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Disaster risk management and climate change adaptation in urban contexts:

Integration and challenges



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Claudia Marina Rivera Escorcía

DOCTORAL DISSERTATION

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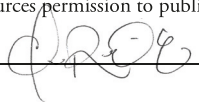
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Disaster risk management and climate change adaptation in urban contexts:

Integration and challenges

Claudia Marina Rivera Escorcía



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KLIMATKOMPENSERAT
PAPPER



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 Escorcía

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.ijdr.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.ijdr.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.
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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 governmental 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 activity (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 system¹ 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 (CEPRENAC) (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 Kappa⁴ 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 planned⁹ 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 & Raghieri, 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 World 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) (Lyll & 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 output¹² 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 thesis¹⁴.

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.

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.

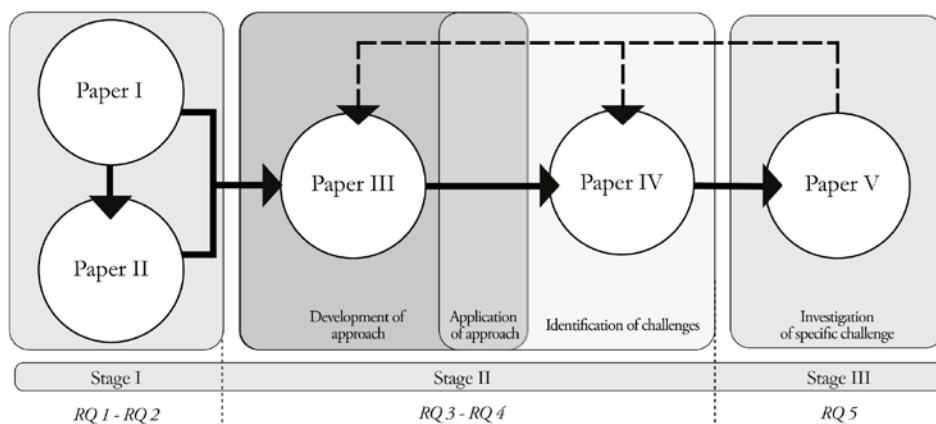


Figure 1. Phases of the research process. Arrows show the relationships between the Papers. Straight lines indicate that the results of one Paper led to the design of the other. Dashed lines indicate that Paper V validated the assumptions developed in the previous Papers.

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 end¹⁵ 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 Paper¹⁶ 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 descriptions¹⁷ 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 & Sköldbberg, 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 & Sköldbberg, 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 system¹⁸ 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 strategy¹⁹ 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).

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	GEOGRAPHICAL 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 Purposive 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 Purposive 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 adaptation 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 examines 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 hypotheses²⁰; (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 UP²¹. 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 CCA²² 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 purpose²³. 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 descriptions²⁵ 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

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?	<p>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.</p> <p>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.</p>
RQ 2: How do disaster risk reduction practitioners in Nicaragua perceive the ongoing integration of CCA into their urban development work?	<p>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.</p>
RQ 3: How can disaster risk management systems (and related integration processes) be evaluated and compared?	<p>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)?</p> <p>The evaluation of a DRM system can focus on the output associated with one or more of these questions. Elsewhere in this</p>

	<p>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.</p> <p>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.</p>
<p>RQ 4: How can systemic challenges be studied and how do they influence integrated CCA and DRM planning on the ground?</p>	<p>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.</p> <p>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.</p>
<p>RQ 5: Do differences in the way risk descriptions are presented influence their perceived usefulness for decision-making?</p>	<p>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.</p>

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 DRM 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 environments 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 flexible 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 maladaptation²⁶.

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 qualitative²⁷ 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. policies 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 becomes 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



Artículo II.

Protocolo de entrevista

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

1. Acerca del participante
<ul style="list-style-type: none">• ¿Cuál es su cargo en la institución?• ¿Podría describir las actividades que realiza?
1. Conocimiento sobre adaptación al cambio climático
<ul style="list-style-type: none">• 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
<ul style="list-style-type: none">• ¿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
<ul style="list-style-type: none">• ¿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
<ul style="list-style-type: none">• ¿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

