Overall, CCA initiatives and progress towards integration is very varied (e.g. McCarthy, et al., 2001; OECD, 2009), and developing countries in particular have made little progress (Matus-Kramer, 2007; Persson, 2008; Saito, 2013). Previous investigations have examined the creation of National Adaptation Programmes of Action (NAPAs) as a pathway to progress (Matus-Kramer, 2007; Saito, 2013), while Matus-Kramer (2007) determined that although Nicaragua lacked a NAPA, awareness and understanding of the value of responding to climate change had increased.

This thesis highlights some of the factors that influence integration in a developing country. Taking Nicaragua as an example, it illustrates the transitional adoption of aspects of CCA from environmental policies into the domains of DRM and UP. It shows that progress has been made, although the extent of integration is different in different fields. In addition, it was shown that modifications and developments are ongoing, and full integration depends on up-to-date, comprehensive policies and regulatory instruments.

International donors play an important role in capacity building and facilitating CCA integration in developing countries (OECD, 2009). The thesis shows how progress in Nicaragua is influenced by international agreements, policies and instruments as national authorities are clearly interested in fulfilling their obligations. National-level policies and instruments are consistent with international interest in climate change;

specifically, the initial focus on mitigation has more recently switched to CCA (IPCC, 2007).

Various authors have noted that many aspects for operationalising CCA remain unclear (Klein, Schipper, & Dessai, 2005; Schipper, 2007). The work presented here confirms their findings. CCA is not completely understood, and this problem underlies a number of challenges. First, in Nicaragua, practitioners perceived CCA to be an issue that mainly concerned environmental institutions; consequently, they were not motivated to add it into their work. Second, many stakeholders perceived the potential negative consequences from climate change to be distant in time. Therefore, they tended to pay attention to risks that they considered more likely to generate negative consequences at the present time, for example seismic risk (see Weber, 2006). Finally, practitioners were most familiar with DRM concepts because government and international cooperation have strengthened DMR capacities. CCA has not received the same attention and many stakeholders assumed that it was already part of DRM and their practice, although future risks were generally not systematically identified or addressed.

A challenge to CCA integration is that policy-making processes and practice have different timeframes (Tschakert, et al., 2013). This was confirmed by comparing progress at policy level with the perceptions and practices of stakeholders. In this context, an important factor is a lack of operational instruments that can guide its integration. Every stakeholder, whether involved in UP or DRM, must have an understanding of how their work relates to climate change and what effective adaptation looks like (Persson, 2008) in order to translate the progress achieved in policies into their practice.

The first part of the investigation highlighted that it is important not only to identify challenges to CCA integration, but also that it is difficult to detect them solely through the exploration of policies, instruments and planning practice. This observation motivated a comprehensive discussion of theoretical approaches, which are presented in the following section.

5.2 Integration of climate change adaptation: investigation of challenges

The initial findings highlighted the need to develop an in-depth approach to studying the challenges to CCA integration. The theoretical discussion focused on the evaluation and comparison of DRM systems, as initial results had suggested that integration concerned not only the addition of CCA into the DRM system, but also improvements to the DRM system itself.

Many methods have been proposed for evaluating DRM systems as a whole, or specific aspects (e.g. Carreño, Cardona, & Barbat, 2007; Jackson, Sullivan-Faith, & Willis, 2010; Quarantelli, 1997). Most focus on how stakeholders manage risk in relation to indicators, standards, etc. However, a standard evaluation method cannot be universally applied as the implementation of both DRM and CCA depend on their context (Adger & Barnett, 2009; McCarthy et al., 2001; OECD, 2009).

Due to the context-specific nature of CCA, the aim of the model proposed in this thesis is that it can be adapted to different enviroments of interest (e.g. countries, regions, cities). To this end, ideas from design science and systems thinking guided the analysis by emphasising the purpose of artifacts when building and evaluating them. The focus of the evaluation is the assumption that the purpose of a DRM system is to reduce long-term losses (see the definition of DRM in Paper III). It is also at the centre of the analysis of whether CCA integration can be seen as successful or not. This approach can help to overcome some of the problems associated with the fact that, like any artifact, a DRM system can serve several purposes, and the purpose ascribed to it might differ according to the context.

This provides a point of departure for the evaluation and comparison of DRM systems irrespective of their stated (legislative) purpose. It is therefore more flexibile than approaches that compare DRM based on standards and indicators. Standards and indicators are difficult to use when the context in which the activity is carried out changes. For example, the practical implementation of Swedish and Nicaraguan DRM systems are very different. Nevertheless, they rely on the same basic functions to limit long-term losses. The use of a standard to assess DRM performance is likely to fail to appreciate that there are different ways to achieve the same purpose, and that some ways might be more suitable in some contexts.

By investigating the challenges that influence system behaviour (in terms of fulfilling its purpose) provides several lessons. For example, there are at least two possible situations: (a) two or more systems have similar challenges: in this case, assumptions could be developed that relate to the causes of these challenges (as it was done in this thesis); or (b) the challenges are different: in this case the influence of the identified challenge in the affected systems could be assessed using the behaviour of the non-affected system. In both cases, the comparison may not only help to determine suitable interventions to improve system behaviour, but also provide information about the functioning of DRM systems in different contexts.

Systems thinking argues that the behaviour of a (DRM) system should be viewed as a whole, rather than a collection of individual parts (Keys, 2013). The definition of systemic challenges flowed from this idea; namely that not all challenges can be detected by studying parts in isolation, and that sometimes it is necessary to study the system as a whole. Consistent with this rationale, the theoretical model can assist in analysing a DRM system and provide a template for the assessment of how the overall

system deals with risk (e.g. the actions performed by the actors in the system). In addition to modelling the structure of the DRM system, it can help to identify its functions (the different parts of the system), how they fulfil a specific purpose and associated challenges.

The model made it possible to analyse system behaviour, which could be measured by outputs (e.g. risk descriptions). From this, conclusions can be drawn about the extent to which the system is achieving its purpose, if there are connections and disconnections between actions (e.g. fragmentation) and how they influence CCA integration. For example, in Nicaragua, risk assessments (the orientation/ anticipation function) produced on the regional level are difficult to use as a basis for decision-making regarding risk-reducing measures, including climate-related risks. This is an example of fragmentation, and it is an important finding as it might hamper CCA integration. For example, if no scenarios related to climate events are described, or if the consequences of such events are not estimated, it becomes difficult to develop CCA measures, eventually leading to, for example, poor planning and implementation, increased vulnerability and maladaptation[26].

A concern when developing the theoretical model was that it was too abstract for any practical applications. Therefore, it was important to test it through an analysis of the Nicaraguan system (and a small part of the Swedish system). This showed that, although not easy to apply, it was a useful tool in detecting challenges to integration.

However, testing the approach and concluding that 'it works' based on the fact that it provides output is questionable. Its usefulness is better shown by the increased value of the output compared to what would otherwise have been possible. From this perspective this study is limited since it does not compare the analysis with and without the proposed framework. Instead, the demonstration of usefulness relies on arguments (presented in Papers III and IV) relating to why it is reasonable to design an approach to evaluate, compare and ultimately identify challenges to the integration of CCA into DRM according to the principles presented here. Although testing suggested that it did produce useful results, it is clear that it needs further refinement and development.

[26] Maladaptation has been defined as a cause of increasing concern to planners, where intervention in one location or sector could increase the risk of another location or sector, or increase the risk of the target group to future climate change (IPCC, 2014b, p. 837).

5.3 Threats to validity and research quality

Validity and reliability are important because the objectivity and credibility of the researcher are at stake (Silverman, 2004). All research designs and methods are exposed to factors that may jeopardise their integrity. This section discusses potential threats in order to assess the quality of the research.

5.3.1 Validity

Validity concerns the "selection of the correct operational set of measures for the concept being studied" (Yin, 2003, p. 34). The case study is like any qualitative[27] research where the researcher is an inherent part of the process (Creswell, 2007; Simons, 2009). The interaction between data and judgement is often ignored as there is no objective way to measure the subjective components of the interpretation (Kaptchuk, 2003).

Yin (2009) proposes three tactics to address threats to validity. The first involves using multiple sources of evidence. Here, this is addressed by triangulation, an approach that uses multiple sources of data to measure the same concept for a single unit (Blatter & Haverland, 2012; Christie et al., 2000). As Table 1 shows, different types of empirical data were used: legislation, regulatory instruments, DRM plans, interviews and experiments.

The second tactic involves establishing chains of evidence. The results of the various studies of the Nicaraguan DRM system are connected by evidence that reflects its different aspects (e.g. polices and practice). For instance, the process of CCA integration in policies and regulatory instruments included an analysis of how CCA was presented in earlier documents and how the latest policies refer to CCA aspects. How CCA (or climate change) was presented in environmental legislation from 1996 (Law No. 217) was compared with the updated, 2008, version (Law 647). This made it possible to detect progress in integration.

The third tactic concerns the review of case study reports by key informants. Interviewees were asked to clarify any unclear comments from the recorded conversations. Furthermore, the final versions of articles were shared with some of the key informants as well as further professionals. For instance, Papers I and II were sent to the General Director of SINAPRED. Although he was not interviewed, his opinion on the findings was considered relevant for the study.

[27] The thesis combines qualitative and quantitative methods (see Section 3.3.2).

Case studies must be credible (Christie et al., 2000). Therefore, internal validation and researcher bias were managed in each Paper depending on the method. Bias in data processing was controlled by including empirical data that was supported by quotations, references and page numbers. Papers I, II and IV include a limited number of direct quotes from documents and interviews (journal word limits meant that not all quotes could be included). Paper I includes both quotations in Spanish and translations into English.

Another aspect that helped to limit potential biases is that many of the reviewed documents (e.g. DRM plans, legislation, policies) and resultant analyses (Papers) are available on the internet. This is important for the following reasons: (a) authors know that readers are able to access the information and corroborate it; and (b) readers (and interviewees) can access and check the information presented.

The threats to validity of experiments are mitigated by the rigorous use of variables and statistical analysis (Yin, 2003). Paper V clearly explains how the experiments were conducted and the statistical analyses that were used to investigate the hypotheses (see Section 3.3.3.6).

External validity is the extent to which findings can be replicated or generalised (Christie et al., 2000). It provides an indication of whether or not the findings from the case study can be generalised to and across measures, people, settings and times (Bobby, Phillips, & Tybout, 1982). The research presented here does not claim to generalise the process of CCA integration. Instead it provides an in-depth analysis of how the process may unfold in a similar context – either other Latin American countries, or so-called low income or developing countries. Although the importance of generalisation should not be underestimated, it is also good practice to limit external validity. Flyvbjerg (2006) notes, "[a] case study without any attempt to generalize can certainly be of value in this process and has often helped cut a path toward scientific innovation".

Papers I and II provide a context-specific analysis of CCA integration, which may only be relevant for Nicaragua. However, this is unlikely as the context is not unique, and shares characteristics with other countries in Central America, where it may be possible to expect similar results.

The idea behind the theoretical model developed in Paper III and IV was that it should be useful in contexts other than Nicaragua. Therefore, since the results (the model) are normative, one interpretation of external validity is the extent to which it is useful in different contexts. A model that is only useful in one country has limited validity. Therefore, it was also tested in Sweden. Moreover, it was developed by three researchers, of which one (not the author of the thesis) was not familiar with the Nicaraguan system. This also reduced the risk that the design was too context-specific, and with limited use in other contexts. With respect to Papers III and IV,

validity was addressed through the contribution of several researchers with different backgrounds, and the clear ambition to develop a model that could be useful in many contexts.

In Paper V, threats to external validity were managed by including several groups of participants with various characteristics. For example, they differed in terms of background (social science/ engineering), familiarity with DRM topics (trained/ untrained), professional experience (students/ practitioners), and context (Sweden/ Nicaragua). Although it is not appropriate to generalise the findings to all groups and people involved in DRM work, the results may also be applicable to other groups. This could be the subject of future studies.

5.3.2 Reliability

Reliability means the study can be repeated with the same results (Yin, 2003). In case study research, it means establishing a document trail and the use of multiple cases (Christie et al., 2000). Although the study of multiple cases has some advantages, in this research the focus on a single case was important. Limiting the research to one case study can increase the quality of the analysis, as a result of the time and energy invested by the researcher (Blatter & Haverland, 2012). It made it possible to focus on many aspects of CCA integration at once (e.g. policies and instruments, perceptions of practitioners, how to investigate the topic, how to evaluate and compare DRM structures, and how risk descriptions can be used to improve integration). Notwithstanding the fact that Sweden's DRM system was added into the analysis in Paper III, the addition of more cases risked narrowing the focus. In addition, Papers I and II showed that the obstacles to CCA integration in the Nicaraguan context needed further theoretical development, and it was clear that there were more complex challenges hidden in the empirical data.

From the point of view of replicability, the appended Papers include detailed methodologies. As mentioned above, most of the empirical data is accessible from the internet (with the exception of interview records). Paper I presents an analysis of policies, regulations and other regulatory frameworks that are readily accessible, while the content analysis provides a quantitative basis for other researchers to track the process. The analysis developed in Paper II is based on recordings and transcripts of interviews, together with protocols (see Appendix 1). Papers III, IV and V used empirical data with high level of confirmability. Papers III and IV included DRM plans from public databases. Paper V includes the experimental template (as an appendix) and the statistical analysis increases reliability.

Although transparency and objectivity were a priority, data interpretation and analysis may not be exactly the same in all studies. However, this can be addressed by

structured techniques, such as comparing data with other researchers (Sapsford & Jupp, 2006). With this in mind, co-authors played an important role and participated fully in discussions of the interpretation of empirical data.

5.4 Future research

Although this thesis provides knowledge about CCA integration and associated challenges, it is important to continue to build knowledge about how to improve synergies between CCA and DRM in different urban settings and contexts. CCA integration into development has been widely discussed, and the potential addition of DRM into this debate is gaining ground within both CCA and DRM communities, who share an interest in disaster reduction. The results of this thesis revealed the potential use of the model for continuing the exploration of challenges of integration in UP. With this in mind, it would be useful to extend the research presented here by investigating in-depth challenges of CCA and DRM integration in UP.

While the results of the thesis provided a comprehensive analysis of the extent of integration of CCA in DRM systems, future research could add more empirical data (e.g. interviews) from other stakeholders of the DRM system to supplement the information gathered here (e.g. Civil Defence in Nicaragua).

In addition, the theoretical model needs to be more extensively tested in different contexts. In particular it would be interesting to extend the investigation in similar (developing) and different (developed) countries, and further explore its linkages to CCA integration. Finally, future studies could extend the usefulness of the theoretical model in order to investigate the reasons for the challenges and suggest improvements to both DRM systems and CCA integration. In addition, the model is useful for detecting similar challenges in other contexts to find ways to understand and overcome them.

Chapter 6. Conclusions

The purpose of this thesis was to increase knowledge about challenges to CCA integration into DRM systems, and to suggest ways to investigate them. It provides an in-depth analysis of the integration of CCA into the DRM system in Nicaragua. The main conclusions are presented below:

- Significant progress has been made in integrating CCA into the DRM policy and regulatory framework in Nicaragua. Nevertheless, DRM lags behind, for example, the environmental management field. One important reason is that the DRM policies and regulation are not updated as frequently as those in other areas. Moreover, current policies are limited in their description of how CCA should be integrated into DRM, and therefore they are less useful in practice.
- Interviews with professionals working in DRM in Nicaragua revealed three challenges to integration: 1) there is a lack of understanding of CCA; 2) there is insufficient guidance on how to integrate CCA in practice; and 3) a lack of instruments means that there are limited opportunities to integrate CCA into UP.
- The most important normative conclusion is the development of a theoretical DRM model that can be used as a basis for investigating challenges to the integration of CCA into DRM.
- The DRM model allows a more in-depth study of so-called systemic challenges to the integration of CCA and DRM. It led to two major conclusions about DRM work in Nicaragua: first, there are two systems working in parallel; one in which authorities at a higher level (e.g. institutions at national level) collect and analyse information related to their specific focus (e.g. flood monitoring), and another in which local authorities (e.g. municipalities) collect and analyse a broader range of (less technical) information. The integration of these systems is limited. This represents a challenge as, even if CCA aspects are integrated into, for example, strategic environmental management, the information is not then integrated into local DRM. The second conclusion is that municipalities appear to be isolated. They rely on local information from community members regarding risks and vulnerabilities and lack technically advanced information from higher-level authorities, e.g. national assessments of flood risks. This isolation influences the integration of CCA into DRM since it become difficult to communicate and analyse the potential benefits of CCA measures.

- Another key contribution of the thesis is the empirical test of one of the key assumptions underlying the theoretical model introduced in Papers III and IV. The results show that the way risk information is presented influences its perceived usefulness as a basis for decision-making, including CCA integration.

This thesis also offers some general conclusions about how challenges to CCA integration can be investigated. It demonstrates that certain challenges can only be detected with an in-depth exploration of the DRM system. Moreover, the application of the theoretical model was useful in developing assumptions about the challenges that were detected. It showed that CCA integration concerns not only its addition into DRM, but also that improving the DRM system itself is crucial. Finally, the results of this thesis pave the way for the consideration of DRM and CCA within urban planning and development, and emphasize the potential for integration that increases resilience in cities.

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Appendices

Appendix 1: Interview protocols

Appendix 2: Author contributions to the appended papers

Appendix 3: Appended Papers

Appendix 1: Interview protocol

Division of Risk Management and Societal Safety

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Artículo II.

Protocolo de entrevista

Integración de la adaptación al cambio climático (práctica y precepción).

1. Acerca del participante

- ¿Cuál es su cargo en la institución?
- ¿Podría describir las actividades que realiza?

1. Conocimiento sobre adaptación al cambio climático

- De las actividades antes mencionadas: ¿Podría identificar cuáles se relacionan con la adaptación al cambio climático y el desarrollo urbano?
- ¿Existe algún programa/ proyecto en ejecución o planificado que incluya aspectos sobre la adaptación al cambio climático?
- ¿Ha recibido alguna capacitación que incluya gestión de riesgos y adaptación al cambio climático?

2. Integración de la adaptación al cambio climático

- ¿Considera importante la adaptación al cambio climático? (¿Por qué?).
- ¿Cómo usted incluye/incluiría aspectos sobre adaptación en sus actividades?
- ¿Cuáles son los instrumentos que usted utiliza/ utilizaría para guiar la inclusión de estos aspectos en su trabajo?
- ¿Es importante integrar la adaptación al cambio climático a la gestión de riesgos y la planificación urbana?
- ¿Cuál sería el beneficio de la integración de estos tres temas en el trabajo que usted realiza?

3. Relación de la adaptación al cambio climático y las áreas urbanas

- ¿Cómo se está integrando la adaptación al cambio climático en el desarrollo urbano?
- ¿Podría relacionar los riesgos a desastres y los impactos del cambio climático con las características físicas urbanas?
- ¿Cree usted que estas características podrían tener potencial para la reducción de riesgos en áreas urbanas?
- ¿Conoce medidas o estrategias que sean efectivas/potenciales para reducir riesgos y adaptar los espacios urbanos ante los impactos del cambio climático?
- ¿Podría identificar si alguna medidas se han implementado en los proyectos que usted/su institución ha ejecutado?

4. Oportunidades y obstáculos para la integración

- ¿Puede identificar oportunidades para integrar la adaptación al cambio climático en la gestión de riesgos y la planificación urbana?
- ¿Considera que hay obstáculos que dificulten la integración de estos tres temas?
- ¿Cuáles aspectos usted considera que se puede mejorar para facilitar esta integración?

¡Muchas gracias por su participación!

Appendix 2: Author contributions to the appended papers

1. Paper I:
   This Paper explores the extent to which climate change adaptation is integrated into the regulatory framework, and disaster risk management and urban planning policies in Nicaragua.
   Contribution: First author. The authors jointly developed the Paper's structure. I was the main responsible for the data collection, data analysis and writing.

2. Paper II:
   The perceptions of disaster risk management practitioners were explored in order to identify how climate change adaptation is integrated into their urban development work.
   Contribution: Single author.

3. Paper III:
   Based on the finding of Papers I and II, which showed how climate change adaptation is integrated into current disaster risk management systems, this Paper focused on system performance in order to establish a theoretical model that helped to understand its functioning.
   Contribution: First author. The authors jointly developed the theoretical model. I was responsible for the data collection and analysis used to develop the model, and writing.

4. Paper IV:
   This study is an application of the model proposed in Paper III. The aim was to explore in greater depth challenges related to climate change adaptation integration into disaster risk management systems. This Paper focused on the implementation of measures at the local level.
   Contribution: First author. I was the main responsible for developing the Paper's structure, data collection, data analysis and writing.

5. Paper V:
   The findings of Paper IV showed how actors interact and share the system's products (e.g. disaster risk management plans, risk assessments), and highlighted related challenges. Paper V investigated how the presentation of the risk assessment influences its usefulness in decision-making.
   Contribution: Second author. I ran the experiments with two groups of participants from Nicaragua and contributed to the writing.

Appendix 3: Appended Papers

Paper I

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Integrating climate change adaptation, disaster risk reduction and urban planning: A review of Nicaraguan policies and regulations

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ABSTRACT

The integration of risk reduction and climate change adaptation has become an urgent task in addressing increasing urban risk more effectively and efficiently. This paper analyses the extent to which climate change adaptation is integrated into the policies and regulatory frameworks that guide urban risk reduction in Nicaragua, and discusses related progress. The results reveal significant progress in integrating climate change adaptation into the policy and regulatory frameworks of the three relatively new fields of (a) disaster risk reduction, (b) environmental management and (c) urban planning. They show that differences in the degree of integration relate to the development and updates to policy instruments in each field, and the extent to which they are related to the implementation of international climate change agreements. Although initially climate change adaptation integration was focused on the protection of natural resources in general, and food production in particular, since 2008 authorities have shown increasing interest in a more comprehensive and integrated approach. Nevertheless, the integration of climate change adaptation into disaster risk reduction and urban planning still lags behind the advances made in the environmental management field. It is concluded that in order to achieve greater and more coherent integration of CCA and, ultimately, improve the way climate-related risks is dealt with, urban authorities need to systematically review current policies and regulations to assess the synergies and gaps. This requires inter-sectoral and participative work with the actors concerned at national and local level, as well as the establishment of related monitoring and learning mechanisms.

1. Introduction

Climate change (CC) contributes to more frequent and more severe disasters [1]. During the last three decades, two-thirds of the world's disasters have been caused by climate-related phenomena [2–4]. So-called developing countries are most affected by climate-related events, with Nicaragua being classified as one of the most affected countries in the last two decades [5].

Given that climate change adaptation (CCA) and disaster risk reduction (DRR) both aim to reduce the impacts of climate-related disasters and associated risks [6,7], the need to integrate them in a coherent way is receiving increasing attention from international communities and academics in both fields (e.g. [7–14]).

Abbreviations: DRR, disaster risk reduction; CCA, climate change adaptation; CC, climate change; UP, urban planning

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In the field of DRR, the World Conference on Disaster Reduction (WCDR) held in 2005 in Kobe, Japan [9] sparked discussions about the importance of integration. As a result, CC considerations were incorporated into the risk reduction strategies of the Hyogo Framework for Action 2005–2015 [15]. In the field of CC, related discussions slowly emerged in 2009 in the context of the United Nations Framework Convention on Climate Change in Copenhagen. It is only recently that the Intergovernmental Panel on Climate Change (IPCC) published a report, which tries to address and link both fields: the special report "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (IPCC-SREX)" [7]. It is now one of the most relevant documents for both disaster risk reduction and climate change adaptation [13].

The increased attention given to the integration of CCA and DRR also relates to the urgency of addressing growing urban risk. There is widespread consensus that urban disasters are increasing exponentially, resulting in escalating human and economic losses [6,16]. In urban settings, hazard impacts are intensified by high levels of vulnerability [17]. There is substantial population growth in risky areas, particularly through unplanned urban development. With an influx of poor and marginalized groups in cities, the proportion of the at-risk population increases [18]. This situation, where cities expand without adequate attention being given to the links between urban planning (UP) and risk increases the potential for disaster [19]. Hence, UP processes, both planned and unplanned, can intensify existing vulnerabilities if DRR and CCA are not fully integrated [20].

The importance of the integration of the three fields of CCA, DRR and UP at policy level was outlined in the latest review of the implementation of the Hyogo Framework for Action 2005–2015 [21]. For instance, the first core indicator of Priority Four that measures progress and challenges in "reducing the underlying risk factors" states:

> Disaster risk reduction is an integral objective of environment-related policies and plans, including for land use planning, resource management and adaptation to climate change [21] (p. 29).

This indicator calls for a better integration of DRR, CCA and UP policies and regulatory frameworks, in order to achieve the goals established by the Hyogo Framework for Action 2005–2015.

Against this background, this paper analyses whether, and if so, to what extent CCA is integrated into current policy and regulatory frameworks for DRR and UP. The research question is: *"How is climate change adaptation integrated into current policies and the regulatory framework that promote urban risk reduction planning in Nicaragua?"* Nicaragua was selected as the focus for the case study as, since 1885, the country has experienced frequent damage and serious losses due to hazards such as earthquakes and floods [22]. Nicaragua is also an interesting case because of recent significant advances in adaptive capacity at institutional level. Following Central America's most recent large-scale disaster, namely Hurricane Mitch in 1998, the government has actively encouraged DRR efforts, which have been supported by a range of international aid organizations [23,24]. As a result, the national framework for DRR has made significant progress and is considered to be one of the best in the region [25]. It therefore provides a good basis for a study of the integration of CCA, DRR and UP, which can provide valuable insights for other countries.

The remainder of this article is divided into four parts: methodology (Section 2); the results of the analyses of policies and regulatory frameworks (Section 3); a discussion of advances in climate change integration into urban risk reduction at policy level (Section 4); and finally the conclusions (Section 5).

2. Methodology

Our work is based on a case study of Nicaraguan policies and regulatory frameworks and a content analysis. Case studies are a useful way to explore new processes and their outcomes [26]. They provide reliable information, which can be used to generalize a phenomenon [27]. Our data was mainly drawn from existing policies and regulatory frameworks concerning DRR, UP and environmental management, and our aim was to explore the extent to which CCA is integrated into them, and, if so, how. Content analysis was selected as the method for the analysis as it leads to valid inferences and makes it possible to highlight aspects related to CCA integration in the documents examined [28]. It enabled a systematic exploration of policies and regulatory frameworks by identifying sections of text that were related to aspects of CCA.

This examination of Nicaraguan policies and regulatory frameworks is based on the following definitions: Climate change adaptation (CCA) is understood as the process and related actions that aim to reduce the vulnerability of systems (e.g. cities) to the adverse impacts of anticipated climate change [29]. Climate change (CC) refers here to any change in climate over time, whether due to natural variability or as a result of human activity [1]. The concept of disaster risk reduction (DRR) is broader. It can be seen as a conceptual and operational approach that aims to reduce risk through systematic efforts to analyse and manage the causal factors of both climate and non-climate related disasters. This includes measures to reduce hazard exposure and vulnerability as well as to improve response and recovery preparedness [30]. Regarding the term urban planning (UP), it is seen both as a discipline and a practical way to shape and modify urban settlements and space [31]. Furthermore, integration is understood here as part of a mainstreaming process, where mainstreaming involves modifications to specific, core operations in order to incorporate and indirectly act upon new aspects or topics [6,32]. In the context of this study, UP and DRR are the core operations, and CCA is the new aspect to be incorporated.

The documentation reviewed in this study consists of those policies and regulations that provide guidance to practitioners in the field. Polices are understood as rules or principles that a group or organization uses to guide its decisions and actions [33]. Regulations are rules or directives drawn up and maintained by an authority [34]. Documents were selected using various Internet search engines.

As regards CC and CCA, three key documents were identified to guide the selection of relevant national policies and regulations:

- "Mapping of Risks, Processes, Public Policies and Actors Related to Climate Change in Nicaragua" [35];
- "Policies, Programs and Case Study about Climate Change in Nicaragua" [36]; and
- "Nicaragua Toward Climate Change" [37].

These documents were compared and a preliminary list of policies and regulations was established using the snowball method [38].

An initial finding was that CC and CCA are generally included in national environmental frameworks. Consequently, the focus of the study was broadened to include an analysis of the integration of CCA into Nicaraguan policies and regulations related to (a) environment, (b) DRR, and (c) UP.

Next, the websites of government institutions responsible for environmental issues, DRR and UP were assessed. This included the website of the National Assembly of Nicaragua, which provides a comprehensive list of the policies and regulatory frameworks approved by the government. The material gathered from this website and legal texts related to the fields of DRR, UP and environment were part of this review.

In addition, the website of the municipality of Managua was examined for material related to the regulation of UP. Managua is the capital of Nicaragua and has the highest number of UP regulations. Many legal instruments were proposed in 1982, following the earthquake in 1972 [39]. Certain aspects of these texts were later updated [40]. For example, the 1982 regulatory plan for Managua was updated by partial plans approved between 1998 and 2001 [40], which were also added to the review. However, the validity and usefulness of these texts was very limited as this study only included UP policies and regulations dating from 1995 or later. This is because in 1992, Nicaragua signed the United Nations Framework Convention on Climate Change (UNFCCC), and in 1995 the National Assembly approved the agreements reached under the UNFCCC with the Decree 50–95: "Ratification of the United Nations Framework Convention on Climate Change" [41]. Consequently, only documents created after this time are likely to contain specific information about CC and CCA.

As a result of this process, a total of 36 relevant documents were identified. They were classified into three groups: environment, DRR and UP. Each document was categorized according to the issuing body and the content of the regulation. Nineteen of the identified policies and regulatory frameworks related to the environment, while four related to DRR. Although there is no national DRR policy, several instruments have been put forward (e.g. national preparedness and response plans, and disaster risk management plans). Most of these proposals are based on the four documents selected for this study. Finally, 13 of the identified policy and regulatory instruments related to UP.

Each category was divided into three sub-categories: legislation, policies and other relevant documents. The "legislation" sub-category consisted of non-policy documents, such as laws and decrees approved by the National Assembly. Although policies could be added to this group (as they are created in the same way), they were included in a separate sub-category. This provides a better overview of policy compared to other regulatory material. The "other relevant documents" sub-category consisted of other official documents, drawn up and published by public institutions.

In the field of environment, six policies, nine legislative instruments, and four other documents were analysed (Table 1). Most of these documents were published in 1996, following the restructuring of the Ministry of Environment and Natural Resources (MARENA),[1] which is responsible for environmental issues. National communications on CC and plans and strategies proposed by the government were included in the sub-category "other relevant documents". The analysis of DRR documents included the "National policy for social protection", a legislative instrument, and two national plans, one for response and the other for disaster risk management (Table 1). The selection of UP documents included a land use planning policy and five legislative instruments (Table 1). Other relevant documents included seven strategy plans and several norms aimed at both national and local (Managua) level.

A content analysis examined the content of the selected policies and regulatory frameworks. Texts were reviewed using keywords (codes). These codes were used to identify sections of text that provided information about the relation of each field to the others, the nature of the connection between them, and synergies. CCA codes were "climate" (clima/climático), "change" (cambio), and "adaptation" (adaptación). UP codes were "urban" (urbano), "planning" (planificación), "land use" (uso de suelo), "land use planning" (ordenamiento territorial) and "cities" (cuidades). DRR codes were: "disaster" (desastre), "risk" (riesgo), "reduction" (reducción), "management" (gestión), "mitigation" (mitigación), "prevention" (prevención), and "vulnerability" (vulnerabilidad).

When a code was found in a document, the section containing the code was classified according to one of the six categories given below:

- (A1) CCA: Extract includes CCA codes.
- (A2) DRR: Extract includes DRR codes.
- (A3) UP: Extract includes UP codes.
- (A4) CCA–DRR: Extract includes codes that show links between CCA and DRR.
- (A5) CCA–UP: Extract includes codes that show links between CCA and UP.
- (A6) DRR–UP: Extract includes codes that show links between DRR and UP.

Next, the results of the content analysis for each classification (environment, DRR and UP) were tabulated. For the review of environmental policies, the six categories listed above were used. For the review of DRR policies and instruments, it was logical to exclude category A2, while category A3 was excluded in the review of the UP material.

[1] Ministerio de Medioambiente y Recursos Naturales (MARENA).

Table 1
List of selected documents.

Environment
Policies
1. Environmental Policy and Plan of Nicaragua 2001–2005 [42][a]
2. Decree No. 25-2001. Establishment of the Environmental Policy and the Approval of the Environmental Plan of Nicaragua [43][b]
3. Decree No.107-2001. National Policy of Water Resources [44][c]
4. Decree No. 70-2006. General Framework for Land Policies [45][d]
5. Decree No. 22-2006. National Policy of Cleaner Production [46][e]
6. Decree No. 69-2008. National Policy for the Sustainable Development of the Forestry Sector of Nicaragua [47][f]

Legislation
7. Decree-Law No. 17-90. Executive Decree for the Creation of the National Commission of Environment and Land Use Planning [48][g]
8. Law No. 217. General Environment and Natural Resources Law [49][h]
9. Decree No. 9-96. Regulation for the General Environment and Natural Resources Law [50][i]
10. Ministerial Resolution No. 014-99. Creation of the Commission for Climate Change [51][j]
11. Decree No. 21-2002. Creation of the National Office of Cleaner Development [52][k]
12. Ministerial Resolution No. 27-2002. National Strategy of Biodiversity and its Action Plan [53][l]
13. Law No. 559. Special Law of Crimes Against the Environment and the Natural Resources [54][m]
14. Law No. 647. Reforms and Additions to the Law No. 217 "General Environment and Natural Resources Law" [55][n]
15. Resolution of the National Assembly No. 003-2009. About Climate Change and its Adaptability in Nicaragua [56][o]

Other relevant documents
16. First National Communication on Climate Change [57][p]
17. National Action Plan for Climate Change [58][q]
18. National Environmental Strategy and Climate Change. Action Plan 2010–2015 [59][r]
19. Second National Communication on Climate Change [60][s]

Disaster risk reduction
Policies
20. National Policy for Social Protection [61][t]

Legislation
21. Law No. 337. The creation of the National System for Disaster Management and Prevention and its Normative [62][u]

Other relevant documents
22. National Disaster Management Plan [63][v]
23. National Disaster Response Plan [64][w]

Urban planning
Policies
24. Decree No. 90-2001. General Policy for Land Use Planning [65][x]

Legislation
25. Decree No. 28-95. Creation of the National Commission for Housing and Human Settlements [66][y]
26. Law No. 309. Regulations, Land Use and Entitlement for Spontaneous Human Settlements [67][z]
27. Decree No. 78-2002. Standards, Guidelines and Criteria for Land Use Planning [68][ab]
28. Municipal Ordinance No. 01-2007 Modifications and Amendments to the Regulations of Urban Development for the Municipality of Managua [69][ac]
29. Law 792. Law of Reforms to the Law No. 40 "Law of Municipalities" [70][ad]

Other relevant documents
30. Proposal of the General Law for Land Use Planning and Territorial Development of the Republic of Nicaragua [71][ae]
31. Regulations for the Central Area of Managua [72][af]
32. General Plan for Municipal Development [73][ag]
33. Minimum Standards for the Dimensioning of Housing Projects [74][ah]
34. Partial Plans of Urban Planning of Managua North-Central, South-West and East [75][ai]
35. National Construction Code [76][aj]
36. National Plan for Human Development 2012-2016 [77][ak]

[a] Política y Plan Ambiental de Nicaragua 2001–2005.
[b] Decreto No.25-2001. Establece la Política Ambiental y Aprueba el Plan Ambiental de Nicaragua 2001–2005.
[c] Decreto No.107-2001. Establece la Política Nacional de los Recursos Hídricos.
[d] Decreto No.70-2006. Marco General de las Políticas de Tierras.
[e] Decreto No. 22-2006. Política Nacional de Producción más Limpia.
[f] Decreto No. 69-2008. Política Nacional de Desarrollo Sostenible del Sector Forestal de Nicaragua.
[g] Decreto-Ley No. 17-90. Decreto Ejecutivo Creador de la Comisión Nacional del Ambiente y Ordenamiento Territorial.
[h] Ley No. 217. Ley General del Medio Ambiente y los Recursos Naturales.
[i] Decreto 9-96. Reglamento de la Ley General del Medio Ambiente y los Recursos Naturales.
[j] Resolución Ministerial No. 014-99. Creación de la Comisión de Cambios Climáticos.
[k] Decreto No. 21-2002. De Creación de la Oficina Nacional de Desarrollo Limpio.
[l] Resolución Ministerial No. 27-2002. Estrategia Nacional de Biodiversidad y su Plan de Acción.
[m] Ley No. 559. Ley Especial de Delitos Contra el Medio Ambiente y los Recursos Naturales.
[n] Ley No. 647. Ley de Reformas y Adiciones a la Ley No. 217, "Ley General del Medio Ambiente y los Recursos Naturales".
[o] Resolución No. 003-2009. Sobre el Cambio Climático y su Adaptabilidad en Nicaragua.
[p] Primera Comunicación Nacional sobre Cambio Climático.
[q] Plan de Acción Nacional Ante el Cambio Climático.
[r] Estrategia Nacional Ambiental y del Cambio Climático, Plan de Acción 2010–2015.
[s] Segunda Comunicación Nacional sobre Cambio Climático.

[t] Política Nacional de Protección Social.
[u] Ley 337. Ley Creadora del Sistema Nacional para la Prevención, Mitigación y Atención de Desastres, sus Reglamentos y Normas Complementarias.
[v] Plan Nacional de Gestión del Riesgo.
[w] Plan Nacional de Respuesta del SINAPRED.
[x] Decreto No. 90-2001. Decreto que Establece la Política General para el Ordenamiento Territorial.
[y] Decreto No. 28-95. Creación de la Comisión Nacional de Vivienda y Asentamientos.
[z] Ley No. 309. Ley de Regulación, Ordenamiento y Titulación de Sentamientos Humanos Espontáneos.
[ab] Decreto No. 78-2002. De Normas, Pautas y Criterios para el Ordenamiento Territorial.
[ac] Ordenanza Municipal No. 01-2007. Modificaciones y Adiciones a las Regulaciones de Desarrollo Urbano del Municipio de Managua.
[ad] Ley No. 792. Ley de Reformas a la Ley No. 40, "Ley de Municipios".
[ae] Proyecto de Ley General de Ordenamiento y Desarrollo Territorial de la República de Nicaragua.
[af] Reglamento del Área Central De Managua.
[ag] Plan General de Desarrollo Municipal.
[ah] Normas Mínimas de Dimensionamiento de Desarrollos Habitacionales.
[ai] Síntesis de los Planes Parciales de Ordenamiento Urbano (Sectores Nor-Central, Sur-Occidental y Oriental).
[aj] Reglamento Nacional de la Construcción.
[ak] Plan Nacional de Desarrollo Humano 2012–2016.

Finally, the historical development of the regulatory framework for each classification was examined, as this provides relevant background in understanding how integration between the fields has developed.

3. Results

The following Sections (3.1–3.3) describe the results of the analysis of the integration of CCA into the 36 selected policies and regulatory frameworks from the fields of environment, DRR and UP.

3.1. Review of the integration of CCA into environmental policies and regulatory frameworks

In 1991, Nicaraguan authorities became interested in the creation of environmental strategies in order to contribute to sustainable development [58]. Five years later, in 1996 the entity that was in charge of environmental issues, the "Institute of Natural Resources" (IRENA),[2] was upgraded to a Ministry, named MARENA. Since then, the new Ministry has gone through a major restructuring process. In 1996, Law No. 217 entitled the "General Law of environment and natural resources" was adopted. This legislative instrument was a major achievement, and the starting point for the creation of policies and instruments for the sustainable management and protection of the environment [58].

By 1992, the Nicaraguan government had accepted the principles and the institutional framework proposed in the UNFCCC and Nicaragua acceded to the Kyoto protocol in 1999. At regional level, in 2008 Nicaragua made a commitment to implement the "Regional Strategy for Climate Change" approved at the Summit on Climate Change and the Environment for Central America and the Caribbean. As a result of these international commitments, MARENA proposed actions to address CC, which were initially focused on CC mitigation and adaptation measures related to ecosystem protection and food production.

[2] Instituto de Recursos Naturales (IRENA).

3.1.1. Environment: Policies

From the overall list of environmental policies, six documents were identified as relevant (Tables 1 and 2). A review of these policies found little information about CC and CCA. There was only one text that addressed all categories (A1–A6). This is the "Decree No. 69-2008: National Policy for the Sustainable Development of the Forestry Sector of Nicaragua". The text promotes the adaptation of land use for vulnerability reduction through, for instance, the restoration of ecosystems, reforestation and the avoidance of deforestation. Because category A1 (CCA) was only mentioned in the above text extract, categories A4 (CCA–DRR) and A5 (CCA–UP) could not be identified in the rest of the documents.

Codes from categories A2 (DRR) and A3 (UP) were more common (Table 2). Twenty-nine references were made in environmental policies to category A2 (DRR) codes and 44 included category A3 (UP) codes. The combined category A6 (DRR–UP) was referenced in six sections of text. There were two policies in particular that included most of the references in this category. They are the "Environmental Policy and Plan of Nicaragua 2001–2005" and the "General Framework for Land Policies" (Table 2). These two documents focus on environmental protection through land use planning and vulnerabilities associated with the degradation of natural resources and productivity. Additionally, both documents highlight links with DRR. For example, the first expresses the importance of monitoring and forecasting disaster risk in order to reduce the negative effect of disasters on the environment.

3.1.2. Environment: Legislation

Three of the nine selected documents in the "legislation" sub-category address CC (Table 2). These documents are:

- "The Ministerial Resolution for the Creation of the Commission for Climate Change" [51]
- "The Decree for the Creation of the National Office of Cleaner Development" [52]
- "The Resolution of the National Assembly: About Climate Change and its Adaptability in Nicaragua" [56].

The first document listed above established a National Commission for Climate Change. It only includes two

Table 2
Classification of references to CCA, DRR and UP codes in current environmental policies and regulatory frameworks[a].

Environment		(A1) CCA	(A2) DRR	(A3) UP	(A4) CCA-DRR	(A5) CCA-UP	(A6) DRR-UP
Year	**Policies**						
2000	Environmental Policy and Plan of Nicaragua 2001–2005	0	4	7	0	0	2
2001	Decree No. 25-2001. Establishment of the Environmental Policy and the Approval of the Environmental Plan of Nicaragua	0	4	8	0	0	1
2001	Decree No.107-2001. National Policy of Water Resources	0	2	0	0	0	0
2006	Decree No. 70-2006. General Framework for Land Policies	0	17	25	0	0	2
2006	Decree No. 22-2006. National policy of Cleaner Production	0	0	0	0	0	0
2008	Decree No. 69-2008. National Policy for the Sustainable Development of the Forestry Sector of Nicaragua	1	2	4	1	1	1
	Legislation						
1990	Decree-Law No. 17-90. Executive Decree of the Creation of the National Commission of Environment and Land Use Planning	0	0	5	0	0	0
1996	Law No. 217. General Environment and Natural Resources Law	0	7	2	0	0	0
1996	Decree No. 9-96. Regulation of the General Environment and Natural Resources Law	0	0	1	0	0	0
1999	Ministerial Resolution No. 014-99. Creation of the Commission for Climate Change	2	0	0	0	0	0
2002	Decree No. 21-2002. Creation of the National Office of Cleaner Development	0	0	0	0	0	0
2002	Ministerial Resolution No. 27-2002. National Strategy of Biodiversity and its Action Plan	0	2	0	0	0	0
2005	Law No. 559. Special Law of Crimes Against the Environment and the Natural Resources	0	1	1	0	0	1
2008	Law No. 647. Reforms and Additions to the Law No. 217 "General Environment and Natural Resources Law	7	3	0	1	0	0
2009	Resolution of the National Assembly No. 003-2009. About Climate Change and its Adaptability in Nicaragua	6	4	0	2	0	0
	Other relevant documents						
2001	First National Communication on Climate Change	15	3	6	0	1	0
2003	National Action Plan for Climate Change	11	6	3	1	0	0
2010	National Environmental Strategy and Climate Change. Action Plan 2010-2015	6	6	3	4	1	2
2009	Second National Communication on Climate Change	14	9	2	5	0	0

[a] The values 0 to X, are the number of document sections containing codes of each field, which are classified according to the following categories: (A1) CCA: Extract includes CCA codes; (A2) DRR: Extract includes DRR codes; (A3) UP: Extract includes UP codes; (A4) CCA-DRR: Extract includes codes that show links between CCA and DRR; (A5) CCA-UP: Extract includes codes that show links between CCA and UP; (A6) DRR-UP: Extract includes codes that show links between DRR and UP.

references to code A1 (CC), which describe the Commission's responsibility for coordinating actions related to CC. This responsibility includes the promotion of participatory approaches to the identification and implementation of CCA measures. The "Decree for the Creation of the National Office of Cleaner Development" allocates institutional responsibilities for follow-up on national commitments made under the UNFCCC agreement and the Kyoto protocol in all sectors. However, this document does not include any codes. The "Resolution of the National Assembly" refers to three categories: A1 (CCA), A2 (DRR) and A4 (CAA–DRR). It emphasizes the importance of CCA due to by the predicted negative effects of CC on human systems in Nicaragua.

The "General Environment and Natural Resources Law" was modified and published as the "Law of Reforms and Additions to the Law No. 217 General Environment and Natural Resources Law". This document includes seven A1 (CCA) codes, but only one A4 (CAA–DRR) code. The same document also contains the definition of CCA proposed by the Intergovernmental Panel on Climate Change (IPCC). This document also shows the importance of incorporating both CC mitigation and adaptation into the planning frameworks of all (urban) sectors:

> Article No. 60. The executive branch of the state must formulate and drive an adaptation policy for climate change, in order to incorporate adaptation and mitigation into sectoral planning (…)[3] [55]

3.1.3. Environment: Other relevant documents

The four documents in the sub-category "other relevant documents" related to environment (Table 2) refer to all six category codes, and include 46 references to code A1 (CCA). The "First Communication on Climate Change" includes one A5 (CCA–UP) code, and the "Second National Communications on Climate Change make five references to A4 (CCA–DRR) codes. The "National Action Plan for Climate Change" suggests CCA measures for the forestry, farming, energy and water resource sectors. Furthermore,

[3] "(…) Artículo. 60. El Poder Ejecutivo deberá formular e impulsar una Política de Adaptación al Cambio Climático, a fin de incorporar la adaptación y mitigación en los planes sectoriales (…)".

in this document CCA is considered in relation to both environmental and more general societal issues:

> (…) adaptation measures are aimed at fulfilling two objectives: to reduce damage and increase the flexibility of societies and ecosystems to unavoidable climate change impacts. In this sense, they usually target the most vulnerable sectors (…)[4] [58]

The "National Environmental Strategy and Climate Change, Action Plan 2010–2015" [59] contains references to all six categories (Table 2). Compared to the other documents in this section it has the largest number of references to categories A4 (CAA–DRR) and A6 (DRR–UP). This document clearly links CCA with DRR, and includes aspects of UP. DRR and CCA are understood as two fields that need to be integrated for the protection of human life. Furthermore, the document shows the need to build capacities and access resources that support integrated actions for DRR, mitigation and adaptation:

> (…)The government has made an effort to build capacity and obtain resources in order to ensure that our population has the capacity to adapt, mitigate and reduce risks in the face of climate change and its negative effects (…)[5] [59]

Most of the environmental policies and legislation that were reviewed focus on the vulnerability of natural resources and the commitments made under international agreements to mitigating CC. Nevertheless, the analysis of other documents highlighted that authorities are expected to integrate CC and CCA issues into all sectoral planning frameworks. In fact, these documents contain the majority of references to the combined categories A4 (CCA–DRR), A5 (CCA–UP), and A6 (DRR–UP).

3.2. Review of the integration of CCA into DRR policies and regulatory frameworks

The negative consequences of the many natural hazards that have affected Central America in the past decade have led to the promotion of DRR both regionally and nationally. A direct outcome was the strengthening of the "Central American Coordinating Centre for Natural Disaster Prevention" (CEPREDENAC)[6] from 1993 to 1998, which coordinates DRR at regional level. In Nicaragua, the "National System for Disaster Management and Prevention" (SINAPRED)[7] coordinates similar work.

SINAPRED was created in 2000 by Law 337 "The Creation of the National System for Disaster Management and Prevention". It remains the most important DRR instrument. Other relevant documents are "The National Plan for Disaster Management" and "The National Response Plan". Many other documents have been proposed by the government in collaboration with other institutions, mostly based upon Law 337.

3.2.1. DRR: Policies

There are no DRR policy documents as such. Although SINAPRED's Executive Secretariat announced on its website plans to develop a DRR policy; since then, nothing has been published. Therefore the analysis focused on the "National Policy for Social Protection", which aims to protect the country's social values.

Category A1 (CCA) codes were not found in any of the DRR documents (Tables 1 and 3). In addition, the "National Policy for Social Protection" contains very little information about UP and DRR. It focuses on addressing poverty and, in this context, includes category A6 (DRR–UP) codes. It outlines the impact of disasters on the urban poor and how this relates to low-quality housing.

3.2.2. DRR: Legislation and other relevant documents

Law 337 "The Creation of the National System for Disaster Management and Prevention and its Normative", the "National Disaster Management Plan" and the "National Disaster Response Plan" include category A6 (DRR–UP) codes. They highlight the importance of land use planning to reduce disasters:

> (…) Article 7. Functions of the National System: (…) No. 5. Anticipate possible damage to the population, physical infrastructure, and environment through a permanent and sustainable process of vulnerability reduction. This must be an essential part of the national development planning through implementation of guidelines and regulation of land use planning (…)[8] [62]

Although this analysis is focused on policies and regulatory instruments at national level, it is important to include relevant instruments at regional level. Nicaragua, like other Central American countries, recognizes the strategic framework for DRR proposed by the Central American Integration System (SICA),[9] coordinated by CEPREDENAC. Related guidelines and commitments are included and coordinated by the "Central American Policy on Comprehensive Disaster Risk Management", which was approved in 2010 [78]. CCA is an integral part of this framework, which aims to strengthen the region's adaptive capacity. In this context, the "Regional Strategy for Climate Change" [79] was proposed. This strategy document reflects the increasing interest of regional authorities in harmonizing current DRR and CC frameworks in Central America.

[4] "(…) las medidas de adaptación persiguen dos propósitos: reducir los daños y aumentar la flexibilidad de las sociedades y ecosistemas a los aspectos inevitables impactos del cambio climático. En este sentido suelen estar orientadas hacia los sectores más vulnerables (…)".

[5] "(…) (el gobierno) ha venido implementando sus propios esfuerzos de gestión, creación de capacidades y consecución de recursos para procurar a nuestra población la capacidad de adaptación, mitigación y reducción de riesgo ante el cambio climático y sus efectos negativo (…)".

[6] Centro de Coordinación para la Prevención de los Desastres Naturales en América Central (CEPREDENAC).

[7] Sistema Nacional Para la Prevención, Mitigación y Atención de Desastres (SINAPRED).

[8] "(…) Art. 7: Funciones del Sistema Nacional: (…) No. 5. Prevé los posibles daños a la población, infraestructura física y el medio ambiente en general, mediante un proceso permanente y sostenido de reducción de la vulnerabilidad, como parte esencial de la planificación del desarrollo nacional, mediante la aplicación de las directrices y regulaciones del ordenamiento territorial (…)".

[9] Sistema de Integración Centroamericana (SICA).

Table 3
Classification of references to CCA and UP codes in DRR policies and regulatory frameworks for DRR[a].

DRR		(A1) CCA	(A3) UP	(A4) CCA-DRR	(A5) CCA-UP	(A6) DRR-UP
Year	**Policies**					
2003	National Policy for Social Protection	0	1	0	0	1
	Legislation					
2000	Law No. 337. The Creation of the National System for Disaster Management and Prevention and its Normative	0	4	0	0	4
	Other relevant documents					
2004	National Disaster Management Plan	0	13	0	0	6
2008	National Disaster Response Plan	0	4	0	0	3

[a] The values 0 to X, are the number of document sections containing codes of each field, which are classified according to the following categories: (A1) CCA: Extract includes CCA codes; (A2) DRR: Extract includes DRR codes; (A3) UP: Extract includes UP codes; (A4) CCA-DRR: Extract includes codes that show links between CCA and DRR; (A5) CCA-UP: Extract includes codes that show links between CCA and UP; (A6) DRR-UP: Extract includes codes that show links between DRR and UP.

> (…) The council of Ministers of the 'The Central American Commission of Environment and Development' (CCAD), in coordination with the board of representatives of CEPREDENAC, will issue measures for aligning the policies, strategies, and strategic plans for both risk reduction and environmental management, within their different components and joint instruments. This refers mainly to components and instruments related to climate change adaptation, the management of the cultural heritage, and more specifically to the prevention of forest fires and the comprehensive management of water resources (…)[10] [78]

3.3. Review of the integration of CCA into UP policies and regulatory frameworks

UP regulations in Nicaragua are very limited [25]. Following the 1982 earthquake in Managua, some important UP instruments were proposed. Nonetheless, few were successfully implemented because of the political situation at the time and their failure to address the national context [39]. Thus, the local authorities of Managua and other major cities still lack planning instruments for the regulation of urban development. The documents related to UP used in the analysis are shown in Tables 1 and 4.

3.3.1. UP: Policies

Neither the "General Policy for Land Use Planning", nor ten of the other 13 documents in the UP section refer to category A1 (CC) codes. However, the "General Policy for Land Use Planning" does include seven references to both category A2 (DRR) and A6 (DRR–UP) codes (Table 4). This document highlights the importance of linking DRR and UP for achieving sustainable development by considering hazards and the vulnerabilities of natural resources and human settlements in land use planning. The following quotation from this policy shows that the general objective of this document directly relates to DRR.

> Article 1. The establishment of the policy of land use planning has the objective to guide the use of the land in a sustainable way. Including natural resources and the prevention and mitigation of natural disasters (…)[11] [65]

3.3.2. UP: Legislation

No codes were identified in the following two pieces of legislation: the decree "The Creation of the National Commission for Housing and Human Settlements"; and the municipal ordinance "Modifications and Amendments to the Regulations of Urban Development for the Municipality of Managua".

In the "Regulations, Land Use and Entitlement for Spontaneous Human Settlements" law, three sections were identified which contain category A2 (DRR) codes and two references were found to category A6 (DRR–UP) codes. The document highlights the importance of avoiding risk areas in urban development. Similarly, the "Law of Reforms to the Law No. 40: Law of Municipalities" includes one reference to both category A2 (DRR) and A6 (DRR–UP) code. Both texts highlight the significant responsibility of urban authorities in the implementation of the construction code to reduce risk.

3.3.3. UP: Other relevant documents

In the "other relevant documents" sub-category, the "National Plan for Human Development 2012–2016" [77] has twenty examples of category A1 (CC) codes. These sections of text show that some aspects of CCA are considered to be of utmost importance to the country's food production, economic development, environment, security and sustainable development. The document encourages the countries of the region to make a joint

[10] "(…) El Consejo de Ministros de la CCAD en coordinación con el Consejo de Representantes del CEPREDENAC, dictarán las medidas para alinear en la escala nacional, las políticas, estrategias y planes de gestión de riesgo y de gestión ambiental en sus componentes e instrumentos comunes, principalmente los de adaptación al cambio climático, de gestión del patrimonio natural, en particular la prevención de incendios forestales y de gestión integral de los recursos hídricos (…)".

[11] "Artículo 1.—Se establece la Política General para el Ordenamiento Territorial, con el objetivo de orientar el uso del territorio en forma sostenible; entre los cuales se incluyen los recursos naturales, la prevención y mitigación de desastres naturales (…)".

Table 4
Classification of references to CCA and DRR codes in current UP policies and regulatory frameworks[a].

UP		(A1) CCA	(A2) DRR	(A4) CCA-DRR	(A5) CCA-UP	(A6) DRR-UP
Year	**Policies**					
2001	Decree No. 90-2001. General Policy for Land Use Planning	0	7	0	0	7
	Legislation					
1995	Decree No. 28-95. Creation of the National Commission for Housing and Human Settlements	0	0	0	0	0
1999	Law No. 309. Regulations, Land Use and Entitlement for Spontaneous Human Settlements	0	3	0	0	2
2002	Decree No. 78-2002. Standards, Guidelines and Criteria for Land Use planning	0	10	0	2	8
2007	Municipal Ordinance No. 01-2007 Modifications and Amendments to the Regulations of Urban Development for the Municipality of Managua	0	0	0	0	0
2012	Law 792. Law of Reforms to the Law No. 40 "Law of Municipalities"	0	1	0	0	1
	Other relevant documents					
1995	Regulations for the Central Area of Managua	0	20	0	0	6
2002	General Plan for Municipal Development	0	6	0	2	2
2005	Minimum Standards for the Dimensioning of Housing Projects	0	1	0	1	1
2005	Partial Plans of Urban Planning of Managua—North Central, South-West and East	0	18	0	0	8
2007	National Construction Code	0	9	0	0	0
2012	National Plan for Human Development 2012-2016	20	19	3	1	2
2012	Proposal of the General Law for Land Use Planning and Territorial Development of the Republic of Nicaragua	5	6	2	4	6

[a] The values 0 to X, are the number of text section that contain codes of each field, which are classified in the following categories: (A1) CCA: Text section including codes from the CCA field; (A2) DRR: Text section including codes from the DRR field; (A3) UP: Text section including codes from the UP field; (A4) CCA-DRR: Text section including codes that show links between CCA and DRR; (A5) CCA-UP: Text section including codes that show links between CCA and UP; (A6) DRR-UP: Text section including codes that show links between DRR and UP.

effort to manage and finance CCA initiatives. It also argues that public and private investors must consider CCA measures and associated budgets:

> (…) the adaptation (to climate change) is closely linked to a model of sustainable development that requires strong public and private investments in infrastructure to reduce vulnerabilities of the population (…)[12] [77]

The "Proposal of the General Law for Land Use Planning and Territorial Development of the Republic of Nicaragua" includes all six category codes (A1–A6). In this document, CCA is presented as an essential condition that has to form part of urban development and land use planning processes to ensure an increase in the adaptive capacity of the country, food security, productivity and the protection of human life:

> (…) Guiding principles: No. 1. Climate change adaptation and mitigation: The territorial development and land use planning processes must take into account both the environmental transformations and the existing risks in the national territory which result from climatic change, and establish the needed measures to increase the adaptive capacity of the country (…)[13] [71]

4. Discussion

In Nicaragua, many of the developments in the fields of environment, DRR and UP have only happened recently. The Ministry of Environment and Natural Resources (MARENA) was established in 1996, and the National System for Disaster Management and Prevention (SINAPRED) was created in 2000. As regards UP, most of the current regulatory instruments have only entered into force in the past decade.

The ratification of the UNFCCC in 1995 and the adoption of the Kyoto protocol in 1999 (through the Decree 94–99: "Ratification of the Kyoto Protocol of the United Nations Framework Convention on Climate Change" [80]) coincided with the restructuring of MARENA, beginning in 1996, which became the institution responsible for CC management. This is why CC and CCA codes were not found in the older instruments included in this analysis.

[12] "(…) La adaptación está íntimamente vinculada a un modelo de desarrollo sostenible que requiere por lo tanto fuertes inversiones públicas y privadas en infraestructuras que reduzcan la exposición de la población a vulnerabilidades (…)".

[13] "(…) Principios rectores: No 1. " Adaptación y Mitigación al Cambio Climático: Los procesos de ordenamiento y desarrollo territorial deben tomar en cuenta las transformaciones ambientales y riesgos en el territorio nacional, como producto del cambio climático, y estableciendo las medidas necesarias para elevar la capacidad de adaptación del país (…)".

Following the restructuring of MARENA, new policies and regulatory instruments have been created and existing ones have gradually been improved through additions and complementary instruments. This has led to significant advancements in the integration of CC, including mitigation and adaptation aspects. The "Ministerial Resolution for the Creation of the National Commission for Climate Change" in 1999 is an example of significant progress.

The development of policies and regulatory frameworks related to the issues of the environment, DDR and UP reflects general developments in the understanding of CCA. It has evolved from a very restricted concept to a more comprehensive approach, which includes the protection of the natural and human environment and need to be mainstreamed into all kinds of urban sector work. The 2003 "National Action Plan for Climate Change" presents CCA as a broad and inclusive concept and refers to the adaptation strategies and measures proposed by the IPCC. However, it was not until 2008 that a more comprehensive approach to CCA began to be integrated into existing regulatory frameworks. Before 2008, efforts to address CC purely focused on climate change mitigation, the protection of natural resources in general, and food production in particular. Since 2008, new environmental decrees and instruments have been proposed that address CC-related risk and vulnerability. Examples are the "Law of Reforms and Additions to Law No. 217" from 2008, which is an update to the national environmental law, and the "National Environmental Strategy and Climate Change Action Plan 2010–2015" from 2010, which states that the infrastructure of cities needs to be adapted to CC.

This review shows that the integration of CCA has seen greatest advances in the context of existing environmental and planning policies and regulations, and not in the field of DRR. However, it is only the government's most recent environmental and planning documents that clearly recognise the need to build on the synergies between CCA, DRR and UP. These are the "National Environmental Strategy and Climate Change, Action Plan 2010–2015", and the "Proposal of the General Law for Land Use Planning and Territorial Development of the Republic of Nicaragua". Both documents promote UP as a tool for the reduction of CC-related vulnerabilities and disasters in general. In contrast, DRR is regulated by Law 337, which lacks policies and other regulatory instruments to support its implementation and integration with CCA.

Whilst links between DRR and UP were seen most frequently in the documents reviewed, there were few concrete proposals for strategies, plans and/or measures to adapt urban environments to CC. This is because of the lack of: (a) up-to-date regulatory frameworks for UP; (b) related operational instruments; and (c) effective enforcement. All of these aspects present a major obstacle to the development and implementation of concrete CCA plans and measures in the urban context.

At the regional level, CCA has only recently been integrated into policies and strategies, but a comprehensive approach that would create synergies between DRR, CCA and UP is lacking. The "Central American Policy on Comprehensive Disaster Risk Management" [78] hardly considers urban risk and vulnerability since it forms part of the "The Regional Agro-Environmental and Health Strategy" [81], which is very much focused on issues of agriculture and health.

Finally, the results of this review show that policies and related changes are strongly influenced by the international community. Many policies related to CCA explicitly refer to regional and international obligations that Nicaragua needs to meet. When it comes to DRR, the lack of national policy means that actions in the field are mostly supported and guided by regional and international frameworks, such as the Central American Policy on Comprehensive Disaster Risk Management [78] and the Hyogo Framework for Action [15]. The policies and regulations examined in the analysis that included CCA information are consistent with the recommendations found in key international documents for improving coordinated action between CCA and DRR (such as the Hyogo Framework for Action 2005–205 [15] and the IPCC-SREX [7]). For example, recommendations related to participative decision-making processes for the inclusion of mitigation and adaptation measures into all planning sectors is one of the responsibilities of the National Commission for Climate Change. Similarly, the "National Environmental Strategy and Climate Change, Action Plan 2010–2015" promotes education programmes that involve local government and the inclusion of traditional knowledge into CCA. In addition, this document indicates that adaptation is possible by using a comprehensive DRR approach that is implemented before, during and after potential hazard occurrence.

In sum, although there seems to be no explicit intention to integrate CCA into DRR and UP, there is a clear concern that coordination between the three fields is needed. However, it is fragmented; it is found in various policies and regulatory instruments, supported in part by international agreements.

5. Conclusions

This study shows the potential challenges that developing countries, mostly in Central America, face in integrating CCA at policy level, and the influence of international and regional agreements. There is clear progress in the integration of CCA into policy and regulatory frameworks concerning the environment, DRR and UP in Nicaragua, although integration is still in an early stage. The integration of CCA into policies and regulations has gradually evolved since it began in 1999. It is subject to ongoing national, regional and international developments. The extent of integration is different in each field. This review demonstrates that CCA integration is most advanced in the field of the environment since Nicaragua's international commitments, such as the adoption of the Kyoto Protocol in 1999, have had a strong influence on the CC integration progress.

The recent creation of the CCA, DRR and UP fields in Nicaragua has brought important advantages and disadvantages for their integration. The analysis shows that whilst regional, national and local authorities are increasingly concerned with CC management, current policies and regulatory frameworks do not yet include consolidated guidance about how to manage CCA in a holistic manner. Nevertheless, the lack of adequate general frameworks also

translates into continuous modifications and the creation of new policies and regulatory frameworks, which offer new opportunities for the integration of CCA.

Although the main focus of current CC-related policies and regulatory frameworks is still the protection of natural resources, agricultural and food production, policy advances and related institutional structures have the potential to increase the effectiveness of CCA integration. The integration process started with a focus on climate change mitigation, during which time official documents and policies were created to manage the causes of CC. Nowadays, related instruments and structures (such as the National Commission for Climate Change) have the potential to assist in supporting and improving the integration of CCA into DRR, UP and other sectors. To tap into this potential, a regular and systematic review of existing policies and regulatory instruments needs to be performed in order to assess the synergies and gaps between CCA, DRR and UP. This requires inter-sectoral and participative work with the actors concerned at national and local level, as well as the establishment of related monitoring and learning mechanisms.

Currently the integration of CCA into DRR regulations is almost non-existent because of the lack of policy and official instruments. Although Nicaragua has achieved significant progress in DRR, its regulatory framework is limited. In practice, DRR actions are mainly supported by regional and international, rather than national instruments. The integration of CCA and DRR is thus not evident at the national policy level. However, the on-going creation of a DRR policy in Nicaragua provides a great opportunity to improve CCA integration. In this process, the authorities need to take into account recommendations found in international policies and documents to increase CCA integration, experience from countries with similar contexts, and identify potential national policies and regulations in order to avoid parallel mechanisms and make the most effective use of resources.

With respect to current UP, this review shows that the integration of UP and CCA is very limited because of the lack of up-to-date regulatory and related operational planning instruments. On the one hand, the review highlights that there are many links between UP and DRR, and most of the instruments show that land use planning and UP in general are seen as important tools for DRR. On the other hand, links between UP and CCA are weak. This relates to the lack of up-to-date regulatory planning policies and regulations, which hinders comprehensive integration. Existing frameworks do not address climate-related problems and vulnerabilities in urban areas. The restructuring and evaluation of current UP policy and the regulatory framework is thus an urgent task. Modifications to these instruments to take into consideration synergies between CCA and DRR are crucial for improved risk reduction and adaptation planning.

Finally, the early stages of the integration of CCA into DRR and UP are an opportunity to consolidate and evaluate strategies for reducing the impacts of CC. In general, this review shows that policies and regulatory frameworks for the environment, DRR and UP include important provisions for the reduction of vulnerabilities to CC in urban systems. The main limitation is that the information in these documents is fragmented. Once again, this shows the need to create mechanisms to evaluate current policy and regulatory frameworks, to monitor related modifications, and to learn from the implementation of urban risk reduction and adaptation planning.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.ijdrr.2013.12.008. These data include Google map of the most important areas described in this article.

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Paper II

PLOS | CURRENTS DISASTERS

Integrating Climate Change Adaptation into Disaster Risk Reduction in Urban Contexts: Perceptions and Practice

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Abstract

This paper analyses the perceptions of disaster risk reduction (DRR) practitioners concerning the on-going integration of climate change adaptation (CCA) into their practices in urban contexts in Nicaragua. Understanding their perceptions is important as this will provide information on how this integration can be improved. Exploring the perceptions of practitioners in Nicaragua is important as the country has a long history of disasters, and practitioners have been developing the current DRR planning framework for more than a decade. The analysis is based on semi-structured interviews designed to collect information about practitioners' understanding of: (a) CCA, (b) the current level of integration of CCA into DRR and urban planning, (c) the opportunities and constraints of this integration, and (d) the potential to adapt cities to climate change. The results revealed that practitioners' perception is that the integration of CCA into their practice is at an early stage, and that they need to improve their understanding of CCA in terms of a development issue. Three main constraints on improved integration were identified: (a) a recognized lack of understanding of CCA, (b) insufficient guidance on how to integrate it, and (c) the limited opportunities to integrate it into urban planning due to a lack of instruments and capacity in this field. Three opportunities were also identified: (a) practitioners' awareness of the need to integrate CCA into their practices, (b) the robust structure of the DRR planning framework in the country, which provides a suitable channel for facilitating integration, and (c) the fact that CCA is receiving more attention and financial and technical support from the international community.

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INTRODUCTION

There is increasing recognition that disaster risk reduction (DRR) should include climate change adaptation (CCA) [1]. CCA and DRR have been developed by different communities, but the aim of both is to reduce vulnerability and hazard exposure in order to increase resilience to the potential adverse impacts of climate extremes [2]. Both DRR and CCA require collaborative and coordinated actions [3]. The integration of the two fields provides opportunities to strengthen the common parts and improve the management of present and future hazards and risks [4]. Moreover, it is commonly accepted that development and sustainable goals may be facilitated by integrating CCA into DRR [5]. Just as importantly, the lack of integration of these fields will lead to redundant and conflicting responses [6].

The need to address DRR and CCA simultaneously in order to achieve coordinated actions has been stressed by both UNISDR [7] and IPCC-SREX report [2]. The latter states, for instance, that "countries more effectively manage risks if they include considerations of disaster risk in national development and sector plans and if they adopt climate change adaptation strategies, translating these plans and strategies into actions targeting vulnerable areas and groups" (p.10).

The need for integration of CCA is especially urgent in cities. The risk in urban areas is, for instance, aggravated by the fact that cities concentrate population, economic activities and built environments [8]. The population of cities is constantly increasing, and if risk management is not taken into consideration in urbanization processes the risks will also increase [9]. Thus, considering urban planning in the process of integration of CCA into DRR is a matter of urgency, not only due to the fact that vulnerabilities of cities need to be addressed, but also urban risk management is a potential entry to CCA and DRR [3].

Against this background, the purpose of this study was to describe the extent to which DRR practitioners are taking into consideration the creation of synergies and coordination between CCA and DRR. More specifically, this paper attempts to answer the question, "How do disaster risk reduction practitioners perceive the on-going integration of climate change adaptation into their work on urban

development?" The integration of CCA into the policies and regulatory frameworks of DRR, the environment and urban planning in Nicaragua was analysed in a previous, quantitative, study [11]. The purpose of the present, qualitative, study of the integration process is to complement this previous study.

The country studied is Nicaragua, which has a long history of dealing with disasters. Considerable amounts of knowledge and experience have been gained, and important advances have been made, in implementing DRR in Nicaragua, as well as in other Central American countries [12, 13]. Exploring how DRR practitioners deal with the integration of CCA provides valuable information on how CCA can be improved and on factors that may be limiting its implementation [14]. Also, understanding the constraints of adaptation, and its integration process, contributes to the ability to assess, and consequently improve, decision-making processes [15].

The paper is organised as follows: Section 2 describes the background of the case study, Section 3 presents the conceptual framework, Section 4 presents the methods used and Section 5 presents the results and the analysis. Finally, the results are discussed in Section 6 and the conclusions are presented in Section 7.

BACKGROUND

After the devastation in Central America caused by the hurricane Mitch in 1998, national and international actors have been working on building capacities at all levels of government in order to reduce vulnerabilities in Nicaragua [16]. The response of the Nicaraguan Government was to pass Law 337, which created the National System for Disaster Management and Prevention (SINAPRED in Spanish). Nowadays, this is the governmental body in charge of coordinating all DRR actions in the country. This system works in a top-down structure that coordinates all the institutions (government, non-government and private institutions) in the country that follow the decision-making process of the national committee formed by the authorities at the national level [17].

The subject of climate change was introduced in Nicaragua after the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The Kyoto protocol was ratified in 1999 by the Nicaraguan National Assembly. Since pledging to adhere to these international agreements, the national authorities have proposed climate policies and strategies [48]. The National Strategy on climate change is managed by a top-down structure, where the decision-making process has three levels: the creation of legislation by the National Assembly, its implementation by the Ministries and their territorial delegations, and its management by the Ministry of Environment and Natural Resources (MARENA in Spanish) [17].

CONCEPTUAL FRAMEWORK

There is an increasing amount of literature that identifies links, and the need to create synergies between CCA and DRR [e.g. 1, 5, 24]. The IPCC-REX report [2] and the "Implementation of the Hyogo Framework for Action" [7] both strongly encourage the actors from both fields to coordinate their actions more closely. Each of these fields has different concepts and approaches that provide important inputs to the knowledge base on how to deal with climate-related events [2]. Descriptions of the most important concepts from both fields, used in this paper, are presented below.

Significant experience in dealing with disasters has been achieved in the field of DRR [25]. DRR was established as a conceptual and operational approach to reduce the risk of disasters through systematic efforts to analyse and manage causal factors of disasters and risk, and includes the reduction of hazard exposure and the reduction of vulnerability of people and property [26]. Substantial efforts have been made within this field to reduce the impact of both natural and manmade disasters on people and their livelihood 1.

Disasters are exacerbated by the effects of climate change, which will continue to affect the goals of achieving sustainable development [2, 27]. One of the latest definitions of climate change, published in the IPCC-SREX report [2], was "a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use". Human and natural systems can respond to climate change by adapting to its impacts [27]. CCA is a process and related actions aimed at reducing the vulnerability of systems (e.g. urban systems) to the adverse impacts of anticipated climate change [20].

The fields of CCA and DRR have significant overlaps in managing risk to development [6, 28]. The main overlaps are: (a) sharing the same aim of reducing the effects of climate-related disasters and associated risks; (b) common stakeholders; (c) activities and measures for addressing climate-related disasters at household or community level [29].

Mainstreaming CCA into DRR is, thus, important in order to take actions to reduce the impact of extreme events [23]. In this paper, mainstreaming is used to describe a specific way of integrating CCA into DRR. The term mainstreaming generally signifies the modification of a specific type of core work (such as urban planning) in order to take a new aspect or topic (such as CCA) into account, and to act indirectly upon it [29, 30, 31]. It does not mean completely changing an organisation's core functions or responsibilities, but instead viewing them from a different perspective and carrying out any necessary alternations. It is about looking into what already

exists and building as much as possible on existing structures, mechanisms and procedures [29].

The integration of CCA and DRR must take into consideration aspects that will reduce vulnerabilities in cities because it is here a large proportion of those at risk from the effects of climate change are to be found [20]. Thus, mainstreaming CCA in urban planning may allow coordinated and strategic actions to avoid the creation of unmanage-able levels of risk to a city's built environment and population [9]. In this paper, urban planning is defined as a discipline and a practical way of shaping and modifying urban settlements and space [18].

There is an increasing amount of literature containing recommendations and approaches for mainstreaming CCA into sustainable development and DRR [e.g. 32, 21, 33, 34, 35, 36]. The main-streaming process depends on the specific decision-making settings in different contexts [33]. The approaches are not identical, but they share some aspects that may support the mainstreaming of CCA into DRR practice. Some studies are focused on overcoming barriers to the mainstreaming of CCA [e.g. 15 , 38], and propose processes related to mainstreaming actions during the planning phase [e.g. 32, 33, 36]. Other studies are focused on mainstreaming CCA at the project level [e.g.21, 33, 34, 35]. Some of the recommendations suggested to have the potential to improve the process of mainstreaming in practice are given in Table 1 below.

Table 1. Approaches for mainstreaming CCA

APPROACHES	REFERENCES
a) Understanding CCA in its political, institutional and government contexts. Practitioners at organisational level must also be aware of the activities of their organisations and relation with CCA.	CARE 2009, OECD 2009, Harris and Bahadur 2011, UNDP-UNEP 2011, Wamsler et al. 2013
b) Understanding the international and national regulatory and political frameworks related to CCA. This approach encourages practitioners to revise their plans, programmes and activities, and their connections with CCA, and to assess how their current and future programmes can be affected by climate change.	Mitchell, Tanner et al. 2006, CARE 2009, OECD 2009, Harris and Bahadur 2011, Wamsler et al. 2013
c) Evaluation and strengthening of institutional capacity to create tools to mainstream CCA and allocate resources.	Mitchell, Tanner et al. 2006, CARE 2009, UNDP-UNEP 2011, Wamsler et al. 2013
d) Engaging stakeholders and building partnerships with government and non-governmental actors at all levels in order to create or improve their degree of coordination.	Mitchell, Tanner et al. 2006, Harris and Bahadur 2011, UNDP-UNEP 2011, Saito 2013, Wamsler et al. 2013
e) Influencing the decision-making process and developing CCA measures.	UNDP-UNEP 2011, Wamsler et al. 2013
f) Improvement of monitoring systems for the mainstreaming process.	Moser and Ekstrom 2010, Harris and Bahadur 2011, UNDP-UNEP 2011, Saito 2013, Wamsler et al. 2013
g) Learning through experience obtained from the implementation of CCA measures at local level.	Mitchell, Tanner et al. 2006, Harris and Bahadur 2011, UNDP-UNEP 2011, Saito 2013, Wamsler et al. 2013

METHODS

The analysis in this study is based on qualitative semi-structured interviews. This method provides the opportunity to identify the meanings people attribute to their experience [39]. The semi-structured interviews used in this study explore the reflections of the practitioners on the extent to which CCA is integrated into their practice of DRR in urban areas. As a way to operationalize the research question, the interviews were designed to collect individual-level information according to five specific aspects: (a) understanding CCA, (b) links between CCA and DRR, (c) links between CCA and urban planning, (d) potential measures to adapt cities to climate change, and (e) obstacles, gaps and opportunities for linking CCA with DRR and urban planning.

Purposive and snowball sampling were used for the selection of respondents. The former was used initially for the selection of respondents, to identify individuals that have knowledge of, or work in, the fields under study [40]. The "Virtual Library of Disasters" [22] was used for guidance. This is a website that has a list of the institutions involved in DRR in Nicaragua. The snowball sampling method was used during the development of the interviews, by asking for the names of other people who knew about the topic, and who worked in the same field [19]. After the interviews, the practitioners that participated were classified into three groups according to the type of organisation in which they worked: government organisations, non-government organisations (NGOs) and universities. Although the public universities included in the third group belong to the government, their work and coordination is quite different from that of the government organisations covered in this study.

Nine interviews were conducted, including three operational officers, three academic staff and three programme managers (Table 2)[1]. Two of these interviewees also work in SINAPRED. Three of the respondents were from international NGOs, and four were from public universities.

[1] Only a limited number of participants were included, but they provided the perspective of the most important groups of practitioners in the country: governmental, non-governmental and academia. The study depended on their willingness to participate and their working agenda. One limitation of this study was confusion by some respondents when recommending other professionals that were not involved in the fields being studied. This can be interpreted as a finding in itself: i.e. that it is difficult for some practitioners to identify professionals working in CCA. Also, a theoretical saturation has occurred when no major new finding was gained and the latest respondents provided similar answers than the previous ones. However, the participants included in the study provided important clues on how integration is being dealt with.

Table 2. Respondents of the semi-structured interviews

INSTITUTION	TYPE OF STAFF	TYPE OF INSTITUTION	LEVEL
SINAPRED	Operational officer	Government	National
SINAPRED	Operational officer	Government	National
DIPECHO- European Commission	Programme manager	NGO	Regional
Habitat for Humanity	Programme manager	NGO	Local
Programme for Climate Change Technology Transfer Centers in Europe and Latin America	Academic	NGO	National
Multidisciplinary Regional Faculty of the Autonomous University of Nicaragua (FAREM-UNAN)	Academic	University	National
National University of Engineering (UNI)	Programme manager	University	National
Cleaner Production Center of Nicaragua (CPML – UNI)	Operational officer	University	National
Programme for Science and Technology for Development (PROCYTED – UNI)	Academic staff	University	Nationa

Transcriptions of the interviews were examined, and segments of data were classified into six categories[2], using the content analysis method [41], using keywords to identify sections of texts that provided information about the relation of each field to the others, the nature of the connection between them and synergies. The following six categories were used:

(A1) CCA: the understanding of CCA

(A2) CCA-DRR: the links between CCA and DRR

(A3) CCA-Urban planning: the links between CCA and urban planning

(A4) CCA measures: potential adaptation measures for urban areas

(A5) Obstacles/gaps: aspects that hinder the integration of CCA and DRR

(A6) Opportunities: opportunities to improve the integration of CCA and DRR

[2] These six categories were also used by Rivera and Wamsler (2014) [11] to explore the integration of CCA into the policy and regulatory frameworks of both DRR and urban planning in Nicaragua.

Section 4 presents the results of this analysis using examples of the most relevant segment of data from the transcribed interviews.

RESULTS AND ANALYSIS

Understanding climate change adaptation

During the interviews, the respondents were asked to explain their understanding of CCA. The key patterns identified were:

- CCA is key for sustainable development,
- CCA is a mainstreaming issue,
- CCA is under the control of environmental and technical institutes in the country, and there is a lack of understanding of how to mainstream CCA in practice.

All the respondents said that CCA is important for sustainable development, and they all considered that CCA is a mainstreaming issue in all working sectors of the country. However, they also expressed the opinion that CCA has been managed by technical institutions. They said that most CCA strategies and plans proposed by the government have been focused on environmental issues. One respondent expressed the following views:

> "(…) there are institutions that think that climate change is exclusively for technical organisations. They do not see it with a multidisciplinary and institutional vision because climate change is not only about the atmosphere (…) it is about health, food security, productivity. I mean, there are many aspects about CCA that are not clear for many institutions, not yet (…)"[i]

The majority of them recognised that it is often not clear how measures for reducing the impact of climate-related events can be introduced into their practice, and in all the sectors of the country. They said that improving the understanding of the impacts of climate change in the DRR community and among urban planners, would be one important way to improve the integration of CCA.

Climate change adaptation and disaster risk reduction

The identified key patterns of the respondents' understanding of the links between CCA and DRR were:

- CCA forms part of DRR actions,

- DRR and CCA are not different fields of work,
- the integration of CCA into DRR has started, and is currently focused on the creation and modification of policy frameworks and existent DRR methodologies, and
- universities are seen as potential driving forces to further integrate CCA into DRR, urban planning, and other areas.

All the respondents said that CCA is part of DRR, since climate-related events are included in DDR activities for managing risks. Furthermore, one respondent expressed the opinion that CCA and DRR converge in the same objective and that, in some way, they are working on the same actions but in different fields. The respondent said:

> "(…) these two worlds have not yet found how to avoid doing the same things, but with different names, … in the end, we employ climate change adaptation, but it is included in disaster risk reduction. Full stop! (…)"[ii]

Two of them expressed the opinion that there is no difference between CCA and DRR. Thus, they said that climate-related risks should be dealt with as part of DRR, and it is not necessary to manage the same risks using two different frameworks. One of these respondents said that managing CCA and DRR in different structures would create confusion and the duplication of actions.

> "(…) conceptually, there is no difference between traditional disaster risk reduction and climate change adaptation. Climate change is a risk just like any other. Perhaps the origin …, some risks might arise from natural hazards, and this is about exacerbated hazards caused by human beings (…)"[iii]

The respondents were asked to give examples of how they link the two fields in their work. The most concrete example was given by the respondents from the government organisation. They said that the integration of these fields has started by improving the current regulation system and creating projects that include issues from both fields. They explained that there are many aspects where CCA is integrated into the DRR framework at regional and national level. They specifically mentioned three ways in which this is achieved. The first is related to the approval of the "Policy on Comprehensive Disaster Risk Management in Central America"[3] (PCGIR in Spanish) in 2010, which includes a programmatic area focused on CCA. The second is

[3] The PCGIR is available at:
http://www.sica.int/busqueda/Centro%20de%20Documentaci%C3%B3n.aspx?IDItem=44921&IdCat=32&IdEnt=22&Idm=1&IdmStyle=1

through the "National Policy of Disaster Risk Reduction" to be approved by the National Assembly. They explained that this policy includes a chapter on CCA. Finally, methodologies for DRR plans at local level are modified by adding CCA aspects.

The respondents from the universities stated that some departments are working on DRR educational projects, while others did not have any specific DRR programmes. One respondent from the National University of Engineering (UNI) said that there was a lack of departments at the university working on disaster risk reduction or climate change. However, some professors are very interested in the topics, and they are developing studies in this area, based on their own initiatives and involving some students.

All the respondents from the universities said that CCA could be easily integrated into their universities' curricula, and that this would facilitate mainstreaming. For instance, the respondent from the National Autonomous University of Nicaragua (UNAN) described a project[4] supported by the Swiss Development Cooperation and the NGO German Agro Action. The objective of this project is to train staff from universities, local government and NGOs in DRR. The project provides knowledge and methodological tools for integrating DRR into practice and improving actions in this field. CCA is one of the aspects included in the training material.

> "(…) we work on the training of technicians from institutions such as municipalities and other governmental organizations and NGOs. So, once they acquire the knowledge, they can apply it locally in preparation for disaster risk reduction (…)"[iv]

Climate change adaptation in urban planning

All the respondents expressed the opinion that managing risks in cities is highly important. The key patterns of the respondents' understanding of the integration of CCA in urban planning are:

- the integration of CCA into urban planning is important to address the increasing impact of climate change on cities,
- few practitioners include CCA in urban planning, and
- very limited advances have been made in urban CCA due the lack of instruments and institutional capacity.

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[4] FAREM-UNAN/Estelí coordinates the project "Center for continuing education and training on risk management and disasters" http://www.farem.unan.edu.ni/riesgo/index.html.

The majority of respondents said that the areas of the country most affected by climate-related events are the largest cities, such as Managua and Estelí. They expressed the opinion that managing risks in cities is important in order to reduce the impact of climate change. A respondent from a government organisation said that land use planning and urban planning are aspects that must be considered in prevention planning. He also said that climate change could not be addressed if the urban contexts were not included in the analysis.

The respondent from the European Commission explained that after long experience of working in rural areas it was realized that DRR is also important in urban centres. For this reason, 75% of their current projects in Central American are focused on urban contexts. This respondent also explained that they are working on promoting DRR at local level through the campaign "Making Cities Resilient"[5] of the United Nations Office for Disaster Risk Reduction. Within the frame-work of this campaign, they are working on training and increasing awareness of disaster risk reduction among the cities' mayors.

Most of the respondents think that only a few practitioners and instruments are focused on managing CCA in urban areas. Two respondents said that local governments have the opportunity to improve DRR actions at local level and to integrate CCA measures in urban areas. However, they said that the few projects that could integrate CCA into urban planning were not noticeable. One respondent said:

> "(…) there have only been a few people working in this area (CCA). I mean, even less than the ones involved in disaster risk reduction, and even less in urban scenarios, but the few people involved have not had the capacity to influence the rest to create a culture in their institutions…at least at the level I participated in or knew (…)"[v]

Also, the majority of respondents said that the integration of CCA in urban contexts is not having a real impact because of the lack of instruments and capacities of local and national governments. There was a general understanding that improvement of the instruments and regulations concerning urban planning could contribute to the reduction of disasters, including those caused by climate change.

Climate change adaptation measures in urban areas

To investigate the understanding of current and potential linkages between CCA and urban planning, the respondents were asked to give examples of potential measures that could be used to adapt cities to climate change. They suggested physical and

[5] http://www.unisdr.org/campaign/resilientcities/

non-physical measures that have potential for adapting urban areas to expected events resulting from climate change (Table 3). They were also asked to describe measures that they had already applied in their programmes. They proposed adaptation measures related to the expected impacts of climate change, such as extreme temperatures, urban droughts, sea and lake level rise, and floods. One respondent had published a book, "Notes on Climate Change in Nicaragua" [42] and referred to the CCA measures included there (Table 3).

Table 3. Measures for adaptation to climate change in urban areas identified by the respondents

PHYSICAL MEASURES	
CURRENT STATUS	**MEASURE**
Implemented	• Relocation of vulnerable settlements. • Housing improvement programmes do not include complete risk assessment studies, but they take into consideration factors that may cause the exposure of existing and new settlements to risks (e.g. proximity to water bodies). • Policies for housing improvement programmes include the protection of vegetation. The replacement of trees and gardens, where necessary, is included in the technical assessment. • The housing programmes include the improvement of water management systems, including waste water management.
Proposed by respondents	• Promotion of mud roofing tiles in order to reduce the temperature inside houses. • Preservation and promotion of the tradition of having trees in backyards and gardens to contribute to water infiltration. • Promotion of green areas in cities in order to reduce run-off water. • Use of native plants that need less water and maintenance in green areas of cities.* • Improvement of indoor comfort by using windows for cross ventilation.* • Building orientation according to the path of the sun in order to decrease the temperature.* • Ensuring that the distance between buildings is greater than 0.6 m.* • The use of light colours on building facades to reflect heat and sunlight.*
NON-PHYSICAL MEASURES	
CURRENT STATUS	**MEASURE**
Implemented	• Monitoring of highly vulnerable locations to prevent relocated populations from moving back. • Improvement of the early warning system designed for climate events.
Proposed by	• Creation of campaigns for cleaning and avoiding garbage in drainage

respondents	systems in order to avoid clogging. • Rainwater collection for irrigation of green urban areas.*
* Milan Pérez (2009)[42]	

Opportunities and constraints on integrating climate change adaptation

During the interviews, the respondents expressed their opinions about the importance, gaps, obstacles and opportunities for the integration of CCA into the fields of DRR and urban planning.

Opportunities

The patterns of the respondent's understanding of the existing opportunities for further integration identified were:

- recognition of the importance of integrating CCA for sustainable development,
- the existing national DRR structure may contribute to improving the integration of CCA,
- the decentralized work of local governments would allow better integration, in accordance with local conditions,
- universities are suitable organizations to improve knowledge and create capacities, and
- CCA is an attractive concept to obtain financial and technical support.

All the respondents said that CCA must be included in any developmental action. It is an aspect of mainstreaming that should be considered in all sectors of the country. One respondent said that the need to consider CCA and DRR always comes across in any study that they conduct, although the aim of their research was not related to this topic.

The government staff considered that the existing structure of SINAPRED provides advantages for integrating CCA. They suggested that the current instruments and tools could be extended, and that these new aspects could be added. They also said that the communication channels they have with all the institutions in the country may be useful to reach the actors concerned.

One respondent mentioned that the autonomy of local governments, in creating plans and managing their own budgets, and their responsibility to establish urban development plans is suitable for integrating CCA into urban planning, according to local conditions.

Most of the academic respondents said that promoting and supporting better training of university staff in climate change and climate change adaptation would allow the transfer of knowledge to future practitioners.

The respondents pointed out that there are many opportunities for obtaining funds for projects focused on climate change from international sources. They expressed the opinion that CCA is attracting the interest of important donors that are willing to help by providing financial and technical support. They mentioned that this is an important incentive for the integration of CCA. One respondent also added that CCA is attractive not only in the public sector, but also in the private sector. If there is awareness among practitioners of the benefits of adapting to and mitigating the effects of climate change, its integration into DRR and urban planning would be improved.

Constraints

The patterns of the respondent's understanding of the existing constraints on further integration identified were:

- poor understanding of CCA,
- CCA being mainly managed by environmental institutions, and
- the lack of connections between universities and other institutions.

The main gaps identified by the respondents concern knowledge and the understanding of CCA. They said that there is confusion regarding the concept of CCA. Two respondents claimed that many practitioners do not understand climate change and its implications. They said that CCA is fragmented between many actors and institutions, and they have not yet reached a consensus regarding concepts and actions.

The respondents said that today, CCA is mainly managed by actors concerned with environmental protection and food security. They argued that CCA must also be promoted in cities by its integration into urban planning, supported not only by technical institutions, but also by all Ministries. However, the focus on environmental issues seems to limit the integration of CCA into other areas of development.

The interviewees expressed the opinion that the new generation of practitioners is not learning modern methodologies and concepts derived from experience due to a lack of cooperation between the institutions working on DRR and universities.

DISCUSSION

This study provides important insights into how the integration of CCA into DRR is hindered, and how it could be improved. The results indicate that most of the

identified constraints on the integration of CCA into DRR are related [17] to the level of knowledge of practitioners concerning CCA. The information obtained from the respondents in the present study concerning their understanding of CCA and its influence on integration can be categorized into three barriers at the stage of understanding, based on the classification of Monser and Ekstrom (2010) [15].

The first barrier at the stage of understanding is related to: "some actors are too distant to the signal to take note" [15] (p.3). The respondents expressed the opinion that CCA has been an issue that has mainly involved environmental and technical institutes. This perception coincides with the process of integrating CCA into policies and regulatory frameworks in the country, in which CCA was managed exclusively by these kinds of institutions [17]. This action contributes to creating the conception that CCA must be managed by scientists, rather than being a problem related to development [25]. It also reveals inadequate "deficit models" [43], where technical and scientific knowledge on CCA is communicated in a top-down structure, using complex language that hardly addresses the common understanding of science. Practitioners obtain most of their information from the authorities through official channels. For this reason, non-scientific practitioners are not encouraged to include CCA in their practices.

A second barrier identified at the stage of understanding is the uncertainty and variability of climate change: "that the signal does not clearly emerge from the background noise" [15] (p.3). Most of the respondents showed uncertainty when discussing the integration of CCA into their practices. However, they are aware of their limited understanding about CCA, and how to deal with expected climate-related events using non-technical and non-scientific approaches. As Gifford (2011) [44] states, the lack of knowledge allows the creation of a gap between attitude and behaviour. Most of the respondents showed a positive attitude towards CCA, and they recognized how its management in urban contexts would reduce damage and loss arising from expected climate-events. However, it was difficult for them to identify direct links between CCA and their practices.

The unclear understanding of CCA has also discouraged practitioners from mainstreaming CCA into DRR. For instance, two respondents stated that instead of considering integration between the two fields, they tended to ignore CCA. One of the reasons for this is that DRR has been strongly promoted and supported by national and international cooperation. As a result, practitioners had a comprehensive understanding of DRR. Thus, the actions taken in the framework of DRR are clearer than the uncertain issues of social responses to climate change [45].

Another aspect that increases the uncertainty concerning climate change is the conception that it is a long-term risk. Practitioners expressed their worry about natural events that they perceived as being more hazardous in the short term, such as seismic activity. As pointed out by Weber (2006) [46], actors often express their

concern and focus their attention on situations that they feel are likely to materialize. This was the case for most of the practitioners interviewed in the present study.

The third and final barrier identified at the stage of understanding is the lack of guidance, which can determine the capacity and willingness to make decisions regarding CCA [15]. A positive aspect related to this barrier, is that the majority of respondents showed an interest in learning about and adopting CCA measures in their work. However, they also identified a lack of proper guidance in dealing with climate change and how mainstreaming CCA into their DRR practices.

Regarding the integration of CCA into urban planning, most of the respondents stated that CCA was not integrated into urban contexts. They mentioned three barriers that hinder the integration of CCA into urban planning. The first is the lack of comprehensive, up-to-date policies and instruments for urban planning. The most relevant documents in the regulatory framework for urban planning in Nicaragua are from 1982, and have not been updated. The second is the complexity of the current urban system, which limits opportunities to create urban processes and adaptive responses that contribute to sustainability in cities. The growth of cities in Nicaragua, mainly Managua, has been the result of urban sprawl for many decades [47]. This situation also contributes to the third barrier, namely inadequate urban planning practice in Nicaragua, mostly due to the reasons discussed above.

From the above, it follows that the lack of up-to-date regulatory planning policies and regulations that has been identified needs to be addressed simultaneously alongside the integration of CCA, with special consideration given to the particularities of urban areas. Urban risk and disasters "are unique in the sense that they occur in an environment that has adapted to absorb large population and services leading to specific characteristics related to: (a) scale, (b) densities, (c) inhabitants' livelihood strategies, (d) economic systems and resource availability, (e) governance systems, (f) public expectations, (g) settlement structures and form, (h) likelihood for compound and complex disasters, and (i) potential for secondary impacts on surrounding rural areas and regions" [29] (p.4). These aspects thus need to be taken into consideration in the integration of CCA into urban planning.

Another finding is that the practitioners who were interviewed revealed that the integration of CCA in practice has reached different levels in DRR and urban planning. The results of this study showed that practice is closely linked to the development of policies and regulatory frameworks. The integration of CCA into policies and regulatory frameworks for the environment, DRR and urban planning in Nicaragua is a gradual process, subject to on-going modifications, which started from a very restricted focus on the protection of natural resources and food security, and developed into the current interest in creating comprehensive approaches to adaptation and risk reduction planning [11]. This study shows that the integration of CCA into urban planning practice is also very limited.

Most developing countries, including Nicaragua, are facing several barriers for the integration of CCA into practice [2]. Effective integration of CCA requires inter-sectoral and participative work that includes stakeholders and practitioners at national and local level as well as related monitoring and learning mechanisms. The policies and regulatory frameworks in Nicaragua are relatively recent [11], and continuous updates and modifications offer new opportunities for the integration of CCA.

Although the integration of CCA seems to be at an early stage, especially in urban planning, the practitioners identified opportunities that have the potential to promote it. They believe that CCA is attractive for obtaining technical and financial support from international aid agencies. Furthermore, practitioners from government organisations expressed the opinion that the channels of communication in the existing structure for DRR provide an easy way of integrating knowledge and actions concerning CCA.

CONCLUSIONS

The integration of CCA into current practices in urban contexts in Nicaragua is at an early stage. DRR practitioners are aware of the need to improve their knowledge, and of the importance of adapting cities to climate change. Although they tend to leave the management of CCA to environmental and technical institutions, most of them expressed their interest in achieving a better understanding of CCA and of becoming actively engaged in the mainstreaming of CCA into their work.

The main barrier is the perceived lack of understanding of CCA. The outcome of this study suggested that this barrier could be overcome by creating professional education programmes and designing better communication strategies between the scientific community working on CCA and other non-scientific actors. Involving practitioners and policy makers in the creation of climate change scenarios and raising awareness about the impact of climate change in the national context would encourage them to find ways to mainstream CCA into their work.

In addition, the study revealed that the progress of integration is closely linked to the improvement and creation of policies and regulatory frameworks. The practitioners showed how receptive they are to international agreements and instruments. The practitioners in government organisations expressed their interest in increasing CCA integration into their practice because of the importance of fulfilling international and regional commitments. The stakeholders at national level were called upon to promote and contribute to CCA integration at policy level, and to enhance engagement among practitioners at all levels.

The practitioners also expressed their confidence in the existing DRR system. They said that the DRR framework in Nicaragua has a robust structure, and that they have achieved a comprehensive understanding of DDR. The creation of coordinated

actions between CCA and DRR would avoid the duplication of effort, and ensure better use of human and financial resources. In order to do so, it is important to reach a consensus among practitioners for the creation of holistic approaches to the coordination of actions between CCA and DRR that need to be included in the policies and instruments of both fields.

The mainstreaming process does not mean the creation of a new separate structure for CCA. Instead, SINAPRED and the organisation that forms the DRR system need to explore the potential for improving the mainstreaming process by: a) reviewing and adapting existing and planned programmes in order to take CCA into consideration; b) by evaluating their institutional policies and capacity, to reduce internal vulnerabilities to climate change; c) strengthening of networks of complementary partners that provide different perspectives and approaches to address climate change; and d) creating mainstreaming monitoring and evaluation mechanisms that offer the opportunity to learn from experience.

Today, CCA is poorly integrated into urban planning in Nicaragua. The interviewees identified shortcomings and gaps in urban planning policies and instruments as one of the main problems. Urban CCA requires tools that can guide the day-to-day work of practitioners in cities at risk. It is important to consider the complex systems of cities and their influence on disaster occurrence; specifically, how cities can modify or exacerbate the characteristics of hazards, local vulnerabilities and the mechanisms for response and recovery [cf. 31]. The revision and improvement of urban planning tools to include DRR and CCA as an integral part are crucial to create mutual integration of the three fields to, ultimately, protect existing urban societies and design resilient cities in the future.

COMPETING INTERESTS

The author has declared that no competing interests exist.

APPENDIX 1

Original quotations

> [i] (…) hay instituciones que piensa que el cambio climático es sólo de las entidades científica técnica, y no lo ven como que deben tener una visión interinstitucional y multidisciplinaria porque el cambio climático nos solamente es la atmósfera (…) es la salud, la seguridad alimentaria, es la producción. O sea hay un montón de elementos -sobre la adaptación al cambio climático- que muchas instituciones no los tienen complemente claro aún (…)

[ii] (…) ahora, esos dos mundos que todavía no hemos encontrado como no hacer lo mismo con nombres diferentes….al final, sí hacemos adaptación al cambio climático, pero está integrado en la operación (de gestión del riesgo) ¡Y punto! (…)

[iii] (…) para mí, conceptualmente no hay ninguna diferencia entre la gestión de riesgo tradicional y la adaptación al cambio climático. – Cambio climático - es un riesgo como cualquier otro. Quizás la etiología aquí, hay riesgos que pueden ser de amenazas naturales y cambio climático es una amenaza exacerbada por el ser humano (…)

[iv] (…) trabajamos en la capacitación de técnicos de las instituciones como la alcaldía y otras instituciones gubernamentales y no gubernamentales. Para que una vez que ellos adquieran el conocimiento, puedan aplicarlos en la preparación local para la gestión de riesgos (…)

[v] (...) ha habido muy poca gente en el tema (adaptación al cambio climático). Que se haya metido en el tema de gestión de riesgos y los escenarios urbanos, menos todavía pero los pocos que se han metido no han tenido la capacidad de incidir sobre los demás de crear una cultura sobre las instituciones... por lo menos en los niveles donde he tenido alguna participación o he sabido (…)

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Paper III

Chapter 4

Evaluating the Performance of Disaster Risk Management Systems – Is It Possible?

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Reduction of disaster risk is becoming a key issue in many countries. This chapter first discusses if, and how, the performance of disaster risk management (DRM) systems can be evaluated. The results of this discussion show the need for the development of a theoretical model that relates the activities performed by a DRM system to the fulfilment of its purpose. Against this background, a functional model is developed and then tested empirically in Nicaragua and Sweden. The empirical test of the model shows that it provides guidance in the practical evaluation of DRM, regardless of the specific context, and that the results of different evaluations can be compared in a meaningful way. We conclude that it is possible to evaluate the performance of DRM systems. However, significant challenges are involved and highlighted in this chapter. The suggested model is a first step in developing a better theoretical foundation for such evaluations.

Keywords: disaster risk management, risk reduction, design science, design perspective, monitoring and evaluation

1. Introduction

The ability to manage and reduce the risk of disasters is being recognized as a key issue in many countries (CADRI, 2011, p. 6; UNISDR, 2015, p. 1). However, a limited number of studies have focused on methods of evaluating and comparing the performance of disaster risk management (DRM) systems (See,

Carreño et al., 2007). The present study was carried out in an attempt towards rectifying this problem. It aims to strengthen the theoretical foundations for conducting evaluations of the performance of national DRM systems (including their formal and informal DRM actors) by reviewing related methodological challenges and assessing how DRM systems can be described so as to be able to evaluate them in a meaningful way.[1]

We start by providing definitions of the two key concepts used in this chapter, namely evaluation and DRM. We then continue with a theoretical discussion of how DRM systems can be described and analysed (Section 3). The following section presents a brief account of previous attempts to evaluate disasters and DRM systems, and highlights associated challenges. Based on this conceptual, theoretical and methodological basis, we conclude that a functional model that systematizes what a specific DRM system does is required to evaluate whether a DRM system achieves its purpose. Against this background, a general structure for such a model is developed in Section 5, which is then tested by comparing parts of the DRM systems in Nicaragua and Sweden. Finally, we present our conclusions on the status of DRM in these two countries, as well as the practical applicability of the functional model (Section 7).

2. Conceptual Points of Departure

DRM is defined in the United Nations International Strategy for Disaster Reduction (UNISDR) as: "The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster." (UNISDR, 2009, p. 4). Based on this definition, it can be argued that the main purpose of DRM is to lessen the impact, as well as the likelihood, of various events that may damage something that is considered valuable. DRM can be applied at different levels, for example, in a city, a region, or a nation.

[1] We acknowledge that this focus has its limitations since managing and reducing the risk of disasters require more than functioning national DRM systems. Disaster risk may, for instance, be reduced despite poorly performing national DRM systems. This issue has only been addressed to some extent, for instance by including also informal DRM actors (e.g., development actors). Further note that the assessment of specific methods, such as SWOT analyses is outside the scope of this study which looks at methodological challenges from a broader perspective.

The term *DRM system* is used here to refer to the actual organisations, rules, regulations, technical systems, etc., used to implement DRM. Thus, the DRM system encompasses the stakeholders that perform related DRM activities.

Evaluating the performance of such a system can mean several things. The two overall goals of evaluation are to determine *accountability* and to achieve *development* (Hertting and Vedung, 2012). However, here we are focusing on the developmental aspects of evaluation, i.e. on *improving* DRM (Patton, 1997; Patton, 2011; Chelimsky, 1997), and thus not on determining the accountability of various stakeholders.

In this context, we are focusing on the *performance* of DRM systems,[2] and not on whether a specific DRM system conforms to some standard or not (For example, the ISO standard for risk management, [ISO 31000:2009] or for emergency response ISO 22320:2011]). In line with this, evaluation is defined here as "…the careful assessment of the merit, worth, and value of organization, content, administration, output, and effects of ongoing or finished government interventions, which is intended to play a role in future, practical action situations" (Hertting and Vedung, 2012, p. 36). This definition is also in accordance with standard definitions used in the literature on DRM evaluation (see, Rossi et al., 1999). Since our main focus is on evaluation from a development perspective, comparisons between different DRM systems are relevant to identify lessons learnt and best practice, although care must be taken regarding the aspects that can be transferred to other contextual settings (e.g. different cultures, political systems, resources, etc.). In addition, evaluation is often seen as a systematic examination for future interventions (Alkin, 2004); in our use of evaluation, it is important to be able to identify the extent to which a DRM system is fulfilling its purpose in order to judge whether a specific intervention is effective or not.

3. Theoretical Points of departure

On the basis of the definitions presented in Section 2, evaluating DRM implies establishing the merit of a DRM system with respect to the fulfilment of its purpose. Consequently, any theoretical approach to evaluating DRM systems

[2] Note that functioning DRM systems require addressing root causes of risk and vulnerability.

must have the purpose of DRM at its core. Design science[3] is in line with this approach, thus providing a theoretical basis for describing and analysing DRM systems. It is "concerned with how things ought to be – how they ought to be in order to attain goals, and to function." (Simon, 1996, p. 4). This is a different approach to that usually found in the natural and social sciences, which have been exemplified, for example, in organisational science (Romme, 2003, p. 559), information systems research (Peffers et al., 2007), and engineering sciences (Horva, 2004, p. 155). According to van Aken (2004, p. 224), the different approaches can be divided into formal sciences, explanatory sciences and design sciences. In contrast to the other approaches, "the core mission of a design science is to develop knowledge that can be used by professionals in the field in question to design solutions to their field problems. Understanding the nature and causes of problems can be a great help in designing solutions. However, a design science does not limit itself to understanding, but also develops knowledge on the advantages and disadvantages of alternative solutions." (van Aken, 2005, p. 22).[4]

Thus, the purpose of an artefact is very important in design science. Since DRM systems are constructed by humans, i.e. they are artefacts, and the purpose of a DRM system is an important aspect when evaluating it, evaluation is a 'natural' part of design science. It thus provides a suitable theoretical point of departure for evaluating DRM systems. The so-called levels of abstraction of design science (Cedergren and Tehler, 2014, p. 90) used to describe the artefact, which in this case is a DRM system, are:

- Purpose,
- Function and
- Form[5].

Although the same physical artefact (i.e. a DRM system) is described at each level of abstraction, the three levels represent different perspectives. Describing an artefact on the Purpose level implies answering the question, "Why does the

[3] Although Simon refers to many different scientific disciplines (e.g. engineering and medicine) when using the word "Sciences of the artificial" the term "design science" is here used when referring to the properties shared by all design sciences.

[4] In contrast to other evaluation approaches, design science evaluation is focused on the question whether a specific artifact fulfills a specific purpose to a higher extent than previous artifacts and aims not only at investigating *if* a specific artifact represents an improvement but also *why*. There is thus a clear ambition to understand the mechanisms involved when an artifact fulfills its purpose.

[5] The *level of abstraction* was first used by Rasmussen (1985), and later developed by Brehmer (2007) and Cedergren and Tehler (2014), among others.

artefact exist?" Analysing an artefact on the Function level implies answering the question, "What does the artefact do to achieve its purpose?" (We will return to the question of how to analyse a DRM system on the Function level in more detail later.) Finally, describing an artefact on the Form level means answering the question, "How does the artefact achieve its functions and thereby its purpose?" Thus the Form level is the most concrete level, and the Purpose level the most abstract. It is important to note that it is the connections between the different levels that provide meaning to the analysis of an artefact. For example, merely analysing what an artefact *does* without relating it to its purpose would be meaningless.

4. Methodological Points of Departure: Previous attempts to evaluate DRM and associated challenges

Our study[6] shows that previous suggestions of ways to evaluate DRM can be described according to whether the focus was on: (a) disaster response (see, Jackson et al., 2010; Dabelstein, 1996; Heath, 1998; Brown and Robinson, 2005; Telford et al., 2006; Larsson and Makowski, 2008; Tabbara, 2008; Tood and Tood, 2011; ADB, 2012; Kim et al., 2004; Salmon et al., 2014, McConnell, 2011), (b) preparedness (see, Norad, 2008; Zantal-Wiener and Horwood, 2010, Alexander, 2015), or (c) risk management (see, Quarantelli, 1997; Cardona, 2005; Carreño et al., 2007; Chen, et al., 2009; UNDP, 2011).[7] In addition, they can be categorised into two different types of approaches according to the methodology used: (a) quantitative, index-based approaches (see, Carreño et al., 2007; Chen et al., 2009) and (b) more qualitative or "important factors" approaches (see, Quarantelli, 1997; Jackson et al., 2010).

[6] The previous evaluation studies were identified by using a scoping study approach (Arksey and O'Malley, 2005) including relevant literature on DRM, risk reduction, disaster response and preparedness.

[7] Note that there is also a range of case-based investigations in crisis management literature. However, a comprehensive recognized theory of how to evaluate DRM systems has also not been developed in this context. Apart from literature related to the evaluation of disasters, crisis and DRM, there is also a limited body of literature concerning the comparison of DRM systems. For instance, Power and McCarty (1998) compared risk analysis and management frameworks, where they proposed eleven aspects for comparison, such as decision making, uncertainty analysis, risk characterization, etc. In addition, there are other studies comparing actions taken for DRM by communities in different contexts (see, Vink and Takechi, 2013), and concepts from different communities that deal with risks (see, McEntire et al., 2002). However, nothing could be found in the literature on the comparison of DRM from a system perspective that could be used as the antecedent for this study (i.e. that focus on evaluating the performance of DRM systems).

Any method for the evaluation of DRM, including those mentioned above, faces methodological difficulties that influence their usefulness. Below we discuss some of the most important difficulties, which are then used as a methodological point of departure for our suggestions on how to approach the problem at hand (Section 5).

5. Cognitive heuristics and biases

It is difficult to assess whether a specific DRM system achieves a certain aim. One reason for this is that the fulfilment of a certain aim or purpose is often an abstract attribute and, thus, any assessment is likely to be affected by the process of attribute substitution. This means that "…an individual assesses a specified *target attribute* of a judgment object by substituting another property of that object – the *heuristic attribute* – which comes more readily to mind. Many judgments are made by this process of *attribute substitution*" (Kahneman and Frederick 2002, p. 53). In other words, attribute substitution can be defined as a mistake that occurs when attribute choices and judgements are made unconscientiously (Smith and Bahill, 2010).

Since the success of a DRM system is an attribute that is quite difficult to assess, questions such as, "Which country's DRM system has the best performance, Nicaragua or Sweden?" is difficult to answer. In searching for an answer to questions such as this, people tend to activate other attributes that are similar to the target attribute (the success of DRM), and instead of answering the initial question, might provide an answer to a slightly different question, such as, "Which country, Nicaragua and Sweden, has suffered the most severe impacts of disasters?" In this case, the target attribute has been substituted by the heuristic attribute, the most severe catastrophes. Moreover, experiments have shown that people may not be aware of the fact that they have actually answered a different question (Thompson, 2009). Thus, cognitive biases may seriously affect the ability to evaluate the performance of DRM systems unless one develops ways of involving the assessment of more concrete attributes. However, assessing or measuring more concrete attributes of a DRM system involves other types of challenges (see below).

5.1. *The limitation of focusing on past losses*

A more concrete and seemingly relevant attribute when evaluating DRM systems is the outcome in terms of the magnitude of past losses suffered by the country, region or city. However, this also results in several difficulties.

Firstly, lessening the likelihood and impact of various events necessitates taking action, and actions are usually preceded by decisions. Therefore, an important aspect of DRM concerns decision making. Consequently, one might be tempted to assume that a good outcome, i.e. few losses, was preceded by good decisions, and that good decisions are a characteristic of a successful DRM system. However, this is not always the case, since good decisions may lead to poor outcomes and poor decisions to good outcomes. As noted by Edwards: "A good decision cannot guarantee a good outcome [and vice versa]. All real decisions are made under uncertainty. A decision is therefore a bet, and evaluating it as good or not must depend on the stakes and the odds, not on the outcome." (Edwards, 1984, p. 7).

Secondly, if past losses are considered when evaluating DRM in different contexts the result is likely to be significantly biased due to the fact that different contexts are exposed to different levels of risk. Let us assume that we are only interested in comparing DRM with respect to earthquakes, and we then compare Sweden and Nicaragua. Using past losses due to earthquakes to evaluate the quality of earthquake DRM would clearly be misleading, since Sweden is not located in a very active seismic region, whereas Nicaragua is.

Thirdly, in order to be able to use disaster losses as a meaningful indicator, one would need to consider losses beyond the sole quantitative data available from national and international databases. Losses would also need to be framed through the eyes of those who face disaster risk on a daily basis, leading to further methodological challenges.

Finally, since past losses reflect previous performance of DRM it is not necessarily a good indicator of the current performance of DRM. Thus, it is possible that the current status of the DRM system and the work being performed therein is significantly different from the quality of the work that was performed fifty, ten or even one year ago.

5.2. *The difficulties in knowing what system behaviour to look for and how to draw conclusions from it*

The above discussion shows that the difficulties encountered when trying to assess the success of a DRM system by focusing on its purpose, aims or

outcomes are significant. Therefore, a more viable approach may be to assess what a DRM system does, i.e. its behaviour, and then infer whether it leads to the fulfilment of its purpose. Although it is easier to assess what a system does, than to directly assess the extent to which it fulfils its purpose, it is necessary to understand how to make inferences about the Purpose level based on observations on the Function level (see Section 3).

Three issues are especially important when discussing how this can be achieved. The first concerns the aspects that characterise the behaviour of the DRM system. The second is concerned with the system's behaviour, that is, how these aspects result in the purpose being fulfilled, and the third is the degree to which each aspect influences the fulfilment of the purpose.

Henceforth, we will use the term "a function" when referring to something that a DRM system does, which in turn determines the extent to which that system's purpose is fulfilled. With respect to the first issue mentioned above, there are examples of "good practice" in areas related to DRM such as crisis planning, that provide guidance concerning what a DRM system does (or should do) in order to be successful (see, Boin and 't Hart 2010, p. 360). Such information can be very valuable when identifying the functions. The structure of such advice is of the general form, "To achieve A you should do B". However, problems can arise with such advice if the descriptions of A and/or B are too vague. This makes it difficult to determine what the appropriate intervention really is (B), or perhaps more commonly, what it actually leads to (A). Not only will this vagueness limit the practical applicability of the advice, it will also limit its usefulness for evaluation. Moreover, such guidance seldom includes an explanation of why a DRM system becomes more successful when the advice given is heeded, which is related to the second issue described above. Thus, the mechanism that leads to the desired effect is lacking, or is not described in sufficient detail. Moreover, when evaluating DRM it will probably be necessary to consider the effect of several factors, and evaluation will be even more difficult if the mechanisms are not explicitly described.

Another challenge related to the third issue above, is how to measure the functions and how these measures can be used to derive a measure of the fulfilment of the purpose. Several scales can be employed: the most common being nominal, ordinal, interval and ratio scales (see description in Stevens 1946). In the context of this study, it is reasonable to assume that the measurement must at least be ordinal to rank different DRM systems, or alternative designs of the same DRM system, based, for instance, on the extent to which they fulfil a specific purpose. Most "good practice" advice is described using 2-level ordinal scales (see, Kim et al., 2004). That is, one either follows advice "B"

or not "Not B", and following the advice is considered better than not following it (B > Not B). However, since descriptions of the important mechanisms (see above) are often lacking, it is difficult to establish a relationship between the functions and the purpose. Thus, it is difficult to determine the effect, in terms of the fulfilment of the purpose, when changing the status of a function.

5.3. *The challenge of focusing on the current level of resources and related aspects*

As noted above, the Form level is the most concrete level of abstraction. It involves how one or several functions are performed. A problem when considering evaluation on the Form level is that it is difficult to arrive at conclusions concerning the purpose. It might, for example, involve studying institutional organisation, the resources devoted to DRM, the methods used for risk assessment, the procedures for sharing information regarding risk, etc. However, although such aspects are relatively easy to assess, they are only means of achieving the purpose of DRM. It is, for example, not certain that a country with the most developed policies and procedures for DRM and the most educated personnel in the area of interest will be most successful in terms of DRM[8]. Therefore, it is also insufficient to use standards and norms (such as the ISO standards) as a benchmark when evaluating the *performance* of DRM systems (cf. Section 2). One reason for this originates from the context. The context, for example, the political system or certain cultural aspects, in one country might simply be more favourable for DRM than in another, and this may compensate for the lack of procedures and education. A similar argument has been presented concerning capability assessment (Lindbom et al., 2015). Many definitions of emergency response capability and methods for assessing such capability focus on the resources available, rather than on what can be achieved with them during an emergency. However, having resources, etc. is not the same as being able to respond appropriately in an emergency. Therefore, as in the case of DRM, if one wants to evaluate emergency response capability it is necessary to consider what can be achieved during an emergency, and not focus only on the resources available (Lindbom et al., 2015; Palmqvist et al., 2014).

Based on the analysis above, we conclude that evaluation based solely on the purpose (or outcome) is not feasible due to the difficulties in assessing such

[8] This issue has also been discussed in the context of climate change adaptation, highlighting that adaptive capacity does not automatically translate into actual adaptation.

abstract attributes, and the limitations of relying on past losses (Figure 1). Moreover, evaluation on the functional level, i.e. the behaviour of the DRM system, can be conducted, but it will require more elaborate models of the important aspects and a more detailed description of the mechanisms that lead to the fulfilment of the purpose. It will also require the development of reliable scales of measurement that facilitate empirical analysis. Focusing only on the level of form is not deemed feasible here. It is similar to the functional level, some indications of the most important aspects is needed. Moreover, focusing only on resources, policies and procedures, etc., and disregarding what the DRM system actually does, leads to the risk of missing the impact of other contextual factors on the management of disaster risk.

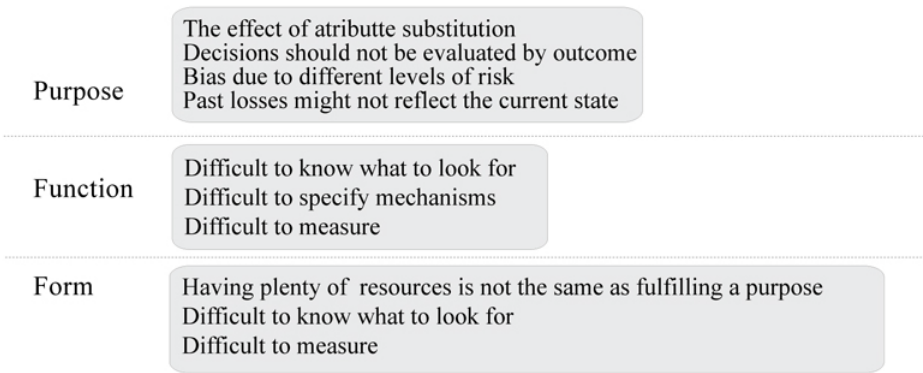

Figure 1. Challenges in evaluation at each level of abstraction (developed by the authors).

6. A functional model of DRM

From the assessment of past approaches to evaluating DRM and related challenges (Sections 4 and 5), we conclude that there is a need to develop a better model of DRM that establishes a clear connection between the purpose and the function levels, i.e. one that explains what a DRM system does in order to achieve its purpose.

Below we suggest a general structure for such a model. We call it a "functional" model of DRM since we wish to stress that the model focuses on the *products or outputs* of DRM, rather than on describing what DRM *is* in terms of processes or activities. Processes and activities are more specific than outputs, and different types of processes and activities may lead to the same product or output. Referring to the level of abstraction (Sections 3), processes and activities

are defined on the level of form, while the output is defined on the level of function. In other words, a function is an abstract concept that is defined based on its output (see description in Cedergren and Tehler, 2014, p. 91).

To create a functional model of DRM we rely on the assessments of existing models of risk management and decision-making as a point of departure. However, it should be stressed that many such models are normative, i.e. they describe how risk management *should* be performed. For example, the ISO framework for risk management (see, e.g., ISO, 2009) is clearly intended to provide suggestions for how organizations should conduct risk management. Moreover, traditional decision theories (see, Keeney and Raiffa, 1976; von Neumann and Morgenstern, 1947) are also normative. Although we ultimately want to provide knowledge on how to perform DRM better, the primary goal here is to describe and analyze DRM so as to be able to understand how the purpose is achieved. Therefore, we use names for the functions[9] of DRM that do not resemble those usually found in risk management literature (e.g. risk identification). Instead, the names and the functional model resemble more those found in descriptive theories of decision making, e.g. the DOODA model (Brehmer, 2006), the COCOM/Extended COCOM model (Hollnagel, 2002) or the Recognition Primed Decision model (Klein, et al. 1989).

6.1. *The information acquisition function*

One function that is necessary for a DRM system to achieve its purpose is information acquisition. Without the ability to obtain information from the system of interest (e.g. a city or region) the DRM system will have no way of "knowing" the state of the system of interest, and it will therefore also lack the ability to anticipate events and act purposefully[10]. Not being able to acquire information from the system of interest (including at-risk citizens) is similar to driving a car by remote control without knowing its position relative to its environment; it is simply impossible. Rasmussen (1997, 196) points out the importance of being able to obtain information from the system of interest when he writes, "No control system will perform better than its measuring channel".

[9] The intention of the model is to provide a simple basis for evaluating and comparing DRM systems. More functions can be added (e.g. evaluation and learning) depending on which aspects are to be evaluated or compared.

[10] It should be noted that even though we discuss the DRM system as if it "knows" and "anticipates" things, this does not mean that the DRM system has cognition. In practice, it is the humans (e.g., municipal staff and at-risk citizens) and the artefacts (e.g. databases) that "know" things, store information, and use it to anticipate events.

This is also true for a DRM system. Inspired by the DOODA loop (see, Brehmer, 2006), we call this function the information acquisition function. Its output is information used by the DRM system.

6.2. *The orientation and anticipation function*

To explain what the orientation and anticipation function does in our model we use a person and a team as an analogy for the DRM system. A person conducting some kind of purposeful activity, for example, managing risk in some situation will, according to the RPD model (Klein and Crandall, 1995), most likely use the processes of situation assessment and mental simulation (Klein and Crandall 1995, p. 326). Thus, he or she will interpret the situation and use that interpretation to "test" different possible actions through mental simulation in order to investigate if an action is appropriate (see, Klein, 1999). Similarly, a team will also use an assessment of the situation and simulation in order to test possible actions. However, as pointed out by Klein (1999, p. 233), the "mind of a team can be easier to study than the mind of an individual". What Klein means is that the assessment of the situation or a simulation performed by a team can be detected by an external observer, whereas the assessment of the situation or mental simulation performed by an individual cannot. Therefore, when discussing the "situation assessment" made by the team, one is referring to the communication between team members and explicit models shared by the team (e.g. drawings on paper), etc. Klein uses the term "preconscious level of the team mind" (Klein 1999, p. 234) when referring to things that an individual team member might know, but has not shared with the rest of the team.

We can use a similar approach when describing DRM systems. When we refer to the preconscious level of the DRM system we mean something that an individual knows that is not shared with the rest of the people making up the DRM system. Moreover, although information about the system of interest, e.g. maps and information concerning how many people live in different locations, may be shared by some people in the DRM system, their number may be so few so that the information can still be considered as being on the preconscious level when considering the whole DRM system (cf. Kramer's discussion on compartmentalization of information (Kramer, 2005)).

The output from the orientation and anticipation function is of two types: one corresponds to the situation assessment referred to above, and one to mental simulations. In the present context, the situation assessment concerns the state of the system of interest. For example, where the roads are located, where people live, where the rivers are, where hospitals are located, etc. This type of

information is essential in order to be able to assess risk. In addition, the equivalent of mental simulation is also required, i.e. descriptions of scenarios that might occur in the system of interest and that can lead to negative consequences (e.g. injury and damage to people and property and loss of livelihood). Each scenario can be considered to be the equivalent of one mental simulation. Thus, the output one should look for when studying DRM systems is descriptions of the state of the system of interest and descriptions of potential scenarios that might harm what is considered valuable. In addition, since the scenarios are potential future developments it is also necessary to look for descriptions of the uncertainties concerning them (e.g. in terms of likelihood assessments).

6.3. *The decision-making function*

It is not sufficient to simply generate data and produce models of the system of interest (including scenarios) to manage disaster risk. It is also necessary to decide on suitable courses of action. Although decision-making is usually seen as something strongly associated with a person, here we focus on the DRM system. The difference is that a decision made by a person might not be observable at all, whereas a decision by the DRM system must be. For example, a decision made by the person in charge of a very important part of the DRM system is not a decision of the DRM system unless that person has communicated their decision in some way to all the others involved. Similarly, a decision made by a person but not yet communicated to the others involved is on the preconscious level of the DRM system. The output of the decision making function consists of descriptions of what should be done (e.g. building a levee) in order to fulfil the purpose of the DRM system e.g., reduce long-term losses. Importantly, this also includes addressing the root causes of risk and vulnerability.

6.4. *The implementation function*

The final function necessary for a DRM system is implementation. The output from this function is the actual change in the system of interest. Without the possibility of influencing a system one cannot claim to be managing risks. It should be noted that the model specified here does not dictate who should be able to influence the system of interest, only that the DRM system must be able to influence it in some way. Therefore, in reality, the actual implementation of this (Form level), and the other functions, may differ considerably in different DRM systems.

Figure 2 illustrates the various levels of abstraction and the functional model of DRM. It describes the functions and the output that the functions generate. Moreover, it also gives examples of the output in a real DRM system (form level).

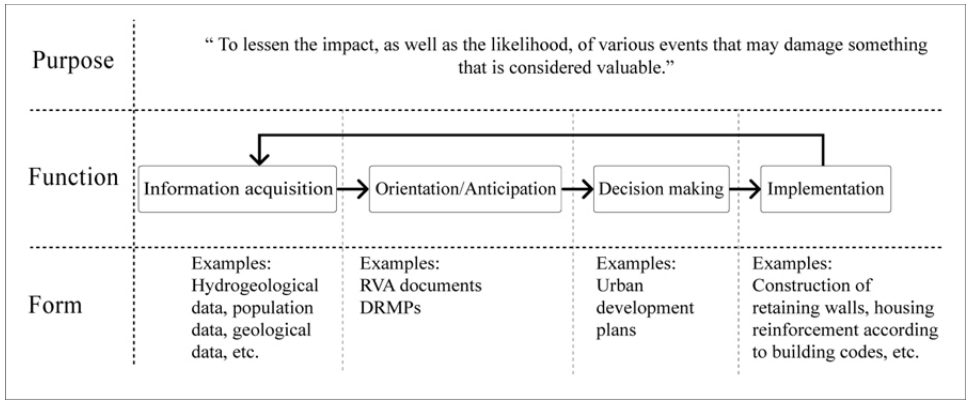

Figure 2. The functional model of DRM.[11]

7. Evaluating DRM in Nicaragua and Sweden

To empirically test the functional model presented in Section 5, we collected new empirical data from the Nicaraguan DRM system[12] and used data from previously published studies on the Swedish DRM system (Abrahamsson and Tehler, 2013; Hassel et al., 2012; Tehler et al., 2012). Below it is shown how one of the functions, the orientation and anticipation function (focusing on anticipation), can be evaluated based on the output it produces[13].

The focus in the Swedish studies was on the extent to which the system was able

[11] RVA: Risk and vulnerability Assessments (Sweden)
DRMPs: Disaster Disk Management Plans (Nicaragua) (See section 6.1)

[12] The selection of the Nicaraguan DRMPs consisted of two parts: the review of available information at regional level and the identification of the DRMPs at departmental level, which provide information in terms of (a) descriptions of possible scenarios, (b) descriptions of possible consequences, and (c) descriptions of likelihood estimates. All the DRM plans are available in the Virtual Library of Disasters http://www.bvd.org.ni/.

[13] The reasons for selecting the Swedish and the Nicaraguan systems were: (a) the authors' prior knowledge and availability of data from these two systems and (b) the fact that they represent two DRM systems from completely different contexts (northern Europe and Latin America), which we believed to be adequate to test whether such comparisons would be generally meaningful.

to generate assessments of risk on different administrative levels.[14] These assessments are examples of output from the orientation and anticipation function in our model/framework. The overviews describe various risk scenarios, their associated consequences and likelihoods. To illustrate how the orientation and anticipation function in two DRM systems can be evaluated and compared, we applied the same approach as that used in Sweden to the data from Nicaragua.

7.1. *Empirical data*

Nicaragua has an established DRM system called the National System for Disaster Management and Prevention (SINAPRED). It consists of stakeholders organized in a top-down structure, composed of committees at regional, national, departmental and local level. To enable an illustrative comparison with the Swedish data from previous studies, we focused on the regional administrative level, as this was the level that received most attention in the Swedish studies.

Although the administrative systems of Nicaragua and Sweden are very different, both countries are divided into several regions. In Sweden, there are 21 regions, and in Nicaragua 17. The actors that produce output in terms of the orientation and anticipation function on the regional level in Sweden are the county administrative boards, and in Nicaragua the Departmental Committee of SINAPRED. The functional output can, for instance, be found (form level) in documents called risk and vulnerability assessments (RVAs) in Sweden, and disaster risk management plans (DRMPs) in Nicaragua.

The data used for the comparison were obtained from 21 RVA reports collected from the Swedish county administrative boards in 2008 and 21 collected in 2010, as well as 16 DRMPs from Nicaragua[15] collected in 2014[16].

To facilitate the comparison between the Swedish and the Nicaraguan systems we used the same classification of the DRMP documents as was used in

[14] Note that the focus of the comparative case study is limited since it is only focused on a particular aspect of DRM, i.e., risk assessment. Nevertheless, it provided a first evaluation of the model at hand and insights for its further development. Further note that the underlying assumption is here *not* that instrumental rationality is obtained by comprehensive data sets analysed by experts. Risk assessment is here seen as one aspect of a DRM system which requires the involvement of many different actors, including development actors and at-risk citizens.

[15] The department of Managua was not included because its DRMP was not published in the sources available.

[16] Although the documents were collected in 2008, 2010 and 2014, they were not necessarily produced in those years, and could have been produced several years earlier. Nevertheless, they represent the most up-to-date descriptions of risk scenarios, etc., on the regional level in the two countries.

the classification of the RVA documents (see Abrahamsson & Tehler (2013). Thus, we analyzed the DRMPs with respect to: (a) whether they provided descriptions of risk scenarios/events; (b) how the consequences of the risk scenarios/events were described; and (c) how assessments of likelihood were described[17]. Each document was rated according to these three aspects using the categories presented in Tables 1 to 3. A detailed description of the development of this rating procedure and the different categories can be found in Abrahamsson and Tehler (2013, p. 82-84, p. 87).

7.2. *Data analysis*

The Nicaraguan DRMPs are the result of the "Natural Disaster Vulnerability Reduction Project (Loan 3487-NI)" of the World Bank[18]. For this reason, the DRMPs show similar structures, but different all-hazard approaches have been employed. All DRMPs include descriptions of multiple hazards such as seismic activity, volcanic activity, floods, landslides, tsunamis, pollution, fire and drought. However, six DRMPs do not consider risk scenarios at all, which means that they do not describe what might happen if, for example, a volcanic eruption were to occur. Instead, they only discuss the presence of hazards. It can be seen from Table 1 that the Swedish RVAs describe potential scenarios to a greater extent than the Nicaraguan DRMPs.

Table 1. Descriptions of risk scenarios in Nicaragua and Sweden

Category	Number of Nicaraguan DRMPs	Number of Swedish RVAs	
	2004	2008	2010
Description of risk scenarios	10	16	20
Only descriptions of hazards – not scenarios	6	5	1

Fourteen of the Nicaraguan documents contain qualitative descriptions of potential consequences of the risk scenarios (Table 2). Most of the documents provide this information by describing how the population might be affected by the various scenarios. However, the key point when comparing them to the

[17] See Abrahamsson and Tehler (2013) for a more detailed description of the different classifications.

[18] http://web.worldbank.org/external/projects/main?pagePK=104231&theSitePK=40941&menuPK=228424&Projectid=P064916

Swedish material is that none of the Nicaraguan documents used a scale to describe the extent of the consequences. Moreover, in two DRMPs hazard-related consequences are not described at all. The Swedish RVAs, on the other hand, usually contain more information concerning the potential consequences of various scenarios. It can be seen from Table 2, for instance, that over half of the Swedish RVAs employ a qualitative ordinal scale when describing the consequences of various scenarios. This allows the severity of the various consequences of risk scenarios to be judged in relation to each other. No such information was available in the Nicaraguan analyses.

Table 2. Scenario consequences

Category*	Number of Nicaraguan DRMPs	Number of Swedish RVAs	
	2004	2008	2010
No consideration of consequences	2	2	2
Qualitative description	14	6	7
Qualitative ordinal scale	-	11	11
Semi-quantitative scale	-	2	1
Quantitative (frequency or probability)	-	-	-

*Qualitative ordinal scale refers to the use of classes, such as *very unlikely*.
The semi-quantitative scale is an ordinal scale with quantitative values. (See, Abrahamsson and Tehler. 2013)

With the exception of one document, the Nicaraguan DRMPs did not contain any descriptions of how likely various scenarios were judged to be, while most of the Swedish RVAs provided some type of assessment of likelihood. Nevertheless, there was still a considerable variation in the descriptions of the likelihood of various scenarios, as can be seen in Table 3.

Table 3. Scenario likelihood

Category	Number of Nicaraguan DRMPs	Number of Swedish RVAs	
	2004	2008	2010
No consideration of likelihood	15	6	4
Verbal description	-	2	5
Qualitative scale (5 classes)	-	9	8
Semi-quantitative* scale (5 classes)	-	4	4
Quantitative (frequency or probability)	1	-	-

*The semi-quantitative scale is an ordinal scale with quantitative values. (See, Abrahamsson and Tehler, 2013)

8. Discussion and Conclusions

On a theoretical level, the results indicate that the functional model developed here can provide guidance in the evaluation and comparison of DRM systems. In addition, the empirical analysis of the Swedish and the Nicaragua systems show that both systems accomplish their functions and fulfil the same purpose, although by using different approaches. Both aspects are discussed below.

8.1. *Comparison of the Nicaraguan and the Swedish DRM systems*

The results showed that the Swedish and the Nicaraguan DRM systems were quite different in terms of how (form level) the orientation and anticipation function is fulfilled at regional level. The Nicaraguan DRM system includes descriptions of risk scenarios to a lesser extent, and qualitative descriptions of consequences to a greater extent, than is the case in Sweden. In addition, descriptions of how likely scenarios are judged to be are seldom included in the Nicaraguan documents, whereas the Swedish documents generally include such judgements.

The key question with respect to the results is, which country succeeds best in fulfilling the purpose of DRM. Whilst our empirical data are too limited to be able to provide an answer to this question, we can provide answers as to how the two systems perform the orientation and anticipation function at the regional level. A DRM system that does not produce risk scenarios can be considered to be weaker in terms of fulfilment of the orientation and anticipation function than one that does. The basis for decision making is seriously compromised when there are no assessments of the potential consequences of various hazards, involving all relevant stakeholders (including at-risk citizens). This situation would be similar to that in which a single person is unable to generate mental considerations or simulations necessary for taking certain decisions. Simulations play an important role in decision making (Klein, 1999; Klein and Crandall, 1995) and similarly, the descriptions of the scenarios are likely to play an important role in a DRM system. Moreover, the usefulness of the information for decision making is further reduced if the potential consequences are not ranked (e.g., no information or only qualitative or only quantitative information is given) (see, Lin, et al., 2015a; Lin, et al., 2015b). Finally, not including descriptions of how likely various scenarios are also decreases the usefulness of a risk description (ibid).

Hence, the Nicaraguan system appears to produce less useful outputs for decision making at regional level than the Swedish system. However, many

aspects were not included in the present evaluation, and the findings presented here cannot be generalised to the whole system. For example, the depth of information contained in the documents was not included (e.g., in relation to addressing root causes of risk and vulnerability), nor was the quality of the judgements presented in the documents considered (e.g. assessments of likelihood).

The fact that the two DRM systems are very different in terms of how (form level) the output of the orientation and anticipation function is produced, i.e., different types of actors and different types of physical documents, illustrates the benefit of using a functional model. For example, if we had analysed the Nicaraguan system using the Swedish DRM system as a "template", little useful information would have been found. For instance, no documents are produced on the regional level called "risk assessments" or "risk and vulnerability assessments" in Nicaragua (as is the case in Sweden). Therefore, the key to successfully comparing the two systems is to focus on *who* (the actor) produces output in terms of descriptions of risk scenarios and judgements of their corresponding likelihood and consequences on the regional level in the two countries, and *how* these descriptions are structured. Although the two kinds of documents, i.e., the RVAs and the DRMPs, are different in many respects, they have in common the fact that they are the most important documents describing risk scenarios, etc. in the various regions of the two countries investigated.

8.2. *Evaluating the performance of DRM systems: A way forward*

This study demonstrates that the answer to the question posed in the title of this chapter, Is it possible to evaluate the performance of a DRM system?, is yes. However, there are many methodological and theoretical challenges associated with carrying out evaluations which have not been dealt with adequately in the past. The functional model developed in this study is a first step to addressing these challenges.[19]

The functional model presented in this study contributes to knowledge concerning ways in which DRM systems can be evaluated based on their behaviour (i.e. their outputs). In contrast to previous approaches, the key advantage of this model is that it explicitly describes and motivates the functions

[19] Note that the model can be used by external assessors as well as people within the actual DRM system (e.g., government officials and/or people at risk). Note however that a highly performing system from the point of view of an external assessor may be less efficient/effective in the eyes of internal actors who have better access to information required for the assessment.

that are necessary for a DRM system to be successful. Although the present form of the model is simplified to the extent that it does not provide guidance for the evaluation of *all* aspects (all functions) of a DRM system, it does provide a good basis for evaluating and comparing specific aspects of it. The comparison of the Swedish and the Nicaraguan DRM systems showed how this can be achieved. The functions defined are the key to such a comparison. Since they are defined based on the systems' outputs, this provides an opportunity to study vastly different DRM systems and to still be able to perform a meaningful analysis of the extent to which these systems fulfil their purposes. This does not mean to underplay politics of evaluation (cf. Lundin, 2007).

In fact, in addition to facilitating a comparison of different DRM systems, the presented model can also be used to detect internal problems in a specific DRM system (including social, economic and institutional/political issues). For instance, the analysis of the connection *between* functions in a system is useful in identifying the fragmentation of DRM functions (which is equivalent to the fragmentation of the risk governance processes as explained by Cedergren and Tehler [2014]). Analyzing a DRM system focusing on the fragmentation of DRM functions implies studying the extent to which information acquisition supports orientation and anticipation, whether orientation and anticipation support decision making, and so on. Previous analyses of the Swedish and the Nicaraguan system have found evidence of such fragmentation (Cedergren and Tehler, 2014; Abrahamsson and Tehler, 2013; Rivera et al. 2015).

Moreover, the functional model presented here is not only useful for describing what to look for when evaluating and comparing DRM systems; it can also be used to define more specifically what a DRM system must be able to accomplish in order to manage risk, i.e.:

- it must be able to perceive the environment and related root causes of risk and vulnerability (information acquisition),
- it must be able to assess the state of the system of interest, including possible scenarios that might harm what is perceived as valuable, and their likelihood (orientation and anticipation),
- it must be able to decide on suitable courses of action (decision making), and
- it must be able to change the system of interest (implementation).

The success of a specific DRM system will depend on the amount and quality of the output produced by each function, as well as the extent to which the

system is successful in integrating and linking the functions. This was indicated in Figure 2 in the form of a feedback loop. This loop should not be seen as a *cause–consequences description*, but rather as an indication of the prerequisites for the various functions.

In order to be able to evaluate a complete DRM system, the model would have to be further developed. For example, it may be necessary to break down each function into sub-functions, and the relationships and feedbacks between the various functions will have to be specified in greater detail. In addition, more research is needed to increase the number of aspects used to evaluate the fulfilment of each function and the purpose, and how they link to root causes of risk and vulnerability. For example, here only three aspects of the output from the orientation and anticipation function were studied. One aspect that could be included in the future is the quality of the background knowledge on which the descriptions of scenarios, judgements of likelihoods and consequences are based (for example, Aven 2012, 2013). The model presented here thus represents a way forward in evaluating DRM systems that can be developed and refined through further analyses.

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Paper IV

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Fragmentation in disaster risk management systems: A barrier for integrated planning

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ABSTRACT

The need to integrate climate change adaptation (CCA) considerations into disaster risk management (DRM) systems is widely recognised. However, successful integration, and thus the implementation of integrated planning measures, is difficult in practice. To understand and reduce the problems encountered, it is important to investigate systemic challenges. These challenges are rooted in the interaction between various stakeholders that affect DRM and the integration of CCA, directly or indirectly. This study explores the degree of integration in on-the-ground measures by studying systemic challenges, using the Nicaraguan DRM system as a case study. A theoretical framework for investigating systemic challenges in DRM systems was developed. It was then used in a retrospective analysis of the different functions of the systems in order to identify fragmentation in knowledge, information and coordination flows at local and national levels of governance. The results revealed several fragmented processes and functions in the Nicaraguan DRM system. These lead to difficulties in consolidating relevant information produced by multiple governmental authorities at different levels, and transferring this information to the local level. Fragmentation also leads, in turn, to little integration of CCA aspects into DRM in both local planning and practice.

1. Introduction

The need for better integration of climate change adaptation (CCA) considerations and disaster risk management (DRM) has been widely recognised [1–5]. However, practical examples are still very limited [5]. To understand why this is the case, it is useful to investigate the challenges to integration faced by the various stakeholders engaged in DRM and CCA activities. Since both DRM and CCA require collaboration between multiple stakeholders, often with considerable differences in objectives and interests, and access to information and other resources, etc. [4], it is necessary to investigate the related systemic challenges, i.e., challenges rooted in the interaction between these stakeholders. We thus use the term "systemic challenge" to denote a challenge that is not apparent when investigating the work performed by individual stakeholders in isolation, but requires the consideration of several stakeholders and their interactions to become visible. As in the case of accident investigations, having too limited a focus on the person(s) or organisation(s) closest to the subject of investigation (the so-called "sharp end"), may lead to a reduced ability to detect problems inherent in the system that indirectly influence the subject of investigation (the so-called "blunt end") [6]. For example, focusing only on the actors responsible for the actual implementation of DRM measures (sharp end) leads to the risk of overlooking challenges rooted in the formulation of laws and regulations relevant to CCA (blunt end).

Against this background, the aim of this study was to investigate systemic challenges in the functioning of DRM systems that could have negative effects on the integration of CCA considerations in on-the-ground measures. The approach employed is based on the assumption that DRM systems are generally more mature than CCA systems, leading to countries' increasing engagement in the integration of CCA considerations in DRM systems [7]. Secondly, although progress has been made in terms of policy integration [8,9], limited progress has been identified in on-the-ground implementation [2,10]. It is thus important to investigate

Abbreviations: CCA, Climate change adaptation; DRM, Disaster risk management

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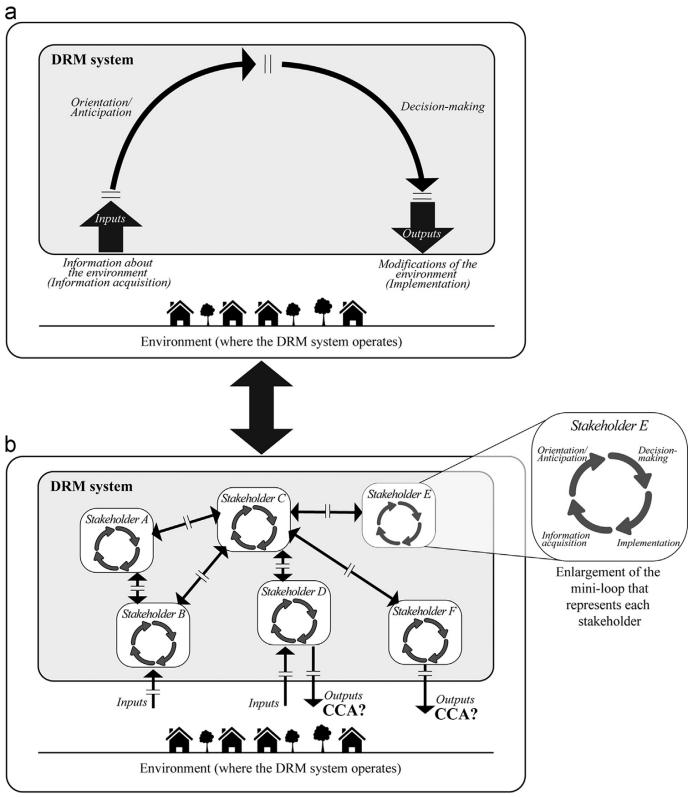

Fig. 1. Simple model of the functioning of a DRM system. (a) Illustrates the various functions of the DRM system. (b) Illustrates the fact that the DRM activities are conducted by different stakeholders. Potential fragmentation between different DRM functions is indicated by the symbol =.

fragmentation in DRM systems.

Nicaragua was chosen for the case study as its comprehensive and multi-sectorial DRM framework has been recognised as the most advanced in Central America [11], and has shown further progress in recent years [9,12,13]. In addition, the integration of CCA considerations into sectorial planning and policy is currently being undertaken (See [9,14]).[1]

Following the discussion of previous studies and considerations relevant to this study, Section 3 describes the conceptual framework used to study systemic challenges in the Nicaraguan DRM system, while Section 4 presents the methodology used for data collection and analysis. Section 5 presents the results, where the fragmentation of the DRM system and it influence on the implementation of integrated on-the-ground measures are presented. Finally, Section 6 gives a summary and discussion of the related conclusions.

[1] Previous studies by our group have explored the integration of CCA considerations into policy, regulations and practice, as well as related stakeholder perceptions in Nicaragua, and formed the basis of the present study.

2. Background

In investigating challenges in the integration of DRM and CCA, past studies have mainly focused on analysing differences between the fields in terms of spatial and temporal scales, norms, knowledge and resources [15], while little attention has been devoted to the analysis of the challenges that result from the interactions of stakeholders in complex DRM systems. Nevertheless, research has been conducted on the reasons why people and organisations fail to manage risk, including studies on high reliability organisations (e.g. [16], normal accidents (e.g. [17], resilience engineering (e.g. [18] and, most importantly, risk governance, which is concerned with investigating barriers to successful risk management. Research conducted in these areas may provide valuable points of departure. For example, the International Risk Governance Council (IRGC) has suggested ways of analysing deficits in risk governance processes that are useful here [19–22]. In addition to studies on different forms of, and barriers to, risk management and governance, previous research has also focused specifically on the challenge of integrating CCA considerations into well-established DRM systems, structures and practices, with the aim of increasing resilience [7,23–27].

Barriers and deficits in risk governance are discussed differently from barriers in CCA. In the case of CCA, barriers often refer to aspects that hamper the adoption or mainstreaming of climate-related issues into existing approaches [28,29]. Deficits in risk governance are more concerned with failure to achieve goals and in the actual management of risks. Moreover, risk governance deficits are generally associated with the activities of multiple stakeholders and their interactions, while it is often not clear whether barriers related to the integration of CCA are related to the challenges associated with a single stakeholder, or to the whole DRM system [30].

3. Conceptual framework

A conceptual framework was developed to identify systemic challenges to the functioning of DRM systems and the integration of CCA considerations, which guided our empirical analyses. The framework, which is illustrated in Fig. 1, is based on our previous work [31] and three assumptions regarding the characteristics and functions of a DRM system (see below). In the framework we use the term "environment" to refer to the context in which the DRM system in question is implemented, i.e., the environment where the overall purpose of the DRM system is to lessen the impact, as well as the likelihood, of hazardous events and resulting damage[2] (Fig. 1).

The first assumption on which our framework is based is that stakeholders act based on *bounded rationality* [35,36]. This means that the stakeholders all pursue their individual goals based on the information they have access to, using the resources (financial, manpower, etc.) and time available to them. When studying a DRM system with the intention of investigating systemic challenges, it is thus important to focus on the goals of the various actors. For example, through studying the regulations governing their operation, the information available, and how they influence the DRM system or the environment.

The second assumption is that the behaviour of a DRM system is strongly influenced by the interactions between various stakeholders who may be operating on different time scales [37]. The ways in which the various stakeholders influence each other must therefore be considered. This highlights the fact that although some stakeholders might not be directly involved in the implementation of DRM measures, they might still play very important roles for the behaviour of the whole system. Moreover, operating on different time scales means that the processes of collecting information, deciding on suitable actions, implementing them, and monitoring their effects may take more or less time, depending on the stakeholder. For example, a stakeholder issuing regulations concerning efforts in a specific area is generally working on a longer time scale than a stakeholder involved, for example, in building a flood protection barrier. Nevertheless, they might influence each other in ways that are important in understanding why CCA aspects were, or were not, integrated into the flood protection project.

The third assumption is that there is a need for systems thinking in order to understand the behaviour of a DRM system, i.e. what it does or produces, and related feedback loops. In the context of our study, special attention must be paid to: (1) how stakeholders in the DRM system obtain information about the environment, (2) how stakeholders in the DRM system arrive at an understanding of the current situation/state of the environment, (3) how stakeholders decide what to do about the situation, and finally, (4) how they implement related actions for improvement (cf. [31]. The four types of output from a DRM system can thus be described as four functions: (1) information acquisition, (2) orientation/anticipation, (3) decision-making and (4) implementation (see Fig. 1).

In accordance with the third assumption, Fig. 1a illustrates the various DRM functions, i.e. what the DRM system does to achieve its purpose, as well as potential fragmentation.[3] Using the two first assumptions, we developed the model illustrated in Fig. 1a into a more detailed model that guided our study (Fig. 1b). Similar to Fig. 1a, it shows the input from the environment to the DRM system, and the output in the form of activities influencing the environment. In addition, it shows that the DRM activities are conducted by different stakeholders who are not necessarily all involved in collecting information about the environment or in influencing the environment.[4] This means that many stakeholders will be dependent on information about the environment that is supplied, and possibly filtered, by others. It also means that decisions concerning changes in the environment, e.g., investments in CCA measures to reduce risk, may have to be implemented by others than those making the decisions about the change. Each box containing a "mini-loop" represents a stakeholder (Fig. 1b). The mini-loops illustrate the assumption of bounded rationality, i.e. stakeholders act according to the information available to them, based on the values they have, and the constraint imposed on them. Thus, one could consider each stakeholder to be a "mini-DRM system" that collects information from, and influences, its own environment. However, other stakeholders might have a considerable influence on the ability of a specific stakeholder to conduct its activities, for example, through legislation and regulations, sharing information, supplying resources, etc. This observation corresponds to the second assumption above, i.e. the importance of the influence of the various stakeholders on each other. This is illustrated in Fig. 1b by the arrows in both directions between the stakeholders. These stakeholders can operate at different administrative levels, and on different time scales, although this is not explicitly shown in the figure.

It is important to note that the conceptual framework in itself is not meant to explain *why* a specific DRM does not fulfil its purpose. The framework is intended to facilitate the analysis of *the extent* to which the system fulfils (or fails to fulfil) its purpose, and to identify related fragmentation. After having concluded from the application of the framework that a specific DRM system might fail to perform certain vital functions, and that it exhibits fragmentation, one can ask *why* this is the case. There may be numerous reasons, including competing institutional claims on authority (turf wars), lack of leadership, unclear responsibilities or resource flows, as well as inadequate working structures, planning procedures, policies, regulations or legislation (see, for example, [9,38,39]. Although the conceptual framework may reveal some of the underlying causes of failure and fragmentation, this is not its primary purpose.[5]

Although the framework described above is based on

[2] Disaster risk (and related risk reduction) relates to both climatic and non-climatic hazards and thus considers both climatic extremes and variability [32]. DRM is based on a multi-hazard approach to reduce related exposure and vulnerabilities [33,34]. CCA is focused on climate-related hazards and related vulnerabilities.

[3] Note that the model in Fig. 1 is not a cause-consequence model, but rather one illustrating the prerequisites for the various functions. For example, in order to make sense of the environment, information about it is required.

[4] Fig. 1 shows hypothetical examples of the interactions between stakeholders. It illustrates that they do not all collect information from the environment (only two of them in this example), and that they do not all influence the environment (only two of them).

[5] Note that the focus of this study is intra-organisational mainstreaming of adaptation to climate change, i.e., the promotion of cooperation between different stakeholders to generate shared knowledge, develop competence, and take joint action to advance adaptation [39].

assumptions regarding the general functioning of a DRM system, which do not provide specific insights into how aspects of CCA might influence such a system, the framework is still useful in assessing the integration of CCA into DRM measures. In fact, we can investigate the extent to which such integration takes place by studying the output from the DRM system and determining whether CCA aspects are present (Fig. 1b). Moreover, to explore whether systemic challenges to integration can be identified we can investigate whether CCA aspects are present or not in the output from other key activities (functions) of the DRM system when: (1) decisions are made regarding DRM measures, (2) when the basis for decisions is created (e.g. risk assessments) or (3) when information is collected about the environment. For simplicity, this aspect was not illustrated in Fig. 1b.

The framework described above thus provides a systematic way of "tracing" the integration of CCA aspects into concrete DRM measures from the sharp end, i.e. the actual integration, to the blunt end, e.g. policies and procedures. In the next sections, we describe and show how this was achieved when analysing the Nicaraguan DRM system.

4. Methodology

Retrospective analysis was used to study the integration of CCA considerations into the Nicaraguan DRM system and, more specifically, to assess systemic challenges to the implementation of integrated on-the-ground measures. Retrospective analyses can be applied to examine findings from a succession of data collection at different points in time [40]. We examined documents produced within the DRM system since 2003 (DRM plans, project reports, etc.) and we conducted interviews with professionals working within the DRM system, to obtain insights into the implementation of DRM measures, as well as the processes preceding their implementation.

4.1. Data collection

Purposeful sampling was used to select the interviewees based on their field of activity, to cover all relevant functions and levels in the DRM system. All the stakeholders were part of the permanent structure of the DRM system. A total of 21 semi-structured interviews were conducted in 2014, with 14 actors at national level and 7 actors at local level. Representatives from the national level included those from the Executive Secretariat of SINAPRED,[6] other governmental agencies and an NGO. The interviewees from the local level were from local municipalities, two universities and an NGO (see Appendix A). Coordination of DRM activities in the Pacific, Central and Atlantic regions of Nicaragua is managed by one municipality located in each region and department. These municipalities were included in this study, and were able to provide information on the work of other municipalities and actors at the regional level. The conceptual framework presented in Section 3 provided the basis for developing our interview guide. The guide included questions about how the stakeholders obtain risk-related information, how and why they interact with other stakeholders, what actions they undertake in relation to DRM and CCA, and which dependencies or barriers exist (see Appendix B).

In parallel with the interviews we collected documents that described the DRM system and related outputs. DRM strategies and associated documents at national, regional and local level were the primary focus. In total, 54 documents were included in the empirical analysis: two national DRM plans (the National Plan for DRM and the National Disaster Response Plan), 16 regional DRM plans, and 36 local DRM plans and related documents from 15 municipalities. The DRM plans at regional level correspond to 14[7] (out of 15) departments and 2 (out of 2) autonomous regions of the country. The municipalities were chosen so as to represent all geographical areas (including the 3 administrative regions: Pacific, Central and Atlantic), and municipalities of various sizes. Selection was also influenced by the availability of plans and other documents. This resulted in the selection of 15 local municipalities,[8] including those with a considerable urban population, such as Masaya, and those with a mainly rural population, such as Telpaneca.[9] Moreover, some municipalities were located by the sea (e.g. Corn Island) or a lake (e.g. Moyogalpa), and others inland (e.g. Masaya, La Paz Centro) or in more mountainous areas (e.g. Estelí).

4.2. Data analysis

The documents and the results of the interviews were analysed based on the conceptual framework presented above. They were coded to determine: (1) the different stakeholders engaged in DRM and CCA activities, (2) their interactions, (3) their functions and related outputs, and (4) potential barriers. Regarding the outputs, our main focus was on identifying which DRM measures were being planned for future implementation, which were being implemented, and which had already been implemented. Once a measure was found in a text segment, it was coded according to three categories:

I. Measures that deliberately address CCA. These DRM measures are explicitly proposed to address specific climate-related impact (e.g. increased precipitation).
II. Measures that do not explicitly address CCA, but indirectly reduce climate-related impact. These measures are not explicitly proposed to reduce the impact of climate change, but will have related effects.
III. Measures that do not address CCA. These are DRM measures that are proposed for reasons not related to climate change, and are not expected to contribute to the reduction of climate-related impact.

4.3. Limitations

There are many potential systemic challenges to the integration of CCA aspects into DRM systems and measures. To limit the scope of the present study, we focused on challenges related to *fragmentation of DRM functions and related processes*, which means a situation where the output from one part or function of the DRM process illustrated in Fig. 1 cannot be used, or is difficult to use, as input to another part or function (cf. [41]). An example of a clear fragmentation of the DRM process would be the case where risk assessments (being an output of the orientation and anticipation function) would be useless for the planning of integrated measures.

It should also be noted that there are several threats to the validity of the present study. Construct validity is central here, and

[6] National System for Disaster Management and Prevention (SINAPRED in Spanish).

[7] One DRM plan was not available at the time of this study.

[8] Pacific Region: Masaya, Chinandega, La Paz Centro, Moyogalpa, El Realejo. Central Region: Estelí, Telpaneca, Palacagüina, Ocotal, Santa María. Atlantic Region: Siuna, Prinzapolka, Paiwas, Corn Island, Laguna de Perlas.

[9] According to the Annual Statistics Report of 2011 of the National Information and Development Institute (INIDE), Masaya has an urban population of 114,852 and a rural population of 49,440 inhabitants. Telpaneca has an urban population of 4947 and a rural population of 16,693 inhabitants.

concerns the relationship between the observed material and the theories used in the study. The most important aspect of construct validity in the present study is the question of whether the empirical material actually reflects the theoretical constructs. We dealt with this threat to validity in several ways. First of all, we developed an interview protocol based on the conceptual framework. Secondly, we reduced the risk of misinterpreting the observations by using several sources of evidence, both interviews and documents, when investigating the functioning of the DRM system. Thirdly, to reduce reactive bias, the respondents participating in the study were treated anonymously. Finally, we did not look for causal relationships, i.e., we do not claim to have discovered "the reasons" for the lack of integration of CCA into DRM measures in Nicaragua. However, exploring systemic challenges and fragmentation of DRM process resembles the task of finding causal factors, and internal validity should, therefore, also be

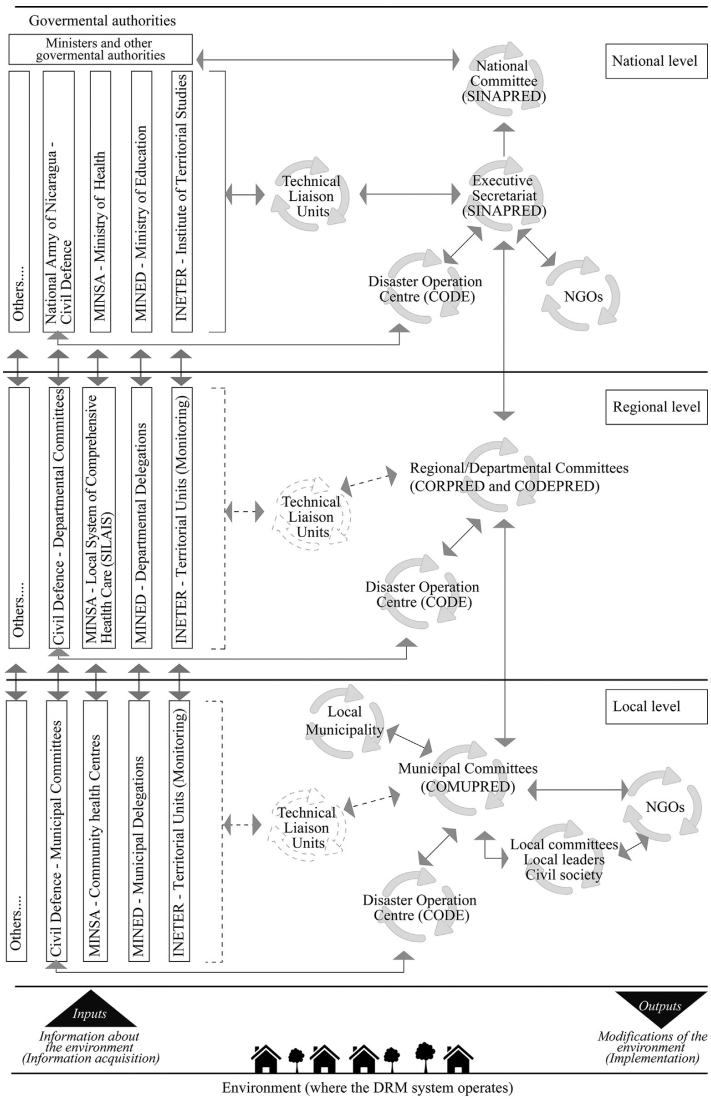

Fig. 2. Actors involved in the Nicaraguan DRM system.

considered. Threats to internal validity were addressed by using multiple sources of evidence, and by actively searching for information from different stakeholders, e.g. in terms of administrative level, geographic location, functional responsibility, etc., in the Nicaraguan system. Thus, claims regarding fragmentation between different functions are only made if they are supported by multiple sources.

5. Results

This section presents the results concerning the functioning and related stakeholder interactions in the Nicaraguan DRM system, the integration of CCA into the implementation of on-the-ground DRM measures, and related systemic challenges.

5.1. The actors of the DRM system and their interactions

Through our analysis we identified the most central actors and interactions in Nicaragua from a DRM and CCA perspective (Fig. 2). The Nicaraguan DRM system is comprised of three administrative levels; national, regional and local.

On the national level, the National Committee of SINAPRED is central. The committee is led by the President of Nicaragua, and includes representatives from each ministry and some national authorities relevant for DRM. An important task of the committee is to approve national strategies for DRM and delegate responsibility for implementing them. Another important national stakeholder is the Executive Secretariat of SINAPRED. This is more operative than the National Committee, and is responsible for ensuring that DRM is coordinated at, and between, different levels, and the related stakeholders. SINAPRED's National Committee bases its work on information from the Executive Secretariat and other national authorities (Fig. 2). Since SINAPRED's National Committee is such a central stakeholder, its work influences all other actors. However, its influence is usually indirect, e.g., through the actions of other stakeholders. For example, the national DRM plan is not specific enough to be used directly by local municipalities. Instead, the plan influences the work of other stakeholders (e.g., national authorities) and, through their work, also the local municipalities. The actors that are directly influenced by the work of the National Committee are the Executive Secretariat and various national authorities through sector-led work commissions, described below.

Moreover, there are nine sector-led work commissions that are responsible for the coordination of various authorities when a disaster strikes, but they also perform important work before and after such events. During non-disaster situations, the work of the commissions is usually carried out by their respective Technical Liaison Units, and each unit serves as the focal point for mitigation and preparedness activities in their respective sector, or area of responsibility (Fig. 2). Each commission is headed by a national authority and its minister, and they focus on different areas of importance in DRM, i.e., health, education, security, natural phenomena, natural resources and the environment, humanitarian supplies, infrastructure, consumer protection and special operations. The national authority in charge of the work of a specific commission depends on their area of interest. In addition to the sector-led work commissions, other governmental authorities are responsible for specific DRM tasks, such as the General Direction of the Fire Department, the National Policy of Nicaragua, and so on. There are also a number of NGOs that operate at the national level (e.g. The European Commission's organisation DIPECHO), and they are an inherent part of the Nicaraguan DRM system. These NGOs have developed several sector-specific programmes and projects in fields such as humanitarian aid, water management, risk reduction, climate change adaptation, etc. The national authorities cooperate with the different NGOs and know their areas of expertise. Therefore, if a national authority needs support, they can communicate directly with the relevant NGO, or the national authority can send a request to the Ministry of Foreign Affairs to find suitable NGOs and help them to establish cooperation. The NGOs that work explicitly on DRM interact primarily with the national actors of the Nicaraguan DRM system. For example, the European Commission's organisation DIPECHO has an office in Managua that coordinates the work of its partner organisations (NGOs) on the local level in Nicaragua. Finally, at the national level, there is also a public entity called The Disaster Operation Centre (CODE) (Fig. 2). This is managed by the Civil Defence branch of the National Army, and is usually active during emergency response, but can also perform some DRM activities under non-emergency conditions.

The key actors identified at the regional levels are representatives of the national authorities and ministries, and they are responsible for the activities carried out in the municipalities included in the departments[10] to which they belong. For example, the Civil Defence Authority has regional units called Departmental Committees of Civil Defence, and Municipal Committees of Civil Defence at local level. Local units are composed of brigades such as Municipal Brigades for Response. The interaction with the rest of the DRM system is managed by technical liaison units in each authority on regional and local level. The National Committee of SINAPRED also has a corresponding structure on the regional level. They are called Regional/Departmental Committees, and they coordinate the actions of the DRM system at the regional level (Fig. 2). In addition, there are Disaster Operation Centres (CODEs) at regional and local levels. The CODEs provide information during emergencies and they support decision-making processes at the various levels. The CODEs at local level also provide information about the environment to the CODEs at regional and national level.

Most national authorities are not represented at the local level, the exception being the municipal committees called COMPUREDs,[11] which are the local equivalent of SINAPRED's National and Regional Committees. They are headed by the mayors and are made up of public and private institutions, NGOs and communal leaders at the local level. COMUPREDs operationalise the strategies established at national and regional level, and coordinate actions between the actors at this level. Moreover, some COMUPREDs have created structures to promote participative processes, e.g., via local committees, family committees, and district committees. Other important types of stakeholders on the local level are various NGOs. Depending on their areas of interest, they support DRM through the activities of the COMUPREDs, for instance, they provide technical or/and financial support for implementing DRM measures, or facilitate communication between actors.

5.2. Implementation of DRM measures and related CCA integration

Although Fig. 2 illustrates important stakeholders and their interlinkages, it does not contain specific information concerning the different stakeholders' actions, especially concerning CCA

[10] Nicaragua has a political administration divided into departments in the Pacific and Central areas, and two autonomous regions in the Atlantic area. Each department or autonomous region consists of municipalities, one of which represents the "head" of the department/autonomous region. These "head" municipalities usually gather most of the representative institutions of the government and provide services to the rest of the municipalities in their departments or autonomous regions.

[11] COMPURED, Comité Municipal para la Prevención, Mitigación y Atención de Desastres.

integration. In order to explore related systemic challenges in the DRM system, we identified the actors that are implementing DRM measures on the ground, and that also address CCA. Attention was thus directed to those stakeholders that correspond to the sharp-end of the DRM system, i.e., those that deal with the implementation of DRM measures in the environment of the DRM system.

Three different types of situations were identified by the respondents in which actual implementation of DRM and related CCA measures could take place.

1) One or several governmental authorities are responsible for implementation, possibly with the support of private companies and COMUPRED at the local level.
2) The local government manages implementation, possibly with financial and other types of support from national level.
3) An NGO manages implementation, possibly with the support of local and/or national authorities.

The first type of implementation process can occur when one of the stakeholders at the national level, e.g., SINAPRED's Executive Secretariat, informs COMUPRED about planned on-the-ground measures. In this case, the national level usually provides the funds, either from the national budget or a cooperation agency. Implementation of DRM measures is then usually performed by one or more national authorities and is coordinated by the Executive Secretariat. However, although a national authority manages the implementation, they often hire private companies to carry out the actual implementation. For instance, one of the largest DRM projects in Nicaragua was financed by the World Bank. The project started with the creation of the Nicaraguan DRM system, and the World Bank supported its work until 2009.[12] This project included the implementation of DRM measures in 30 municipalities. Physical disaster mitigation measures were implemented in 11 of them, in coordination with COMUPRED. Implementation was executed by the Nicaraguan Social Investment Fund Programme (FISE), who managed activities such as issuing calls for tenders, hiring private companies and consulting firms, financial management and evaluation. Local authorities usually only followed up the progress of the work. The following quotes from two respondents illustrate this implementation processes.

> *"The projects we carry out are formulated by us in cooperation with our donors. For instance, we say to UNDP:'We need to train ten emergency committees in Estelí". So, we propose the project, the rationale, the needs, and we prioritise some municipalities of the Department of Estelí. Then, we sit down together and agree on the operating procedures in order to initiate the project." – Director of Operations, ES-SINAPRED (national level)*
>
> *"Environmental assessments are an integral part of our projects. As a result of the environmental assessments, "environmental measures" are proposed (…). Generally, all (infrastructure) measures are then supervised by a contractor. Construction work and project supervision are also outsourced. Our Environmental Unit follows up and supervises projects only in cases where supervision is not included in the design of the project". – Environmental Unit, MTI (national level)*

The second type of implementation process can occur when a local authority identifies risk-related problems that they consider important to solve. In these situations, the mayor can request technical and financial support from national authorities through COMUPRED, CORPRED[13] and SINAPRED's Executive Secretariat. Also, the municipalities can request to be included in existing programmes that are executed by governmental authorities. For example, due to frequent floods in a neighbourhood of Managua, the municipality issued a request to the Central Government that the affected families be included in the programme "Housing for the People" to allow their resettlement. This is coordinated with the Institute of Rural and Urban Housing (INVUR) and the Institute for Social Security (INSS), but the local municipality implements the measure, possibly with the support of national authorities.

The third type of implementation process relates to the work of NGOs and municipalities on DRM and development in general. In an attempt to have their projects implemented, NGOs promote their ideas to create interest by the local authorities and to make them aware of the benefits for the local community. The NGO then often carries out the implementation of DRM or CCA measures, usually with the participation of local and/or national authorities. The second and third types of implementation process can be illustrated by the words of an NGO representative:

> *"At the local level, once the needs have been identified, the communities often become active themselves, asking for support (to the national level), until their requests become a project. There is also another way; when the idea comes from us, from external institutions, and we present it to the communities. But in both cases, it is key that the community becomes involved from the very beginning of the project." – Habitat for Humanity (local level).*

To obtain an overview of the actual DRM measures that are implemented on the ground, we analysed the transcripts of the interviews and 52 DRM plans at regional and local level. We searched for text segments related to measures, and found a total of 167 different measures relevant to all types of hazards. They do not, however, include measures that are explicitly suggested (in the interviews or the DRM plans) for CCA. Nevertheless, 26 measures were identified that link DRM with CCA considerations (Appendix C). The hard measures found relate mainly to the construction and maintenance of infrastructure, for instance, improving the canal lining of the Zanjón los Cedros in Estelí,[14] resettlement, for instance, moving houses that are located in areas at extreme risk of flooding and landslides,[15] and more ecosystem-based approaches, for instance, soil conservation by promoting reforestation in order to protect riverbeds.[16] Soft measures included campaigns to increase awareness of risks, and conducting risk assessment studies (including climate-related considerations).

5.3. Systemic challenges

The analysis of the actors, their interactions, and resultant on-the-ground measures shed light on existing systemic challenges related to the fragmentation of DRM processes. The two most critical challenges identified were related to: (1) difficulties in integrating two parallel systems for information acquisition, orientation and anticipation, and (2) isolation of the local municipal level.

[12] Natural Disaster Vulnerability Reduction Project, Nicaragua. World Bank. Available at: http://documents.worldbank.org/curated/en/2009/08/11091981/nicaragua-natural-disaster-vulnerability-reduction-project. Some of the DRM plans developed during this project are part the sample investigated in this study.

[13] CORPRED and CODEPRED are the structures of SINAPRED at regional level (See Fig. 2). Regional Committee for Prevention, Mitigation and Response to Disasters (CORPRED), and Departmental Committee for Prevention, Mitigation and Response to Disasters (CODEPRED). The former operate in the autonomous regions of the Atlantic and the latter work in the departments of the Central and Pacific areas of Nicaragua. CORPRED is used in this paper to refer to both structures.

[14] Measure proposed in the DRM Plan of the Municipality of Estelí, page. 49

[15] Measure proposed in the DRM Plan of the Department of Chontales, page 37.

[16] Measure proposed in the DRM Plan of the Municipality of Corn Island, page 43.

5.3.1. Inability to integrate two parallel systems for information acquisition, orientation and anticipation

In order to implement DRM measures (as described in Section 5.2) the different stakeholders need information about the environment. This information must then be analysed, and the state of the environment (e.g., the potential hazards that might cause harm, etc.) must be assessed. When analysing the empirical data we found two parallel and, to a certain extent, isolated, systems for information gathering and analysis.

The first system for information gathering and analysis involves governmental authorities. They collect data relevant to their area of responsibility and some information is used as the basis for assessing risks. Interviewees indicated that the sector-led work commission for natural phenomena, headed by the Nicaraguan Institute of Territorial Studies (INETER) (Fig. 2), is one of the most important actors in this respect. INETER monitors volcanic-, seismic-, landslide- and climate-related hazards with different methods, and they coordinate the collection of the data with the Civil Defence Authority, which has regional and local units in the field INETER produces different types of hazard and risk information, and provides this to SINAPRED's Executive Secretariat. Several other governmental authorities collect data, process it, and send it to the Executive Secretariat. The following quotes illustrate the first type of system for information gathering and analysis:

> *"(…) they [INETER] assess natural phenomena, but not from social or economic perspectives, and how they affect the surroundings (…) Hence, our work at the local level is learning-by-doing. There we discuss and analyse what is happening. And if necessary, we discuss disaster mitigation strategies also at the local level, and who should be involved in their implementation. This means that today, we get the basic information at the local level from local people, the municipality and ourselves." – Technical advisor, ES-SINAPRED (national level).*
>
> *"We take the information that is available from the governmental institutions, but we then verify it in the field, or replace it with new information from the local level." – Land Use Planning Unit, INETER (national level)*
>
> *"We have definitely had to create our own tools in order to be able to decide whether our interventions should be carried out or not. We cannot depend on the risk assessments carried out by the institutions concerned. Ideally, it would be good to have a more decentralised system with field offices which can offer their services at the local level to support municipalities." – Habitat for Humanity (local level)*
>
> *"For instance, my boss tells me,"You are going to be part of a commission to conduct an evaluation and monitor what is going on in a specific area'. This commission then works together with community leaders and has the responsibility of submitting a final report of its findings to higher authorities. We do not propose any measures, this is done by other authorities." – Municipality of Managua (local Level)*

The second way in which information about the environment is gathered and analysed is by different stakeholders at the regional and local levels, such as the local authorities, NGOs and civil society organisations. Some of it is communicated to the COMUPREDs, which then use it as the basis for the development of local DRM plans. Related processes are complex. For example, in the case of Managua, information about local hazards, vulnerabilities and capacities is primarily obtained from community leaders. In addition, NGOs often collect information about the environment and share it. Finally, the governmental institutions of the local level also collect and share information. However, since local authorities often do not have the technical expertise necessary, for example, in areas such as geology or hydrology, they need support from the technical liaison units of the relevant governmental authorities or, in most cases, they use external consultancy firms to help them in their risk assessments. The COMUPREDs then send the information collected, such as maps of affected areas, vulnerability reports, reports of available resources and capacity, etc., to the CORPREDs at the regional level, where they form the basis for regional risk assessments, which are then sent to SINAPRED's Executive Secretariat at the national level.

There are thus two parallel systems of information acquisition about the environment, one that goes through the governmental authorities, and one that goes through the local authorities. An important difference between the two is that the governmental authorities focus only on hazards related to their specific areas of interest, e.g. geological hazards, whereas the local authorities focus on all possible hazards in their area. The different governmental authorities are thus more limited in terms of their knowledge on the local environment and their work-related perspective. Therefore, from a DRM perspective, integration of the more technically focused knowledge of governmental authorities and the broader context-specific knowledge of the local authorities is required, and a necessity for integrated on-the-ground measures. This could be a key function of the COMUPREDs, which provide the formal link between local and national authorities. However, this is not the case in practice, as considerable challenges were found in the integration of the material. No respondent was able to provide a clear picture of the ways in which the different stakeholders of the DRM system share their risk information. Neither do the legislation nor the DRM plans provide specific information on how the different actors should collect and communicate such information to one another. Examples are the main legislative instrument of the Nicaraguan DRM system, Law 337, and the National DRM Plan. Although these documents are supposed to guide the distribution of responsibilities among the various actors, they do not provide sufficient guidance regarding the type of information that should be shared by whom and in what way (see [42,43]. Moreover, as shown by [31], the DRM plans produced on the regional level are limited in terms of their descriptions of key elements of risk, such as possible scenarios, how likely various events are judged to be, and their consequences. Thus, their usefulness as a basis for decision-making can be questioned. In the present study we detected similar problems in the local DRM plans. Only 6 of the 15 DRM plans studied included a description of potential consequences due to various undesirable events, and none of them contained any judgements of how likely the events and consequences would be. Moreover, there was no clear connection between the risk assessment and the measures suggested to reduce risk in 15 of the 16 DRM plans at regional level or in 10 of 15 plans at local level. This is yet another indication of a fragmented DRM process.

An explanation of these limitations in terms of the information and material useful for decision-making is that the governmental authorities do not collect data that is of use to improve local DRM. However, according to the interviewees (see quote below), several authorities, such as INETER, do have data that could be very important in improving the usefulness of the DRM plans and, in turn, the development of integrated on-the-ground measures. For example, they publish reports and data on their website about hazard monitoring.[17] Therefore, the identified lack of integration seems rather to be rooted in the fragmentation of the DRM functions and related processes. Thus, the detailed information about various hazards possessed by the governmental authorities is not used by the local municipalities. Similar problems were also detected in the national and the regional plans, indicating that the

[17] http://www.ineter.gob.ni/

output from the orientation and anticipation function produces outputs that are difficult to use as the basis for decision-making at all levels.

> *"The information given is often much too technical. Information such as seismic reports are released, and… the information that actually reaches the municipalities is much too technical. It is not useful because it can not be used in practice. The idea is to analyse the existing information and, based on this, create specific projects together with the municipalities, focusing on projects for disaster response and early warning." – Technical advisor of the General Director, ES-SINAPRED (national level).*

5.3.2. Isolation of local municipalities

The inability to collect information useful as a basis for decision-making discussed above also has the effect that local municipalities become rather isolated, i.e., they do not receive adequate support from higher levels, and the usefulness of the information they supply to other stakeholders becomes questionable. In addition to the fragmentation discussed above, we found additional fragmentation related to the isolation of the local municipalities, which became apparent when studying decision-making with respect to DRM measures. Many stakeholders actually implementing DRM measures do not decide whether or not to implement the measures in the first place. According to most interviewees, SINAPRED's National Committee is very influential in DRM decision-making, with the Nicaraguan president being the chair of the committee. However, the committee does not make decisions regarding concrete DRM measures; they decide the overall strategy. This is directly linked to the Human Development Plan [44], produced by the Secretariat of the President of Nicaragua, in which the goals for DRM are defined. Thus, although the DRM goals and the national DRM plan do not specify which measures should be implemented where, they are very influential for related decisions. Therefore, it is important to note that the plan for 2012–2016 and related goals for DRM clearly link CCA with DRM, and describe expected related results for the DRM system.[18] The plan proposes the promotion of sustainable development through twelve guidelines, one of which (No. 12) is focused on reducing vulnerability by integrating CCA and DRM efforts. Moreover, one of the stakeholders that is closely involved in making decisions concerning concrete DRM measures is SINAPRED's Executive Secretariat, which receives information from both the parallel information acquisition systems (see Section 5.2). However, as noted above, the usefulness of the information SINAPRED receives from the COMUPREDs and the CORPREDs can be questioned.

When studying the implementation of the decisions made by national authorities, such as the Executive Secretariat of SINAPRED, other indications of the isolation of the local level were found. For example, there were several examples of measures proposed by a higher-level authority that were not taken into consideration at the lower levels. For instance, the Departments of Estelí, Madriz, Masaya and Nueva Segovia suggested the construction and maintenance of a rain drainage system in urban and rural areas in their regional DRM plan (Appendix A). However, none of the local municipalities studied in those departments included such measures in their plans. According to the interviews, this is related to difficulties in understanding information from higher levels (see the above quotation from the Habitat for Humanity). Moreover, several of the respondents from the local level said that stakeholders from the national level respond slowly to their requests for assistance or information, and they therefore mainly seek other types of solutions and resources, for instance, by collaborating with NGOs. Thus, the actors at local level solve their immediate needs through collaboration with actors that may not see the integration of CCA aspects into DRM as a priority, in contrast to the national goals. Overall, it appears that the local municipalities are rather isolated or disconnected form higher-level processes, which might be one reason why advances in CCA integration at national policy level are less reflected in the DRM measures at local level.

6. Discussion and conclusions

This paper presents a conceptual framework for analysing systemic challenges in DRM systems that can also inhibit the integration of CCA considerations. The results of applying this framework to the Nicaraguan DRM system show that, although there are national policies and regulations that explicitly demand DRM–CCA integration, this is poorly reflected in planned and implemented on-the-ground measures.

We found several indications of fragmented DRM processes and functions that influence the integration of CCA aspects into DRM measures, two of which were deemed more important. Firstly, the various stakeholders in the DRM system have problems in producing information that is useful for decision-making regarding the implementation of climate-relevant DRM measures. The problem is most obvious regarding the integration of information concerning different types of hazards. Secondly, the DRM work of the stakeholders at local level is isolated from related work at regional and national levels. Consequently, integrated measures suggested by regional and national authorities are not implemented at the local level. Furthermore, certain information relevant to DRM that exists at the national level (e.g. within national authorities) does not reach the local level, hampering adequate decision-making.

There may be many reasons for these problems. However, as a starting point for improving the integration of the DRM work of the various stakeholders, and thereby increasing the likelihood of integration of CCA aspects into DRM measures, it is important to clarify the ways in which risk-related information can be communicated and combined. The most important aspect in this context is to define the required risk information and related communication channels so that the information from different governmental authorities can easily be used as a basis for decision-making at lower levels, e.g. that it is accessible and makes clear how potential DRM measures can influence potential future hazard events. If improvements can be made, it will be easier to show how DRM measures that consider CCA can better reduce potential negative outcomes. This improves the potential for local municipalities not only to obtain adequate assistance from the national authorities, e.g. in terms of information, but also to contribute to promoting the integration of CCA considerations into DRM in the whole country.

Although the generalisability of our context-specific results is limited as we have only studied one DRM system, other aspects of generalizability are important here. First of all, an important contribution of this study is the development of the conceptual framework that can facilitate the study of systemic challenges. From this perspective, the Nicaraguan DRM system served as a test case, i.e., a way of testing the framework in practice. The demonstration of the utility of the framework for the identification of fragmentation in the Nicaraguan DRM system can be seen as

[18] "The Human Development Plan 2012–2016 proposes, for instance, a programme called 'Defence and Protection of the Environment, Climate Change Adaptation and Disaster Risk Management'. The expected results of the programme are the improvement of environmental education, forest fire protection, water resources management, and the empowerment of local governments for environmental management" (p. 64).

"proof of concept", indicating the usefulness of the approach in other contexts. Another aspect of generalizability refers to the findings of this study. For example, to what extent can we claim that they are valid for other DRM systems? Although the aim of this study was not to provide generalisations to other cases, we still believe that the findings are not unique to Nicaragua (see, for example, [41] where similar findings have been reported from Sweden), and could thus be an important starting point for further studies.

We thus conclude that the conceptual framework developed here is useful in identifying systemic challenges and related fragmentation of DRM processes and functions. Since there is no off-the-shelf solution or approach for effective DRM–CCA integration (due to its complex, diverse and context-specific nature) [2,5], taking a systemic approach can pave the way for further advancements. In fact, although our framework is in the early stages of development, it has the potential to contribute to more systematic investigations of the systemic challenges related to the integration of CCA aspects into DRM measures and to DRM in general. Further testing and development are, however, required to adapt its usefulness in other contexts.

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Appendix A

See Table A1

Appendix B

See Table B2

Table B2
Interview protocol.

Division of Risk Management and Societal Safety, Lund University

Lund University Centre for Risk Analysis and Management (LUCRAM)

Instituto de Geología y Geofísica (IGG/CIGEO)

Universidad Nacional Autónoma de Nicaragua, Managua

- Introduction to the study
- General description of the interview

1. **Basic Information about the interviewee**
- Name of institution
- Position
- Current duties

2. **Data acquisition**

21. Do you take part in risk assessment studies?
22. Where do you obtain information about DRR/CCA?
23. Do you collect data used for DRR and CCA?
24. Do you share this information? (How?)
25. Could you provide an example of DRR/CCA (environmental) assessment?

3. **Orientation/Anticipation**

31. What are the criteria you use to decide about DRR and/or CCA?
32. Could you explain how you integrate risk issues in your tasks?
33. How do you decide what should be done in terms of DRR/CCA?
34. How do you assess risk? How do you present the information you generate in terms of DRR/CCA? (descriptions, scales, models, scenarios – methods)

4. **Decision-making**

41. How do you plan what to do in terms of DRR/CCA?
42. Do you propose measures for DRR/CCA?
43. How do you communicate it? (To whom?)
44. How do you present the actions that have to be taken for DRR/CCA? (Plans, reports – the outputs)

5. **Implementation**

51. How do you implement plans or measures for DRR/CCA?
52. Who is involved in the implementation process?
53. Do you monitor the implementation of measures for DRR/CCA?

6. **Suggestions**

61. What do you think could be improved in your work?
62. How the integration of DRR and CCA in urban planning projects can be improved?

Thank you for your participation

Tabel A1
Participants of the interviews.

Level	Type of respondent	Organisation	Type of institution
National	Programme manager	Division Relief and Response, ES-SINAPRED	Government
National	Programme manager	Direction of Operation, ES-SINAPRED	Government
National	Operational officer	Division of Development and Management, ES-SINAPRED	Government
National	Operational officer	Division of Response and prevention, ES-SINAPRED	Government
National	Operational officer	Technical Advisor, ES-SINAPRED	Government
National	Operational officer	Technical Advisor to the General Director, ES-SINAPRED	Government
National	Operational officer	Adjunct Assistant to the General Director, ES-SINAPRED	Government
National	Programme manager	Land Use Planning Unit, INETER	Government
National	Operational officer	Technical Assistance, INETER	Government
National	Operational officer	Division of Geophysics, INETER	Government
National	Operational officer	DRM Office, MTI	Government
National	Operational officer	Division of Urban Investments, MTI	Government
National	Programme manager	Environmental Unit, MTI	Government
National	Programme manager	DIPECHO, European Commission	NGO
Local	Academic staff	Docent and independent Consultant, UNAN-Managua	Government
Local	Programme manager	Habitat for Humanity	NGO
Local	Operational officer	Unit of Urban Planning, Municipality of Ticuantepe	Government
Local	Operational officer	Unit of Projects, Municipality of Ticuantepe	Government
Local	Operational officer	General Unit of the Environment, Municipality of Managua	Government
Local	Operational officer	General Unit of the Environment, Municipality of Managua	Government
Local	Academic staff	Docent, UNI	Government

ES-SINAPRED – Executive Secretary of the National System for Disaster Management and Prevention.
INETER – Nicaraguan Institute of Territorial Studies.
MTI – Ministry of Infrastructure and Transport.
UNAN-Managua – National Autonomous University of Nicaragua.
UNI – National University of Engineering.

Appendix C

See Table C3

Table C3
DRM measures identified that include CCA considerations.

Measures proposed at regional level	Regional level (Departments)	Local level (Municipalities)
Hard measures		
1. Proposal of projects for building infrastructure in order to protect river banks and flood-prone areas (e.g. dams, flood barriers, etc.)	Boaco, Carazo, Chinandega, Chontales, Estelí, Granada, Jinotega, León, Madriz, Masaya, Matagalpa, Nueva Segovia, RAAN, RAAS, Río San Juan, Rivas	Masaya, Estelí, Santa Maria, Prinzapolka, Telpaneca, Palacagüina, Ocotal, Corn Island, Paiwas, Siuna, Laguna de Perlas
2. Construction and maintenance of rain drainage in urban and rural areas	Boaco, Estelí, Granada, Jinotega, León, Madriz, Masaya, Matagalpa, Nueva Segovia, RAAN, RAAS, Río San Juan, Rivas	
3. Environmental studies for new investment projects. These studies must include the disaster mitigation and prevention measures proposed by the Ministry of Environment and Natural Resources (MARENA) and the DRM plans.	Boaco	
4. Reforestation and restoration of degraded forests in areas close to water bodies, river banks, basins and areas prone to landslides with indigenous species	Boaco, Carazo, Chinandega, Estelí,	Estelí, Santa Maria, Prinzapolka, Telpaneca, Palacagüina, Ocotal, Corn Island
5. Implementation projects for dredging and cleaning riverbeds	Carazo, Chontales, Granada, Jinotega, León, Madriz, Masaya, Matagalpa, Nueva Segovia, RAAN, RAAS, Río San Juan, Rivas	Telpaneca, Palacagüina, Ocotal, Corn Island, Paiwas, Siuna, Laguna de Perlas
6. Repair of the drainage system and building of new elements to improve it	Carazo, Chinandega, Chontales,	Estelí, Santa Maria, Prinzapolka, Telpaneca, Palacagüina, Ocotal, Corn Island, Paiwas, Siuna, Laguna de Perlas
7. Creation of resettlement action plans in order to move those living in disaster-prone areas	Chontales, Granada, Jinotega, León, Madriz, Masaya, Matagalpa, Nueva Segovia, RAAN, RAAS, Río San Juan, Rivas	Estelí, Santa Maria, Prinzapolka, Telpaneca, Palacagüina, Ocotal, Corn Island
8. Creating projects for water supply and management in order to avoid contamination by waste water	Estelí, Granada, Jinotega, León, Madriz, Masaya, Matagalpa, Nueva Segovia, RAAN, RAAS, Río San Juan, Rivas	
9. Building flood protection barriers along roads		Chinandega, La Paz Centro, Moyogalpa, El Realejo
10. Evaluating the characteristics (height) of new constructions in areas prone to floods		Chinandega, La Paz Centro, Moyogalpa, El Realejo
11. Construction of pedestrian bridges over deep rivers		Chinandega, La Paz Centro, Moyogalpa, El Realejo, Estelí, Santa Maria, Prinzapolka
12. Construction of vehicular bridge sin roads affected by floods		Estelí, Santa Maria, Prinzapolka
13. No modification of the natural direction of river flow.		Chinandega, La Paz Centro, Moyogalpa, El Realejo
Soft measures		
14. Promotion of comprehensive approaches for water supply, sanitation and water basin management	All regions	
15. Protection of the national system of protected areas for the conservation of biodiversity and water resources	All regions	
16. Implementation of programmes for the control and prevention of forest fires	All regions	
17. Establishment of municipal programmes for waste management	All regions	
18. Adaptation of agricultural techniques for soil conservation and protection of river banks and areas prone to landslides	Boaco	Estelí, Santa Maria, Prinzapolka, Paiwas, Siuna, Laguna de Perlas
19. Creation of projects and promotion of cleaning campaigns to prevent standing water and floods	Boaco, Carazo, Chinandega, Chontales	
20. Enhancing capacities for the use and monitoring of early warning systems for floods	Boaco	Masaya, Telpaneca, Palacagüina, Ocotal, Corn Island
21. Promotion of prevention and mitigation measures for landslides, floods and earthquakes in order to increase awareness in society	Boaco	
22. Requesting risk assessment studies in order to identify flood-prone areas and evaluating the capacity of the current infrastructure	Carazo, Chontales	
23. Creation and implementation of projects to manage and protect water basins	Carazo, Chontales, Granada, Jinotega, León, Madriz, Masaya, Matagalpa, Nueva Segovia, RAAN, RAAS, Río San Juan, Rivas	Paiwas, Siuna, Laguna de Perlas
24. Design of land use and urban development plans considering disaster-prone areas in order to avoid human settlement in areas that may be affected by volcanic eruptions, floods or landslides	Chinandega, Estelí,	Masaya, Chinandega, La Paz Centro, Moyogalpa, El Realejo, Telpaneca, Palacagüina, Ocotal, Corn Island
25. Promotion of organic farming in order to avoid water contamination by the use of agro-chemicals	Chinandega	Paiwas, Siuna, Laguna de Perlas
26. Prohibition of the construction of buildings less than 15 m from river banks		Chinandega, La Paz Centro, Moyogalpa, El Realejo

Appendix D. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.ijdrr.2015.09.009. These data include Google maps of the most important areas described in this article.

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Paper V

Communicating Risk in Disaster Risk Management Systems – Experimental Evidence on the Perceived Usefulness of Risk Descriptions

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Abstract

Disaster risk management (DRM) requires the collaboration of a variety of stakeholders from different sectors. They are dependent on each other to share information on risks. The communication of risk descriptions in a DRM system is therefore a key issue for the success of DRM activities. The purpose of this study was to investigate how descriptions of risk should be communicated so as to increase their usefulness in decision-making. We studied how changes in two aspects of risk descriptions, one related to the type of hazard and the other to how the likelihood and consequences of the risk scenarios are expressed, affect the perceived usefulness of the risk descriptions in decision-making. We concluded that the type of hazard did not affect the perceived usefulness to any significant extent. However, the expressions of likelihood and the consequences of the scenarios affected the perceived usefulness of risk descriptions. The results indicate that the way in which risk is communicated in a DRM system can have a significant impact on the ability of stakeholders to make well-informed decisions. Finally, the results show that quantitative and semi-quantitative methods of expressing likelihood and consequences are perceived as the most useful way of communicating risk.

Keywords: disaster risk management (DRM); disaster risk management (DRM) system; design science; design perspective; evaluation; perceived usefulness

Introduction

Societies around the world are suffering increasing losses due to disasters. Improving our ability to manage the risks associated with disasters is thus of the utmost importance (CaDRI 2011; UNISDR 2007). It has also been recognized that disaster risk cannot be reduced by a limited number of stakeholders alone, such as emergency management agencies. Collaboration between various stakeholders is necessary, both public and private, across the whole of society (Caudle and de Spiegeleire 2010; Wilkins and McCarthy 2009; Wyman 2009). Here, we use the term disaster risk management system to describe the broad collection of stakeholders involved in implementing disaster risk management (DRM) activities.

The overall purpose of DRM is to '…lessen the adverse impacts of hazards and the possibility of disaster' (UNISDR 2009). To achieve this, the stakeholders engaged in DRM must be able to identify, assess, and evaluate different risks and make informed decisions on how to deal with them. However, many disaster risks are transboundary in nature (Ansell, Boin, and Keller 2010; Boin 2009), i.e., they may result in crises that affect several functional and policy sectors. Therefore, a single stakeholder, e.g., a local rescue service, seldom has the information necessary to make adequate assessments of these risks. They are, instead, dependent on information from others in order to produce credible assessments. In fact, in an institutionally fragmented but technically tightly connected environment, such as today's societies, it is highly likely that most stakeholders involved in managing risks are dependent on information from others (Almklov and Antonsen 2010; de Bruijne and van Eeten 2007; De Bruijne et al. 2006).

As a result of the need for information from several sources, the communication of information on possible risks between stakeholders in DRM systems is a key issue. If this communication is successful, the stakeholders in a DRM system will be able to find, acquire and synthesize information from other stakeholders and use it to support decision-making. However, failure to communicate information on risks is likely to result in fragmented attempts to deal with the risks to which society is exposed (see, for example, [Cedergren and Tehler 2014]), resulting in a failure of the stakeholders in the DRM system to synthesize risk information (see for example [Kramer 2005]), i.e. to detect threats that span multiple administrative and/or functional sectors. Scholars seem to agree that communication is very important when multiple stakeholders are involved in managing risks (van Asselt and Renn 2011; IRGC 2009; Renn 2014). Nevertheless, relatively little attention has been devoted to risk communication between professionals, compared to communication between professionals and the public (Bier 2001). Moreover, although there are many normative contributions in the area of decision-making and risk, for example, from classical decision theory (Savage 1954; Von Neumann 1947) and more recent contributions focusing on situations of great uncertainty (Cox 2012; Karvetski and Lambert 2012; Aven 2013), few descriptive studies of decision-making in the context of a DRM system have been conducted. For example, the question of how to communicate information on risks, e.g. how to express the information in a report, so as to best support decision-making in a DRM system in the best possible way, has received limited attention.

The study described here is a descriptive study aimed at improving our understanding of how descriptions of risk should be communicated so as to increase their usefulness in decision-making in DRM systems. We have conducted two experimental studies in

which the perceived usefulness of various types of risk descriptions, as the basis for decision-making, were investigated. We concentrated on the effect, in terms of perceived usefulness, when changing two aspects of a risk description. The first aspect is the type of hazard or scenario being described, and the second is related to the way in which the likelihood and consequences of various scenarios are expressed.

We first provide a brief overview of previous research in the area of communicating risk descriptions, and then introduce the theoretical concepts used in the present study. In the following section we describe the two experiments used to investigate factors that influence the perceived usefulness of a risk description. We then discuss the results and limitations of the study, together with some suggestions for future research. Finally, we present our conclusions.

Background

Research on risk communication was initially focused on the problem of communicating with the public in order to convince them of the adequacy of the assessments made and measures taken by experts (Fischhoff 1995; Renn 2014). Communicating risk was largely regarded as a one-way process, focusing on getting the appropriate message across to the public. The field of risk communication research has advanced considerably since then, and communicating risk is now recognized to be a much more complex activity (see, for example, reviews in [Gurabardhi, Gutteling, and Kuttschreuter 2004, 2005; Bradley, McFarland, and Clarke 2014]), which is imperative in the management of risk involving multiple stakeholders, and in contexts characterized by high levels of ambiguity, complexity, and uncertainty (Hermans, Fox, and van Asselt 2012; van Asselt and Renn 2011). Some researchers have pointed out that risk communication is a multi-dimensional

and interactive process between all the stakeholders and decision-makers, since it involves sharing the results of risk assessment and other risk-related information, ideally from the very beginning and throughout the risk analysis process (MacDiarmid and Pharo 2003). However, much risk communication research is still concentrated on the relation between the experts and the public, while considerably less attention has been paid to communication between experts (Bier 2001; Thompson and Bloom 2000).

Communication of risk between experts from different sectors can be difficult, as illustrated by several disasters such as the 9/11 attacks in the USA in 2001 (Kramer 2005) and hurricane Katrina in 2005 (Comfort 2007; Garnett and Kouzmin 2007). In terms of research on risk communication, Kramer's study of the 9/11 attacks highlights the risk of dispersed responsibilities in the management of risk, as was also pointed out by the International Risk Governance Council (IRGC 2009). Kramer (2005) investigates the effect of uncommon categorization, i.e. the use of different ways of coding and categorizing information by different stakeholders. Uncommon categorization of risk information has been found in the Swedish DRM system (Abrahamsson and Tehler 2013; Tehler, Brehmerc, and Jensen 2012), and is probably present in other DRM systems as well. Rectifying the problems associated with coding and categorizing risk information in different ways in a DRM system, involves choosing a suitable format for the expression and communication of risk.

Previous studies on risk communication between professionals include an interview study by (Thompson and Bloom 2000), who investigated risk communication between risk assessors and risk managers, and a review of risk communication to decision-makers by (Bier 2001). Part of her review focuses on the form used to

communicate risk, which is highly relevant in the present study. Moreover, in a previous study, how different aspects of risk descriptions contributed to the description's perceived usefulness for decision-making in the context of a DRM system has been investigated (Lin et al. 2015). Lin et al. studied risk descriptions taken from the Swedish DRM system and asked professionals working in the system to judge their usefulness. The results of that study showed that there was a relationship between the way in which risk descriptions were expressed and their perceived usefulness, but also led to new questions; in particular, to what extent would the results be valid for groups that were not trained professionals in DRM? As Lin et al. based their study on documents produced and used within the Swedish DRM system, their ability to limit the influence of external factors was restricted. Therefore, the study reported here is based on experiments where the authors were able to control the influence of external variables to a greater extent, resulting in higher internal validity than in the previous study. Moreover, we were also able to investigate the generalizability of the results to groups other than professionals in the area of DRM, and to other nationalities than Swedes. The aim of the present study is thus to further improve our understanding of how risk descriptions in a DRM system can be communicated so that professionals within the system perceive them as useful for decision-making. Although a risk description may serve several purposes (Goble and Bier 2013), the basis for decision-making is one of the most important. Nevertheless, guidance in terms of how information on risks should be communicated in DRM systems is sometimes sparse (Vastveit, Eriksson, and Njå 2014), and the results presented here may therefore provide a valuable contribution to the further development of guidance in how to communicate risk in such systems.

Theoretical Concepts

The theoretical concepts used in this study are similar to those employed in the previous study conducted by Lin et al. (2015). The perceived usefulness was also defined in the same way, as 'the degree to which a person believes that a specific risk description would enhance the basis for decision-making' (Lin et al. 2015). Perceived usefulness is the dependent variable in both experiments carried out in this study. The risk framework presented by Aven (see, for example, [Aven 2007; Aven 2010; Aven 2011]) was used. Risk descriptions were considered to be artifacts that are communicated between various stakeholders to achieve some type of purpose. As noted above, one important purpose is to support decision-making. Therefore, perceived usefulness is suitable in the present study if the insights obtained from the present study are to be used as a basis for normative design research, where the goal is to increase the usefulness of risk descriptions. Descriptions of the use of design research in this context are given in, for example, (Abrahamsson and Tehler 2013; Cedergren and Tehler 2014).

The present study is concerned with how the way in which risk descriptions are presented influences their perceived usefulness. The notation for a risk description using Aven's risk framework referred to above is (C′, Q, K), where C′ denotes the description of the consequences, Q the description of the uncertainty concerning the consequences, and K is the background knowledge on which the descriptions are based (Aven 2012). Specific events that lead to the consequences C′ are denoted A′ (Aven 2012). The independent variables in the present study can be described based on Aven's framework. The first variable is called *type of scenario* and is denoted by A'_{Type}. This refers to the type of hazard that is responsible for triggering a specific

scenario. Two scenarios were considered in the present study: flooding and fire. Thus, A'_{Type} may be either "Flood" or "Fire". The effect of varying A'_{Type} was investigated in one experiment (Experiment 1), while in Experiment 2 only flooding was considered (A'_{Type} = "Flood"). In Lin et al.'s study (2015), the effect of describing the consequences ($C'_{Consequences}$) and the likelihood of various consequences ($Q_{Likelihood}$) in different ways was investigated. The different ways of describing both likelihood and consequences were: (1) Not included, (2) Qualitative description, (3) Qualitative ranking scale, (4) Semi-quantitative ranking scale, or (5) Quantitative scale (probabilities or frequencies). For further details, see (Lin et al. 2015). Thus, in a single risk description, the likelihood of certain consequences occurring might be described using a semi-quantitative ranking scale, whereas the consequences could be described using a qualitative ranking scale. Unlike the previous study, both the likelihood and the consequences were described using the same approach in the present study. Thus, instead of having two variables denoting how the likelihood is described ($Q_{Likelihood}$) and how the consequences are described ($C'_{Consequences}$), we use only one variable, QC', denoting how *both* likelihood and consequences are described. This variable can assume five possible states: (1) Not included, (2) Qualitative description, (3) Qualitative ranking scale, (4) Semi-quantitative ranking scale, or (5) Quantitative scale.

Using the theoretical concepts described above, we designed two experiments to explore how the way in which the likelihood and consequences of various scenarios (QC') are described influences their perceived usefulness. The first experiment, to investigate whether the choice of type of scenario in a risk description influenced the perceived usefulness, served as a pilot study for the second experiment. The results

were then used in the design of the second experiment.

Experiment 1 – The effect of using different types of scenarios in risk descriptions

Overview

The choice of type of scenario might affect the perceived usefulness of a risk description. However, if the risk descriptions were similar, in terms of the amount of information given and the way in which it is expressed (e.g. a description of the context followed by a description of the consequences, etc.), no significant difference between scenarios would be expected. We therefore used the first experiment to investigate whether this was the case. The first hypothesis investigated was:

Changing the type of scenario in a risk description does <u>not</u> influence the perceived usefulness of the description.

We tested this hypothesis by comparing the perceived usefulness of risk descriptions in which QC' was the same, but A'_{Type} differed. Constructing scenarios that differ only with respect to A'_{Type} is not easy, since we did not want to introduce additional factors that may affect the results. For example, we were concerned that the length of the risk descriptions might influence their perceived usefulness. We therefore tried to use the same number of words to describe both types of scenarios, and used the same way of expressing the likelihood and the consequences of both types of scenarios. Although Lin et al.'s study (2015) of risk assessments within the Swedish DRM system indicated that there were five main ways of expressing likelihood and consequences, we used only the quantitative descriptions (QC' = 'Quantitative scale') in this experiment, to limit the number of assessments required by the participants.

Method

Participants

A 7-point Likert scale was used to measure perceived usefulness (see the '*Procedure*' section) and it was not assumed that the results were normally distributed. Non-parametric methods were thus used to investigate differences between the perceived usefulness of the risk descriptions. This means that it was necessary to use an approximation when determining the minimum sample size. As the difference in perceived usefulness between different kinds of descriptions was investigated using the Wilcoxon signed-rank test (see the following '*Results*' section), the required sample size was first calculated assuming that a paired t-test would be used, and then adjusted for the fact that the Wilcoxon signed-rank test would be used[1]. This means adding roughly 5% to the required number of participants, i.e., approximately 21 participants would be required[2].

A class of 30 students on the Master's Program in Risk Management at [name deleted to maintain the integrity of the review process] was identified as a suitable group for this experiment. Students were chosen as we wanted participants that could easily comprehend the risk descriptions used in the experiments. All students had passed a basic course in risk assessment. They were recruited by email, and 28 of the 30 students agreed to participate in the study; 15 women and 13 men. The participants were aged between 22 and 31 years, with a mean age of 24.

[1] The power efficiency of the Wilcoxon signed-rank test is 95% of that of the t-test for small sample sizes(Siegel and Castellan 1988)

[2] The minimum relevant difference between the two experimental conditions was set to 1 step on the Likert scale. The standard deviation of the differences between the perceived usefulness was unknown, however, the standard deviation in a similar study was 1.5. We therefore assumed it to be the same in this study. Finally, α was assumed to be 0.05 and β, 0.2.

Procedure

Students participating in the study were sent a link to a webpage. A short description of the study was provided on the first page, informing them that the experiment was on the usefulness of different types of risk descriptions, and that on the following pages two types of risk descriptions from a local municipality would be presented. They were also informed that they would be asked a series of questions on each risk description.

One type involved severe flooding scenarios (A'_{Type} = 'Flood') and the other severe fire scenarios (A'_{Type} = 'Fire'). The descriptions were kept rather short so that the participants did not have to scroll through several pages in order to read them. The two types of risk description were designed to have similar length, and structure (see Appendix A). Moreover, we tried to use similar language, and content to the risk descriptions found in real documents describing risks and vulnerabilities in local municipalities in Sweden. The participants were asked to assume the role of a professional who was required to use the descriptions as the basis for decision-making, e.g., to determine whether risk-reduction measures were necessary. Finally, they were asked to indicate the extent to which they agreed with the statement: 'The risk description is useful for decision-making' on a 7-point Likert scale (1 indicating that they strongly disagreed, and 7 that they strongly agreed). Each participant thus rated two similar risk descriptions of two types of hazards, one involving flood scenarios and one involving fire scenarios, based on how useful they perceived them to be.

Results

The mean values of the participant's ratings of the usefulness of the risk descriptions were 4.8 for the flood scenarios and 4.4 for the fire scenarios (the median was 5 both types of scenarios). The Wilcoxon signed-rank test showed that there was no significant difference between the perceived usefulness of the risk descriptions associated with the serious flood scenarios and those associated with the severe fire scenarios ($W = 34$, $p = 0.203$).

Although no significant difference was found in this experiment, it is of course possible that a difference may exist when comparing risk descriptions involving other types of scenarios. Nevertheless, the results indicate that the scenario involved in a risk description does not strongly influence the perceived usefulness of the description, as long as the descriptions have similar contents in terms of length and structure (in support of hypothesis in experiment 1). We therefore proceeded with the second experiment focusing on only one type of scenario: flood.

Experiment 2 – The effect of describing likelihood and consequences in different ways

Overview

In the second experiment we set out to investigate whether the participants would perceive a difference in the usefulness of a risk description depending on how the likelihood and consequences were expressed. The description of the flood scenarios (quantitative) used in the first experiment was complemented with descriptions on the other four levels described above, so as to provide all five kinds of risk descriptions. The descriptions differed only in terms of how the likelihoods and consequences were

described, and all other information was identical (see Appendix B).

Lin et al.'s study (2015) involving documents from the Swedish DRM system indicated that professionals working in the area of disaster management perceive the usefulness of risk descriptions to be different depending on how the likelihood of scenarios and their consequences are expressed. Therefore, we expected to see a similar difference in the present experiment. The second hypothesis investigated was:

Changing the way in which consequences and likelihood are expressed in a risk description will influence the perceived usefulness of the description.

Moreover, in line with the findings of the previous study, we also expected the quantitative and semi-quantitative risk descriptions to be perceived as being more useful than qualitative descriptions, or when descriptions of likelihood and consequences were lacking.

Method

Participants

Three different groups of participants were used in this experiment. One group was made up of graduates from the Bachelor's Program in Fire Safety Engineering and the Master's Program in Risk Management at [name deleted to maintain the integrity of the review process]. They were recruited by sending an email to approximately 400 graduates randomly selected from the list of all graduates of these programs (approx. 800). Fifty of the graduates agreed to participate in the study; 40 men and 10 women. The participants were between 23 and 62 years old; the mean value being 35. The participants had been working in the area of risk management (including fire safety) for an average of 8 years. This group was denoted Group 1. Since the members of this

group have formal training in risk assessment and a considerable amount of experience in working with risk and safety issues, we expected their perception of the usefulness of the risk descriptions to differ from those of other groups with no formal training or experience. To investigate if this was indeed the case, we identified a group with some experience of reading and producing risk assessments, but ruled out members of the general public, as we were concerned that they would not understand the risk descriptions.

We were given the opportunity to enlist a group of students that were studying urban planning and another group working as urban planners, in Nicaragua. The urban planners did not have any formal training in risk assessment, but they frequently dealt with issues related to various hazards, for example, floods. Thus, they were not as experienced in the area of risk assessment as the first group, but they did have sufficient knowledge of matters related to risk assessment to understand the risk descriptions. Not only are these two groups different from the first in terms of their expected degree of knowledge concerning risks, they are also different in terms of their national background. We denote the student group, Group 2, and the professional group, Group 3. Group 2 consisted of 31 individuals, 17 males and 14 females, aged 19 to 33 years (mean 21 y). Group 3 included 33 participants, 19 males and 14 females, aged between 23 and 62 years (mean 36 y). They had between 1 and 25 years of experience as an urban planner (mean value 6 years).

Thus, a total of 114 participants took part in the second experiment.

Procedure

The experiment was both web-based and paper-based. Groups 1 and Group 3

completed the web-based version and Group 2 the paper-based version. Group 1 completed the experiment in Swedish, while Groups 2 and 3 conducted their respective tests in Spanish. The authors, who include native speakers of both Swedish and Spanish, translated the two versions. Participants completing the web-based version were provided with a link to a webpage, where a short introduction was first provided. After reading the introduction, the participants were instructed to click a button to the first webpage that gave one of the five risk descriptions. The students completing the paper-based version were given the same text as in the web-based version, but printed on paper. The participants were shown a risk description on each webpage (or sheet of paper), and asked to rate how useful they thought it was for decision-making on a 7-point Likert scale, as described above.

We wanted the participants to evaluate the alternatives concerning how the risk was described in relation to each other. Therefore we used a within-subject experimental design. The drawback of this approach, compared to a between-subject design, is that spurious effects may be introduced due to the so-called 'demand effect'. This implies that the subjects might anticipate the intentions of the researchers, and consciously or subconsciously attempt to provide answers that fulfill the researchers' expectations (Charness, Gneezy, and Kuhn 2012). Although the participants were aware that we were investigating the perceived usefulness of the descriptions, they were not provided with any information that would help them discern the intentions of the researchers. Another type of bias that might occur in within-subject designs is the learning effect, i.e. the respondent's answers to later questions may be affected by the experience of having responded to previous questions. To reduce the learning effect, the order in which the different descriptions were presented to the participants was randomized.

Results

As in the first experiment, the mean values were calculated from the results of the Likert scale assessments, and are given in Table 1.

Table 1. Mean Likert scale values for the three groups when assessing the five kinds of descriptions of the flood scenario

Description of likelihoods and consequences (QC′)	**Group 1**	**Group 2**	**Group 3**
1. Not included	2.94	5.61	4.70
2. Qualitative description	3.32	5.06	5.00
3. Qualitative ranking scale	3.98	5.23	4.91
4. Semi-quantitative ranking scale	5.56	6.23	5.45
5. Quantitative scale	5.08	5.68	5.67

A Friedman test was conducted to determine whether the perceived usefulness differed depending on how the risk was described using an α-level of 0.05. Statistically significant differences were found in all three groups: Group 1: χ^2 (4, n=50) = 96.8, $p < .05$, Group 2: χ^2 (4, n=31) = 15.6, $p < .05$, and Group 3, χ^2 (4, n=33) = 20.7, $p < .05$. Thus, we can rule out the possibility that the way in which likelihood and consequences are expressed in risk descriptions, has no effect, which supports hypothesis 2.

Analysis with the Wilcoxon signed-rank test was conducted to investigate the differences between the ratings of the different kinds of description in more detail. A Bonferroni correction was applied, resulting in a significance level of $p < 0.005$ for each group. The results of these tests are given in Table 2. Statistically significant differences in terms of perceived usefulness are indicated by *p*-values in boldface (i.e. $p < 0.005$).

Table 2. Results of the analysis of differences between the various risk descriptions. A *p*-value below 0.005 indicates a statistically significant difference between the two experimental conditions compared. *W* is the Wilcoxon test statistic and A_{12} is the measure of stochastic superiority.

Comparison between descriptions	**Group 1**			**Group 2**			**Group 3**		
	p	***W***	A_{12}	***p***	***W***	A_{12}	***p***	***W***	A_{12}
1 & 2	$9.27 \cdot 10^{-2}$	84	0.61	0.100	149	0.45	$3.22 \cdot 10^{-1}$	56	**0.74**
1 & 3	$\mathbf{8.20 \cdot 10^{-4}}$	79	**0.71**	0.101	89	0.55	$3.56 \cdot 10^{-1}$	58	0.65
1 & 4	$\mathbf{2.07 \cdot 10^{-8}}$	24	**0.89**	$4.15 \cdot 10^{-2}$	35	0.53	$3.49 \cdot 10^{-2}$	56	0.70
1 & 5	$\mathbf{5.54 \cdot 10^{-7}}$	94	**0.85**	0.933	97	0.66	$1.12 \cdot 10^{-2}$	49	0.53
2 & 3	$\mathbf{2.21 \cdot 10^{-4}}$	11	0.67	0.492	87	0.63	$5.78 \cdot 10^{-1}$	79	0.55
2 & 4	$\mathbf{1.05 \cdot 10^{-8}}$	4	**0.91**	$\mathbf{1.42 \cdot 10^{-3}}$	35	0.65	$5.86 \cdot 10^{-2}$	15	0.58
2 & 5	$\mathbf{1.75 \cdot 10^{-6}}$	72	**0.82**	$7.85 \cdot 10^{-2}$	82	0.61	$4.12 \cdot 10^{-2}$	51	0.67
3 & 4	$\mathbf{3.50 \cdot 10^{-7}}$	23	**0.82**	$\mathbf{8.56 \cdot 10^{-4}}$	5	0.53	$1.64 \cdot 10^{-2}$	19	0.50
3 & 5	$\mathbf{1.32 \cdot 10^{-3}}$	130	**0.72**	0.241	60	**0.71**	$1.02 \cdot 10^{-2}$	33	0.62
4 & 5	$2.60 \cdot 10^{-2}$	319	0.61	$3.40 \cdot 10^{-2}$	133	**0.73**	$6.10 \cdot 10^{-1}$	74	0.67

The size of the effect was estimated using the A_{12} measure of stochastic superiority (Delaney and Vargha 2002). A_{12} is the probability that the perceived usefulness will be higher for the first risk description than in the second for a randomly selected participant. The values of A_{12} are also given in Table 2. For example, it can be seen that the value of A_{12} when comparing the perceived usefulness of descriptions 1 & 4 is 0.89 in Group 1, which means that there is an 89% probability that a randomly drawn

participant from Group 1 will have expressed a higher perceived usefulness for description 1 than description 4. It can be seen from the results given in Table 2, that the effect size was moderate to high for Group 1 (graduates in fire safety and risk management), except when comparing descriptions 1 and 2[3]. The results obtained from the other two groups (students and practitioners of urban planning in Nicaragua) showed more varied results in terms of the effect size.

Discussion

The two experiments described above provide several insights into the aspects of risk description that influence perceived usefulness. For example, the results from Experiment 1 show that the type of scenario (A'_{Type}) did not affect the perceived usefulness to any great extent when comparing flooding and fire. Although the results support hypothesis 1, the experiment included only two types of scenario, and it is therefore difficult to generalize the conclusions to other types of scenarios. Nevertheless, the conclusion is probably valid for other types of scenarios as well, provided two conditions are satisfied. The first is that the important characteristics of the risk description, such as the number of words used, the level of detail in the description, the use of numerical data, etc. should be similar. The second is that the level of expertise of those assessing the perceived usefulness with respect to the scenarios should not differ too much.

The results of the second experiment support the general trend observed in Lin et al.'s (2015) study on real documents. Thus, changing the way in which likelihood and consequence descriptions are presented will influence the perceived usefulness of a

[3] Delaney and Vargha (Delaney and Vargha 2002) suggest that an A_{12} value of .56 corresponds to a small effect size, .64 to a medium effect, and .71 to a large effect.

risk description. Moreover, quantitative or semi-quantitative ranking descriptions of consequences and the likelihood of scenarios tend to be perceived as more useful than the other kinds (no information, qualitative description or qualitative ranking). This was the case in all three groups participating in Experiment 2 (see Table 1). However, the differences between the various kinds of descriptions were not statistically significant in all groups (see Table 2). In general, the differences are statistically significant in Group 1, but not in the other two, non-expert, groups. Nevertheless, the results support hypothesis 2. Moreover, the results given in Table 1 indicate that the ranking of the perceived usefulness of the risk descriptions is not sensitive to whether the individuals have experience in risk assessment or not. However, the differences in terms of perceived usefulness between the five kinds of description investigated here seem to be greater among those with more experience of risk assessment.

Conclusions

We have investigated the effect of the way in which risk descriptions are presented in terms of how likely various scenarios are and their associated consequences on their perceived usefulness. We conclude that the way in which a scenario is described has a considerable effect on the perceived usefulness of the descriptions. Moreover, risk descriptions using quantitative and semi-quantitative ways of expressing likelihood and consequences are perceived as more useful than when likelihood and consequences are lacking or are expressed in qualitative terms (including qualitative ranking scales). The results show that the effect is present in all three groups investigated here (risk and safety professionals in Sweden, and students and practitioners of urban planning in Nicaragua). It therefore appears that the extent of knowledge in risk assessment is not a key factor determining the ranking of risk

descriptions in terms of perceived usefulness. Nevertheless, those with experience in risk assessment seem to perceive a greater difference in terms of the usefulness of the risk descriptions when likelihood and consequences are expressed in different ways.

In addition, our results also show that the quantitative and semi-quantitative risk descriptions are perceived as the most useful. However, this does not imply that one should always use quantitative descriptions of risk in DRM systems. The kind of risk description suitable in each situation will be determined by the purpose of communicating this information, as well as the context in which it will be used. Variations in terms of, for example, the experience and skills of the recipients of the descriptions, will play a role in the decision. Nevertheless, our findings indicate that quantitative or semi-quantitative descriptions of likelihood and consequences should be used to achieve a high level of usefulness.

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Appendix A

Experiment 1 – The effect of using different types of scenarios in risk descriptions

Fire Scenarios

There are several large public buildings where serious fires might occur in the local municipality. The fire protection measures in most of these are judged to be good and in compliance with current regulations. Therefore, if a fire should occur in any of these buildings the consequences will probably not be serious in terms of fatalities or injuries, as the fire will probably be extinguished quickly. If it is not extinguished quickly, it will probably be possible to evacuate the building. Nevertheless, there is a small probability that the consequences of a fire could be significant if several unfortunate circumstances coincide, for example, if one or more of the emergency exits is blocked at the same time as the fire load on the establishment is higher than expected. Two fire scenarios are used to represent the fire risk in the local municipality: (1) a small fire, and (2) a large fire.

Scenario 1: A small fire

A small fire scenario means that a fire with significant smoke generation occurs in one of the larger buildings in the local municipality. Initial attempts by those in the building to extinguish the fire are unsuccessful. During the evacuation of the building it is assumed that several people are exposed to large amounts of smoke, which results in a few fatalities and several people requiring hospital care.

The likelihood of Scenario 1 has been assessed to be once every 30 years. The consequences have been assessed to be the following: 40 people will be seriously injured by smoke and 1 person will die.

Scenario 2: A large fire

A large fire scenario means that a fire with significant smoke generation occurs in one of the larger buildings in the local municipality. Initial attempts by those in the building to extinguish the fire are unsuccessful. In addition, the evacuation of the building is delayed for some reason. Many people are exposed to significant amounts of smoke, which leads to several fatalities and many people requiring hospital care.The likelihood of Scenario 2 has been assessed to be once every 150 years. The consequences have been assessed to be the following: 60 people will be seriously injured by smoke and 20 people will die.

Flood Scenarios

There are several waterways that may cause flooding in the local municipality. However, the risk of flooding has been judged to be greatest along the waterway. The waterway has the largest catchment area and the most populated areas of the local municipality are located close to it. The areas that are threatened by flooding if the water level in the waterway rises are comparatively flat, which means that the area affected by a flood will be large. In the municipal risk assessment, it is assumed that the flood risk can be represented by two scenarios: (1) slight and (2) serious flooding.

Scenario 1: Slight flooding

Slight flooding implies that the water level in the waterway rises 1.5 meters above the normal level, which means that AREA 1 will be flooded. There are several residential areas and critical infrastructures (power distribution stations and roads) in AREA 1.

The likelihood of scenario 1 is assessed to be once every 20 years. If the scenario occurs, the consequences are judged to be: flooding of approximately 1000 residential homes, one electrical substation, and one highway.

Scenario 2: Serious flooding

Scenario 2: Serious flooding implies that the water level in the waterway rises 2.5 meters above the normal level, which means that AREA 1 and AREA 2 will be flooded. There are residential areas as well as several critical infrastructures (electrical substations, roads and railroads) in these areas.

The likelihood of scenario 2 is assessed to be once every 100 years. If the scenario occurs, the consequences are judged to be: flooding of approximately 2000 residential homes, one electrical substation, one highway and one railroad.

Appendix B

Experiment 2 – The effect of describing likelihood and consequences in different ways

Five risk descriptions using different ways of expressing likelihood and consequences were used in Experiment 2.
In the experiment, the order in which the five risk descriptions was presented was randomized in order to reduce learning effects among the participants.

Risk Description #1: Likelihood and consequences (QC′) Not included

There are several waterways that may cause flooding in the local municipality. However, the risk of flooding has been judged to be greatest along the waterway. The waterway has the largest catchment area and the most populated areas of the local municipality are located close to it. The areas that are threatened by flooding if the water level in the waterway rises are comparatively flat, which means that the area affected by a flood will be large. In the municipal risk assessment, it is assumed that the flood risk can be represented by two scenarios: (1) slight and (2) serious flooding.

Scenario 1: Slight flooding

Slight flooding implies that the water level in the waterway rises 1.5 meters above the normal level, which means that AREA 1 will be flooded. There are several residential areas and critical infrastructures (power distribution stations and roads) in AREA 1.

Scenario 2: Serious flooding

Scenario 2: Serious flooding implies that the water level in the waterway rises 2.5 meters above the normal level, which means that AREA 1 and AREA 2 will be flooded. There are residential areas as well as several critical infrastructures (electrical substations, roads and railroads) in these areas.

Risk Description #2: Qualitative description of Likelihood and consequences (QC′)

There are several waterways that may cause flooding in the local municipality. However, the risk of flooding has been judged to be greatest along the waterway. The waterway has the largest catchment area and the most populated areas of the local municipality are located close to it. The areas that are threatened by flooding if the water level in the waterway rises are comparatively flat, which means that the area affected by a flood will be large. In the municipal risk assessment, it is assumed that the flood risk can be represented by two scenarios: (1) slight and (2) serious flooding.

Scenario 1: Slight flooding

Slight flooding implies that the water level in the waterway rises 1.5 meters above the normal level, which means that AREA 1 will be flooded. There are several residential areas and critical infrastructures (power distribution stations and roads) in AREA 1.

The likelihood of Scenario 1 is judged to be moderate. The consequences are judged to be serious for the people that live in AREA 1, as well as for the electrical substations and roads in that area.

Scenario 2: Serious flooding

Scenario 2: Serious flooding implies that the water level in the waterway rises 2.5 meters above the normal level, which means that AREA 1 and AREA 2 will be flooded. There are residential areas as well as several critical infrastructures (electrical substations, roads and railroads) in these areas.

The likelihood of Scenario 2 is judged to be low. The consequences are judged to be very serious for people that live in AREA 1 and AREA 2, as well as for electrical substations, and road and railway transport in the same areas.

Risk Description #3: Qualitative ranking scale for Likelihood and consequences *(QC′)*

There are several waterways that may cause flooding in the local municipality. However, the risk of flooding has been judged to be greatest along the waterway. The waterway has the largest catchment area and the most populated areas of the local municipality are located close to it. The areas that are threatened by flooding if the water level in the waterway rises are comparatively flat, which means that the area affected by a flood will be large. In the municipal risk assessment, it is assumed that the flood risk can be represented by two scenarios: (1) slight and (2) serious flooding.

Scenario 1: Slight flooding

Slight flooding implies that the water level in the waterway rises 1.5 meters above the normal level, which means that AREA 1 will be flooded. There are several residential areas and critical infrastructures (power distribution stations and roads) in AREA 1.

The likelihood has been assessed using a five-level scale (Very low, Low, Moderate, High, Very high). The consequences have been assessed similarly using a five-level scale (Very limited, Limited, Serious, Very serious, Catastrophic).

The likelihood of Scenario 1 is judged to be Moderate. The consequences of the scenario are judged to be Serious. The residents, the electrical substation and the roads will be primarily affected in AREA 1.

Scenario 2: Serious flooding

Scenario 2: Serious flooding implies that the water level in the waterway rises 2.5 meters above the normal level, which means that AREA 1 and AREA 2 will be flooded. There are residential areas as well as several critical infrastructures (electrical substations, roads and railroads) in these areas.

The likelihood of scenario 2 is judged to be Low. The consequences of the scenario are judged to be Very serious. The residents, the electrical substations, the roads and the railroads in AREA 1 and AREA 2 will be primarily affected.

Risk Description #4: Quantitative scale for Likelihood and consequences *(QC′)*

There are several waterways that may cause flooding in the local municipality. However, the risk of flooding has been judged to be greatest along the waterway. The waterway has the largest catchment area and the most populated areas of the local municipality are located close to it. The areas that are threatened by flooding if the water level in the waterway rises are comparatively flat, which means that the area affected by a flood will be large. In the municipal risk assessment, it is assumed that the flood risk can be represented by two scenarios: (1) slight and (2) serious flooding.

Scenario 1: Slight flooding

Slight flooding implies that the water level in the waterway rises 1.5 meters above the normal level, which means that AREA 1 will be flooded. There are several residential areas and critical infrastructures (power distribution stations and roads) in AREA 1.

The likelihood of scenario 1 is assessed to be once every 20 years. If the scenario occurs, the consequences are judged to be: flooding of approximately 1000 residential homes, one electrical substation, and one highway.

Scenario 2: Serious flooding

Scenario 2: Serious flooding implies that the water level in the waterway rises 2.5 meters above the normal level, which means that AREA 1 and AREA 2 will be flooded. There are residential areas as well as several critical infrastructures (electrical substations, roads and railroads) in these areas.

The likelihood of scenario 2 is assessed to be once every 100 years. If the scenario occurs, the consequences are judged to be: flooding of approximately 2000 residential homes, one electrical substation, one highway and one railroad.

Risk Description #5: Semi-quantitative ranking scale for Likelihood and consequences *(QC')*

There are several waterways that may cause flooding in the local municipality. However, the risk of flooding has been judged to be greatest along the waterway. The waterway has the largest catchment area and the most populated areas of the local municipality are located close to it. The areas that are threatened by flooding if the water level in the waterway rises are comparatively flat, which means that the area affected by a flood will be large. In the municipal risk assessment, it is assumed that the flood risk can be represented by two scenarios: (1) slight and (2) serious flooding.

Scenario 1: Slight flooding

Slight flooding implies that the water level in the waterway rises 1.5 meters above the normal level, which means that AREA 1 will be flooded. There are several residential areas and critical infrastructures (power distribution stations and roads) in AREA 1.

The likelihood of Scenario 1 is judged to be Moderate (once in 10 to 100 years). The consequences of the scenario are judged to be Serious. The residents, the electrical substation and the roads in AREA 1 will be primarily affected.

Scenario 2: Serious flooding

Scenario 2: Serious flooding implies that the water level in the waterway rises 2.5 meters above the normal level, which means that AREA 1 and AREA 2 will be flooded. There are residential areas as well as several critical infrastructures (electrical substations, roads and railroads) in these areas.

The likelihood of Scenario 2 is judged to be Low (once in 100 to 1000 years). The consequences of the scenario are judged to be Very serious. The residents, electrical substations, the roads and the railroads in AREA 1 and AREA 2 will be primarily affected.

Description of scales used to describe likelihood and consequences

The likelihood of the scenarios has been assessed using a five-level scale: Very low (less than once in 1000 years), Low (once in 100 to 1000 years), Moderate (once in 10 to 100 years), High (once in 1 to 10 years), Very high (more than once every year).

The consequences were similarly assessed on a five-level scale:

Very limited: Small direct health effects, very limited disturbances in societal functions, temporary distrust in a particular public institution, very limited damage to property and the environment.

Limited: Moderate direct health effects, limited disturbances in societal functions, temporary distrust in more than one public institution, limited damage to property and the environment.

Serious: Considerable direct health effects, serious disturbances in societal functions, lasting distrust in multiple public institutions, serious damage to property and the environment.

Very serious: Very serious direct health effects or considerable indirect health effects, very serious disturbances in societal functions, lasting distrust in multiple public institutions, very serious damage to property and the environment.

Catastrophic: Catastrophic direct health effects or very serious indirect health effects, extreme disturbances in societal functions, permanent distrust in public institutions, catastrophic damage to property and the environment.