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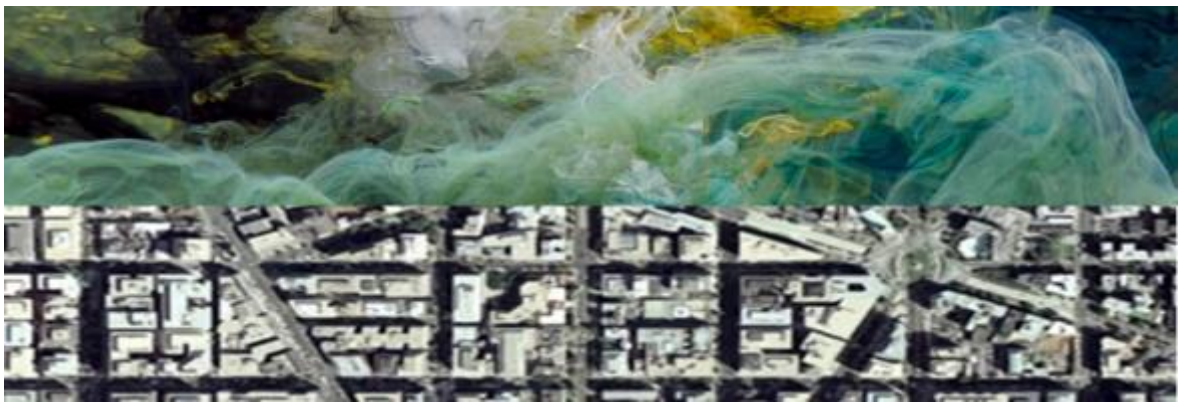

SOCIAL-ECOLOGICAL RESILIENCE OF LOCAL COMMUNITIES TO CLIMATE CHANGE:
Guidelines for the Brazilian Context

Kátia Virgínia Cañellas

Supervisor: **Doctor Maria do Rosário Sintra de Almeida Partidário**

Thesis approved in public session to obtain the PhD Degree in
Climate Change and Sustainable Development Policies
(Specialty in Environmental Engineering)

Jury final classification: **Pass**

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DEDICATÓRIA

Aos meus pais: *Clóvis e Loti*

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ABSTRACT

In recent years, people all over the world have been confronted with the reality of climate change. Vulnerable communities are the most affected because they lack effective coping strategies to deal with the challenges they face. Personal experience facing real situations motivated this research to explore an interdisciplinary view combining environmental and social sciences. The purpose of this thesis is to analyze the process of building Social-Ecological Resilience (SER) to identify how local communities can reduce their vulnerabilities to climate change. The literature review is based on three conceptual pillars: Adaptation, Transformation, and SER. The confirmation of the future impacts of climate change provoked a shift in the understanding of adaptation. The incremental approach was no longer enough to address climate challenges in vulnerable communities. These cases in contrast, require a systemic and transformative approach. Action sharing can trigger the social dynamics that promote the transformations necessary to build SER. The objectives of this research are to: Define the factors of a transformative process; Discuss how to create and/or increase SER in vulnerable communities; Define a mechanism to evaluate how different social drivers act in the process of building SER and test them in the case study. The hypothesis is that local communities' capacity to reduce their vulnerability to climate change depends on knowledge, governance mechanisms and, community culture. The research strategy is based on two approaches: theoretical development and a case study (Blumenau/Brazil). The findings of this research pointed to three social dimensions - stakeholder engagement, knowledge brokerage, and collective action (such as "action sharing") - that can trigger the social dynamics needed to ensure a transformative process and improve adaptive capacity. In this context, governance is responsible for ensuring the necessary environment for change. It enables adaptive process in Social-Ecological Systems (SES), connecting individuals, organizations, agencies, and institutions, including processes of participation, collective action, and learning. Social learning and innovation are important factors in the transformative process for building SER. The links between them are crucial to understanding how knowledge can support communities to build innovative solutions. The conceptual framework synthesizes the process of building SER and its instrumental mechanism is tested in the case study. Pathways are identified for the community of Blumenau to improve its SER.

Keywords: climate change adaptation, transformative adaptation, social-ecological resilience, knowledge brokerage, action sharing.

RESUMO

Nos últimos anos, as pessoas em todo o mundo estão sendo confrontadas com a realidade das alterações climáticas. As comunidades vulneráveis são as mais afetadas pois não possuem estratégias de enfrentamento eficazes para lidar com os desafios que enfrentam. A experiência em situações reais motivou a pesquisa para explorar uma visão interdisciplinar combinando ciências ambientais e sociais. O objetivo desta tese é analisar o processo de construção da resiliência socioecológica (RSE) para identificar como as comunidades locais podem reduzir suas vulnerabilidades às mudanças climáticas. A revisão da literatura baseia-se em três pilares conceituais: Adaptação, Transformação e RSE. A confirmação sobre os impactos das mudanças climáticas no futuro causou uma mudança na compreensão da adaptação. A abordagem incremental da adaptação pode não ser suficiente para enfrentar os desafios climáticos em comunidades vulneráveis. Isso requer uma abordagem sistêmica e transformadora. Ações compartilhadas podem desencadear a dinâmica social que promove a transformação necessária. Definir os fatores essenciais para um processo transformador; discutir como criar ou aumentar a RSE de comunidades vulneráveis; definir um mecanismo para avaliar como diferentes agentes sociais atuam no processo de construção de RSE e testá-lo no estudo de caso são os objetivos desta pesquisa. A hipótese para esta tese é de que "a capacidade das comunidades locais de reduzir suas vulnerabilidades às mudanças climáticas depende do conhecimento, dos mecanismos de governança e da cultura da comunidade. A estratégia de pesquisa baseia-se em duas abordagens: o desenvolvimento teórico e um estudo de caso (Blumenau / Brasil). Os resultados desta pesquisa confirmaram que os três fatores sociais: envolvimento das partes interessadas, intermediação de conhecimento e ação coletiva, chamados de "ação compartilhada", são capazes de desencadear a dinâmica social necessária para assegurar um processo transformativo e melhorar a capacidade adaptativa. Neste contexto, a governança é responsável por assegurar o ambiente necessário para a mudança. Ela permite o processo adaptativo no RSE, conectando indivíduos, organizações, agências e instituições, incluindo processos de participação, ação coletiva e aprendizagem. O aprendizado social e a inovação são fatores essenciais no processo transformativo para a construção do RSE. As ligações entre eles são cruciais para entender como o conhecimento se torna o suporte para as comunidades construírem soluções inovadoras. Um quadro conceitual sintetiza o processo de construção do RSE e seu mecanismo instrumental é testado no estudo de caso. Os caminhos são identificados para que a comunidade de Blumenau melhore sua RSE.

Palavras-chave: adaptação às mudanças climáticas, adaptação transformativa, resiliência socioecológica, intermediação de conhecimento, ação compartilhada.

RESUMO ALARGADO

Nos últimos anos, as pessoas em todo o mundo estão sendo confrontadas com a realidade das alterações climáticas. As comunidades vulneráveis são as mais afetadas porque não possuem estratégias de enfrentamento eficazes para lidar com os desafios que enfrentam. O Relatório de Impacto Humano: Alterações Climáticas (Global Humanitarian Forum, 2009, p.1) indica que a cada ano as alterações climáticas deixam mais de 300.000 mortos, 325 milhões de pessoas seriamente afetadas e perdas econômicas de US $ 125 bilhões. Quatro bilhões de pessoas são vulneráveis, e 500 milhões de pessoas estão em risco extremo. O Quinto Relatório de Avaliação do Painel Intergovernamental sobre Alterações Climáticas (IPCC, 2014) apresenta para os próximos anos e décadas uma perspectiva adversa para pessoas e comunidades desfavorecidas, independentemente do nível de desenvolvimento do país. Segundo o relatório, as alterações climáticas causarão impactos generalizados nos sistemas socioecológicos. Além disso, esses riscos serão ampliados, surgirão novos riscos e sua distribuição será desigual. De acordo com o relatório "Understanding Vulnerability to Climate Change" (CARE Poverty Environment and Climate Change Network, 2011), as alterações climáticas serão sentidas de forma desigual por diferentes comunidades e indivíduos, com base em suas características únicas. O grande desafio é desenvolver estratégias de adaptação que levem em conta essas características específicas. Os impactos desproporcionados nessas comunidades estão muitas vezes ligados à pobreza e à falta de infraestrutura básica, o que, combinado com a falta de informação, pode limitar a capacidade de adaptação das pessoas. Nesse sentido, existe uma necessidade urgente de examinar como essas comunidades estão lidando com essa situação e que opções elas têm para aumentar autonomamente sua resiliência. A complexidade desses problemas aumentou o interesse em investigar como o conceito de resiliência socioecológica (RSE) poderia ser usado no planejamento para adaptação às mudanças climáticas. O conceito de RSE desenvolvido por Adger et al (2011) é assumido nessa investigação. Segundo os autores RSE é “capacidade de absorver perturbações sem alterar a função geral do sistema, a capacidade de adaptação dentro dos recursos do próprio sistema, e a capacidade de aprender, inovar e mudar”. A motivação para desenvolver esta investigação partiu da experiência vivida por essa autora em situações reais de desastres climáticos no Brasil (Blumenau, SC). Sendo assim, o objetivo desta investigação é analisar o processo de construção da RSE para identificar como as comunidades locais podem reduzir suas vulnerabilidades às mudanças climáticas. Para tanto, essa pesquisa se propõe a definir os fatores essenciais para um processo transformador; discutir como criar ou aumentar a RSE

de comunidades vulneráveis; definir um mecanismo para avaliar como diferentes agentes sociais atuam no processo de construção de RSE e testá-lo no estudo de caso, Blumenau, SC, Brasil. As questões que orientam essa investigação são: i) O que faz um processo transformador de adaptação às mudanças climáticas?; ii) Como as comunidades vulneráveis podem aumentar o RSE em seus desafios climáticos? e; Como Blumenau (Brasil) pode preparar a comunidade para enfrentar os desafios do clima? A hipótese para esta tese é de que "a capacidade das comunidades locais de reduzir suas vulnerabilidades às alterações climáticas depende do conhecimento, dos mecanismos de governança e da cultura da comunidade. A estratégia de pesquisa baseia-se em duas abordagens: o desenvolvimento teórico e um estudo de caso (Blumenau / Brasil). O desenvolvimento teórico baseia-se na revisão da literatura sustentada em três pilares conceituais: Adaptação, Transformação e RSE. A revisão da literatura sobre o tema “Adaptação” revelou que a confirmação sobre os futuros impactos das alterações climáticas, com riscos ampliados para determinadas regiões promoveu um novo entendimento sobre o conceito de adaptação. Os estudiosos afirmam que a abordagem incremental da adaptação defendida nas últimas duas décadas especialmente pelo Painel Intergovernamental de Alterações Climáticas (IPCC – sigla em inglês), pode não ser suficiente para enfrentar os desafios climáticos em comunidades vulneráveis. Essa abordagem baseia-se em intervenções técnicas pontuais e em programas de formação para minimizar os riscos associados a impactos climáticos específicos. Dessa forma, nos últimos anos o meio científico tem apontado a necessidade de uma transição nos processos de adaptação às Alterações Climáticas que adotem ações mais sistêmicas ou transformadoras, com iniciativas que respondam às necessidades e aspirações das comunidades vulneráveis. Isso requer uma abordagem que olhe para as causas da vulnerabilidade. Nesse sentido, na avaliação da vulnerabilidade são considerados fatores sociais como o contexto político e socioeconômico, e a vontade de adaptar. A transformação nesta pesquisa é entendida de acordo com Pelling (2001), que defende mudanças fundamentais na distribuição de poder e representação de interesses e valores. No desenvolvimento da revisão de literatura sobre transformação identificou-se três fatores sociais que compõem o que foi chamado de “ação compartilhada”: o envolvimento das partes interessadas, a intermediação de conhecimento e a ação coletiva. Essas ações são capazes de desencadear a dinâmica social necessária para assegurar um processo transformativo e melhorar a capacidade adaptativa das comunidades vulneráveis. Neste contexto, a governança é responsável por assegurar o ambiente necessário para a mudança. É a partir de mecanismos de governança que o processo transformativo de adaptação ocorre, conectando indivíduos, organizações, agências e instituições, incluindo

processos de participação, ação coletiva e aprendizagem. O aprendizado social e a inovação são fatores essenciais no processo transformativo para a construção do RSE. As ligações entre eles são cruciais para entender como o conhecimento se torna o suporte para as comunidades construírem soluções inovadoras. A teoria integrativa estudada por Gunderson e Holling (2002) esclarece o processo adaptativo de um sistema socioecológico (SSE), organizado em níveis dentro de um ciclo que envolve nascimento, crescimento e maturidade, morte e renovação de um sistema. As duas etapas distintas de transição do ciclo adaptativo, que alternam longos períodos de agregação e transformação de recursos, com períodos de tempo mais curtos criando oportunidades de inovação, sugerem que essa lógica é adequada para enfrentar problemas complexos como as mudanças climáticas. Retomando o conceito de RSE adotado nesta investigação, as comunidades vulneráveis precisam buscar dentro de seus próprios recursos ou em conexão com os apoios externos, meios para identificar e reconhecer suas vulnerabilidades, avaliar suas ações anteriores de adaptação e, aprender com seus erros e acertos. Assim, elas podem gerar novas formas de agir. Em muitos casos, isso exigirá pensamento sistêmico e uma ação inovadora, que pode originar mudanças no funcionamento do sistema como um todo, nas relações sociais e de poder, para assegurar o processo transformativo de adaptação. Esse processo deve basear-se na troca de conhecimentos, uma vez que este tipo de ação requer um período de experimentação e avaliação para garantir uma transição segura para a nova abordagem de adaptação. As interações entre conhecimento, cultura de comunidade e mecanismos de governança, assumidas nesta investigação como os três fatores sociais para a construção da resiliência, compõem um quadro conceitual que sintetiza o processo de construção do RSE. A interação entre o conhecimento e os mecanismos de governança ocorre através da intermediação de conhecimento. Esta interação é capaz de produzir inovação. Mas para que isso aconteça é necessário criar espaço para pesquisa e experimentação, formação de redes de conhecimento, financiamento para pesquisa e uso de conhecimentos específicos para apoiar a tomada de decisões. A interação entre conhecimento e cultura da comunidade também ocorre através da intermediação do conhecimento. Esta interação pode produzir aprendizagem social. O acesso à informação, o reconhecimento dos conhecimentos locais, a criação e o uso das redes sociais, e a cultura da auto-organização estão na base desse processo. Finalmente, a interação entre os mecanismos de governança e a cultura da comunidade empodera os agentes envolvidos e promove as transformações necessárias para aumentar a capacidade de adaptação e construir a RSE. Isso pode ocorrer com o estímulo ao envolvimento das partes interessadas, à ação coletiva, a tomada de decisão participativa e a modelos adaptativos de governança. O quadro conceitual elaborado gerou

um mecanismo instrumental denominado: Roda de Avaliação de Capacidade Social para Construção da RSE. Esse instrumento permite a avaliação da capacidade social da comunidade para construção da RSE através da avaliação de fatores chamados de ativadores de interações sociais. A aplicação desse mecanismo no caso de estudo serviu para testar a ferramenta e identificar caminhos para que a comunidade de Blumenau melhore sua RSE.
Palavras-chave: adaptação às mudanças climáticas, adaptação transformativa, resiliência socioecológica, intermediação de conhecimento, ação compartilhada.

SUMARY

FIGURES

TABLES

LIST OF ACRONYMS

ACCCRN - Asian Cities' Climate Change Resilience Network

AMBH - Associação de Moradores Belo Horizonte (Residents' Association of Belo Horizonte)

AMC - Associação de Moradores Coripós (Residents' Association of Coripós)

AMEW - Associação de Moradores Emil Welmuth e transversais (Residents' Association of Emil Welmuth and surrounding areas)

AMIV - Associação de Moradores Ina Valparaíso (Residents' Association of Ina Valparaíso)

AMLG - Associação de Moradores Loteamento Girassol (Residents' Association of Sunflower land division)

AMLH - Associação de Moradores Leopoldo Hering (Residents' Association of Leopoldo Hering)

AMME - Associação de Moradores Margem Esquerda do Rio Itajaí (Residents' Association of the left side of Itajaí River)

AMMH - Associação de Moradores Morro Hadlich (Residents' Association of Morro Hadlich)

AMMS - Associação de Moradores Maria Schumann (Residents' Association of Maria Schumann)

AR4 - Fourth IPCC Assessment Report

B-ON - Online Library of Knowledge

CAPRA - Central America Probabilistic Risk Assessment Program

CEPED - Centro Universitário de Pesquisas e Estudos sobre Desastres (University Center for Disaster research and studies)

CEGERD - Comissão Especial para Gestão de Riscos e Desastres Naturais (Special Commission for Risk Management and Natural Disasters)

CNPq - Conselho Nacional de Desenvolvimento Científico e Tecnológico (National Council for Scientific and Technological Development)

COMDEC- Conselho Municipal de Defesa Civil (Municipal Council of Civil Defense)

DCCS - Durban Climate Change Strategy

DRR - Disaster Risk Reduction

EIRD - Estratégia Internacional para Redução de Desastres (International Strategy for Disaster Reduction)

EM-DAT - Centre for Research on the Epidemiology of Disasters Database

FAEMA - Fundação do Meio Ambiente (Environmental Foundation)

FNA - Federação Nacional de Arquitetos (National Federation of Architects)

FURB – Universidade Regional de Blumenau (Regional University of Blumenau)

GEAMBH - Grupo de Pesquisa e Extensão de Gestão de Ambientes Naturais e Construídos em Bacia Hidrográfica (Research Group and Extension of the Management of Natural and Manmade Watershed Basins)

GEE - Greenhouse Gases

GIDES - Integrated Management of Natural Disaster Risk

GRAC- Grupo de Apoio (Aid Group)

GRACO – Grupo de Pesquisa e Gestão de Riscos e Participação Comunitária (Research Group and Risk Management of Community Participation)

HDI – Human Development Index

IBGE – Instituto Brasileiro de Geografia e Estatística (Brazilian Institute for Geographic and Statics)

IPA/ FURB - Environmental Research Institute

IPCC - Intergovernmental Panel on Climate Change

ISDR - International Strategy for Disaster Reduction

JICA - Japan International Cooperation Agency

MCTI – Ministério de Ciência e Tecnologia (Science and Technology Ministry)

MPSC - Ministério Público de Santa Catarina (Prosecutor for the State of Santa Catarina)

NC – NUDEC Coripós

NNE – NUDEC Nova Esperança

NUDEC - Núcleo Comunitário de Defesa Civil (Community group for civil defense)

ONU – Organização da Nações Unidas (United Nations)

PCRD - Promoção da Cultura de Riscos de Desastres (Promotion of the Culture of the risks of disasters)

PECCN - Poverty, Environment, and Climate Change Network

PMHIS - Municipal Housing Plan of Social Interest

PMRR - Municipal Risk Reduction Plan

PNAMC - National Plan for Adaptation to Climate Change

PNPDEC - Política Nacional de Proteção e Defesa Civil (National Protection and Civil Defense Policy)

PNUD - United Nations Development Program

PROGEM - Procuradoria Geral do Município (General Municipal Prosecutors Office)

RSE – Resiliência Socioecológica (Socio-ecological Resilience)

SC – Santa Catarina

SEDEC - Secretaria Nacional de Defesa Civil (Nation Civil Defense Secretary)

SEDESCI - Secretaria de defesa do cidadão (Citizenship rights Secretary)

SEMED - Secretaria de Educação (Education Secretary)

SEMOB - Secretaria de obras públicas (Public Works Secretary)

SEMUS - Secretaria de Saúde (Healthcare Secretary)

SEPLAN - Secretaria de Planejamento Urbano (Urban Planning Secretary_

SER - Social-ecological resilience

SES - Social-ecological systems

SESUR - Secretaria de serviços Urbanos (Urban Services Secretary)

SINPDEC - Sistema Nacional de Proteção e Defesa Civil (National System for Protection and Civil Defense)

UFSC - Universidade Federal de Santa Catarina (Federal University of Santa Catarina_

UNEP- United Nations Environmental Program

UNFCCC - United Nations Framework Convention on Climate Change

UNIBLAM - União Blumenauense de Associação de Moradores (Residents' Association Union of Blumenau)

UNIVALI – Universidade do Vale do Itajaí (Itajaí Valley University)

USA – United States of America

USJ - Universidade de São José (San José University)

WMO - World Meteorological Organization

1. INTRODUCTION

The Human Impact Report: Climate Change (Global Humanitarian Forum, 2009, p.1) indicates that, “every year climate change leaves over 300,000 people dead, 325 million people seriously affected, and economic losses of US$125 billion. Four billion people are vulnerable, and 500 million people are at extreme risk.”

In addition, the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2014a) gives an adverse outlook for disadvantaged people and communities, regardless of the country's development level, for the coming years and decades. It provides clear evidence of the anthropogenic influence on climate change, confirms that levels of greenhouse gases in the atmosphere are the highest in history, and that climate change will cause widespread impacts on social-ecological systems (SES). Moreover, these risks will be amplified, new risks will emerge, and their distribution will be uneven.

CARE’s Poverty, Environment, and Climate Change Network (PECCN), is an international organization with some of the most extensive experience in the analysis of vulnerability to climate change in communities around the world. In its report, “Understanding vulnerability to climate change” (CARE Poverty Environment and Climate Change Network, 2011), it points out that for some communities, climate change is simply a matter of changes in weather patterns that does not compromise their livelihood or security. Yet for others, it is a matter of survival, with lack of or excess water, insufficient food, and/or safety hazards. The disproportionate impacts of climate change in many vulnerable communities are often linked to poverty and the lack of basic infrastructure, which combined with a lack of information, can limit the ability of people to adapt. According to the report, climate change will be felt differently by distinct communities and individuals based on their unique circumstances. The great challenge is to find adaptation strategies that consider these features.

Generally, vulnerable communities are the most affected because they lack effective coping strategies to deal with recurring shocks and stresses of extreme weather events. Often these communities must resort to ineffective responses that worsen their already precarious situation (CARE Poverty Environment and Climate Change Network, 2011). This suggests the urgent need to examine how they are dealing with this problem currently and what options they must autonomously adopt to increase their resilience.

The first responses to the effects of climate change were intended as “adjustments”, where adaptation was addressed in an incremental way, based on “technical interventions and training programs to minimize the risks associated with specific climate impacts” (Inderberg, O´Brien, Karen, & Sygma, 2015). Then, there was consensus among scholars that only incremental measures would not be sufficient to respond to major foreseen impacts.

In recent years, some authors have demonstrated the need for a transition in the processes of adaptation to climate change in order to adopt more systemic or transformative actions and initiatives that are responsive to the vulnerable communities’ needs and aspirations (Kates, Travis, & Wilbanks, 2012; Nelson, 2009; O’Brien, 2012; Pelling, 2011; Wise et al., 2014). The concepts of transformation and transformability advocated by these authors are best defined within the Resilience theory (Folke, Carpenter, Walker, Scheffer, & Chapin, 2010; Nelson, 2011).

However, the most common and traditional definitions of climate resilience have a narrow vision that focuses on "preparedness" in face of crisis or disaster and the capacity of communities to "bounce back" after natural disasters or similar events. The debate about the meaning of resilience expanded with “The Urban Resilience Research Prospectus Report” (Alliance & Resilience Alliance, 2007), that classifies resilience as a capacity of social-ecological systems (SES) and names it as social-ecological resilience (SER). The report considers SER as a systemic logic of ability to change and of continuous adaptation, considering flows, social dynamics, governance networks, and the biophysical environment (Barnett & Bai, 2007).

The complexity of climate change makes the problem difficult to address. Despite advanced studies on the subject, there are still large knowledge gaps to fill and surprises in face of extreme events are inevitable, especially regarding the uncertainties of nature, magnitude, and intensity of the event, particular locations and their corresponding vulnerability. The complexity of these problems has increased interest in investigating how the concept of SER could be used in planning for adapting to climate change.

Indeed, SER can facilitate understanding of the problem and avoid adaptive management in only one direction. It allows the system's capabilities and characteristics to be strengthened, maintaining flexibility for survival, learning, and adaptation during a dynamic and unpredictable process of change(Buschbacher, 2014; Gunderson & Holling, 2002).

Similarly, the Human Development Report of the United Nations Development Program (2014) defends SER from a human development perspective to ensures that the state, community, and global institutions work together to empower and protect people. The report highlights the importance of a transformative approach to adaptation that focuses on the empowerment of local communities. It highlights that soon it will not be possible to protect people from disorders, shocks, and disasters because they will reach a level that has never been seen before. It will be essential to prepare people and communities to cope autonomously with these disorders, as well as the ability to recover and adapt to new situations (United Nations Development Programme, 2014).

In this investigation, the concept of Social-ecological Resilience follows the perspective of Adger et al.(2011, p.757), who define resilience as "the ability to absorb perturbations without changing overall system function, the ability to adapt within the resources of the system itself, and the ability to learn, innovate, and change." Here SER is a skill that can be developed, but it depends fundamentally on how well communities can learn collectively, work on a common goal, and thus, transform their reality (W. Neil Adger et al., 2011; Olwig, 2012; Rodima-Taylor, Olwig, & Chhetri, 2012).

An important aspect in this context is how knowledge is created, and how the communication between technical-scientific discourse and local knowledge occurs. The literature highlights the contribution of local knowledge to offering alternative wisdom based on knowledge and practices acquired in a dynamic process of continuous learning about the use of local resources (Folke, 2004; McCarthy et al., 2012; McCarthy, Crandall, Whitelaw, General, & Tsuji, 2011). According to Partidario and Sheate (2013, p.3), a shift of the very linear model of knowledge transfer (from those who know to those who do not) to a much more dynamic view of knowledge, favors learning processes and allows knowledge to circulate among the different spheres of communities. Knowledge brokerage facilitates knowledge transfer and knowledge exchange, in short knowledge in transition.

The issue of SER to address climate change is not new. Over the last two decades, there has been an explosion of research on attributes that may promote system resilience. Many international institutions such as Resilience Alliance, Arup International Development, Asian Cities Climate Change Resilience Network, and Stockholm Resilience Center have explored

the concept of resilience in their case studies, focusing on different principles that increase SER. The focus of this research is on the social dynamics that can contribute to building or increasing SER.

The social importance of the current investigation lies in the fact that the approach toward building SER can shed light on a proactive process of transformation that can create social empowerment. Despite the many challenges that climate change brings to vulnerable communities, there are opportunities for many positive changes and innovative approaches. SER adopts a systemic vision that involves transformation and learning, can reinforce positive actions, and points the way to initiatives that address the needs and priorities of vulnerable communities. Effective and equitable actions when properly facilitated can trigger an empowerment process that ensures knowledge and adaptability.

The academic importance of this research is its contribution to the advancement of scientific knowledge on the SER building process in providing vulnerable communities a means to autonomously find ways to address climate challenges through a transformative perspective. Therefore, this dissertation proposes to explore the concept of social-ecological resilience through a proactive and strategic approach to insert it in the planning and in the practice of adapting to climate change.

The motivation for this investigation comes from personal experience in extreme weather events in Blumenau, SC, Brazil. The Itajai Valley region, since its colonization by German immigrants in 1859, has suffered from flooding. In 2008 there was a major disaster. Heavy rainfall in a short period triggered floods, landslides, and mudslides, which caused 24 deaths and a great deal of material damage (Vieira, Jansen, & Pozzobon, 2015). Experiencing this episode and the two years recovery was essential to realizing the difficulties public institutions face when dealing with these situations, and especially how many communities must resort to autonomous stopgap solutions. This context led this author to believe that vulnerable communities must increase their ability to reduce their vulnerabilities and enhance their resilience to climate change impacts.

Regional geomorphological characteristics and human settlements in areas of risk due to poor socio-economic conditions of some local communities were the key factors that exacerbated the scale of the disaster in Blumenau (Brazil) and the region (Claudia Siebert, 2012). Other regions of Brazil such as Rio de Janeiro, São Paulo, Minas Gerais, Bahia, Pernambuco, and Alagoas regularly suffer from similar experiences. Yet this is not just a Brazilian problem. Many communities across Latin America, Africa, and Asia are victims of climate-related disasters every year.

The Global Climate Risk Index 2016 (Sönke, Eckstein, Dorsch, & Fischer, 2015), 2015) highlights Honduras, Myanmar, and Haiti as the countries that have been the most affected by climate-related disasters in the last 20 years. They rank among the first due to an exceptionally devastating sequence of events, such as Hurricane Sandy in Haiti and Hurricane Mitch in Honduras. However, the worst of them was cyclone Nargis that hit Myanmar in 2008 and was responsible for an estimated loss of 140,000 lives, with approximately 2.4 million people affected.

On the other hand, countries such as the Philippines, Nicaragua, and Bangladesh are considered hotspots of climate-related disasters. Every year typhoons, tropical storms, floods, and landslides threaten them, with a high number of deaths and people affected.

The importance of choosing Blumenau as a case study is due the great national repercussions of 2008 climate event. Since then, all scientific production of knowledge about disaster risk reduction (DRR) in Brazil has been reviewed and expanded, changing many of the public policies at the national level. Identifying the results of these changes becomes interesting in the context of this research.

The purpose of this research is to investigate how local communities can reduce their vulnerabilities to climate change through processes based on building SER.

Figure 1 shows the approach of this research, which explores the process of building SER. It seeks to understand the main social dimensions that interact to generate a transformative process and increase the adaptability of local communities to reduce their vulnerability.

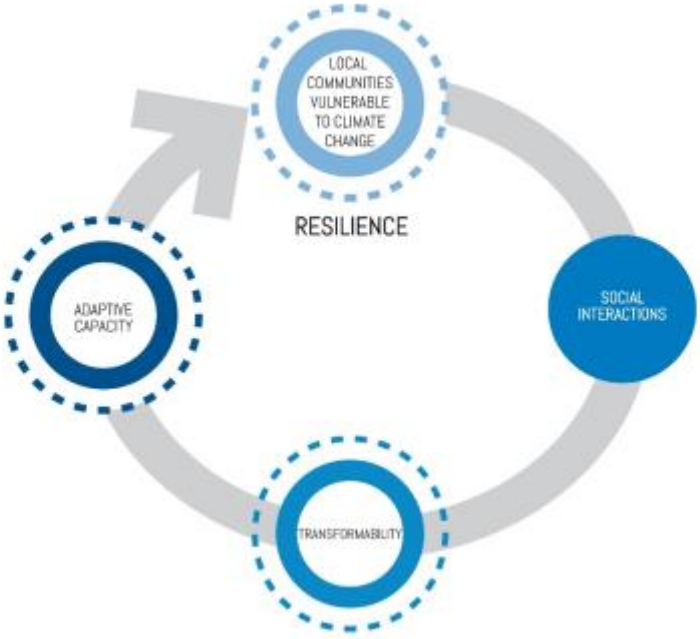

Figure 1: Conceptual approach of this thesis

1.1 Objectives

The main objective of this investigation is:

- ❖ To explore if SER increases when local communities acquire the capacity to manage and/or decrease their vulnerabilities.

The specific objectives are to:

1) Define the essential factors for a transformative process of adaptation to climate change;
2) Discuss how to create or increase the SER of vulnerable communities to climate change;
3) Propose a mechanism to evaluate the social capacity of community of building SER to climate change;
4) Instrumentally test if and to what extent social actors in Blumenau (Brazil) learned from the 2008 disaster how to better prepare the community to face future climate change challenges using local assets.

1.2 Research Methodology

A scientific investigation is a cognitive activity based on a systematic, flexible, and objective inquiry process to explain the phenomena studied (Marconi & Lakatos, 2003). The methodology is the strategy or action plan that links the choice and use of methods to achieve the desired results. It reflects the nature of the research approach, defining how the investigator will examine different spheres of research (Crotty, 1998). The methodology chosen depends on the purpose and the issues that the investigation aims to answer. However, the methodological options are not defined only as a simple cause- effect relationship of these two aspects. The theoretical assumptions adopted by the investigator are decisive in the choice of a research paradigm (Marconi and Lakatos, 2003). Therefore, the coherence between the object of study, purpose, assumptions, and methodology adopted is essential.

This research is focused on the SER of local communities to climate change in order to understand how they may develop their capacity to reduce their vulnerabilities. Building SER depends primarily on the understanding of local communities about their vulnerabilities, and on the knowledge and capabilities they need to increase their adaptive capacity.

Therefore, this research was based on a relativist ontology, with the construction and validation of knowledge within an interpretive epistemological paradigm. It has an exploratory

purpose and a deductive perspective. It is a qualitative research study using a strategy based on grounded theory and a case study.

Ontology refers to the way in which one understands the nature of the world and the essential components of reality. The ontological assumptions determine the epistemological and methodological decisions. The relativistic ontology, also called subjective reality, involves multiple and dynamic realities, and considers reality as a social construction, i.e. it is possible to comprise the various interpretations of the natural and social world (Guba & Lincoln, 1994). Thus, the choice of interpretative paradigm is appropriate, since it focuses on the "meaning" that individuals give to the phenomena and seeks to understand how things happen. This paradigm highlights assumptions of multiple types of knowledge. It considers the context of knowledge and the interdependence between theory and practice (Crotty, 1998). It hopes to answer questions such as "how" and "why". Exploratory research aims to provide greater familiarity with the problem, making it more explicit and facilitating the setting of hypotheses (A. C. Gil, 2008; Antonio Carlos Gil, 2002). The deductive method begins by understanding the general rule and then the specific cases. According to Freixo (2013, p.99), "the deductive logic aims to evidence premises". The observation of reality provides data to develop hypotheses which then become the thesis in the course of the investigation.

The hypothesis for this work is:

- ❖ Local communities' capacity to reduce their vulnerability to climate change depends on interactions of knowledge, community culture, and mechanisms of governance.

Research questions

- ✓ What makes a transformative process of adaptation to climate change?
- ✓ How can vulnerable communities increase SER to their climate challenges?
- ✓ How can Blumenau (Brazil) prepare the community to tackle climate change?

As a qualitative study, this work seeks to understand and comprehend problems through moments and meanings. It addresses issues comprehensively at the time and in specific contexts. According to Denzin and Lincoln (2011), qualitative research locates the observer in the world. It consists of a set of interpretive and material practices that make the world visible. Qualitative researchers study things in their natural settings, interpreting phenomena according to the meaning that people bring to them.

The research strategy is based on two approaches: bibliographic research and a case study. The specific case (Blumenau - Brazil) was the motivation to develop this investigation. It came from natural observation of reality, in which the observation conditions are not planned.

It was non-participant observation, where the researcher takes on the role of spectator (A. C. Gil, 2008). The literature review and the exploration of other case studies helped to better understand the situation and define the research problem. The theoretical option used in this research is based on the human development perspective as part of the process of building SER to climate change. The social dimension of local communities is the active part in the process of reducing their vulnerabilities. The social interactions between knowledge, community culture, and governance mechanisms are essential to building SER.

The literature review is based on three conceptual pillars: Adaptation, Transformation, and SER. Figure 2 shows the theoretical approach of the investigation, were the social interactions occur through knowledge brokerage and increase adaptive capacity. This dynamic can build SER.

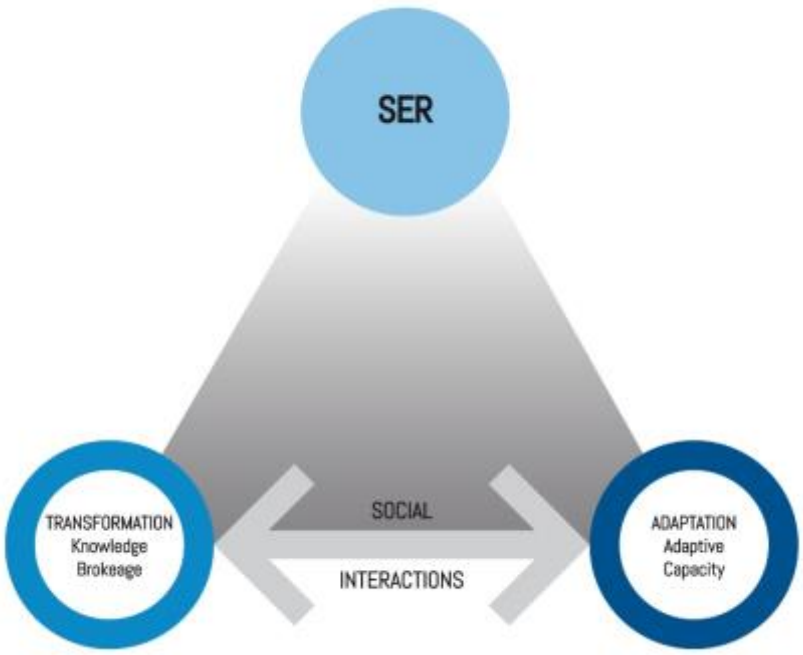

Figure 2: Theoretical Pillars of Thesis

The literature review summarizes contributions from different authors, determines the level of knowledge on the subject up to the present time, and establishes relationships between different topics studied. The assumptions and theoretical foundations of the research are established in the literature review. The objective and the investigation hypothesis have been constructed from the analysis of the relationship between observations of reality, the identified problem, and literature review.

In this study, the review and critical analysis of the literature was designed in a multiple and complementary interpretive way, as an ongoing process seeking to understand *how* things happen. Figure 3 shows the methodological pathways of the study.

Figure 3: Methodological pathways

Figure 4 shows a synthesized diagram of the research methodology, linking the different steps with discussion topics, research questions, and the objectives of each stage.

The research comprises four stages of development. The first stage is the definition of the problem. Here, the main goal is presented and the research hypothesis is formulated. A brief review of complementary concepts helps to contextualize the problem and define some assumptions. The second stage is a literature review of the conceptual pillars of the research. It develops interpretations that generate the theoretical results and define a mechanism to instrumentally test the results. The third stage develops the case study. The last stage explains the results obtained in the theoretical body, analyzes the proposed mechanism and its application, reflects on limitations of this work, identifies lines of future research, and finally, presents the conclusions of this investigation.

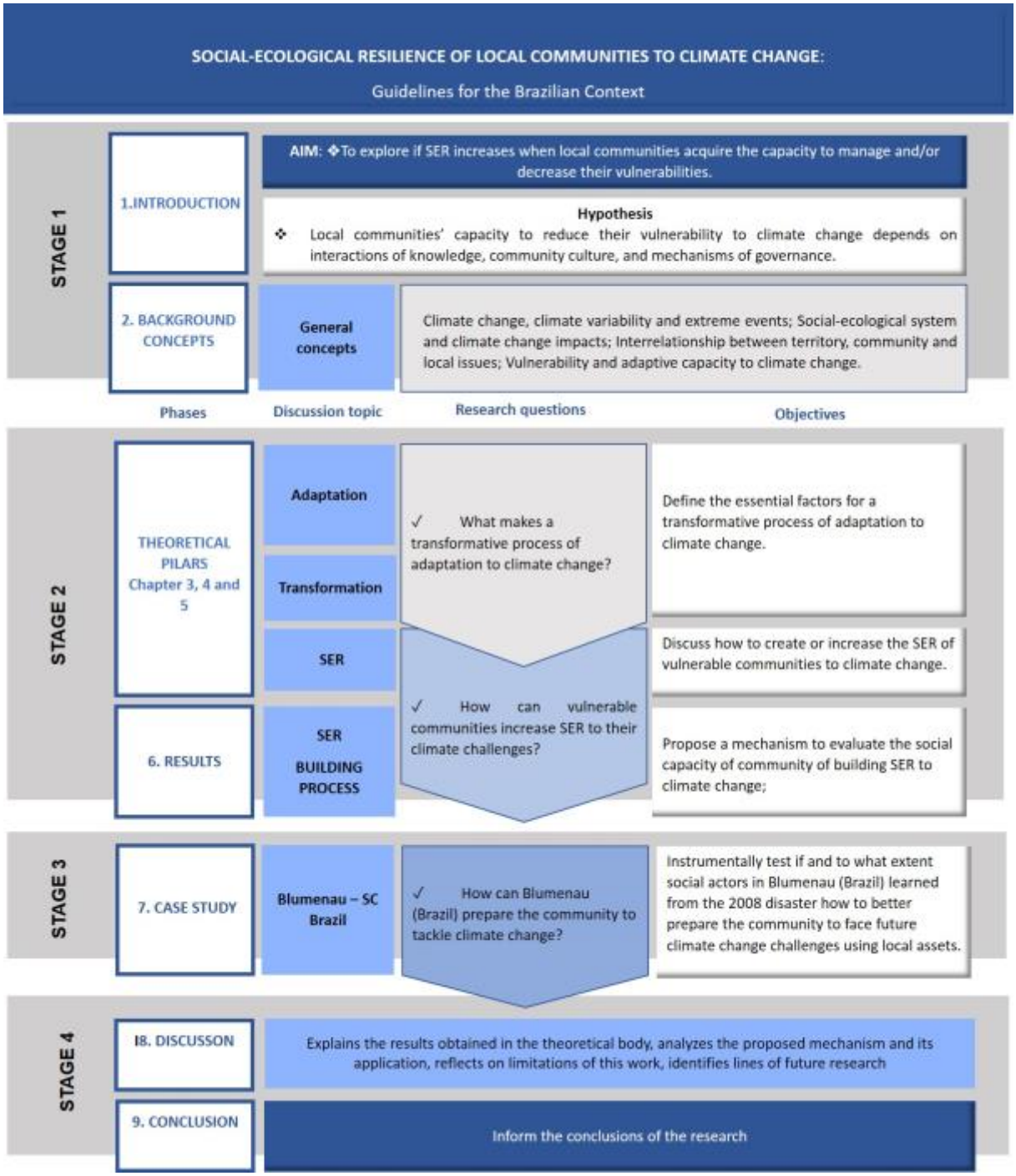

Figure 4: General view of methodology

1.2.1 Methods of bibliographic research

The first part of this work focused on a bibliographical research to achieve the first three objectives of the study. Peer review articles obtained in search engines such as Google Scholar and B-on were the main sources of data. Books and reports from international organizations were also used as complementary sources. The initial data collection was

focused on the overall theme of the study: resilience. This preliminary understanding made it possible to define the conceptual pillars of the thesis.

Firstly, a literature review was conducted on adaptation to climate change over the last thirty years. A search on the Web of Knowledge (WoK) was based on the association between topics related to the term "adaptation" and "theoretical and conceptual approach" in the period from 1996 to 2016 (the last 30 years). The refinement of the research was based on the language chosen (English); the domain of science (Science technology; or social sciences); the research area (Environmental science; ecology; or social sciences - other topics; or science technology - other topics; or geography); and the type of document (article; or editorial; or letter; or review). Subsequently, specific journals on the subject matter were selected and papers with titles that had no link with the research were excluded. A total of 83 papers were selected that addressed the theory of adaptation in either the title or the abstract. Finally, different stages of concept evolution were found and the assumptions that determine the different approaches for adaptation were identified. This is the evolutionary basis of the concept of adaptation established the theoretical context for the continuity of research.

Subsequently, transformation and social-ecological resilience were subjects of research. Reading sheets synthesized the information gained and mind maps were used to organize different topics. A series of diagrams that summarize the concepts identified were used to compile the results. The purpose of these diagrams was to guide the identification and interpretation of links between the different concepts as well as to understand how they work together to generate new knowledge. Flow charts and block diagrams made it possible to understand and communicate the steps of the process. Interrelationship diagrams helped to clarify how issues are related to one another as well as distinguish between the causal issues and outcomes of the actions. Thus, an iterative process was established, which changed the phases of research and interpretation of the results, until the research questions were answered. The knowledge was consolidated with the development of the theoretical basis in a sequential interpretative process. At the end of the work it was possible to present theoretical contributions through the results.

At the end of the first part of the study, the need to discuss some complementary concepts that were not treated in the body of work became evident to enable the reader to better understand the approach of the research. In this sense, a new literature review was performed to fill the identified gaps and the results were presented in the preliminary chapter called Review of Background Concepts.

1.2.2 Methods for interpretation of thesis results and elaboration of evaluation tool

The proposal of a mechanism to evaluate the social capacity of building SER begins with the results achieved from the previous objectives. The analysis of the social dynamics generated in the relationship between the different factors of a transformative process made it possible to identify the social dimensions involved, that is, the driver and the agents of change. The next step was to analyze how the interaction between these different social dimensions produces the necessary elements for building SER. The results of this analysis were expressed in a conceptual diagram that synthesizes the relationships between all the concepts discussed in this thesis.

Then, new data was collected to translate the conceptual diagram into a tool for practical evaluation. This search was based on a review of reports from international organizations on resilience strategies and practical experiences. The goal was to identify some mechanisms of social interaction capable of generating the necessary elements for building SER. Finally, the parameters for evaluating the outcomes were based on the analyzed examples and/or on fictitious situations identified as ideal. The scores used ranged from zero to three, with zero being the worst situation and three the best.

1.3 Organization

This thesis presents the research in nine chapters:

The **Second Chapter** reviews the background concepts that are discussed in the thesis, which are not the focus of the work, but support the discussion. They are: Climate change, climate variability, and extreme events; Social-ecological system and climate change impacts; Territory, community, and local issues and; Vulnerability and adaptive capacity to climate change; and finally, Systemic vision.

The **Third Chapter** discusses the conceptual understanding of adaptation to climate change over the last three decades and analyzes its contribution to vulnerable communities dealing with climate challenges.

The **Fourth Chapter** discusses the challenges of transformative adaptation. It seeks to understand the key factors that determine a transformative process. It analyzes the role of stakeholders' engagement, knowledge brokerage, social learning, and collective action as a trigger of social interactions that assist in creating or increasing SER. It aims to contribute to a better understanding of the need for community involvement and the value of community empowerment for motivating shared responsibility in building SER.

The **Fifth Chapter** discusses the concept, characteristics, and increasing of SER in communities vulnerable to climate change.

The **Sixth Chapter** presents the thesis of this investigation. It discusses the process of building SER in communities that are vulnerable to climate change. It exposes a theoretical discussion of the social components that determine the responsiveness of the community to climate challenges, and presents the conceptual framework as results of research. At end, it develops a framework to operationalize the conceptual model, and establishes assessment parameters to analyze the process of building SER in a real case.

The **Seventh Chapter** presents the case study (Blumenau, Santa Catarina, Brazil) and discusses what guidelines must be followed in this case to enhance SER to climate change. The answer for this issue is based on what is already being done in Blumenau, the institutional structures established, barriers and potential areas to be explored, and the climatic and non-climate challenges to be faced.

The **Eighth Chapter** discusses the results obtained in the theoretical body, analyzes the proposed mechanism and its application, reflects on work limitations and identifies lines of future research. Finally, **Chapter Nine** presents the conclusions.

2. REVIEW OF BACKGROUND CONCEPTS

The complexity of the theme “resilience to climate change” demands prior understanding of some implicit concepts, which are not the specific object of this research. This chapter aims to establish how they are used in this work. This is crucial because some of the concepts discussed here are used in different areas of knowledge, which can lead to multiple interpretations or even cause confusion in the understanding of the research itself. Others are very similar, and the differences, however subtle they may seem, need to be explained so that a one is able to have a clear understanding of this work.

2.1 Climate change, climate variability, and extreme climate events

The climate is one of the factors responsible for life on Earth. It directly influences the development of natural and human systems, making climate change one of the most important challenges of our time.

Despite the progressive scientific advances on the subject, political frameworks to address climate change have been developed since the 1980s. In 1988 the United Nations Environmental Program (UNEP) and the World Meteorological Organization (WMO) created the Intergovernmental Panel on Climate Change (IPCC) as a scientific body responsible for providing evidence on climate change. In 1992 the United Nations Framework Convention on Climate Change (UNFCCC) was founded as a political body encompassing the IPCC (E. Schipper, 2006).

Currently, scientists can say with a high degree of certainty that human activities, especially the results of economic and population growth of the pre-industrial era, have influenced the pattern and speed of climate change (IPCC, 2014). Evidence of human influence on climate change was clear from the Fourth IPCC Assessment Report (AR4). Moreover, recent anthropogenic emissions of greenhouse gases have intensified the greenhouse effect, responsible for climate change (IPCC, 2007b).

Climate is naturally variable both spatially and temporally. The variability of different seasons is well understood. But long-term changes, over years, decades, centuries, and millennia, are not well understood and largely unpredictable (Smithers & Smit, 1997).

Climate change is a long-term change. It refers to 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” (IPCC, 2013, p.1450). Climate variability refers “to shorter term (daily, seasonal, annual, inter-annual, several years) variations in climate,” including fluctuations associated with El Niño (dry) or La Niña (wet) events (IPCC, 2013, p.1451). An extreme weather event (or extreme climate event) is a “rare event in each place and time of year. The characteristics of what is called extreme weather may vary from place to place” (IPCC, 2013, p.1454).

Changes in the occurrence of extreme events have been observed from about 1950, including a reduction of cold temperature extremes, an increase in extreme hot temperatures, an increase in extreme high sea levels, and an increase in the number of heavy precipitation events in diverse regions. Despite this, the level of confidence in the evidence varies both on a global to regional scale (IPCC, 2014b).

Therefore, according to Füssel (2009), the current situation is becoming uncomfortable because the estimates of climate change risks continue to increase while the time for effective mitigation actions is quickly running out. This indicates the urgent need for the implementation of more efficient mitigation policies, as well as comprehensive and equitable adaptation policies.

2.2 SES and climate change impacts

There are many understandings of the term "social-ecological system" (SES). The Stockholm School simply defines it in terms of the relationship between humans and nature (Berkes & Folke, 1998). More formal definitions along these lines refer to integrated systems of ecosystems and human society with reciprocal feedback and interdependence (Alliance & Resilience Alliance, 2007). These are ecological systems strongly influenced by human

activities and also social systems dependent on resources and services provided by SES (Berkes, Colding, & Folke, 2003). Its social component (individuals, community, society, and institutions), and its ecological component (ecosystems and natural resources) are interdependent and co-evolve constantly both spatially and temporally (Folke et al., 2010; Folke, Hahn, Olsson, & Norberg, 2005; Pelling, 2011; Walker, Holling, Carpenter, & Kinzig, 2004). These components establish relationships with each other in different ways making it a complex system with many uncertainties (Berkes & Folke, 1998).

It is difficult to understand the dynamics of the ecosystem and its ability to generate services without paying sufficient attention to the human dimension. On the one hand, nature provides the biophysical base and ecosystem services for the social and economic development of society. On the other hand, human actions directly or indirectly affect the ability of ecological systems to support the development of society (Walker & Salt, 2006).

For most ecosystems, human interactions, perceptions, and behaviors primarily determine their structure and function. Many human actions, motivated by economic, political, social-cultural, and/or legal matters, can affect the ability of ecosystems to deliver goods and services, either degrading or improving (International Social Science Council & UNESCO, 2013).

Figure 5 shows that social aspects such as values, traditions, identity, potential services, and culture influence attitudes, skills, and the form of governance, which can then determine perceptions and decisions. Consequently, different perspectives on interactions between social and ecological components will influence vulnerabilities as well as the adaptability and transformability of the SES (Berkes et al., 2003).

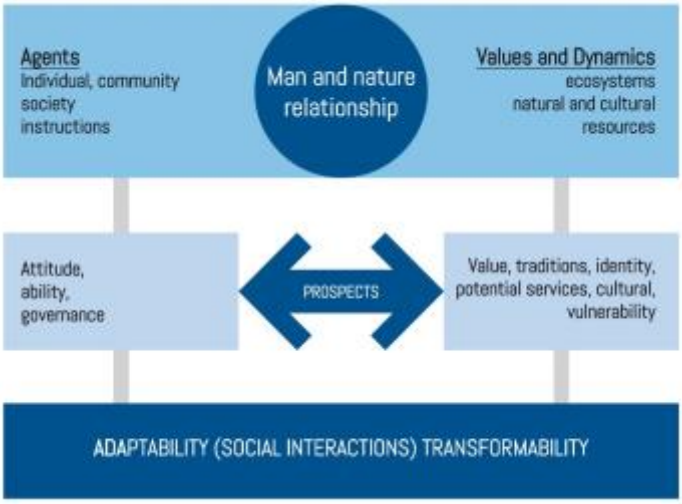

Figure 5: Conceptual map of SES

A good example of SES, as Ostrom (2009) explains, is a forest ecosystem, which brings together different interest groups (lumbermen, farmers, ranchers, indigenous communities, settlers, and conservationists) pursuing multiple (often contradictory) goals (production, profit, fairness, conservation, and cultural retention). Thus, the biophysical factors (water, soil, biodiversity, and climate) affect and are affected by human activities. Furthermore, internal, and external factors, from the local, national, and international level (policies, culture, and power) influence the dynamics of SES.

Climate change can be considered a major stressor in vulnerable SES. Each territory has SES with specific characteristics, different relationships of dependence between society and nature, and different climate impacts to be faced.

In recent years, the world has witnessed several extreme weather events that have caused devastating impacts on the SES. According the “Human Costs of Natural Disasters 2015: Global Perspective”, a report of Centre for Research on the Epidemiology of Disasters (Centre for Research on the Epidemiology of Disasters, 2015), in its EM-DAT database, 6,873 natural disasters were recorded worldwide between 1994-2014, which claimed 1.35 million lives or almost 68,000 lives on average each year. Climate-related disasters have come to dominate the risk landscape to the point where they account for more than 80% of all major internationally reported disasters. Between 1994-2014 they composed 87% of climate-related disasters and 91% in 2014. Flood and storms represent 71% of total global disasters. Flooding caused most disasters between 1994-2013, accounting for 43% of all recorded events and affecting nearly 2.5 billion people. Asia and Africa were the most affected. Floods also became more frequent, rising from 123 per year on average between 1994-2003 to an annual average of 171 from 2004-2013. Storms were the second most frequent type of disaster, killing more than 244,000 people and costing US$936 billion in recorded damage. This is considered the most expensive type of disaster. Drought affected more than one billion people between 1994 and 2013, or 25% of the total global affected (41% in Africa). Droughts are associated with agricultural failures, loss of livestock, shortages of drinking water, and outbreaks of epidemics and diseases. Droughts can last for several years, causing extensive, long-term economic impacts, and resulting in the displacement of large numbers of the affected population.

The high level of interdependence between social and ecological components of a SES have been decisive in determining the level of impact of extreme weather events on communities around the world. Analysis of EM-DAT data shows how income levels impact the death tolls in disaster areas. On average, more than three times as many people died per disaster in

low-income countries (332 deaths), than in high-income nations (105 deaths). A similar pattern is evident when low- and lower-middle-income countries are grouped together and compared to high- and upper-middle-income countries. Moreover, higher-income countries experienced 56% of disasters, but had 32% of the recorded fatalities. Yet, lower-income countries experienced 44% of disasters, and suffered 68% of deaths. This demonstrates that levels of economic development, rather than hazards per se, are the major determinants of mortality (Centre for Research on the Epidemiology of Disasters, 2015).

However, the impacts of climate change affect more than human lives. They also affect physical, biological, and social systems. Figure 6 shows the IPCC Synthesis Report (2014) overview of the impacts on physical, biological, and social systems in different regions of the globe based on the available scientific literature since the Fourth Assessment Report (IPCC, 2014b).

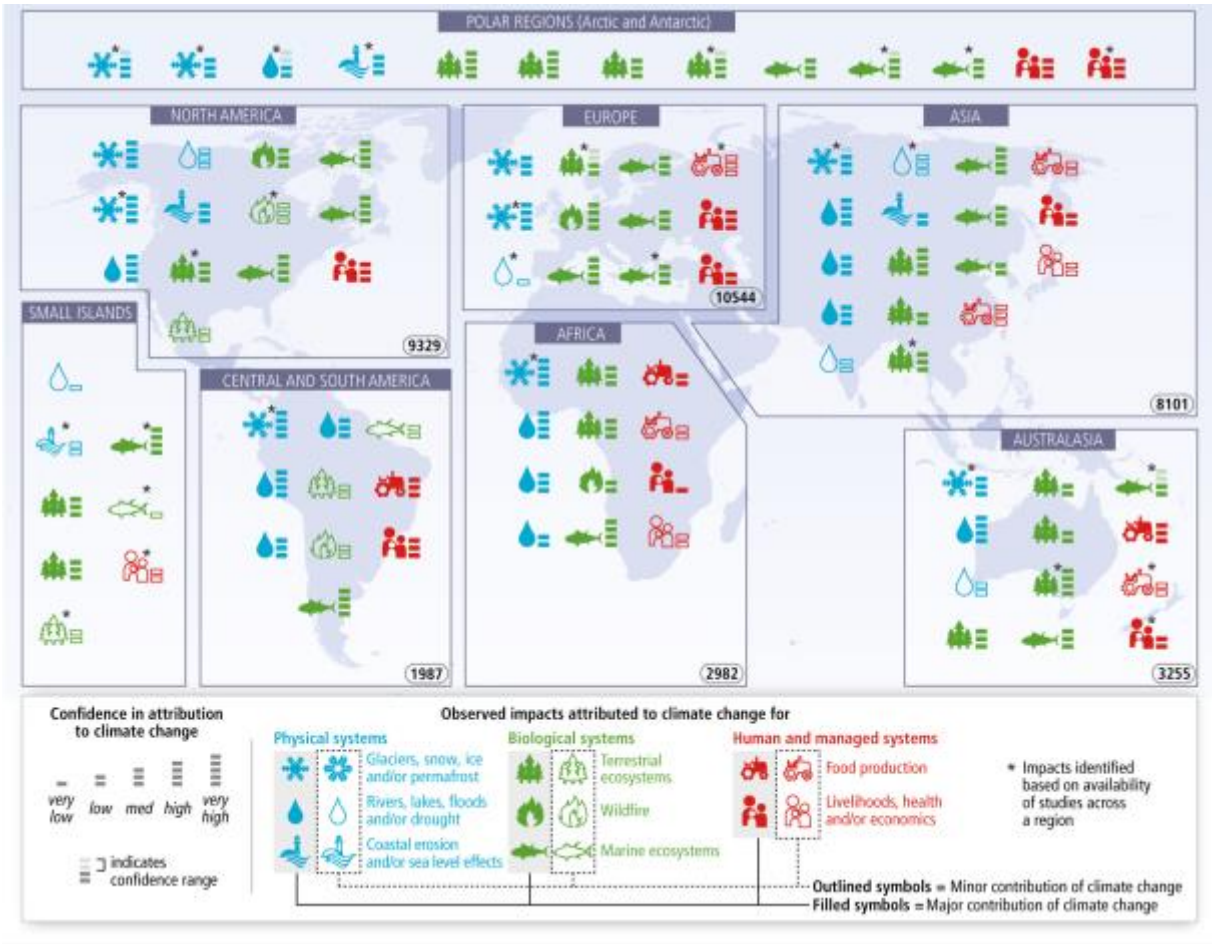

Figure 6: Widespread impacts attributed to climate change
Source: IPCC (2014, p.50)

Nonetheless, the expected impacts in each region will have different effects from one location to another. This mainly reflects the specific vulnerabilities of each community and their causes.

For some time, the effects of climate change were assessed based on impacts from a biophysical perspective. When scholars argued for the importance of social dimensions on the impacts of climate change, the concept of vulnerability began to be used in adaptation planning (Kelly & Adger, 2000).

2.3 Territory, community, and local issues

The concepts of territory, community, and local issues are important for the context of this investigation. The focus of this study on local communities seeks to explore a bottom-up approach to adaptation. Though climate change occurs on a global level, impacts are focused at the local level. Most of the time the local community is the first to notice the effects of climate change on SESs and also the most interested in finding solutions (Baker, Peterson, Brown, & McAlpine, 2012; IPCC, 2007a).

This study uses the territory concepts presented by Delaney (2009) and Haesbaert (2008). According to Delaney (2009), territory is a limited and a significant social space that expresses a fusion of meaning, power, and social space. In a territory, it is clear the meaning that the social space has for the community and the dynamics of power expressed there. Territory is commonly discussed in terms of the social or psychological functions it serves. It is a device to reach certain objectives such as the control of resources, efficiency or convenience, stability, or security.

Haesbaert (2008) also affirms that the territory is both functional and symbolic. People exercise control over space to perform "functions" and to produce "meanings". For the author, the domination and/or appropriation of social space occurs on a “continuum” ranging from the political-economic domination more 'concrete' and 'functional' until an appropriation more subjective and/or 'cultural-symbolic". The way a community uses and appropriates a biophysical space defines the characteristics of a territory. If different communities use the same biophysical space, it will acquire unique territorial characteristics that depend on the social aspects of each community, such as politics, economics, or culture. The author argues that, all "transformative actions" that one wants to deploy, including those for adaptation to climate change, must take into account the "multiplicity of territories, whether or not they will reach any innovative change effectively" (Haesbaert, 2008).

Community is understood here as a local group, variable in size, composed by people who occupy a geographically defined territory that share the same cultural and historical heritage. This concept encompasses two dimensions: Spatial and significant. In general terms, a community is a group of people linked by common identity, commitment, interest or concern (Kirmayer, Sehdev, Whitley, Dandeneau, & Colette, 2009). Peruzzo and Volpato (2009) affirm that communities are often complex and not cohesive. Some divisions may exist within a community depending on differences of wealth, activities, social status, and functions among people living in the same area. On the other hand, individuals may be members of different communities at the same time due to several factors such as location, occupation, economic status, sex, religion, or cultural interests. According to Rappaport (1993) the primary community is one that provides values, norms, history and a sense of continuity. The individual identifies his fundamental role and social identity there.

Human beings are fundamentally social and therefore the community acquires greater importance (Bauman, 2001). Some fundamental elements which characterize a community today are: a) sense of belonging; b) sense of community; c) permanence (as opposed to ephemerality); d) territoriality (real or symbolic); e) own form of communication between its members through specific channels.

There are many interconnected factors that influence the vulnerability of a community (eg physical, human, financial, natural, and social aspects). The complexity and dynamics of this context require a systemic approach that considers how these factors influence each other. In the case of vulnerable communities and climate change impacts, these characteristics can ensure greater cohesion among the group to act collectively.

The concept of "local" complements this understanding, when it is a space with unique characteristics, which evokes feelings of familiarity and neighborhood, and brings together identity and history. The notion of “local” ranges from technical aspects, such as the physical limits (rivers, oceans, lakes, mountains, differences in climate, soil characteristics), political and economic, to diverse social-cultural, historical, identity, language, traditions, and values, etc. What is at stake are the various singularities that are constructed in social practices. The neighborhood, the district, city or urban region are relatively stable reference points, but as contexts, these levels are defined differently (Peruzzo and Volpato, 2009).

2.4 Vulnerability and adaptive capacity to climate change

The term vulnerability is used in a wide range of disciplines, "from economics and anthropology to psychology and engineering” (Adger, 2006, p. 269). Studies on vulnerability

to climate change are based in geography and natural hazards, but they are influenced by other areas such as human ecology, economic policy, public health, among others (W. Neil Adger, 2006; H.-M. Füssel, 2007).

The variety of contexts and the different fields of knowledge which conceptualize vulnerability makes the understanding of the concept in climate change particularly problematic. This is due to the interdisciplinarity of the theme, which includes the collaboration of different research traditions, such as climate science, risk assessment, development, economics, and policy analysis (H.-M. Füssel, 2007). To facilitate discussion between different research traditions, Füssel (2007, p.6) proposed a nomenclature "to fully describe a vulnerable situation: vulnerability of a system's attribute(s) of concern to a hazard (in temporal reference)". as an example, he cites "vulnerability of an ecosystem's net primary production to wildfires in 2050".

Despite differences in the approaches, Adger (2006, p.270) states that vulnerability to environmental change is closely related to the "economic policy of use of resources".

The literature shows a close relationship between the concepts of vulnerability, exposure, sensitivity, and adaptive capacity (W. Neil Adger et al., 2011; Folke & Gunderson, 2010; Gallopín, 2006; Barry Smit & Wandel, 2006).

IPCC (2014b, p. 1775), defines vulnerability as "the propensity or predisposition to be adversely affected." It encompasses a variety of other concepts and elements which are relevant in this context. According the report, vulnerability to climate change is a function of:

> "• Exposure to climate variability and change, which refers to the degree of climate variability and change that an entity (a country, community, individual or ecosystem) experiences;
> • Sensitivity to climate shocks and stresses, which is an assessment of the amount of impact climate factors have on the entity; and,
> • Adaptive capacity, which describes the ability of the entity to manage the negative impacts and take advantage of any opportunities that arise" (IPCC 2014b, p.1151)

Exposure and sensitivity are properties of a system (or community) that are related to each other and depend on the interaction between system characteristics and attributes of the climate stimulus (Smit and Wandel, 2006). Yet, adaptive capacity is clearly affected by non-climatic factors (H. Füssel & Klein, 2006). Therefore, the relationships between social, economic, cultural, and political conditions can be potential causes of vulnerability. Figure 7 shows how non-climatic factors are decisive causes of vulnerability, and the effects of mitigation and adaptation on the vulnerability. Mitigation reduces emissions of greenhouse gases responsible for climate change, and can contribute to adaptation. In turn, adaptation

decreases the potential impacts of climate change and increases the adaptive capacity of the system.

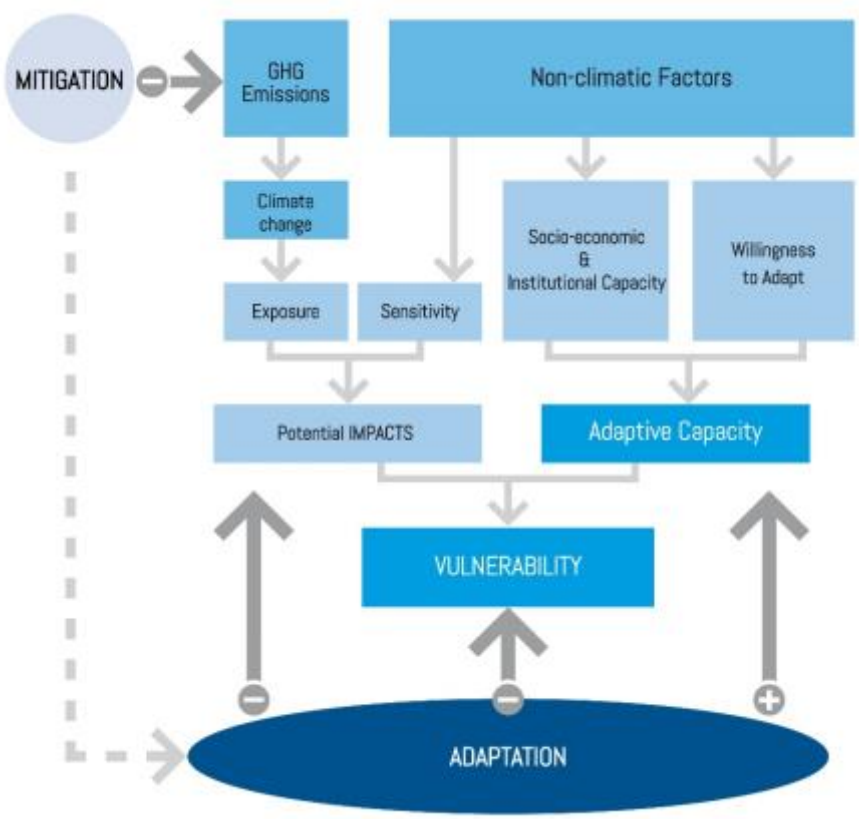

Figure 7: Vulnerability diagram adapted from Swart et al. (2009)

An analysis of the root causes of vulnerability is missing in most assessments of responses to climatic effects. Usually, the focus is on immediate social conditions such as poverty and lack of capacity. People without social abilities have no means or power to influence the political economy to create assets and adequate social protections (Ribot, 2011). Socioeconomic patterns of land use and dependence on natural resources also influence or constrain a system's adaptive capacity and affect its vulnerability (Martine et al., 2013; Barry Smit & Wandel, 2006).

In the field of climate change, adaptive capacity is defined as, ''the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences'' (Gallopín, 2006, p.300). Adaptability, coping ability, management capacity, stability, robustness, flexibility and resilience are other used concepts related to adaptive capacity (H. Füssel & Klein, 2006; Gunderson & Holling, 2002; Barry Smit & Wandel, 2006). While in biological

systems the response to disruptions is reactive, in social systems it can be reactive and proactive. Proactivity is crucial to reducing vulnerabilities. In this sense, Gallopin (2006, p. 301) points out that, “in general terms, adaptive capacity would seem to be broader than capacity of response”. In many cases, adaptation may include “modifying the sensitivity of the system to perturbations, increasing its resilience, and reducing the exposure of the system to perturbations.”

In fact, adaptive capacity is not static or constant. It is context-specific and can change based on location, social-economic conditions, as well as over time. There are many forces that influence the capacity of a system to adapt. At the local level, Smit and Wandel (2006, p. 287) point to "management capacity, access to financial resources, technology and information, infrastructure, institutional environment in which adaptation occurs, political influence, kinship networks, etc.” Moreover, some authors (W. Neil Adger et al., 2011; Folke & Gunderson, 2010; Ostrom, 2004) consider adaptive capacity an important component for building resilience, particularly in SES.

2.5 Systemic approach

Understanding the relationship between man and nature established in a SES is a complex task. For a long-time the world has been viewed within an analytical approach that is increasingly limited to the understanding of today's increasingly complex and unpredictable reality (Kirsch, Cotrin, & Vieira, 2010). In this approach, only what could be proven and tested objectively was considered true. For this, it was necessary to divide the object into simpler parts and exhaustively seek the causes of the problem from the easier piece solution. In other words, the parts were analyzed in isolation, sectoral, and independently of each other, so that their essence could be obtained through the sum of their totality. This fragmentation made it difficult to understand global problems. To understand the present objective reality, it is necessary to transcend the disciplinary and conceptual limits of reductionism in the Cartesian theory, thus reinforcing the tendency towards an integrative and interdisciplinary process (Kirsch et al., 2010).

In order to study phenomena globally, to involve all the interdependencies of each part with the whole, and to constitute a larger functional unit, Bertalanffy (1973) developed the general systems theory. It emphasizes the relationship much more than isolated entities. For the author, systems exist within systems and their functions depend essentially on their structure, which may be physical or concrete (objects, real things), or even abstract or conceptual (concepts, plans, ideas). He conceived the open system model, composed of elements in constant interaction and interchange with the external environment, and its

components constantly influence and are influenced by the characteristics of the system itself.

From there, Edgar Morin (2005) extended the view of Bertalanffy with the idea of complex systems. For him, all key objects constitute systems and they are interconnected with each other. There are links between individuals and the whole; the idea of system refers to the complex unity of the interrelationship; and the idea of organization refers to the arrangement of the parts within the whole.

In the systemic approach, the world is a set of living organisms, whose organic structures determine a process guided by cyclical and often variable models, with a certain degree of internal flexibility and plasticity. The principle of self-regulations is the dynamic relationships that controls plasticity and internal flexibility, capable of renewing and recycling (self-renewal), and moving beyond the frontiers of physical learning (self-transcendence) generating dynamic stability (Kirsch et al., 2010).

The principles discussed by these authors are essential for determining systemic thinking, especially when addressing socioecological resilience. The relationships between society and the environment are discussed in this research in the light of the systemic paradigm with the objective of finding ways to overcome the problems related to climate change.

2.6 Discussion

Climate variability and increases in extreme weather require local communities to adapt to new situations and develop the capacity of coping with the possible disturbances without collapsing. Any strategy to increase the adaptive capacity of these vulnerable communities implies a broad and clear understanding of elements of SES and the dimensions involved in searching for solutions. Knowledge of the effects of climate change, including climate variability, extreme events, local vulnerabilities, and their contexts are essential to increase communities' adaptive capacity and consequently build resilience.

The concepts above contextualize the problem discussed in this thesis and assist in the understanding of the essential factors to build SER. Climate change can be understood as a threat to local communities or as an opportunity for societal transformation. The effects of climate change are not felt in the same way in all parts of the globe. Each territory is composed of characteristics that define its vulnerability. Climate variability and extreme weather become very important for the social, economic, and environmental development of vulnerable communities because these phenomena are short-term and their intensity and frequency are variable. Alternative ways to reduce vulnerability and increase the adaptive

capacity of these local communities should be designed to use the existing social capital or activate latent social capacity. This thesis is focused on trying to understand the forms of SER building through human development and changing social systems for a transformative process that improve adaptive capacity of local communities to climate change.

3. ADAPTATION TO CLIMATE CHANGE

Adaptation is a concept that only entered the political debate regarding climate change in the 90s. Its relevance derives from the evolution of scientific knowledge regarding climate change, the understanding and acceptance of the occurrence of this phenomenon, and consequently its influence on political debate.

At first mitigation policies, being relatively easier to establish, became the political priority in the majority of cases. Mitigation is normally established through a top-down approach, with both regulatory and market mechanisms centrally defined. The adoption of legal limits on emissions, regulation and control of products and markets (such as the carbon market) are stimulus determined, or created by national government interventions in order to comply with international agreements. These national initiatives subsequently establish pathways for sectoral, regional or local government actions to adopt specific measures. The governance capacity is clear; the responsibility lies with public authorities to establish the mitigation rules (Schipper, 2006).

Adaptation measures however, which demand resources and action where the problems occur, engage a variety of stakeholders. They sometimes require large infrastructures, changes in the patterns of land-use, as well as changes in individual, community, and organizational behavior. Collaborative action and knowledge exchanges are also required. Unlike mitigation, national governments are not necessarily held responsible for adaptation, since it very often needs to take place at the local level, being quite intrinsic and specific to local communities. Local and regional public authorities often see adaptation as a cost that can be postponed. The perception of need usually coincides with the occurrence of extreme events. And after the extreme event is over, the need for immediate intervention is no longer perceived.

In the 1990s, difficulties in reducing greenhouse gas emissions, particularly the inability to involve countries such as the United States and China in signing the Kyoto Protocol (1997), and the evidence of climate change from experience of their negative effects, have changed the political vision (Schipper, 2006).

Natural as well as technological responsiveness have been insufficient to address the pressures associated with climate change. Therefore, impact and vulnerability assessment became research questions and issues of debate. Non-climatic determinants of vulnerability, such as demography, economy, socio–political conditions, and technological development, which raised discussions around the nature of society responses were considered (H. Füssel & Klein, 2002, 2006; Kelly & Adger, 2000). Defensive or reactive approaches to adaptation were progressively transformed into anticipatory measures that could preempt more serious consequences, also changing the temporal and spatial scope of actions and the sharing of responsibilities.

3.1 Climate change adaptation: understanding and evolution of the concept

The term adaptation is generally understood as a modification of an organism or its parts that makes it more fit for existence under the conditions of its environment (https://www.merriam-webster.com/). Although it has been used for a long time in different scientific areas associated with evolution, ecology, and environmental change, it is relatively recent in the climate change context (Simonet, 2010; B Smit, Burton, Klein, & Wandel, 2000).

In biology, adaptation is understood as evolution, interaction, and acclimatization. It had its conceptual glory with Darwin´s theory of evolution, where living beings adapt to the environment. For Simonet (2010) the evolution of life forms and climatic evolution are closely linked. Yet, he also relates the concept of adaptation to other interdisciplinary notions that can be relevant to climate change adaptation: change and evolution; semantic duality; influence, modification, interaction, and organization; survival and balance; innovation and apprenticeship; speed; plasticity; the spatial scale; and finally, perception, information, and decision making.

In the context of climate change the relevance of the term “adaptation” in the political debate results from the evolution of scientific knowledge and its influence on the understanding and acceptance of this concept (Pelling, 2011; E. Schipper, 2006; B Smit, Burton, Klein, & Street, 1999). It also comes from the evidence of climate change events in the last few years (Bassett & Fogelman, 2013).

For some authors, the discussions around the concept of adaptation to climate change are ambiguous and enable different interpretations. This is because adaptation involves uncertainty, complexity, interdependencies, and multiple perspectives (Collins & Ison, 2009). Rickards (2010, p.1) admits that adaptation to climate change is a “Trojan horse” of contested ideological meanings. Giddens (2010, p. 202) considers it a “misleading term” as it implies reacting to the consequences of climate change only after they occur. Whereas Pelling (2011, p.13), considers adaptation a “slippery concept” because some (such as Smit et al., 2000) defined it as a technical term (as mitigation concept) and others have a broader view of it as a research field (O’Brien, 2012). Finally, Simonet and Fatorić (2015) argue that adaptation can be considered a “mirror” concept because it gathers dimensions of resignation and opportunity.

For many years adaptation was seen as an "adjustment” of the system’s vulnerable elements (Bassett & Fogelman, 2013; Park et al., 2012; Pelling, 2011; Wise et al., 2014). This understanding was closely linked to the concept defended by IPCC, which is similar to the Hazard's School. IPCC advocated adaptation as a technological concept (a method, as in mitigation), an “adjustment” to ensure clarity in policy formulation (IPCC, 1996, 2001, 2007a). In practice, adaptation actions were mostly based on short-term incremental tactical decisions, focused on specific causes. IPCC assessment reports still dominate this debate. Most of their concepts refer to adjustments of a system in response to climatic stimuli, despite having differences in scope, application, and interpretations of term (Bassett and Fogelman, 2013; Smit et al., 2000).

The First IPCC Assessment Report (IPCC, 1991) did not address the topic of adaptation, focusing exclusively on mitigation research and policies for reducing greenhouse gases (GEE). The first definition of adaptation as a planned action in the climate change context was in 1994 (Brussels), with a proposal from Australia and New Zealand at the tenth session of Intergovernmental Negotiating Committee (INC-10) at the United Nations Framework Convention on Climate Change (UNFCCC). Adaptation was defined here as "all purposeful activity and deliberate decision in response to or in anticipation of the adverse effects of rapid climate change" (Schipper, 2006, p.88).

Since the Second IPCC Assessment Report (IPCC, 1996) adaptation has been seen as a way of dealing with the effects of climate change. The concept of adaptation is related to climate change impacts, and implicitly recognizes that future climate changes will occur and must be addressed in policy.

The Third IPCC Assessment Report (IPCC, 2001) concluded that adaptation was important to complement mitigation´s increased efforts. From data presented, climate experts and politicians recognized that society needed to consider adjustments to reduce their vulnerabilities (Bassett and Fogelman 2013). The Third IPCC Assessment Report (IPCC, 2001) focuses on the characterization of biophysical impacts and gradually integrates economic and social impacts.

The Fourth IPCC Assessment Report (IPCC, 2007b) finally declares that climate change occurs and that a more extensive adaptation policy would be required. It identified an integrated understanding between physical and social impacts. This established that the impacts of climate change depend on the characteristics of natural and human systems, their patterns of development and their specific locations.

The last IPCC Report Assessment (IPCC, 2014) sought to reflect the progress of science. Although it understands adaptation in a broader, process-oriented vision (a process and a result), it still retains the term "adjustment" in its concept.

Nonetheless, other authors have looked at adaptation from a broader perspective, as a process, a research field, and discussed it using other approaches beyond the notion of "adjustment". In fact, Smit and Wandel (2006), Füssel (2007), and IPCC (2014) expanded the concept of adaptation as an outcome. Smit and Wandel (2006, p.286) argue that adaptation is “a process, action, or outcome in a system (household, community, group, sector, region, country) for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity.” Füssel (2007) states that adaptation is “the process by which individuals and societies make and implement decisions regarding the use of adaptive capacities to manage risk and moderate harm from perceived or projected change.” An advance in the pages of the fifth IPCC assessment report (IPCC, 2014, p.76) was its consideration of adaptation and mitigation as two complementary strategies for responding to climate change, and its definition of adaptation as “the process of adjustment to actual or expected climate and its effects which moderates harm or exploits beneficial opportunities.” Going further, other authors highlight the need for a transition to more systemic or transformative actions (Kates et al., 2012; Nelson, 2009; O’Brien, 2012; Pelling, 2011; Wise et al., 2014). This idea is based on concepts of transformation and transformability defended by Nelson et al. (2007) and Folke et al. (2010) from the resilience theory.

For example, Pelling (2011) identifies three levels at which adaptation can interfere in development: Resilience, transition, and transformation. He sees resilience through a

physical lens, distinct from adaptation, because the search for stability, functional persistence and status quo maintenance. Transition is an intermediary form of adaptation, with incremental social change and the exercising of existing rights. Lastly, transformation is a radical change, with new rights claims and changes in political regimes.

Moreover, Roggema et al. (2012) see incremental adaptation as a slow process, which slightly modifies the landscape. They argue that, adaptation as transition is a clear shift toward a new future in an improved version of the present, whereas transformation is a change for a future fundamentally different from what exists. Kates et al. (2012) also classify climate change adaptation as incremental actions and behaviors that reduce losses or increase the benefits of climatic variations and extreme events. But the authors emphasize that the climate change literature is increasingly recognizing a move towards transformational adaptation. They describe transformational adaptation as actions in three situations: “Those that are adopted at a much larger scale or intensity, those that are truly new to a particular region or resource system, and those that transform places and shift locations” (Kates 2012, p.7156). According to these authors, transformational adaptation will be required in the future due to the high vulnerability of populations and natural systems, and because of more severe climate change. In fact, in some places and for some systems, the risks and vulnerabilities can be so great that incremental adaptations to climate change are insufficient. They require anticipatory and transformative adaptation.

Furthermore, Park et al. (2012) consider two adaptation response strategies: Incremental and transformational change. According to these authors, both processes can occur simultaneously at different times within a complex system. The difference between them lies in the extent of change. In practice, incremental adaptation means maintaining the essence and integrity of a system or process at a given scale, and transformational adaptations are changes in the biophysical, social, or economic components of a system from one state to another.

O´Brien (2012) affirms that a deliberate transformation is a “multi-definitional concept depending on one’s values and worldview; associated with changes in meaning-making processes, calls for new critical approaches and challenges paradigms.”

Basset and Fogelman (2013) review the conceptualization of climate change adaptation in the literature and classify the adaptation concepts into three categories: Adjustment (return to the desirable equilibrium state), reformist (altered rules and decision-making processes, but do not significantly alter norms and principles of government), and transformative

(fundamental social change). This classification is partly inspired in Pelling's three adaptation types (Pelling, 2011) and is also related to the concept promoted by Kates et al. (2012) .

Preston et al. (2013, p. 1025) argue that an adaptive transformation is "a fundamental alteration of actors' perspectives on sustainability, societal objectives and how they can be achieved."

Wise et al. (2014) explore a broader conceptualization of adaptation as an element of pathways where global changes and societal responses interact together. Their approach integrates incremental actions for specific causes with transformative aspects of social change. According to the authors a transformative adaptation requires a change in basic assumptions, where institutions, organizations, community, and individuals get the skills and capabilities necessary to guide, facilitate, and manage the adaptation process for building resilience, transforming values, decision-making processes, and governance. They advocate that the process of adaptation to the current impacts of climate change can be a way "to reflect on and reconsider the social norms and societal values that underlie existing problems" (Wise et al., 2014, p.234).

Pelling et al. (2014, p.116) state that a transformative process expands the policy options for adaptation so that: "a) measures taken to preserve stability and resist the drivers of hazard and vulnerability, and (b) incremental adjustments that preserve systems integrity when conditions change, to include (c) measures that challenge the stability of current systems". And, finally, Eriksen et al. (2015, p 524) see adaptation as a political act and describe transformational adaptation as "a contested social-political process that mediates how individuals and collectives deal with multiple types of simultaneously occurring environmental and social changes."

3.2 Climate Change Adaptation – Analysis of different perspectives

Based on the literature review we identified that the term adaptation has been defined in a fragmented way. From an incremental intervention to a transformative approach, the different perspectives around the concept of adaptation evolved based on certain framings and assumptions, such as: a) How the relationship between adaptation and mitigation is understood; b) Focus or the point of view of the action; c) The choice of different types of climate change assessment; and d) Based on the level of change that is desired. These factors are related to each other in an integrated way. According to Collins and Ison (2009) awareness and knowledge of these assumptions can assist in the development of more effective policies and praxis. These assumptions will now be addressed in greater detail.

a) The Adaptation and Mitigation binary

The two fundamental societal responses to reducing the risk of climate change are mitigation and adaptation (Füssel, 2007). The most immediate interpretation of adaptation to climate change was as the "flip side of mitigation" (Rickards, 2010). This approach reinforces the idea of complementarity, divides science into two research fields, and establishes governance levels for each area. Mitigation is treated in the sphere of international politics, normally established through both regulatory and centrally defined market mechanisms. Adaptation takes place at local and regional level, but can actually be quite intrinsic to a community (Adger, 2001). According Rickards (2010), this duality creates the impression that mitigation and adaptation are opposites. It suggests that mitigation comes before adaptation, with the latter being reactive. Adaptation is therefore narrowly interpreted as "fitting to" the environment with a biological bias that focuses on physical stimuli. Climate change is seen only as a bad phenomenon and adaptation takes on a "fatalistic" and "defeatist" character (Rickards, 2010; Schipper and Pelling, 2006).

Collins and Ison (2009) discussed an alternative way to conceptualize adaptation, supported by Pelling (2011). In their view, adaptation is a process of humans "fitting with" the environment. Mitigation is incorporated under adaptation as a set of social, political and economic adaptive actions that can reduce the emission of greenhouse gases and their concentration in the atmosphere (Collins and Ison, 2009; Pelling, 2011; Rickards, 2010). According to Rickards (2010), framing mitigation as a type of adaptation, adaptive efforts are recognized as positive changes. The climatic impacts are expanded to a broader level, incorporating the idea of beneficial opportunities (Rickards, 2010). The Intergovernmental Panel on Climate Change (IPCC, 2007, p 749) advocates synergies between adaptation and mitigation because their combined effect is greater than the sum of their effects implemented separately.

b) Adaptive actions perspective

According to Smit et al. (1999) the term adaptation can refer to a "process of adapting" as well as the condition of "being adapted". If the focus of adaptation is to deal with the negative impacts of climate change, it is framed as an outcome or one-way action. The actions are focused on recovering or protecting elements of a system that are vulnerable to climate change impacts without interfering with the system *per se*. Typically, an outcome frame emphasizes a static view of the future and the adaptive options are resolved in a technological way, such as building sea walls or flood barriers (Fünfgeld and McEvoy, 2011).

According Collins and Ison (2009), adaptation framed as “a process” adopts a systemic view, and favors the understanding on SES. It focuses on the dynamic and mutual interaction between man and nature. It tries to understand the causal structure of vulnerability in different contexts (social, political, economic, or environmental) and seeks to increase the adaptive capacity of individuals and groups. Eriksen et al. (2015, p.524) understand “adaptation not as a single decision or measure, but as a social process wherein social and political relation shape the simultaneous management of diverse changes”.

c) The choice of different types of climate change assessments

Understanding how to respond to current and future climate change impacts is one of the greatest challenges of our time. Climate change assessments can be delivered through instruments that help decision-makers to identify, develop, and agree upon suitable responses for carbon off-set programs and effective adaptations. The assessment tools are not always made explicit by proponents of different approaches, but they play a very important role in the early stages of adaptation planning (Fünfgeld and McEvoy, 2011). These assessments provide a better understanding of the effects of current and future climate change in certain regions, both for populations, communities, as well as their natural, economic, and social resources (Carter et al., 1994).

The types of assessment differ in terms of their goals, theoretical foundations, forms of data inputs, and the kinds of information they provide about the effects of climate change. These then demand different adaptation responses (Burton et al., 2002; Carter et al., 1994; Füssel, 2007). The climate change literature presents three evolutionary phases of assessment methodologies.

The first is climate impact assessment, which analyzes the positive and negative effects of the climate on the natural, social, and economic system. It focuses on biophysical and/or socioeconomic effects in a particular "exposure unit", namely according to the IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptation (1994) as “the activity, group, region or resource exposed to significant climate variations” (Carter et al., 1994, p.3). This became known as a “standard approach”, also considered the “first generation” of adaptive studies (Burton et al., 2002; Füssel and Klein, 2006; Füssel, 2007). This approach was not necessarily designed to generate adaptation options, because it can be conducted on various scales, from the national to local. But it can also be used on a smaller scale to verify the possible responses of individual organisms with specific biophysical impacts (Carter et al., 1994). In the case of the coexistence of multiple climatic and non-climatic stressors, a more integrated assessment approach is needed.

The second is the climate risk assessment that, as part of the risk management approach related to extreme events, deals with the uncertainty inherent in climate impact assessments. This methodology is used to formulate disaster risk reduction strategies, as well as climate change adaptation. Füssel and Klein (2006) classified this methodology as the first generation of vulnerability assessment. Risk assessment is a process to determine the nature and extent of risk and to quantify the likelihood and harmful consequences of climate impacts for different scenarios. This approach considers the influence of non-climatic stressors on these impacts. Exposure and vulnerability are key determinants of risk. The IPCC Special Report (IPCC, 2012, p.5) defines exposure as “the presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected” and vulnerability as “the propensity or predisposition to be adversely affected.”. Risk can therefore be measured as a low, medium, or high probability of a hazard occurring. This approach enables stakeholders to assist in the understanding of cause and effect between the predicted hazard and vulnerability of the exposed system and its immediate physical consequences (Füssel and Klein, 2006, 2002).

Thirdly, the vulnerability assessment combines natural and social science perspectives. Füssel and Klein (2006, p.319) consider this approach the second-generation vulnerability assessment. They argue that: it aims to “estimate realistically the vulnerability of certain sectors or regions to climate change, together with other stress factors and considering the potential for possible adjustments to reduce the negative impacts.” Hence, two aspects become relevant: The influence of non-climatic factors determined by non-climate drivers (economy, demography, technology, etc.) and the adaptive capacity of a system or society, i.e., the system or society´s capacity "to modify its characteristics or behavior to better cope with the changes in external conditions."

d) The desired level of change approach

Different perceptions about the relationship between the present and the future can define the level of change that adaptation must achieve. Rickards (2010, p.4) classifies these interventions as “partial repair, full repair and improvement position”. The “partial repair” is related to “acceptance,” based on the assumption that some climate harm is impossible to adapt to. This type of intervention is often defended by economists who base their decisions on cost-benefit analysis. Thus, in situations where there are choices and trade-offs, adaptation focuses on achieve the greatest benefits for the most vulnerable groups. The second type of intervention, “full repair, ” is based on the damage ratio. It seeks to neutralize

the impacts of climate change to restore balance and status quo. Finally, the “improvement position” tries to enhance life under conditions of climate change in terms of absolute and relative progress. It aims to ensure that life will not only survive but thrive. This intervention has to do with the evolution of the concept of adaptation to climate change and how it is discussed by Pelling (2011), Kates et al. (2012), Park et al. (2012), Basset and Fogelmann (2013) Wise et al. (2014) and Eriksen et al. (2015), among others.

3.3 Climate change adaptation research today

In recent years, a great deal of research, and in particular practice-oriented research, has been dedicated to the issue of adaptation (Swart et al., 2014). Nonetheless, Adger & Barnett (2009) argue that adaptation processes remains confusing because of the unclear relationship between the concept and its practical application. Other authors also stress the need for greater integration between the theory and the practice of adaptation (Eakin and Patt, 2011; Patwardhan et al., 2009; Swart et al., 2014). Swart et al. (2014, p.1) highlight that “emphasis on the ´science of´ adaptation can lead to improved understanding of the conditions to successful ´science for´ adaptation.”

Previous research and empirical evidence indicate a gap in the relationship between the theory and the practice of adaptation. While adaptation theory evolved slowly, policy has developed quite rapidly. This is relevant because the proper understanding and depth of the concept of adaptation is essential for decision-making (Moser and Ekstrom, 2010; Swart et al., 2014; Wise et al., 2014). If decisions are not well founded and structured around key concepts, understandings and information, policies cannot meet social needs. On the other hand, the theory and practice of adaptation may benefit each other if they are in a permanent interaction (Patwardhan et al., 2009).

The advancement of research in the evaluation of adaptation policies and decision-making processes reveal practical results, the past difficulties, and future possibilities. These practical aspects broaden the knowledge base that supports evolutionary theory. In turn, actions based on this new knowledge, if correctly designed, may avoid situations of maladaptation (Swart et al., 2014). In fact, Swart et al. (2014) and Preston et al. (2015) argue that the abundance of strategies, plans, and programs around the globe is not reflected in practice. They emphasize the importance of the development of a solid knowledge base to accelerate this progress, but the scientific community has disregarded this. According to these authors, practice-oriented research is insufficient to the support policies and practice of adaptation in a productive manner.

Many authors discuss the barriers that prevent or hinder the implementation of adaptation in practice (Adger et al., 2009; Barnett et al., 2015; Eisenack and Stecker, 2011; Oberlack and Eisenack, 2014; Tompkins et al., 2010). According to Barnett et al. (2015) the barriers are context specific, whereas Klein R.J.T. et al. (2014) cite many constraints such as knowledge, awareness, and technology; the physical environment; biological tolerances; economic factors; financial factors; human resources; social and cultural factors; and governance and institutional processes.

Social, political, and institutional barriers for adapt called attention to the human dimensions of adaptation. As a matter of fact, 10% of literature reviewed focuses on this issue,including risk perception, ethics, justice, stakeholders' engagement, knowledge exchange and learning (Adger, 2003; Few et al., 2007; Moser, 2014; Pelling et al., 2008; Ross et al., 2015). Some authors such as Adger et al. (2009) and Eriksen et al. (2015) examine the complexity of social and individual processes that mediate decisions about biophysical changes. They recognize the important contributions made by social scientists to understanding the issues of inequality and social justice within the adaptation debate.

3.4 Discussion

The literature review shows an evolution of the understanding of the concept of adaptation to climate change over the past 30 years. It was first understood within a technical logic and it was presented as a timely "adjustment", focused on the vulnerable elements of systems. This adjustment understands it as a reaction to bring back balance that was lost due to the effects of climate change. It is a short-term view focused on the "outcome" and stems from the mitigation experience. As an easier policy to implement, it was prioritized as a response to climate change. Using a top-down approach, mitigation is based on technical decisions that set legal limits for emissions, regulation, and control of products and markets.

Over time, the impacts of climate change were confirmed and this caused a change in the understanding of adaptation. Due to scholars' recognition of the influence of non-climatic factors on the climate change impacts and vulnerability, it began to be understood more broadly, within a systemic vision. It was argued that adaptation could not focus only on results, but it must adopt a processual logic, with successive incremental actions.

In recent years, because of research that proved earlier forecasts and continued worsening impacts of climate change in some regions, the focus has turned to finding appropriate responses to very vulnerable areas with poor people whose livelihood is based on fragile ecological systems. Here there is a consensus among scholars that only incremental

measures would be insufficient to respond to the major foreseen impacts. Many authors suggest the necessity of an approach that addresses the vulnerability causes that, in most cases, are based in social factors. Transformation is thus an essential element in the process. This current view of adaptation as transformation is rooted in resilience theory.

In the literature, we identified two perspectives of transformative adaptation: a) the most effective short-time and incremental actions based on biophysical characteristics, changing the nature, composition and/or activity location or systems; b) a transformation focused on reducing risks and vulnerabilities by changing the dynamics and structure of the systems, their economic and social relations, as well as beliefs and behaviors of individuals and groups to increase their adaptive capacity.

Therefore, it is possible to identify a gap between the evolution of the understanding of adaptation and the mechanisms that transfer theory to practice. None of the conceptual frameworks analyzed draw clearly from the current understanding of adaptation as a transformative process that considers the causes of vulnerability, the synergies between adaptation and mitigation, and the changes in the dynamics of the SES. This thesis aims to contribute to the construction of a broader and systemic concept of adaptation. It also argues that changing both individual and group beliefs and behaviors are decisive factors for increasing the adaptive capacity and reducing vulnerabilities to climate change and point to ways to change these behaviors.

4. TRANSFORMATION

In addition to simply resigning to suffering, for a longtime mitigation and adaptation were seen as the only other responses to climate change. Yet, in recent years, some authors have discussed another possible choice: transformation (O'Brien, 2012; O'Brien and Sygna, 2013; Park et al., 2012; Fazey et al., 2017). Transformation is a term widely used in various areas of knowledge such as mathematics, genetics, education, business, among others. It has different meanings in each context, but for the most part is based on qualitative change (Feola, 2015). Some disciplines have investigated transformation in the context of global environmental change, including risk management, sustainability, adaptation to climate change, and reducing the risk of disasters (Mustelin et al., 2013).

Feola (2015, p.3) points to significant ways that transformation overlaps with other concepts such as "resilience, adaptation, critical transition, and sustainable development." Yet, he cautions that these relationships "are interpreted from a range of perspectives." Pelling (2011) and Park et al. (2012) differentiate transformation of transition. Pelling (2011) makes clear distinctions between transformation and resilience, while Walker et al. (2004) and Folke et al. (2010) consider transformability a fundamental feature of a resilient system. Some authors state that the transformation process is not well understood (Nelson, 2009), whereas others argue that there is still no solid theory of transformation (O'Brien, 2012; O'Brien and Sygna, 2013). According to Feola (2015), the plurality of concepts and lack of consensus on the issue could be detrimental to the implementation of effective actions, that are so necessary now. Table 1 summarizes some concepts of transformation in the climate change literature.

Authors	Definition of transformation
(Biology Online Dictionary);	The act, state or process of changing, such as in form or structure; the conversion from one form to another"
Walker et al., 2004	"The capacity to create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable"
Nelson et al., 2007, p.397	"A fundamental alteration of the nature of a system once the current ecological, social, or economic conditions become untenable or are undesirable"
Park et al., 2012, p. 119	"A discrete process that fundamentally (but not necessarily irreversibly) results in change in biophysical, social or economic components of the system from one form, function and location (state) to another, thereby enhancing the capacity for desired values to be achieved given perceived or real changes in the present or future environment"
Pelling, 2011, p. 84	"Fundamental shifts in power and representation of interests and values"
IPCC, 2014, p.1774	"A change in the fundamental attributes of natural and human systems"

Table 1: Definitions of the term transformation found in the literature

In this research, the concept of transformation is based on Pelling's (2011) definition, as "fundamental shifts in power and representation of interests and values." O´Brien (2012) and, O´Brien and Sygna (2013) complement the understanding, arguing that it is a complex process, which involves changes in a system from one state to another, at a personal, cultural, physical, organizational, and institutional level (O'Brien and Sygna, 2013). This includes new social dynamics and new relationships of power (O'Brien 2012). Transformation therefore affects social and ecological components of a system, and it can involve, institutional changes or collective action in a coordinated manner (Marshall et al., 2012).

In this context, it is important to distinguish between two related concepts that are widely used in this discussion: social interactions and social dynamics. A social interaction is an exchange between two or more individuals; it is defined as the way people talk to and interact with one another (Becker, 1971). Social dynamics on the other hand, can refer to the behavior of groups that results from the interactions of individual group members as well to the study of the relationship between individual interactions and group level behaviors (Durlauf and Young, 2001).

O'Brien et al. (2015) points out that transformations are understood in the literature from two angles. On the one hand, some authors (Brooks et al., 2011; Denton et al., 2014; Kates et al., 2012) consider effective actions based on bio-physical characteristics, changing the nature, composition and/or location of activities or systems. These transformations therefore involve more intense, longer term large-scale actions. On the other hand, other authors

(O'Brien 2012; Denton et al. 2014; Pelling 2011) advocate focused transformation, meaning changing the dynamics and structure of systems, economic, and social relations, as well as both individual and group beliefs and behaviors.

According to O'Brien and Sygna (2013), transformation takes place in three interconnected areas: Practical, political, and personal. The practical sphere involves behaviors and technical responses that may include social and technological innovations. The political sphere involves the systems and structures that support transformations in the practical sphere. Moreover, the personal sphere involves beliefs, values, worldviews, and paradigms that determine how systems and structures are understood and the types of solutions that are adopted (O'Brien and Sygna, 2013, p.5).

4.1 The transformative process of adaptation to climate change

The transformative process of adaptation is the change in social-ecological systems that produces a transformation in the system. A transformative process of adaptation is characterized by a fundamental change in the functioning of systems (Pelling et al., 2014), that through appropriate social dynamics, generates an important paradigm shift: responsibility for adapting.

Previously, adaptation was understood as an "adjustment" that governments and public policy makers were responsible for both planning and overseeing. Actions were focused on recovering or protecting a system's vulnerable elements to climate change impacts, without necessarily interfering with the system itself (Smit et al., 2000). This approach is now considered insufficient in the academic literature (Eriksen et al., 2011; O'Brien, 2012; O'Brien et al., 2009; Pelling, 2011; Roggema et al., 2012), particularly in cases when the disruption caused by the impacts of climate change is quite significant. Particularly when the lack of infrastructure, financial resources, and the performance of public institutions are inadequate or unable to improve adaptive capacity. Concentrating the decision-making power in the hands of public policy makers is not conducive to understanding the real needs of vulnerable communities, and hampers an adequate adaptation process.

A growing body of scientific literature (Feola, 2015; Nelson et al., 2007; O'Brien, 2012; O'Neill and Handmer, 2012; Park et al., 2012; Pelling and Manuel-Navarrete, 2011; Roggema et al., 2012) has discussed adaptation using a systemic view, asking social dynamics that motivate fundamental change in social systems and integrating the contextual perspectives. Some researchers have shown that local-level capacities appear to be critical

for successful adaptation to climate change, and that the human actions dominate the changes in a SES (Holling, 2001; Walker et al., 2006, 2004).

Many researchers recognize the role of individuals, communities, society, and institutions in the adaptation process (Adger et al., 2005; Nelson, 2011; Park et al., 2012). The pathways of change and responses to climate change are directly linked to social aspects (Park et al., 2012; Pelling, 2011; Wise et al., 2014). Transformative adaptation requires a paradigm shift, where institutions, organizations, communities, and individuals obtain the skills and capabilities necessary to guide, facilitate, and manage the adaptation process to build resilience, transform values, decision-making processes, and governance arrangements (Wise et al., 2014). These new skills and capabilities empower people to share the responsibility to adapt.

4.2 Action sharing, social dynamics, and empowerment

The basis of a transformative adaptation process is the social dynamics that promote new insights about the responsibility for adapting. Thus, it is understood as a contribution to processes of social dynamics. Social dynamics enable empowerment and consequently increase climate change adaptive capacity. The trigger to promote these social dynamics is a set of joint actions that we call "action sharing". This is therefore a fundamental condition to enable a transformation that increases the system's capacity to adapt. Figure 8 synthetizes the transformative adaptation process.

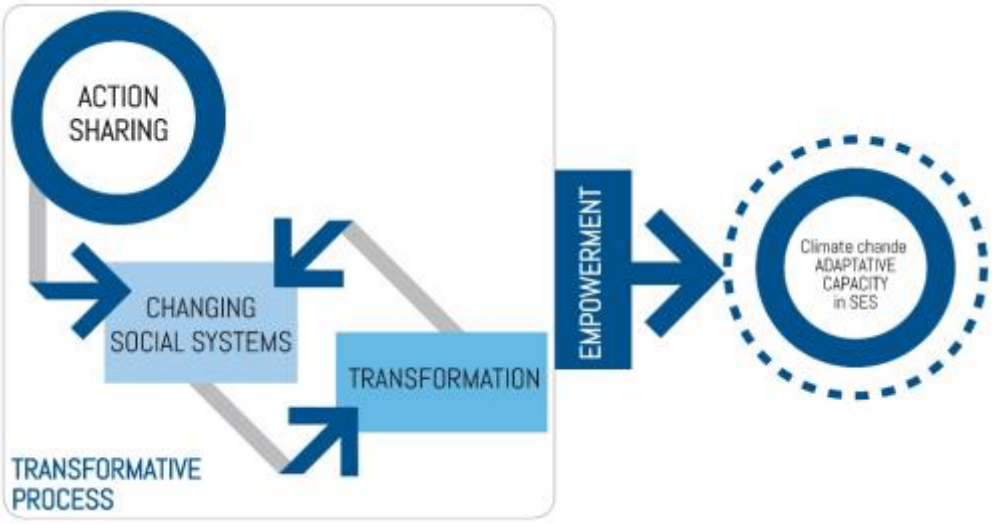

Figure 8: The transformative process and climate change adaptive capacity

The sharing of responsibilities of adaptation to climate change, through a set of actions, may induce changes in social systems and consequently transformations in SES. "Action sharing"

can therefore be a key element to induce positive social interactions and promote the empowerment of stakeholders. As seen above, changes in the social system generate transformations that can include new social changes.

The empowerment of communities and individuals is an outcome of this process, which motivates people to become more active in adaptation to climate change in the future. Narayan-Parker (2002, p. 10) defines empowerment as “the process of enhancing the capacity of individuals or groups to make choices and to transform those choices into desired actions and outcomes. According to the author, community empowerment involves the expansion of assets and capabilities of people to participate, negotiate with, influence, control, and hold the institutions that affect their lives accountable. It includes four key elements: Access to information; inclusion and participation; accountability; and local organizational capacity (Harriss, 2007).

As seen in Chapter 3, for a long time, responsibility for adaptation was assigned to the institutional level, specifically cooperation between local authorities and institutions at different levels. However, in many poor regions of the world with severe climate vulnerabilities, governments and institutions are unable to cope with future circumstances. In many cases, most of the population lives with precarious conditions including poor infrastructure, inefficient services, institutions, and regulations that cannot reduce risks. In addition, communities are complex, poorly organized, and lack access to information and expertise. Hence, the top-down conventional governance model may need to be changed. A possibility may be a future transfer of leadership and responsibility to the community. This requires the engagement of stakeholders (institutions, community, groups, and individuals) led by a common purpose: Acquiring and improving skills and capabilities to meet the challenges of climate change.

Adger (2003) considers adaptation a dynamic social process, where the ability of society to adapt is determined by its capability to act collectively. Based on this statement and other references in the literature, “action sharing” can trigger social interactions. Empirically, we identified three fundamental components in "action sharing": Stakeholder engagement, knowledge brokerage, and collective action (Figure 9). These generate social interactions between individual actors, actor networks as well as, and consequently, their initiatives. Governance provides the necessary support for these actions.

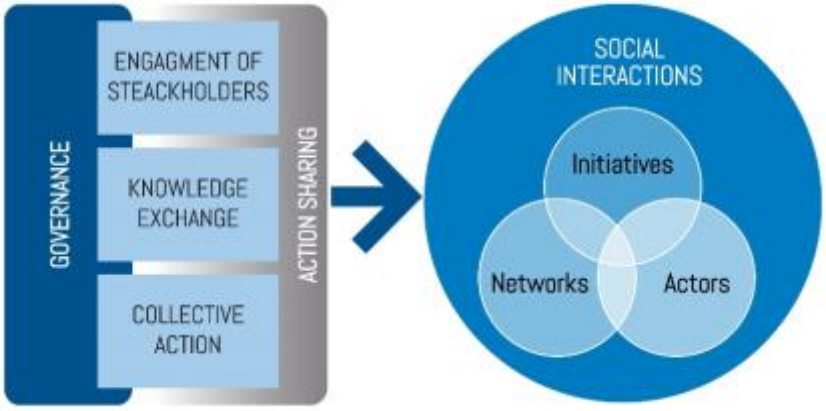

Figure 9: Action sharing and social dynamics

According to Adger et al. (2005, p.79), increasing adaptive capacity depends on "communicating information on climate change, raising awareness of potential impacts, ensuring well-being, protecting property or land, maintaining economic growth or taking advantage of new opportunities." Here knowledge is essential, because it provides the necessary support for actions to develop properly.

Thus, the local specificity of adaptation requires the interaction between scientific and expert knowledge and, local knowledge. Each contributes to the understanding of the reality in question. The consequent knowledge exchange creates dynamic social learning, through a participatory process. As an active social process, participation implies the mutual engagement of actors in social communities as well as the recognition of individual and common needs. This gives credibility, relevance, and legitimacy to decisions that are eventually made. Collective action therefore reinforces working toward a common goal.

The interaction between these three components of action sharing (engagement of stakeholders, knowledge brokerage, and collective action) are the triggers of social dynamics and they have great potential to create new initiatives, expand networks, and involve new actors. In this context governance issues, can be decisive. Some governance attributes such as a multi-scalar structure and a participatory and deliberative decision-making process are essential to enhance the capacity to manage action sharing.

4.2.1 Participation process and stakeholders' engagement

There is a growing consensus on the need for active participation of local vulnerable communities in climate change adaptation planning (Amaru and Chhetri, 2013; Eakin and Lemos, 2006; Nakagawa and Shaw, 2004; Pelling and High, 2005; Ross et al., 2015; Stringer et al., 2006). Amaru and Chhetri (2013) emphasize the importance of interaction

between institutions and actors at different levels. These interactions can limit or facilitate adaptations, and create new knowledge. According to the authors, the collaboration of multiple stakeholders can help to identify weaknesses in strategies and contribute to more dynamic and flexible solutions. Ross et al. (2015) claim that, by being familiar with the social, historical, and political contexts of specific locations, vulnerable communities can clearly understand the possible response and practical benefits of needed actions. Furthermore, by including climate change adaptation in discussions with stakeholders and communities, general resistance to change can be addressed to overcome apathy, lethargy, and the lack of credibility in public policies.

The shift in the climate change debate from the global to the local scale has generated a new discussion about who can legitimately participate in the creation and implementation of policies. International development agencies, such as the Organization for Economic Co-operation and Development (OECD) and the World Bank, encouraged official participatory events. Community members were stimulated to engage beyond a simple consultation, identifying local priorities and discussing how to address them. Local governments have taken the necessary financial and institutional support for these projects. In this way the broad goals were replaced by a more instrumental approach to participation that focused on reducing costs and increasing compliance (Aylett, 2011). This was the approach advocated by the IPCC.

This approach was largely confronted. According to Corwall (2002) participation can be used by state or development agencies to ensure the efficiency and effectiveness of projects, without however empowering the local community to question project objectives. Thus, other types of participation take the form of direct action, autonomously managed community projects, and protests. To the author, citizen participation should give the ability to influence the approach to climate change in order to meet local needs and without ignoring pre-existing inequalities.

Effective action sharing requires *partnership* between policy-makers and other stakeholders to work together. According Arnstein (1969), partnership is the negotiation between citizens and power holders to ensure sharing power, assigning shares of planning, and responsibilities in decision-making. A series of publications (Australian Government - Department of Immigration and Citizenship, 2008; Krick et al., 2005; Partridge, K.; Jackson, C.; Wheeler, D.; Zohar, 2005) focus on orienting policy-makers how to appropriately engage stakeholders. They seek to clarify the benefits of engagement, how to identify the relevant

stakeholders, how to choose the best techniques for engagement, and identify when and how to inform them of the scope of knowledge and action.

Stakeholder identification is a difficult and an iterative process (Tompkins et al., 2008). Three factors (*credibility, relevance, and legitimacy*) are considered essential to proper stakeholder engagement. *Credibility* depends on people, specifically the use of clear objectives, appropriate methods, and transparency. It ensures continuous involvement. *Relevance* in actions motivates participation, especially if stakeholders perceive a real impact. The perception of justice, a just balance of multiple stakeholders, and that their interests are being considered ensures the *legitimacy* of the process (Krick et al., 2005).

Engaging stakeholders and promoting their active participation allows for cultural interaction with the exchange of ideas and different types of knowledge. This is the second component of action sharing. To build an interactive process involving a wide range of stakeholders that incorporates different viewpoints, the participatory process must be inclusive and consider participants´ values and experiences. It therefore needs to engage people willing to enter a multidisciplinary discussion in an open, free, and respectful manner (Ross et al., 2015).

4.2.2 Knowledge brokerage and social learning

Management and governance of complex adaptive systems can benefit from the combination of different forms of knowledge. In the case of climate change on SES, the literature highlights the contribution of local knowledge to offering alternative wisdom based on its own knowledge and practices acquired in a dynamic process of continuous learning about the use of local resources (Folke et al., 2005; Leonard et al., 2013; McCarthy et al., 2012, 2011; Olsson et al., 2004).

The interaction between scientific knowledge and local knowledge has many advantages in dealing with climate challenges. On the one hand, the local community has access to reliable data of possible effects of climate change in their region. On the other hand, scientists and experts have local community feedback regarding the perceived impacts and their autonomous solutions. This interaction allows an integrated approach to adaptation with simple and creative solutions, that are less technological and cheaper. In the process of adaptation to climate change, knowledge and understanding of potential impacts and risks are essential. Understanding the local effects can help to identify the impact on ecology, infrastructure, economy, culture, and social interactions, and may reveal how communities can strengthen their adaptive capacities. (Ross et al., 2015). From the moment that

community becomes aware of its challenges and opportunities, it can integrate more actively in the adaptation process.

Knowledge brokerage is understood as an interactive process of wisdom co-creation involving producers and users of knowledge. This process is important to enable decision makers to use research evidence in both practical and policy decisions (Mitton et al., 2007). Partidario and Sheate (2013) highlight that the increasing inclusion of citizens in decision-making reflects the recognition of the value of other forms of knowledge, beyond expert knowledge. The concrete experience and active experimentation of lay and tacit knowledge are welcome when it comes to solving environmental issues and sustainability. The authors state that the creation of more participatory spaces can promote the exchange of knowledge.

The opportunity to share and co-create knowledge can incite social learning, enabling social interactions in which people learn from each other. This increases the potential of building capacity among stakeholders and favors SES. Social learning occurs when changes in the understanding of the individuals involved reaches a broader scale through social interaction (Reed et al., 2010; de Kraker, 2017).

Though social interaction can occur on a one-to-one level, the most important influence is through a larger network structure. Social networks can link the individual and local level to macro level (institutions, culture, and collective norms). Information transmission and deliberation are the two basic types of interaction. Knowledge of new facts and the exchange of ideas and arguments to solve a problem are effective ways of learning (Reed et al., 2010). In the theories of social interaction, joint networks are increasingly qualified as a social capital. Yet, social capital involves three aspects: Social norms, interpersonal relationships, and formalized social organization (Pelling and High, 2005).

Knowledge brokerage, participation and negotiation enhance ownership, fairness, responsibility, and empower participants to act (Stringer et al., 2006). Networks and the flow of information between individuals and groups to assist decision-making are the basis for a collective action (Adger, 2003).

4.2.3 Individual and collective action

Increased environmental vulnerability is linked with social inequalities in poor countries. Recognition of the importance of the social dimensions of climate change bring to the fore the role of local institutions in the potential rise of local adaptive capacity and structure collective actions regarding environmental management (Rodima-Taylor, 2012).

When individuals engage in collective action, the group works towards a common goal. Knowledge and efforts are combined to achieve the proposed objectives. Collective action is established through social networks, support structures, and formal processes of governance (Ireland and Thomalla, 2011). The possibility of collaborative work between actors from the state and civil society enables trust to be built and strengthens cooperation in the process of adaptation to climate change. This brings several benefits, such as promoting sustainability and legitimacy in adaptation strategies through social cooperation and inclusive institutional decision-making. Bottom-up approaches based on local knowledge also bring perceptions of a global problem to the local level. Thus, people are more likely to feel connected to the causes and consequences of change and they are encouraged to increase their adaptive capacity (Adger, 2003).

Collective action can be associated with various objectives, such as information sharing, coordination of activities, resource mobilization, and even the development of institutions. Technology, group characteristics, governmental actions, and institutional arrangements can facilitate collective action (Poteete and Ostrom, 2004). Mediation between local institutions (formal and informal) and social capital provides knowledge and procedures for the collective management of resources (Pelling and High, 2005). In many cases, collective action promoted by the mobilization of social capital can replace measures that were previously considered the responsibility of the state (Adger, 2003).

4.2.4 Governance and action sharing

Policies and institutions play an important role in developing people's capacities to adapt to climate change. The complexity of the subject and restricted government resources has generated the need for the cooperation of other actors to effectively govern (Newman,2001; Taylor, 2007). Yong (1992) cited by Lebel et al. (2006, p.2) defines governance as "the structures and process by which societies share power and shapes individual and collective actions".

Difficulties in tackling complex problems as climate change, have led some international bodies such as the European Union, the World Bank, and the International Monetary Fund to promote governance. In a normative and prescriptive view, the emphasis of governance was on creating consensus and common purpose among actors with different interests and priorities. But, according to Bridge and Perreault (2009), when addressing an environmental problem with an emphasis on consensus, the political dynamic is lost. This posture can generate governance systems that are intentionally designed to achieve a specific purpose. In a critical and analytical view, the authors defend the networks of governance that originate

in a more organic way and out of centralized control. Thus, the various actors feel more at ease in challenging the unequal social, economic, and environmental impacts and proposals that do not meet the needs of the community.

According to Lebel (2006) it is part of “good” governance, e.g., “participation, representation, deliberation, accountability, empowerment, social justice, and organizational features such as being multilayered and polycentric”.

The current period of global environmental change requires the capacity of institutions to sustain growth and to facilitate the adaptation process. This calls for a broad vision of social learning that can support collaborative environmental management (Armitage et al., 2008). Folke et al. (2005) state that adaptive governance connects different stakeholders and transforms the environmental process management into a learning environment. Teams and stakeholder groups use various systems of knowledge and experience to develop new policies.

Democratic adaptive management seeks the involvement and collaboration of different agents and establishes new links between science, institutions, knowledge, and power (Stringer et al., 2006). There are many advantages of integrating the participation of local people in decision-making processes. For example, diverse stakeholders give a more complete view of the real situation, which reduces uncertainty and facilitates the adaptive management process. Participatory techniques can also combine local and scientific knowledge to develop new initiatives. Citizen participation brings social, ethical, and political issues to the process that are not found in scientific approaches. Moreover, participation of different actors gives legitimacy to the adaptive process. It acquires a critical and control function over the direction and speed of the proposed changes. In addition, participation strengthens political issues such as empowerment and democracy. Lastly, the incentive to work together with different stakeholders strengthens the social learning process, transforms relationships, and favors the change in perception of different viewpoints (Stringer et al., 2006). The adaptive capacity of populations is affected and hence their vulnerability. Knowledge of the multiple causes of the problem implies the involvement of different stakeholders and public participation. This makes it possible to come to closest to problems from multiple perspectives and thus find appropriate solutions.

Therefore, action sharing can be considered a driving force in a transformative process because it acts as a trigger for social interactions that promote transformations. It empowers the community by integrating different stakeholders, promoting the exchange of knowledge,

leveraging social learning, and fostering collective action. Linking all of the stages of the adaptation, it gives dynamism, credibility, relevance, and confidence to the process.

4.3 Discussion

Growing interest in discussing transformative processes of adaptation is closely linked to the fact that in many cases damages caused by the impacts of climate change will be much greater than previously expected. This process becomes relevant in situations where vulnerability is the result of social processes, in those that limit the way people see themselves, perceive their relationship with the environment, and their role in public policy. These cases require a paradigm shift in the social structure, with institutions, organizations, communities, and individuals taking on new roles in the adaptation process by changing the way they are organized, their values, beliefs, and decision-making processes. Governance must support this transformation by creating opportunities for action sharing that promote social interactions that guarantee representation, deliberation, accountability, empowerment, and social justice.

The concept of transformative adaptation is best defined in resilience theory and is directly related to the concept of SER. Here, the ability of a system to adapt is related to its ability to change, learn, and innovate. In this chapter, it is identified a set of factors called “action sharing”, as those able to trigger the social interactions needed to ensure a transformative process of adaptation, and governance is responsible for ensuring the necessary environment for change. Moreover, stakeholders’ engagement is the mechanism of change, knowledge is the fundamental basis of change, and collective action is the way promote change. These factors incorporate new actors through new networks and initiatives. The key to success is information, knowledge development, and community involvement. This process is more likely to occur in communities with decentralized governance, a participatory and inclusive process to promote autonomy, transparency, accountability, and flexibility. This creates community empowerment and strengthens all actors to assume new responsibilities in the adaptation process.

5. SOCIAL-ECOLOGICAL RESILIENCE

Although the concept of resilience is currently discussed a great deal related to the analysis of complex systems, it is not a new concept. Originally the term was used in physics to describe the stability of materials and their resistance to external shocks. An example is the characteristic of a spring that, compresses under pressure and returns to its normal state without it (Norris, 2008; Davoudi, 2012). It is also associated with the notion of stability, called engineering resilience by many authors (Folke, 2006; Gunderson, 2000). It is defined as the ability of a system to return to equilibrium or to a steady-state after a disturbance (Holling, 1973).

Since the 1960s, during the rise of systems thinking, resilience took over the field of ecology and new meanings of the term emerged based on different currents and scientific traditions (Dadouvi, 2012). But Holling (1973), in his seminal article "Resilience and stability of ecological systems", distinguished the concept of resilience from the definition of stability. He linked resilience instead to the ability of ecosystems to absorb shocks and still continue to function. His definition of resilience was therefore, “the persistence of relationship within a system and a measure of the ability of these systems to absorb changes of state variables, driving variables and parameters, and still persist” (Holling, 1973, p. 17). Thus, Holling assumed the possible co-existence of multiple equilibria in the same system, where the time it takes to return to its original state of equilibrium is only a way of evaluating a system in terms of resilience (Gunderson, 2000). Therefore, ecological resilience was introduced. According to Folke (2006), Holling’s (1973) greatest contribution was to demonstrate that the idea of equilibrium in SES is only valid in limited scales of time and space.

Currently, the concept of resilience has a variety of definitions associated with different disciplines. In addition to ecology, it is also found in anthropology, planning, social

innovation, among others. Most definitions derive from systems theory and complexity theory. But resilience theory was best developed in relation to the analysis of social-ecological systems (SESs). This occurred because this concept fits perfectly with the idea of dynamic, nonlinear systems, and unexpected changes. The Resilience Alliance identifies three defining characteristics of SER:

“the amount of change the system can undergo and still retain the same controls on function and structure, or still be in the same state, within the same domain of attraction;

the degree to which the system is capable of self-organization; and the ability to build and increase the capacity for learning and adaptation” (Berkes et al., 2003, p.13).

According to Buschbacher (2012), the theory of resilience recognizes the system which enables the understanding of the processes of change. He argues that the basis of resilience theory is that:

“Uncertainties and inevitable surprises in the dynamics of complex systems hamper their management in a predetermined path; instead of conducting to a specific direction, it is better strengthening capabilities and features of system that maintain the flexibility to survival, learning and adaptation during a dynamic and unpredictable process of change” (Buschbacher, 2014, p.12).

Nonetheless, resilience is currently defined in the literature as “the capacity of a system to absorb disturbance and re-organize while undergoing change to still retain essentially the same function, structure, identity, and feedbacks” (Walker et al, 2004, p.5). Disaster Risk Reduction is a scientific area that follows this vision. It defines resilience as: “the ability of a system to reduce, prevent, anticipate, absorb and adapt, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions” (UN, 2014).

However, some authors argue that resilience is only the capacity of systems to absorb shocks and still continue to function, that is, the persistence or robustness of systems. This is applied in various branches of science. As an example, Adger (2000) defined social resilience as “the ability of human communities to withstand external shocks to their social infrastructure, such as environmental variability or social, economic, and political upheaval” (Adger, 2000 cited in Folke, 2006, p.259).

But Folke (2006, p.253) highlights another aspect of resilience that concerns “the capacity for renewal, re-organization, and development, which has been less in focus but is essential for

the sustainability discourse". In this sense, the author emphasizes that "the concept of resilience in relation to SES incorporates the idea of adaptation, learning and self-organization in addition to the general ability to persist disturbance" (Folke, 2006, p. 259).

In spite of the various differences, there is consensus among experts on two aspects of resilience: "resilience is more a 'capacity' or a 'process' rather than an 'outcome'; and resilience is more associated with 'adaptability' than with stability" (Farrall, 2012, p.51). This investigation adopts the concept of social-ecological resilience (SER) defined by Adger et al (2011, p.757) as "the ability to absorb perturbations without changing overall system function, the ability to adapt within the resources of the system itself, and the ability to learn, innovate, and change".

5.1 SER as a paradigm shift

Resilience theory has created a paradigm shift in social-ecological science. The scientific view based on balance and stability has been confronted with evidence of a world of uncertainty and thresholds.

The scientific advances of Descartes and later Newton's theories, led scientists to analyze complex systems in the universe as parts of a whole. They understood that a phenomenon discovered in a field of science (as physics) could explain phenomena that occurs in other branches of science (such as biology). This understanding of the universe as a set of parts that interact in an orderly and balanced fashion, characterizes the reductionist approach (Carneiro, 1996). Here everything works like a machine and a system's variable can be modified without affecting the other parts. This mechanistic view of nature generates a deterministic dynamic to the facts based on the law of causality, in which every phenomenon is the effect of a cause. The success of the reductionist approach has consolidated the paradigm of how the universe works. Hence science was divided into disciplines, and each of them investigated one part of the whole. According to Buschbacher (2014), this static view also emerged in ecology that established types of ideal systems, determined by specific characteristics of climate and soil. In this view, even with disturbance, the system would return to an optimal static condition, i.e. ecosystems have a certain degree of natural balance.

Currently, there is a consensus among scholars that the reductionist paradigm has many limitations, especially in the analysis of complex and open SESs. Scientists argue that changing one variable in a system inevitably implies the modification of other variables (such as the butterfly effect). Thus, science has used new scientific methods, such as computer

models and simulation, to understand the complex and adaptive behavior of open systems. As a result, studies have shown that systems tend to produce order and structure, but their trajectories cannot be predetermined. The explanation for this is the positive feedback mechanism. Open systems are dynamic, and positive feedback amplifies changes and creates nonlinear and unpredictable trajectories. Therefore, analysis depends on a systemic approach, which is being consolidated as a new scientific paradigm (Buschbacher, 2014). Thus, the theory of resilience has been considered a way of applying this new paradigm in the context of SESs because it encompasses the foundations of systems theory and complexity theory.

5.2 SER and dynamics of SES

The perspective of resilience of SES developed by Holling (1973) fits with the dynamics of complex adaptive systems. According to Folke (2006), a complex adaptive system consists of a heterogeneous set of individual agents (social and ecological), which interact at different scales of time and space under varying physical conditions and, consequently, evolve in different ways, such as genetics, behavior, and spatial distribution.

Folke (2006, p. 253) argues that this approach “emphasizes nonlinear dynamics, thresholds, uncertainty, and surprise, how periods of gradual change interplay with periods of rapid change and how such dynamics interact across temporal and spatial scales". Thus, instead of controlling change in a supposedly stable system, it becomes more important to manage the system's ability to cope with, adapt to, and shape change (Berkes et al., 2003; Folke, 2006; Smit and Wandel, 2006).

To understand how changes in SES occur, Walker et al. (2006) describe the dynamics of systems within and across scales of an adaptive cycle. The authors consider resilience, adaptability, and transformability to be properties of SES that determine these dynamics.

According to Walker et al. (2004), adaptability or adaptive capacity is “the capacity of actors in the system to influence resilience”. Adger el al. (2011) classify adaptability as the key characteristic of SES and they consider it essential for building SER. Adaptability comprises several resources that may be available in the system, such as physical capital, technology, infrastructure, information, knowledge, institutions, the capacity to learn, social capital, as well as the capacity to mobilize these elements to create adaptation conditions. Hence, they argue that adaptability in SES is supported by a set of attributes - the ability to learn, innovate, and change - that can be developed and consequently define a system as resilient or vulnerable.

The conceptual approach of this investigation assumes that the human-nature relationship occurs from through dynamic and continuous interactions, which result in the level of the SES. Figure 10 shows how these dynamics may occur. The attributes of a SES increase its adaptive capacity, extend its resilience, and consequently reduces its vulnerability. Learning and innovation are essential to promote transformation that supports adaptation.

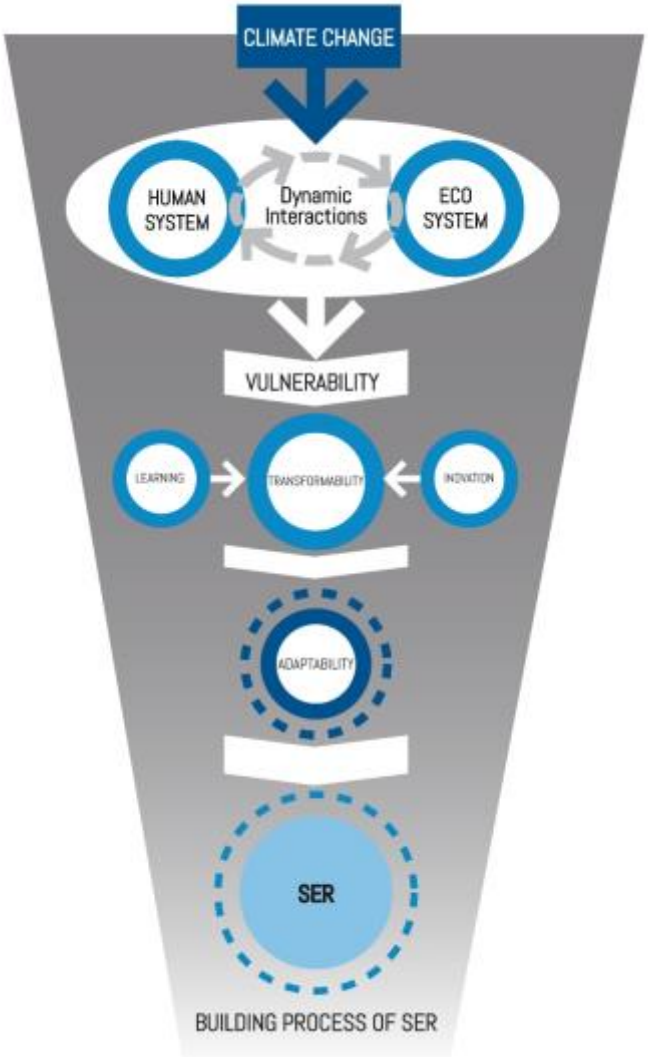

Figure 10: Dynamic interactions of a SES

As described above, resilience is the ability of a SES to absorb or resist disturbances and other stressors and still remain within the same regime, essentially maintaining its structure and functions (Holling 1973, Walker et al., 2004). In fact, Buschbacher (2014, p. 18) emphasizes the importance of differentiating the "state" of a system of from its "regime". "The state refers to the specific conditions at a given time, while regime refers to the general

characteristics of structure and function of a system." Therefore, a resilient system changes its state constantly but these changes take place within the same system regime. The author uses the example of a forest, where the system regime is a "forest" and its "state" is constantly changing, from "new forest" to "mature forest". But if there's a devastating event that changes the climate and results in the loss of seeds, making it impossible to save the forest, the "forest regime" ceases to exist and there is a “regime change”. This regime change is negative. On the other hand, resilience is not always positive. Buschbacher cites the “poverty trap” as an example of negative resilience. In this case, a regime change would be preferable (Buschbacher, 2014, p.18). This discussion is crucial to the understanding of resilience, because it highlights another related concept: transformability, i.e. the system’s ability of self-organization. Hence, when a “regime change” occurs, there is a transformation. The transition between alternating states can be slow and gradual, or incisive and disastrous. The structure and functions of the system change according to their internal dynamics or external influences (Walker et al (2006). Folke (2006) states that the regime change in a SES is an increasing consequence of human actions that diminishes its resilience

5.3 An Integrative Theory

In recent years, an increasing number of authors have come to see resilience as the best approach for understanding the dynamics of a SES (Berkes et al., 2003; Farrall, 2012; Folke, 2006; Folke et al., 2010, 2005; Holling, 2001; Walker et al., 2006, 2004; Walker and Carpenter, 2002). In the early 2000s, an international group of ecologists, economists, social scientists, and mathematicians worked in a project about Resilience and developed an “integrative theory”. Its goal was to develop and test elements of the integrative theory with the simplicity necessary to understand them and the complexity required to develop sustainability policies. In fact, Gunderson and Holling (2002) published the core of this theory in their work “Panarchy: Understanding transformations in Human and Natural Systems”.

5.3.1 Adaptive Cycle

Resilience theory is based on Holling’s (2001) adaptive cycle, the model that emerged from the comparative study of ecosystem dynamics. It is fundamental for understanding complex systems from the smallest cells all the way to ecosystems and societies. It is made up of three properties: wealth, controllability, and adaptive capacity. Holling (2001, p.394) explains that “wealth or potential sets limits or possibilities for alternatives in the future. Connectedness or controllability, determines the degree to which a system can control its

own destiny. Resilience, achieved by adaptive capacity, determines how vulnerable the system is to unexpected disturbances."

The adaptive cycle presents two main stages (or transitions) alternating between long periods of aggregation and resource transformations with shorter periods that enable opportunities for innovation. The first stage, often referred to as the fore loop, from (r) to (K), is the slow, incremental stage of growth and accumulation. The second stage, called back loop, from (Ω) to (α), is the quicker step of reorganization and renewal. This cycle focuses attention on the destruction and reorganization processes, which are often overlooked in favor of growth and conservation. Looking at all of these processes provides a complete view of the system's dynamics.

Figure 11 illustrates a two-dimensional view of the Holling adaptation cycle (2001). The first phase is exploratory (r), characterized by rapid growth from the resources available, the accumulation of the structure, and high resilience. This phase requires more energy than the other phases, because the structures and connections between the components of the system increase.

The second phase is the maintenance stage (K), where the system has slow net growth, but is increasingly connected and less flexible, making it vulnerable to external disturbances.

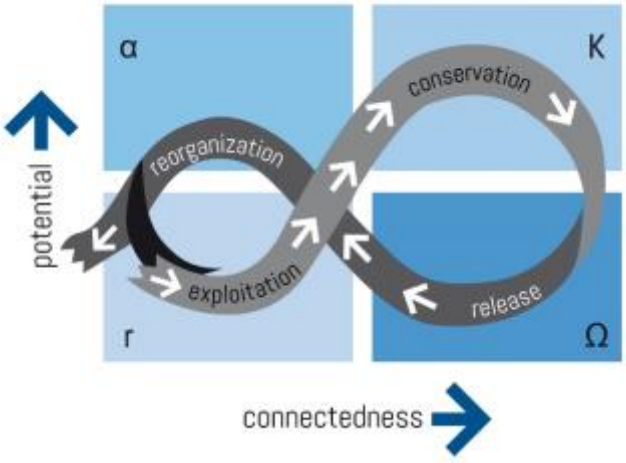

Figure 11: Adaptive cycle of ecosystems
Resource: Holling, 2001

The third phase, release (Ω), is generated from external disturbances that dispense resources linked to the system. Then, accumulated structure collapses. The next phase, called alpha (α), is a reorganization phase which can generate innovation and lead to a new adaptive cycle. Holling (2001) observes that when the cycle closes, the two objectives are sequential: the first maximizes production and accumulation (connectedness) promoting

growth and stability, and the second favors invention and a new classification (potential) promoting change and variety.

However, when a third dimension is added to the adaptive cycle, as shown in Figure 12, different perspectives emphasize the properties of each phase.

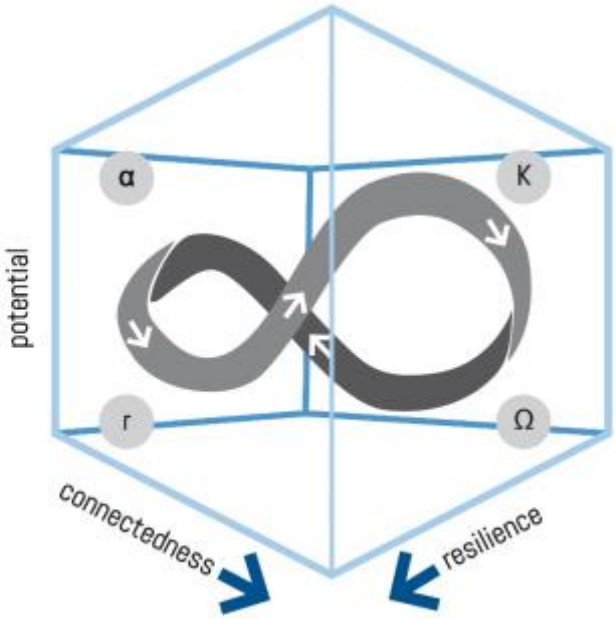

Figure 12: Resilience: the third dimension of adaptive cycle
Resource: Holling, 2001

Adaptive cycles are organized in a hierarchy in time and space. Thus, in some cases they can generate new combinations that are tested during the accumulation phases. The continuity of the system is guaranteed by the past and distant memory that the major and slower components of the hierarchy provide, which facilitates the recovery of minor cycles that adapt more quickly.

5.3.2 Panarchy

All systems (and especially SES) exist and function at various scales of space, time, and social organization. Interactions between scales are crucial in determining the dynamics of the system in any focal range. "Panarchy" is the interaction between a set of hierarchically structured scales (Gunderson and Holling, 2003). Refers to the notion of hierarchy and rationalization that integrates change and persistence, between the predictable and the unpredictable. According to Holling et al. (2002), the interaction between built-in scales can represent structures that sustain experiences, test their results and allow for adaptive evolution.

Figure 13 shows how panarchy connects adaptive cycles in a nested hierarchy. Connections can occur between different phases of an adaptive cycle, or from one level to another. Faster connections, with smaller nested levels, are called "revolt" that invent, experiment, and test, while higher, slower levels, called "remember", stabilize and preserve the memory of the dynamics accumulated in the system.

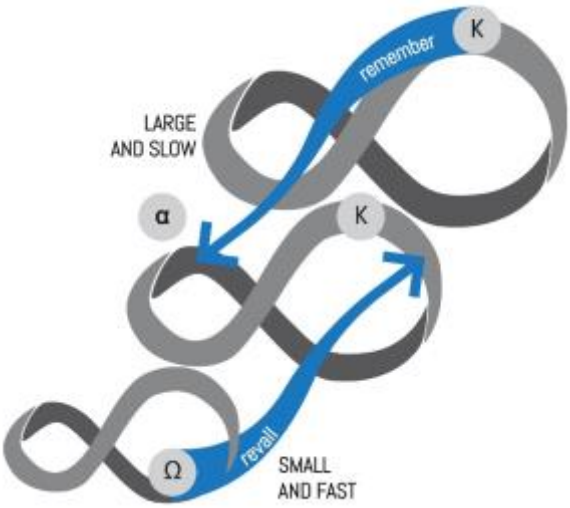

Figure 13: Panarchy connections
Source:(Holling, 2001)

However, the dynamics of each level are organized in a four-phase cycle: birth, growth and maturity, death, and renewal. This cycle is the engine that periodically generates new variability that experimentation depends on. The structure and processes of a system can be reorganized because of the periodic phase of transient destruction (omega phase) and its rearranging (alpha stage). This reorganization allows the new settings and opportunities for the system to be established, incorporating foreign participants into the system.

Systems with high adaptability are better able to re-configure without significant changes in key functions or declines in ecosystem services. Loss of adaptability results in lost opportunities and limited options during periods of reorganization and renewal.

Adaptability in SESs is related to genetic diversity, biological diversity, and heterogeneity, as well as the existence of institutions and learning networks, knowledge, and space to experiment and create flexibility for problem solving. The balance of power between interest groups plays an important role.

5.3.3 SER and Climate change

Events related to climate change reveal the difficulties faced by local communities in managing these complex situations. Some have historical familiarity with climate disasters,

which is rooted in emergency actions and the stigma of reconstruction. This reinforces the view of both the population and the managers that the problem has a biophysical origin and that solutions are only physical and structural (Vieira et al., 2016).

Yet, new discussions on public policies to address the effects of climate change, including disaster risk reduction (DRR) must be promoted. The challenges faced by vulnerable communities has motivated research to explore an interdisciplinary view by combining environmental and social sciences. The main idea is to understand the dynamics of social learning, transformation processes, and social innovation to promote human development and enhance SER.

The literature shows that countries and cities that are continuously affected by extreme weather events have been looking to review their ways of dealing with these challenges. In recent years, several cities located in vulnerable areas of Africa, Asia, and Latin America admitted their difficulty in dealing with these climate challenges and appealed to international organizations for guidance in formulating strategies.

In many cases, international organizations have adopted strategies with approaches based on concepts of SER. A good example is the remarkable work done by Asian Cities Climate Change Resilience Network (ACCCRN), an initiative of the Rockefeller Foundation, with communities in core Asian countries such as India (Surat, 2011; Gorakhpur and Indore, 2012; and Guwahati, 2013), Indonesia (Bandar Lampung and Semarang, 2011), Thailand (Chiang Hai, 2011), and Vietnam (Quy Nhon, 2010; and Da Nang, 2011).

In South Africa, the Durban experience is worth mentioning. In 2008 and 2009, this community faced a series of tornadoes that resulted in severe infrastructural damage and destroyed around 400 homes. The magnitude and impact of these events had political repercussions and led the city to solve the problem in a structured and planned way (Roberts, 2010). Under the influence of ACCCRN, eThekwini Municipality presented the Durban Climate Change Strategy (DCCS) in 2014 as part of its Municipal Climate Protection Program. The process had several stages, the engagement of stakeholders, pilot projects in vulnerable communities, and was based on the concept of SER (eThekwini Municipality, 2014).

In Latin America, Colombia, El Salvador, Dominica, Panama, Ecuador, Costa Rica, and Peru are currently preparing major public investment plans, based on risk assessments conducted through the Central America Probabilistic Risk Assessment Program (CAPRA) in a partnership between the World Bank, the Inter-American Development Bank, UNISDR, the

Coordination Center for the Prevention of Natural Disasters in Central America, and other governmental institutions (World Bank, 2013).

Over the last few decades, some researchers (Biggs et al., 2015; Moench et al., 2011; Tyler and Moench, 2012; Walker and Salt, 2006), have focused on defining the properties of systems that can promote or undermine the resilience of SES. A wide range of disciplines including social, economic, political, and ecological sciences point to a diversity of potential traits, but this has led to a somewhat dispersed and fragmented understanding of the importance of different factors that increase resilience.

Principles/ Qualities/ Values of a Resilient System		**Authors**						
		Walker & Salt, 2006	ACCCRN, 2009	Moench et al., 2011; Tyler et al. 2012; ISET, 2012	Asian Development Bank, 2014	Arup, 2014	Biggs et al., 2015	TOTAL
1	Diversity/ Redundance	■	■	■	■	■	■	6
2	Modularity	■		■				2
3	Flexibility		■	■	■	■		4
4	Connectivity/ Integration / Social Capital/ Access to Information	■		■	■	■	■	5
5	Reflectivity				■	■		2
6	Robustness				■	■		2
7	Ecological Variability	■						1
8	Sensitivity to Feedback	■					■	2
9	System Thinking						■	1
10	Capacity to Learn/ Experimentation/ Knowledge/ Innovation	■	■	■			■	4
11	Participation/ Inclusion			■	■	■	■	4
12	Polycentric Governance	■					■	2
13	Safe Failure			■				1
14	Responsiveness		■	■				2
15	Resourcefulness			■	■	■		3
16	Focus on Slow Variables						■	1
17	Structures of Rights and Entitlements			■				1
18	Clear Decision-Making Process	■		■				2
19	Ecosystem Services	■						1

Table 2: Principles of Resilient System by Authors

Table 2 shows an overview of properties assigned to resilience of SES by different authors. Some of the investigations present practical cases. For example, ACCCRN (2009) tested resilience strategies in Asian cities in the countries of Vietnam (Can Tho Quy Nhon Da

Nang); India (Gorakhpur Surat Indore); Indonesia (Semarang, Bandar Lampung); Thailand (Chiang Rai Hat Yai). These projects seek to build redundancy, flexibility, learning and reorganizational capacity in vulnerable systems. Based on this study, Moench et al (2011) created “The Urban Climate Resilience Planning Framework” and applied it in the same cities tested by ACCCRN (2009). Also, the Asian Development Bank (2014) applied the resilience qualities defined by ARUP (2014) in the same cities as ACCCRN (2009), yet they focused on the evaluation of some specific sectoral projects. Lastly, Arup (2014) developed a framework composed of three elements: categories (4), indicators (12), and quality (7). Theses seven principles of system quality (Reflective, robust, redundant, flexible, inclusive, and integrated) were then applied to the cities of Surat (India), Concepción (Chile), New Orleans (USA), and Semarang (Indonesia).

The effort to define common qualities or values found in resilient SESs led Biggs et al. (2015) to publish *Principles for Building Resilience: Sustaining Ecosystem Services in Social Ecological Systems*. This book presents the following principles: maintaining diversity and redundancy, managing connectivity, managing slow variables and feedbacks, promoting complex systems of adaptive thinking, encouraging learning, broadening participation, and promoting polycentric governance systems.

These discussions have contributed to the progress of the SER theory and especially defining goals for building resilience. This research seeks to contribute to resilience theory in another way, by discussing how local communities can achieve these goals, which will be discussed in the next chapter.

5.4 Discussion

The review of SER theory supports the understanding and approaches adopted in this work. The conceptual path to define resilience taken by different scientific branches are distinct: part of a physics concept, goes through an ecological approach and soon afterwards social and acquires many other biases. Increased interest in SER is due to the involvement of human and nature in the same context. The very complex interrelationships and dynamics portray the system in its current form, open and full of singularities.

The integrative theory proposed by Gunderson and Holling (2002) clarifies the adaptive process of a SES, organized in various levels within a cycle that involves birth, growth and maturity, death, and renewal of a system. The two distinct stages of transition of the adaptive cycle suggest that this logic is adequate to tackle complex problems such as climate change. The alternation between long periods of resource aggregation and transformation and

shorter periods create opportunities for innovation. As shown in Figure 5.3, this process relates stages of connectivity with stages of exploration of innovative potential to build resilience.

The concept of SER used in this study was defined by Adger et al. (2011, p.757),as "the ability to absorb perturbations without changing overall system function, the ability to adapt within the resources of the system itself, and the ability to learn, innovate, and change." This makes it is possible to understand how to build resilience.

Vulnerable communities must use their social and environmental resources and attributes to fully understand their vulnerabilities. This entails much more than simply looking at climatic factors and their possible bio-physical impacts. It is necessary to go to the roots of their vulnerability, which for the most part is socio-economic. Therefore, they need to find a way to identify and acknowledge their vulnerabilities, evaluate their past adaptation actions and, learn from their mistakes and achievements using their own resources or/ in external support. This will allow them to generate new ways of acting. In many cases, it will require systemic think and innovative action, which can prompt changes in the functioning of the system as a whole, both social and power relations to ensure the transformative process of adaptation.

Yet, it must be based on the exchange of knowledge, since this type of action requires a period of experimentation and evaluation to ensure a safe transition to a new adaptation approach. Interactions between knowledge, community culture, and governance mechanisms, which are understood as the three social pillars for building resilience, can enable increasing adaptive capacity and consequently resilience.

6. BUILDING SOCIAL-ECOLOGICAL RESILIENCE

In previous chapters, several concepts were discussed based on one specific goal: To understand how to build the SER of local communities to climate change. Knowledge has been gradually introduced in each new chapter to facilitate the understanding of the relationships between the various concepts, and enable an interdisciplinary analysis. Chapter two focused on a review of complementary concepts, addressing basic issues such as the differences between **climate change, climate variability, extreme weather events,** and the **impacts of climate change on SES**. The discussion of **vulnerability and adaptive capacity** showed that local communities' vulnerability to climate change goes beyond how it is affected. Other socio-economic and institutional factors are also key to defining adaptive capacity, and consequently determining the consequences of potential impacts.

As mentioned earlier, adaptability, coping ability, management capacity, stability, robustness, flexibility, and resilience are other concepts that have been used that relate to adaptive capacity and that are associated with the social ability of a community to respond to its climate challenges. Thus, social relationships are crucial in order to define the performance of the institutions dealing with risk, and especially to understand how certain members of the community interact with the natural system. In fact, social relationships occur within a **community**, in a **territory** where people perform functions and create meanings through specific elements of identity as a fusion of meaning, power, and social space.

Chapter three discussed how **adaptation** has been understood throughout the years, how policies have been developed, and why its implementation took time. With predictions that

climate change would be far more significant than previously predicted, the specific focus of the "adjustment" approach was not enough to meet the new challenges ahead.

This realization led many scholars to consider new approaches to adapt to climate change, based on the analysis of the causes of communities' vulnerability and acting in a "transformative way". As shown in chapter 4, transformation is possible when interfering with socio-economic and institutional aspects of the communities through social dynamics. This could be a way to transform SES, promoting the empowerment of individuals and providing greater adaptive capacity. With this approach, the problem of climate change could be addressed on different fronts, while simultaneously improving people's standard of living and well-being.

As seen previously, there are many authors who advocate a transformative process of adaptation to face future climate challenges. In the fourth chapter, through Figure 4.2, the elements that trigger "social dynamics" to promote a **transformative process** and improve "community empowerment**"** were discussed. It was argued that a model of active, decentralized, and participatory governance can promote what was called "action sharing**"**. This concept encompasses the "engagement of stakeholders" in a participatory process; the "knowledge brokerage" that enables co-creation of new knowledge, social learning, and the experimentation of new ideas; and the articulation of "collective and individual actions". This set of actions has the potential to generate or increase the social capital of the community through networks, new initiatives, and different actors, and subsequently increase the "adaptive capacity" of the community (a key factor for building SER).

Chapter five discussed the concept of **SER** in more detail, as well as its relationship with the dynamics of SES. The integrative theory shows the process of relationship between adaptive capacity, transformability, learning and innovation: the basis for building SER as the thesis defended in this investigation. It has been shown how the concepts of **resilience, adaptability, and transformability** are related and how social dimensions are crucial in the process of building SER. In this thesis, the adaptability in SES is supported by a set of its own attributes that can be developed, which are the **ability to learn**, **to innovate**, and consequently **to change** (transformability).

In the following sections, a **conceptual framework** is elaborated based on social interactions between social dimensions (knowledge, community culture, and governance mechanisms) for the **building of SER** in local communities vulnerable to climate change.

6.1 Social interactions for building SER

The concept of "action sharing", presented in chapter four, is considered a triggering element of social dynamics capable of generating transformations that would promote community empowerment and increase adaptive capacity, a key element for the building of SER.

Figure 14 explores this approach. As Adger (2011) highlights, the capacity for transformation must bring social learning and innovation. The links between the two are crucial to understanding how knowledge can support communities to build innovative solutions.

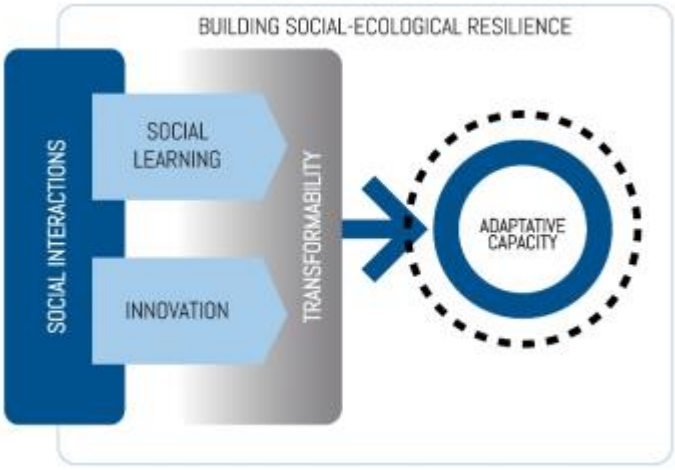

Figure 14: Social interactions to build social-ecological resilience

According to (Sol et al., 2013, p.1), social learning enables stakeholders “to take advantage of the diversity in perspectives, interests and values for generating more sustainable practices and policies.” Social learning begins with the collective memory of the many times a community has faced a problem, the types of action used in each case, knowledge brokerage between local, scientific, and experimental knowledge; the way of transmitting this knowledge, through experimentation and in capacity to generate innovative solutions (Pelling and High, 2005).

Adaptation demands technological, institutional, and relational innovation. According to Rodima-Taylor et al. (2012, p.107), all innovations are “human adaptations to changing needs and social-economic conditions and, therefore, are embedded in social processes.”

Westley (2008) defines social innovation as “an initiative, product or process or program that profoundly changes basic routines, resource and authority flows or beliefs of any social system.” She presents a model of innovation in Figure 15, built on Holling’s (2001) “adaptive cycle”. According to the author, "it could represent the evolution of a single innovation from idea to maturity, or the organization that designs and delivers that innovation.".According to

her, the resilience seen as the ability to adapt to shocks and change is important when it maintains sufficient coherence to preserve the identity of the system. The author presents the different phases of the adaptive cycle to the process of innovation. The launch of the idea happens in the exploration phase (r) and the maturation of the idea occurs in the conservation phase (K). Then, the resources are released in the search for novelty or change (Ω), consolidating the idea. The reorganization stage (α), corresponds to the development of the idea.

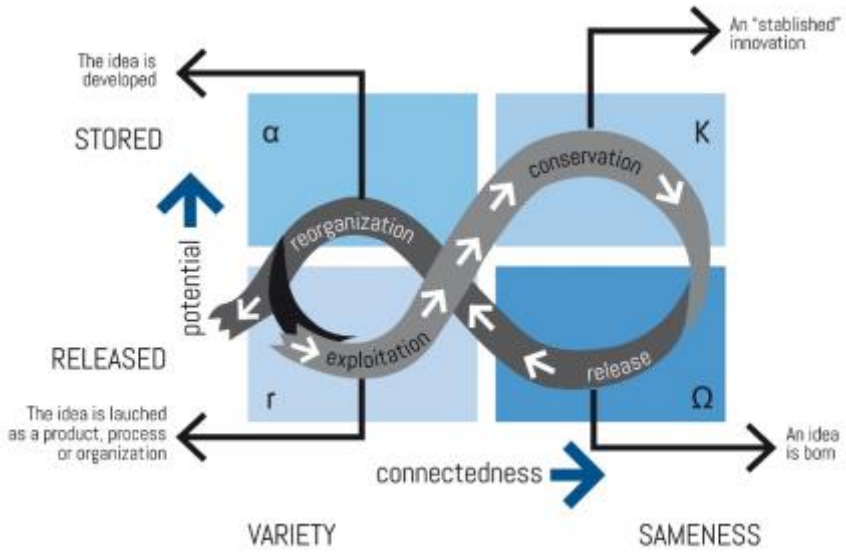

Figure 15: Model of Innovation in "adaptive Cycle"
Source: Westley, 2008.

For Rodima-Taylor (2012), social innovation occurring within the embedded scales of the adaptive system encourages collective action and learning. Knowledge exchange through participative practices is the basis of this process. Yet, Berkes (2008) argues that knowledge is not easily separated from its institutional and cultural contexts. The reciprocity between owners of formal and informal knowledge can establish links between local users, governments, and scientists (Folke, 2004). Colloff et al. (2017) identify values, rules and knowledge as aspects of societal decision-making process that enable or constrain adaptation. These aspects are here translated as knowledge, community culture, and governance mechanisms and understood as the social dimensions of adaptation process. The interaction between these three social dimensions con increase adaptability and create resilience. These dimensions will be discussed below.

6.2 The role of social dimensions in process of building resilience

The three social dimensions and their interaction generates dynamics for building resilience to climate change: Knowledge is the driver of change, whereas community culture and

governance mechanisms are the agents of change. Each of these factors have a specific function and the interaction of the three is what determines a community's ability, or lack of, to build resilience to climatic challenges.

6.2.1 Knowledge:

Cambridge English Dictionary (2010) defines knowledge as "the understanding of or information about a subject that you get by experience or study, either known by one person or by people generally." Although Foucault distinguishes power and knowledge in his book "*Power / Knowledge",* and much of the literature on adapting to climate change does as well, Partidário and Sheate (2013) argue that when it comes to strategic environmental and sustainability assessment, the relationship between knowledge and power is coherently defined in the literature on "adaptive capacity, institutional learning, and institutional resilience." In this sense, it can be said that this relationship makes sense in processes of adaptation to climate change with SER approach. According to Partidário and Sheate (2013, p. 3), "there is a recognition that citizens need to be involved in an early and effective manner in decision-making." Knowledge empowers people and enables more effective action in participatory decision-making processes.

Raymound et al. (2010, p. 1767) analyze the literature on environmental management and classify knowledge into three distinct classes: i) Experiential/ local: "those of a more personal nature, such as personal, lay, tacit or implicit knowledge"; ii) Scientific: "those generated through more formalized processes such as through research and/or applying scientific methods" iii) Hybrid' knowledge: "to those that are embedded in and interact with traditional cultural rules and norms". They identify 12 different types of knowledge within these classes: "indigenous, traditional ecological knowledge, local ecological, personal, lay, local or situated, tacit, implicit, informal, non-experts, novice experts, explicit and formal."

Many authors emphasize the importance of integrating more than one form of knowledge, especially scientific and local knowledge to address the challenges of climate change (Folke, 2004; Folke et al., 2005; Leonard et al., 2013; McCarthy et al., 2012, 2011). According to Partidário and Sheate (2013, p.3) the "science-policy debates are centered on the value of different forms of knowledge in policy making and the role in particular of science and how science is used in policy making." Naess (2013, p. 100) argues that local knowledge can be defined as "the unique knowledge developed over an extended period and held by a given society in a specific location." It is based primarily on observation, experimentation (processes of trial and error), and the transmission of assimilated knowledge from generation to generation. He argues that local or traditional knowledge can help adaptation process in

three ways: i) Biophysical and social exposure; ii) Sensitivity to change and variability; and iii) Adaptive capacity and adaptation processes.

On the other hand, he points to the challenges of integrating local knowledge with scientific knowledge, namely that the former can be treated "merely as information that can be extracted and disassociated from its original cultural context. The knowledge is trivialized and loses its integrity, richness, and dynamism." In addition, Naess (2013, p.99) suggests that strong traditional beliefs, such as religion, may make people less likely to acquire new knowledge and discourage their actions to adapt to climate change. This issue depends heavily on the culture of the community and the type of governance.

Hence, the integration of different types of knowledge is a complex task and requires intermediation. According to Partidario and Sheate (2013, p.3) "knowledge brokerage is the process of facilitating knowledge transfer and knowledge exchange, in short knowledge in transition". It can be understood as a mechanism that facilitates the exchange of knowledge in "two-way or even multiple ways of connecting people to share ideas and stimulate solutions, as implicit in its use in the context of networks that are based on less directional models." Their previous work indicates that the following conditions are necessary for knowledge brokerage to succeed in the context of environmental decision-making (Sheate and Partidário, 2010, p. 279):

- "The appropriate range of stakeholders needs to be engaged in the decision-making process;
- Resources, time, and space need to be created for engagement and exchange of knowledge to take place;
- That time and space need to provide a conducive, open-dialogue and non-judgmental environment in which that exchange can take place;
- A proponent will need to be alerted to the advantages of knowledge input to make him/her receptive to external inputs to decision- making;
- A proponent will need to be actually willing to make use of other forms of knowledge."

Observing these conditions, knowledge brokerage can be a facilitating mechanism for social learning and innovation, and consequently the empowerment of communities. Therefore, knowledge serves as the driver of change in the social dynamics for building SER.

6.2.2 Culture of Community:

Culture is a phenomenon that concerns the society and mediates changes (Adger et al., 2013; Heyd and Brooks, 2009; Swidler, 1986). Adger et al. (2013, p. 112) define culture "as the symbols that express meaning, including beliefs, rituals, art and stories that create collective out-looks and behaviors." According to the authors, climate change threatens

cultural dimensions that include “material and lived aspects of culture, identity, community cohesion and sense of place.” Heyd and Brooks (2009, p. 270) on the other hand, define culture as “comprising the ways of living involving values, beliefs, practices, and material artefacts that condition the production of tangible as well as intangible goods and services needed for the satisfaction of a human group’s needs and wants.”

Culture plays an important role in mediating human responses to climate change. This study, also considers government mechanisms to be agents of change. Responses depend on how social groups relate to the physical or natural environment as well as how human systems affect and are affected by the behavior of natural systems. Failure to recognize the importance of this man-nature relationship and complete human dependence on natural systems can have profound developmental consequences (Heyd and Brooks, 2009).

Culture defines the dominant modes of production and consumption, the lifestyle and social organization, which is responsible for greenhouse gas emissions and non-climate related vulnerability aspects. On the other hand, solutions are conceived and implemented through culture. Cultural factors shape how people support adaptation interventions and their motivation to respond to them (Adger et al., 2013).

According to Swidler (1986, p. 273), cultural experience reinforces or refines the habits, skills, and styles with which people construct "strategies for action". The author presents two models of culture that, in the same situation, can work very differently. He differentiates between “settled” and “unsettled” lives. In the former, culture is intimately integrated with action, as it is bound up with tradition, common sense, and continuity. In structural circumstances, cultural factors are reinforced. Although in the short term it exercises weak control over actions, in the long term it creates continuity and provides resources to build action strategies. For "unsettled lives" in contrast, ideology dominates action. With high consistency and coherence, it competes with other cultural visions, exercising strong control over actions. It creates new strategies of action that, for a long time, is limited by the structural opportunity to survive to ideologies with which it competes. One aspect that can define the cultural model for actions is religion. This cultural aspect defines values that can influence decisions, relations, authority, and participation.

6.2.3 Governance Mechanisms:

Governance is defined by Young (1992) cited in Lebel et al. (2006) as the “structures and processes by which societies share power, shapes individual and collective actions.” It is the social dimension that enables adaptive process in SES, connecting individuals,

organizations, agencies, and institutions, including “processes of participation, collective action, and learning” (Folke et al., 2005, p.447).

To address the challenges of climate change in SES, scholars primarily advocate adaptive governance because it is sensitive to emerging problems and knowledge about complex ecological systems (Folke et al., 2005; Gunderson and Light, 2006; Koontz et al., 2015; Olsson et al., 2004; Olsson and Gunderson, 2006). Folke et al. (2005) argue that an adaptive governance system recognizes the needs of individuals, such as leadership, trust, vision and meaning; their social relationships, such as groups of actors, systems of knowledge, social memory; and social networks. As will be discussed in greater detail, these social dimensions are essential for building SER. The authors highlight four interacting aspects in adaptive governance of complex social-ecological systems: i) “Build knowledge and understanding of resource and ecosystem dynamics”; incentives for combination of different knowledge systems can achieve it; ii) “Feed ecological knowledge into adaptive management practices;” that is, adaptive responses based on continuous tests, monitoring and reevaluation, considering the uncertainty inherent in complex systems. iii) “Support flexible institutions and multilevel governance systems;” by linkages among user groups or communities, government agencies, and nongovernmental organizations and; iv) “Deal with external perturbations, uncertainty and surprise”; accepting uncertainty, being prepared for change and surprise, and enhancing the adaptive capacity to deal with disturbance (Folke et al., 2005, p.463).

Some attributes are part of “good governance”. Lebel et al. (2006) suggest the following attributes: “participation, representation, deliberation, accountability, empowerment, social justice, and organizational features such as being multilayered and polycentric.” According to the authors, these attributes can act in some characteristics of system such as scale, uncertainties, fit, thresholds, knowledge, and diversity, to develop the main capacities to manage resilience: self-organization, learning and adaptation.

6.3 Conceptual SER Framework

Figure 16 shows the conceptual SER framework cross-relating knowledge, governance mechanisms and culture of community. The understanding of the framework is theoretically supported upon the different concepts discussed in previous chapters.

The interactions between knowledge and community culture, and knowledge and governance mechanisms occur through knowledge brokerage. The exchanges of knowledge that occur within the community promote social learning. When they happen in a context

where governance mechanisms are favorable, they promote integrated and creative solutions that can generate innovation.

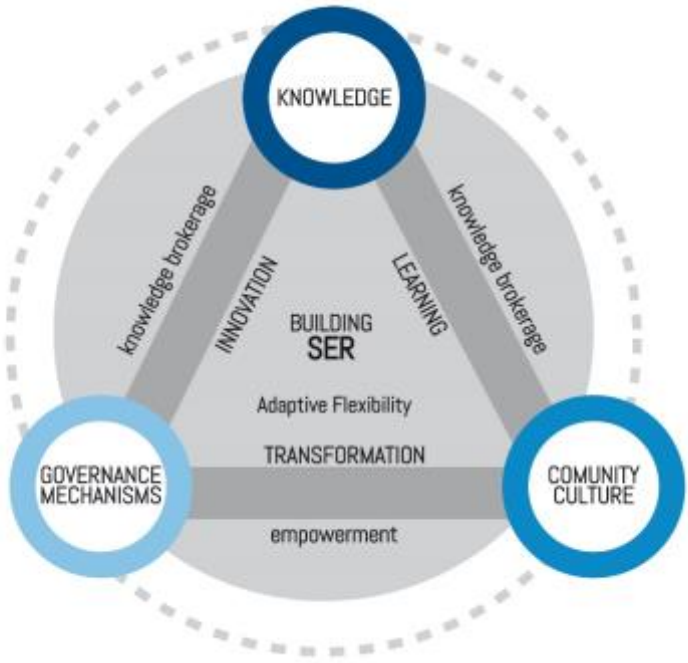

Figure 16: Conceptual SER Framework

In the same way, the interaction between governance mechanisms and community culture empowers the community and promotes the necessary transformations in social systems to increase flexible adaptive capacity and build SER. Social learning, innovation and transformation are considered the basis for building SER (Adger et al.,2011).

As shown in the literature review, social learning is a powerful tool to adapt to climate change (Collins & Ison, 2009; Pelling & High, 2005), and for resilience ins SES (de Kraker, 2017). Changes in social system are necessary to adequately address environmental challenges that threaten human life and ecosystems. Social learning can support this change through critical reflection and collaborative nature. According to McCarthy et al. (2011), social learning is “an on-going, adaptive process of knowledge creation that is scaled-up from individuals though social interactions, fostered by critical reflection and the synthesis of a variety of knowledge types that result in changes to social structures”.

Although there is evidence that participatory processes can stimulate and facilitate social learning, this is not always the case. Typically, social learning occurs from social networks, but it can be initiated by mass media or other non-participatory means. According to Reed et al. (2010), learning can occur through two basic types of social interaction: information

transmission, that is, simple learning of new facts through social interaction; and deliberation, that is, exchange of ideas and arguments during which ideas and perceptions change through persuasion.

The challenge of a successful social learning process, according Sol, Beers, & Wals (2013) lies not only in the understanding of stakeholder interactions, but also in the dynamics between knowledge and social relationships produced by these interactions.

Thus, McCarthy et al. (2011), advocate the interaction of different types of knowledge in learning process: scientific, local and governance knowledge. According to the authors, scientific knowledge is universal, invariable and context independent. It brings great rhetorical weight in a political context as it is generated through normal and western scientific methods. Local and governance knowledge are pragmatic, variable and context dependent. The first is generated through local experience and the historical interactions of the community, which favors the contextualization of the discussions. The second involves deliberation on values that reflect the understanding and interpretation of national, regional and local laws, regulations and policies for a specific issue.

Shadow space, that is, "the space of informal interaction that lies outside of but interacts with formal institutions and relationships" (Pelling, High, Dearing, & Smith, 2008, p.6), contributes for communities to build their experiences and self-organized actions in an informal way. In addition to one-to-one bases of information, participation in social networks enhances learning outcomes. According to Pelling and High (2005), people need to learn to learn, learn from past experiences, and through adaptive actions that provide conditions for socializing.

In the same way, knowledge brokerage was pointed out in the previous chapters as a powerful tool for promoting creative and innovative solutions to problems in a community (Partidário and Sheate, 2013). The exchange of knowledge is essential for innovation, where something new is developed, adding social value and wealth. In a traditional vision, the novelty is based on the process of creating knowledge to find new ways to see reality and solve problems (Westley and Antadze, 2010). This can mean new technologies, new operational processes, new marketing practices, small changes or adaptations that generate a gain for those who put them into practice. But the innovation thus understood can take time to consolidate. In addition to knowledge, it often depends on technological developments and/or large investments, and its assimilation is conditioned to the culture of the population and their purchasing power. Then, the success of different types of innovation are impacted by social values, ideologies, institutions, power imbalances, and by the prevailing patterns of innovation themselves (Howaldt & Schwarz, 2010). Innovation which takes place through the

interaction between individual initiatives of specialized actors and collective processes to harmonize tasks and incentives (Rodima–Taylor, 2012).

However, in recent decades social innovation has gained momentum, because it is distinctive both in its outcomes and in its relationships, in relation to the new forms of cooperation and collaboration that it brings. A social innovation, according to Howaldt & Schwarz (2010), is a process of collective creation in which the members of a particular collective unit acquire the cognitive, rational, and organizational skills necessary to better satisfy or respond to common needs and problems, on the basis of established practices. As a collective process, it implies the coordination of knowledge distributed in different sectors or institutions. Collective and cumulative learning is constructed from past experiences and, at the same time, limited by specific technical and procedural choices (Pelling and High, 2005). Collaborative exchanges depend on the access to people, facilities, documents and other forms of knowledge among the different partners with objectives to innovate. Social innovations can emerge from interactions between knowledge and governance mechanisms, and they can contribute to transformations in social system.

However, the literature review demonstrated the importance of empowering stakeholders in the transformation of the social system (Narayan-Parker, 2002). People or groups are empowered through the widening of knowledge, and the perception of the environment in which they live. With better arguments, they feel free to discuss, give an opinion, and actively participate in decision-making processes that affect your lives (Harriss, 2007). Engagement in participatory processes favors collective actions, where the community assumes an important role in the search for better and more adequate solutions to its essential issues (Adger, 2003). This engagement drives transformations in decision process, in order to make it more open, participatory, inclusive and deliberative. The participatory processes guarantee them the opportunity of argumentation and negotiation, influencing the elaboration of new policies and the control of implementation (Ireland and Thomalia, 2011; Narayan-Parker, 2002). In addition, the ability to take on new responsibilities can lead to changes in governance model in order to make it decentralized and integrative. Under this view, opportunities for engagement, experiences in collective actions, the type of decision-making process, and the governance model can facilitate transformation as previously discussed, and as conditions for transformative adaptation.

6.4 Operationalization of the conceptual model

In order to operationalize the conceptual model presented above and enable its application in a real case, it was essential to identify in the literature factors that could generate or enhance the necessary interactions between the different agents to promote social learning, innovation and transformation. Thus, twelve potentiating factors, called "enablers", were established to improve social capacity of communities to building SER to climate change.

For each of the interactions, four enablers were established. Each of the agents involved in these interactions defines the characteristics of two enablers. Thus, the interaction between knowledge and community culture can generate social learning. For this, the established enablers were: on the one hand, access to scientifically based information and valuation of local knowledge, which are directly linked to knowledge; and on the other, the use of social networks as a form of knowledge sharing, and the capacity for self-organization, factors determined mainly by the culture of community. The interaction between knowledge and governance mechanisms can generate social innovation. The established enablers are: on the one hand, investigation and experimentation on the theme of climate change and all its implications, and the participation of research and government agencies in knowledge networks, knowledge-related factors; on the other, the financing of research and decision-making supported by scientific knowledge. These enablers are linked to governance mechanisms. Finally, the interaction between community culture and governance mechanisms can generate transformations in the social system. The established enablers are: on the one hand, stakeholder engagement and collective actions, related to community culture; and on the other, the participatory decision-making process, and the decentralized governance model, determined by the governance mechanisms.

At a later stage, the evaluation parameters for each enabler were developed based on an ideal situation pointed out in the literature review, and a reference scale for this evaluation was defined. The evaluation indicators follow a score of zero (0) to three (3). The definition of values took into account two distinct situations: the absence of situation related to enabler in the case to be evaluated that corresponds to zero value (0); or the existence of situations to be evaluated that can reach three levels of development (values between 1 and 3). The value one (1) refers to an inscipient level of the enabler development, where much needs to be developed to reach the appropriate parameter; the value two (2) refers to an intermediate level, where there are consolidated actions that characterize this enabler, but it would still have aspects to be improved; and finally, the value three (3) that corresponds to the evaluation parameter suggested in the literature.

This scale of assessment is indicative, and aims to show the situation of the analyzed case, its deficiencies, limitations and potentialities to be explored. The results will depend on the characteristics of the evaluation team and the degree of perception it has of the analyzed reality.

Therefore, it is suggested that this evaluation be carried out by a multidisciplinary group and with great mastery of the real local situation. Representatives of the community, public and private institutions, as well as technicians and experts should form a working group to discuss each of the enablers, and define the best evaluation for each of them.

The following are detailed each of the twelve enablers, pointing out the bases of the literature that gave rise to this selection and the parameters of evaluation to be considered. At the end of each step is presented a table that summarizes the main information of each enabler, along with the literature sources that based its choice and evaluation parameters.

6.4.1 Enablers of social learning (interactions between knowledge and community culture)

The first enabler of social learning was *information access*. In a context of uncertainty and complexity, scientifically-based information is essential both to increase the perception of risks and vulnerabilities, to support decision-making in public policies, or even to generate new knowledge. Adger (2003) emphasizes the importance of reciprocity of information between the public power and the community in the elaboration of public policies adapted to the local needs, and in the confrontation of disasters related to the climate. Assessing how the community accesses specialized information on climate change (potential impacts and risks, ways to mitigate impacts, warnings of extreme events, supports available in a disaster) can facilitate understanding of the situation, improve interest in knowing more, and looking for alternatives to lower their vulnerabilities, and increase their resilience. Creation and consolidation of accessible, and user-friendly information media, is a powerful resource for developing social learning.

Cherotich et al (2012) recommend parameters in their conceptual model to assess how community access information to climate change and adaptation. The model evaluates access to climate change information and support services by the vulnerable groups for adaptive capacity development. The dissemination of information and support services through accessible and effective channels, with easy-to-use attributes are the essential assumptions. The sources of information considered important in this model are: researchers, meteorological agencies, indigenous knowledge, and development agencies. For the authors, it is necessary to understand the pattern of media use by the vulnerable

community, but they consider four groups of media that can be effective in this process, if they use user-friendly attributes: mass media (tv and radio) print media (pamphlets, brochures, newspapers and posters); electronic media (internet and sms suport services); and community channels (extensions offices, neighbors/friends, local administration, and indigenous knowledge forecasters). These characteristics serve as parameters for assessing access to information in the case study.

The second enabler of social learning was *local knowledge*. Local people continually need to adapt and develop knowledge to deal with environmental change. In general, this knowledge is transmitted orally or practically to a closed group, despite being in constant interaction with other forms of knowledge (Tengo et al, 2014). Berkes and Folke (2002) recognize the importance of valuing and strengthening local knowledge as a way of learning and responding to these experiences to build resilience. Numerous authors emphasize the importance of knowledge exchange and the integration of different types of knowledge for learning (Hiwasaki et al ,2014; Tengo et al, 2014; Raymound et al, 2010; Naess, 2013). Naess (2013) highlights that local knowledge is developed over a long period of time and maintained by a particular society in a specific location. From this perspective, local knowledge can contribute with years of observation of local conditions, with experience of practices that have worked or not, and with perception of community values, beliefs and ways of acting. But for Hiwasaki et al (2014, p.15), integration between traditional knowledge and science is necessary before using it in policies, education, and practical adaptation actions and DRR. This process “identify knowledge that can be integrated with science, which could then be further disseminated for use by scientists, practitioners and policy-makers; and safeguard and valorize those that cannot be scientifically explained”.

The evaluation´s parameter of this enabler in operational model is based on three approaches to create synergies among knowledge systems (Tengo et al, 2014). They are: (a) Knowledge integration through processes: it attempts to incorporate components of one knowledge system into another, through a validation process based on the latter system. Scientific validation of traditional or local knowledge is an example of this approach; (b) Parallel approaches to the development of synergies in knowledge systems: it emphasizes complementarities while presupposing validation in knowledge systems. In this case, the two types of knowledge can be pursued separately, but in parallel, enriching each other as necessary; and (c) Co-production of knowledge: local knowledge participates in all stages of knowledge generation. Examples of this approach include cases of co-management, community-based management, and participatory natural resource monitoring.

Social network is the third enabler of social learning. The use of social networks has shown to be a strong ally in the interaction of different agents for sustainability (Sol et al., 2013). According to the authors, networks of multiple actors at the regional level, and consequently local, favor the creation or improvement of knowledge. From social networks, the stakeholders can find new answers to existing social, economic and ecological problems (Reed et al., 2010). Indeed, Adger (2003) considers the use of social networks as an effective means for public authorities to inform the community about the use of resources and practical changes, resolving conflicts directly with users, and building the necessary confidence among stakeholders. In disasters, social networks play a primary role in adaptation and recovery because, according Cunnigham et al (2017), individual parts share information about their condition and operational status to improve the function of the whole system.

As a community has access to specific spaces to exchange information on ways to mitigate, adapt, prevent, address, and/or recover from the impacts of climate change, it becomes aware of the situation, increases knowledge and becomes the key to reducing its vulnerabilities. Usefull information broadens alternatives, and helps in choosing better options for public policies (McNie,2007**)** In an operational model, evaluation of social networks as a way to increase SER takes into account the institutionalized use of the three types of social networks cited by Cunnigham et al. (2017): 1) *Operational networks*, that include the formal relationships between people in an institution in order to ensure its better functioning; 2) *Personal networks*, that people develop, both formally and informally, to help them function in society; and 3) *Strategic networks*, that are formed to help deal with the future disruption of an institution's operation. The use of these three types of networks by a vulnerable community is considered as an ideal situation in the evaluation of concrete situations.

Finally, the fourth enabler of social learning is *self-organization*. When the community organizes itself, and creates its own conditions to face its problems in situations where public power does not meet its needs and expectations, it acquires its own repertoire of solutions, strengthens the engagement of stakeholders, promotes collective actions and increases its autonomy in building of resilience (Nederhand et al (2016).

Pelling et al. (2008) and Leck and Roberts (2015) highlight the importance of shadows spaces to increase the adaptive capacity of communities. Community organizes through shadow or informal systems, networks and spaces to generate collective actions, independently of institutions considered canonical, that is, formal. This spaces support innovation, knowledge exchange and mutual learning. Identifying whether the community

develops autonomous and structured actions to address its climate challenges can help to perceive capacity of community to learn and change. According to Nederhand et al (2016), successful self-organization presupposes the presence of trust relations among the actors. Several different networks, consolidated contacts, and shared stories from past collaborations can help break down barriers to collective action. In order to evaluate this enabler, these aspects were used as a parameter for successful self-organization. Table 3 summarizes the social learning enablers.

Enablers of social learning (interactions between knowledge and community culture)			
Enabler	**Source in literature**	**Description**	**Evaluation parameter**
Information Access	Ross et al., 2015; Reed et al., 2010; Harris, 2007; Cherotich et al (2012)	How community has acess to specialized information on adaptation to climate change?	Community uses information channels with user-friendly attributes to disseminate information and improve knowledge, such as: mass media (TV and radio) print media (pamphlets, brochures, newspapers and posters); electronic media (internet support services and sms); and community channels (extensive offices, neighbors / friends, local administration and local meteorologists). The sources of information considered important are: researchers, meteorological agencies, indigenous knowledge and development agencies.
Local Knowledge	Folke et al., 2005; Leonard et al., 2013; McCarthy et al., 2012, 2011; Olsson et al., 2004; Tengo et al, 2014	How local knowledge integrates climate change adaptation process?	Three approaches to create synergies among knowledge systems: (a) integration of knowledge, (b) parallel approaches to developing synergies across knowledge systems, and (c) co-production of knowledge.
Social Network:	Pelling and High, 2005; Reed et al., 2010; Adger, 2003; Cunnigham et al. (2017)	How does the community use social networks to enhance adaptive capacity?	The local community has developed mechanisms that use social networks (operational, personal and strategic) to improve its adaptive capacity.
Self-organization	Stringer et al., 2006; Pelling et al, 2008 Rodima–Taylor, 2012; Nederhand et al (2016)	How does community react when it faces situations in which the public power does not give the adequate answers to their needs?	Community has well-structured and continuous mechanisms of self-organization to find suitable solutions to various situations in which the public power has not attended to their needs and expectations.

Table 3: Social learning enablers

6.4.2 Enablers of innovation (interactions between knowledge and governance)

The first enable of innovation is *investigation and experimentation*, that is, how does the community search and experiment new ways to meet its challenges. Rodima-Taylor et al. (2012a) state that effective responses to climate change require technological, social and relational innovations. According to Westley and Antadze (2010), the development of innovative solutions depends on an environment conducive to research and experimentation.

The authors advocate the involvement of different teams in a phase of exploration of ideas. A later evaluation defines the most appropriate ideas, to which the efforts and investments are directed in order to make feasible its practical application. Popp (2010) classifies this process into three phases: invention (when good idea is born), innovation (when products and processes are feasible for practical use), and diffusion (when innovation is assimilated and people use it). The evaluation of this enabler is related to the type of investigation that the local research institutions carry out, and how its practical application to the community takes place. According to Rodima-Taylor (2012b, p.109), "institutionalized research is crucial for producing innovations leading to advanced technologies capable of making society resilient and adaptable". The diversity of scientific areas involved, the integration with local knowledge, and practical experimentation within the community enhance the opportunity to come up with creative and innovative ideas.

The second enabler of innovation is *knowledge network*. Many authors argue that the exchange of knowledge and information is the basis of innovation (Moore and Westley, 2011; Sol, Beers and Wahls, 2013; Schmid et al., 2016.). Multi-actors network can generate new knowledge, and social learning from shared multi-projects. For Moore and Westley (2011), networks facilitate innovations by sharing experiences and mitigating the difficulties of complex problems, favoring changes in scales, and thus increasing resilience. Therefore, knowing how the policy planners interact with other sources of knowledge is essential to evaluate this enabler. Parameters for this enabler are: the adaptation planners participate in knowledge networks with different research agencies (local, national, and international), develops joint projects, and gets support to manage its climate challenges creatively, planned and systematically.

Funding to investigation is the third enabler of innovation. Moore and Westley (2011) point to the lack of investment in research and development as the main barrier for innovation. The authors argue that networks can establish trust and commitment between actors and institutions favoring institutional entrepreneur performance, that is, actors or groups of actors who leverage resources to create new institutions or transform existing ones. In this sense, to evaluate this enabler it is important to identify if the community capture funding to develop research, attracts funds from different national and international development agencies, integrating efforts to develop new ideas to face their climatic challenges.

Finally, *knowledge supporting decisions* is the fourth enabler of innovation. Some authors question the effectiveness of current modes of knowledge production and their use in practice (Frazey et al, 2017; Swart et al., 2017, Preston et al, 2015). In recent years the science of adaptation has evolved rapidly, supposedly to meet the demand for knowledge to

facilitate adaptation policy and practice. But the evidence shows that the evolution of science did not translate into implementation of adaptation (Preston et al, 2015). To evaluate the enabler, it is necessary to identify how specialized knowledge supports local decisions. Huggel et al. (2015) establishes three stages of adaptation process in which science can contribute in science-policy process: (1) framing and problem definition, (2) scientific assessment of climate impacts, vulnerabilities and risks; and (3) assessment of adaptation options and their implementation. These can be taken as assessment parameters for this enabler. Table 4 summarizes the innovation enablers.

Enablers of innovation (interactions between knowledge and governance mechanisms)			
Enabler	**Source in literature**	**Description**	**Evaluation parameter**
Investigation and experimentation:	Rodima-Taylor et al. (2012a, 2012b); Westley and Antadze (2010)	How does the community research and experiment new ways to meet its challenges?	Local research institutions carry out extensive research on a diversity of scientific areas, reserches integrate local knowledge, and they include practical application to the community.
Knowledge Network	Moore and Westley, 2011; Sol, Beers and Wahls, 2013; Schmid et al., 2016.	How does the adaptation planners interact with other sources of knowledge?	Adaptation planners participate in knowledge networks with different research agencies (local, national, and international), develops joint projects, and gets support to manage its climate challenges creatively, planned and systemiatically.
Funding to investigation	Moore and Westley (2011)	How does the community seek funding to develop appropriate solutions to its climate challenges?	Community capture funding to develop research, attracts funds from different national and international development agencies, integrating efforts to develop new ideas to face their climatic challenges.
Knowledge supporting decisions	Frazey et al, 2017; Swart et al., 2017, Preston et al, 2015: Huggel et al, 2015.	How specialized knowledge supports local decisions?	Science can contribute in science-policy process: (1) framing and problem definition, (2) scientific assessment of climate impacts, vulnerabilities and risks; and (3) assessment of adaptation options and their implementation.

Table 4: Innovation enablers

6.4.3 Enablers of transformation (interactions between community culture and governance)

The first enabler of transformation is *engagement*: There is a consensus that a transformative process of adaptation requires transdisciplinary approaches involving different stakeholders (state, civil society and market actors). The union of their efforts and capabilities favors the generation of creative solutions and makes each one of them feel part of the change (Wamsler, 2017). However, Moser (2014) states that engagement in

adaptation is highly dependent on the context in which it occurs and there are many variables that lead people to participate or not. According to the author, the decision to participate may be influenced by a prior communication that arouses interest or by conflicts related to climate change. However, generally the quality of the discussions is linked to the pre-existing knowledge about the subject in question. Governance that promotes decentralized citizen engagement is considered more flexible and democratic in dealing with public problems (Fischer, 2006). Rowe and Frewer (2008) point out the many variables for selecting appropriate participatory mechanisms. According to the authors, the choice depends on the objectives of the proposal. But for them, some aspects can significantly influence their effectiveness, such as how to control who participates, how they interact, or the presence or absence of facilitator in the process of participation. To analize this enabler, it is important to identify how is local community involvement in formulation of local public policies. Wramsler (2017) identified in his study four main aspects that have influenced the level of involvement, inclusion and / or exclusion of stakeholders in the process of developing adaptation strategies: 1) the influence of highly motivated people who drive the development process adaptation strategies on internal and external stakeholders; 2) the pre-existence of an institutional structure that promotes interdepartmental and intersectoral cooperation; 3) institutional power structure that influences the involvement of internal stakeholders; and 4) preexisting situations of cooperation or contestation of external stakeholders (citizens, municipalities, academia) that influence their own agents to participate. The existence or not of these aspects in the community are considered as parameters of evaluation of the potential of stakeholder engagement in the formulation of adaptation policies.

Second enabler of transformation is *collective action* which involves the voluntary engagement of a group of people in actions of common interest. Adger (2003, p. 387) considers adaptation a “dynamic social process determined, in part, by the ability to act collectively”. The collective approach has been valued in recent years. It facilitates a wide range of social interaction initiatives and favors social networks that provides access to resources and support (Patino, 2011). Ireland and Thomalia (2011) argue that collective action must be considered in the development of adaptation strategies to climate change because it plays an important role in enhancing adaptive capacity, although the way this occurs is not well developed in the literature. According to the authors, collective action may target for resource mobilization, coordination of activities, sharing of information or development of institutions. It occurs in informal social networks and governance structures, usually supported by communities and NGOs. These local informal institutions can play an important role in resource management and the claim process, leading to institutional

changes (Rodima-Taylor et al., 2012). However, collective action is necessary especially when adaptation involves the provision of public goods and resources of a common pool (Marshall, 2013). Beyond this question, Vanni (2014) adds other benefits of collective action: broadens the exchange of knowledge and social learning, enhances the credibility and legitimacy of decision-making, enables the collection and sharing of information at lower costs, and enables local problems to be addressed efficiently. The parameters of collective action assessment are based on the three types of connectedness of Pretty (2003) quoted by Vanni (2014, p.31): Bounding, bridging and linking. Bounding represents a group composed of people with strong ties (friends, family and associates); Bridging: represents the connection between more diverse associations, with weaker links (interest groups or social and leisure clubs); and Linking represents the connection with people in positions of power who seek the support of formal institutions. The existence of examples of these three types of connections in the study community represents a strong capacity of the community to act collectively.

Third enabler of transformation is *participative decision-making process.* Stakeholder participation is commonly advocated in adaptation policies (Stringer et al., 2006; Few et al., 2007; Ross et al., 2015). Citizen participation brings to the process social, ethical, and political issues that are not found in scientific approaches, gives legitimacy, assumes a critical and controlling role in the direction and speed of proposed changes, strengthens political issues such as empowerment and democracy, reinforces the social learning process, transforms relationships and favors the change in the perception of different points of view (Stringer et al., 2006). However, public participation is considered a fundamental challenge in climate policy, as it involves power relations (Few et al., 2007). Therefore, the adaptation process requires the creation of intermediate spaces for participatory practices, in order to readjust the boundaries between the state and its citizens (Fischer, 2006). Thus, the parameters for its evaluation are based on the characteristics of a fully democratic deliberative process established by Carson and Hartz-Karp (2005, p.122), which are: influence (stakeholders must have the ability to influence policy and decision-making); inclusion (population represented in different points of view and values, with equal opportunities for participation); and deliberation (open dialogue, access to information, respect, opportunity for opinion, and search for consensus). The existence of participative spaces with these characteristics in adaptation process becomes decisive for this enabler.

Finally, *governance model* is the fourth enabler of transformation. The governance model based on a polycentric and multi-layered institutional arrangement is considered ideal for the adaptive process. According to Biggs et al. (2015, p.16), “a governance system in which

multiple governing bodies interact to make and enforce rules within a specific policy arena or location, is considered to be one of the best ways to achieve collective action in the face of disturbance and change". This system favors connections between knowledge, action, varied contexts, and social and ecological dynamics of different places. With this, societies respond more adaptively and at appropriate levels (Lebel et al, 2006). The involvement of multiple sectors and scales, including the growing activity of external actors, such as non-governmental and private organizations, requires multi-layered systems and cross-scale networks linking organizations and individuals (Adger et al., 2005, Olsson et al., 2006, Bowen et al, 2013). Galaz et al. (2012) define communication dynamics, degree of formalization and structural network patterns as characteristics to establish the degree of polycentric order in a governance system. The authors characterize a strong polycentric system when the trust ties between the central group of actors are long lasting and strong; there are communication links to a wider set of peripheral actors; mechanisms for resolving internal problems and conflict resolution emerge; and there is a sharing of information strategically coordinated by key actors. Therefore, the strong polycentric governance model, which integrates multiple sectors and scales, including private and non-governmental organizations, is considered essential for a transformative process of adaptation and serves as a parameter for the evaluation of this enabler. Table 5 summarizes the transformation enablers.

Enablers of transformation (interactions between governance mechanisms and community culture)			
Enabler	**Source in literature**	**Description**	**Evaluation parameter**
Engagement	Rowe and Frewer (2008); Wamsler (2017); Moser (2014) Fischer (2006)	How is community involvement in formulation of local public policies?	The existence of highly motivated people who drive the development process adaptation strategies; an institutional structure with interdepartmental and intersectoral cooperation; institutional power structure that influences the involvement of internal stakeholders; and cooperation or contestation of external stakeholders
Collective action	Adger, 2003; Patino, 2011; Ireland and Thomalia, 2011; Rodima-Taylor et al., 2012; Vanni, 2014	How is the integration between public power and community coping with community problems?	Community develops three types of connections: bounding, bridging and linking.
Participatie decision-making process	Stringer et al., 2006; Few et al., 2007; Ross et al., 2015; Fischer, 2006; Carson and Hartz-	How are decisions made in local government?	Existence of participative spaces with a fully democratic deliberative process of adaptation that envolves: influence, inclusion and deliberation
Governance model	Adger et al., 2005; Olsson et al., 2006; Bowen et al, 2013; Galaz et al., 2012.	What is the local governance model?	The existence of a strong polycentric governance model, which integrates multiple sectors and scales, including private and non-governmental organizations.

Table 5: Transformation enablers

6.4.4 Wheel of Social Capacity Assessment to build SER

To complete the analysis and to promote a visual reading of the results obtained in the enablers assessment, a diagram based on the previously presented conceptual model (figure 16) was developed: The *Wheel of Social Capacity Assessment to Build SER* is presented below.

The diagram (Figure 17) is made of three superimposed circles, divided into three equal parts. Each of the divisive elements represents a social factor for the construction of SER (knowledge, mechanisms of governance and community culture). Each of the parts resulting from this division represents the interaction between the two extremes – the social dimensions (social learning, innovation, and transformation).

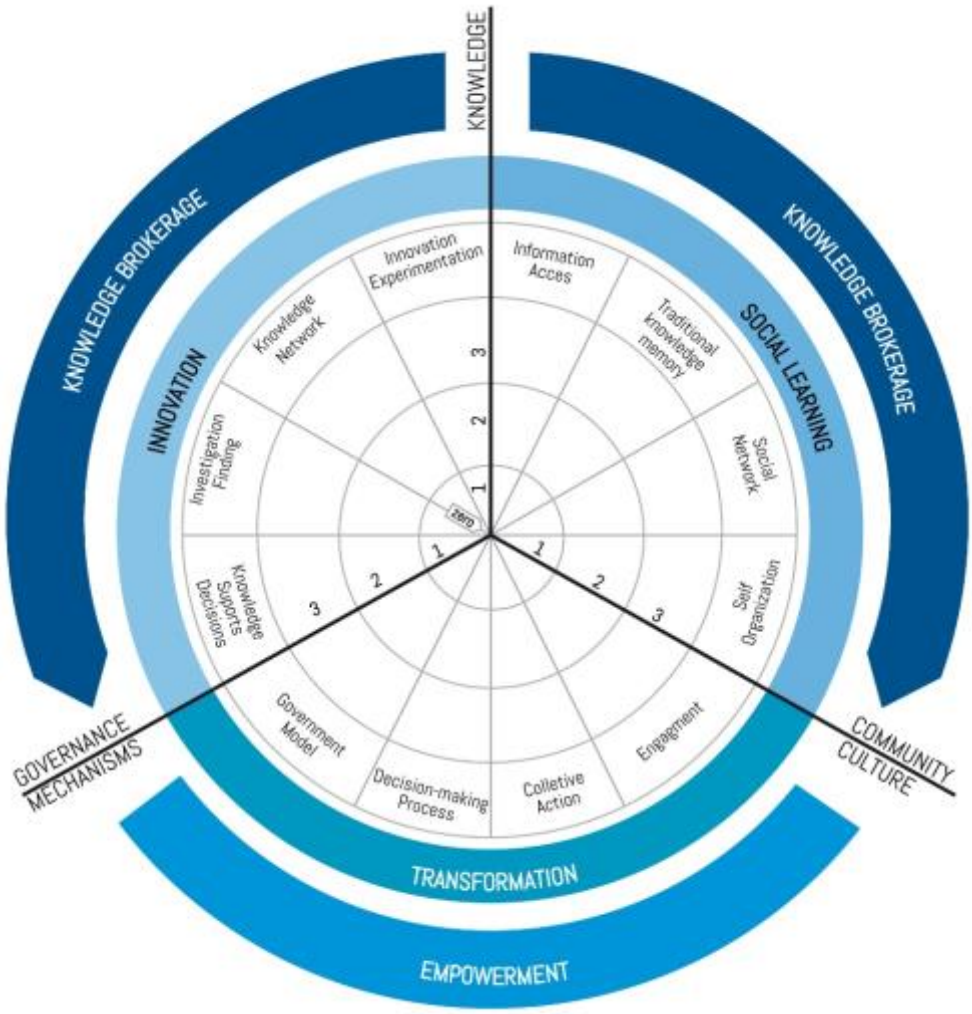

Figure 17: Wheel of Social Capacity Assessment for build SER

The middle circle corresponds to four enablers of each social interactions, and the inner circle identifies the score with values from 0 to 3, evaluated for each enabler. Externally, there are two arched arrows that depart from the "knowledge" social factor toward governance mechanisms and to community culture. It represents the instrument (Knowledge brokerage) that makes the interaction between the two social dimensions. Finally, the external arch that unites mechanisms of governance and community culture represents the process of empowerment that occurs in this interaction.

After evaluating the twelve enablers by the working group, it is possible to translate the results into this diagram, filling in the spaces corresponding to the score identified for each of the enablers. In a quick overview, it is clear which interactions are deficient and need to be potentiated, and which ones are already consolidated. Most of the time, at the end of discussions, the work group perceives the results, but the visual diagram facilitates the understanding in a simple and clear way, favoring the argumentation and helping decision makers to understand quickly their community's strengths and weaknesses in capacity to adapt and improve SER to climate change. In addition, the evaluation parameters can suggest ways to be adopted in situations considered deficient.

Finally, in APPENDIX I, a form is presented that assists the conduct of the discussions of the working group for the evaluation of the social capacity to build SER. In addition to the enablers and evaluation parameters, the form contains an area with informations that were identified as essential in discussions to validate the tool applicability.

The first aspect refers to the temporal scale of the changes and the effects to be considered, that is, long-term changes (climatic change), short-term changes (climatic variability), and climate extremes events. Each of the effects has a specific need for response and the community must be aware and prepared for it. The integration of different approaches, whether of adaptation or reduction of disaster risks, should be foreseen in a temporal scale of actions.

The second aspect refers to the impacts of climate change on the SES, that is, the identification of the expected impacts on the community. The same community may be vulnerable to more than one impact. To assess the adaptive capacity of a community, it is necessary to know to what effect it is and/or will be vulnerable.

The third aspect is related to the causes of local vulnerability. It is important to identify which social (socio-economic or institutional) factors increase vulnerability or undermine the adaptive capacity of the community. From the knowledge of the causes of vulnerability, the community has more strength to seek ways to solve or minimize effectively its effects.

And finally, it is important to highlight the perspective in which adaptation is understood in this process. The conceptual development of the present study defended a transformative adaptation as a form of building resilience to climate change. In this sense, adaptation is understood here in a systemic view, as an iterative process involving incremental and transformative actions integrated at three dimensions: adaptation, mitigation, and DRR. The focus of transformations is on the dynamics generated by social interactions that can increase the knowledge of stakeholders to promote social learning, generate innovation, empower people, and transform social system. In this way, the community can increase the adaptability and reduce the vulnerabilities of the SES to the impacts of climate change.

6.5 Discussion

This chapter presented synthesises the discussions of the previous chapters and generated a conceptual framework of the process of building SER to climate change as the outcome of this thesis.

If previous solutions presented by scholars and policy makers to adapt to climate change are no longer be sufficient to ensure the well-being and security of local communities, new ways of adapting must be sought. The first step is to understand the dynamics of a SES and that “social dynamics” are responsible for most of the transformative processes. Therefore, the transformation of social systems has become a way in this complex context of climate change. The theory of resilience was the means used to face this challenge, with adaptation and transformation as essential components, and social learning and innovation supporting the transformative process.

The findings of this research have shown that the interaction between different social dimensions can contribute to creating social dynamics capable of increasing the adaptive capacity of local communities and reducing their vulnerabilities to climate change.

The conceptual model proposed in this chapter relates the social dimensions (knowledge, community culture, and mechanisms of governance), to create transformative dynamics in the adaptation process. "Enablers" are the mechanisms that fuel these dynamics, and they can act as parameters for assessing the social capacity of a community to build SER to climate change.

At the root of this process is "action sharing": stakeholder engagement, knowledge brokerage, and collective action. These actions support participation, social learning, and the empowerment of individuals and communities, making it possible to find innovative solutions to problems.

7. CASE STUDY

7.1 Natural disasters in Brazil

Natural disasters as floods, landslides, and mudslides are relatively frequent in Brazil, and they usually occur in the rainy seasons (UFSC - CEPED, 2013). Rio de Janeiro, São Paulo, Minas Gerais, Bahia, Pernambuco, Alagoas and Santa Catarina are the regions that suffer most from this problem (Ministério da Integração Nacional, 2014). These events have recently increased due to the unplanned growth of cities and the poor use of river basins, aggravated mainly by deforestation. The most affected populations are those socially excluded, which due to lack of economic conditions occupy environmentally fragile areas, such as hillsides, coastal regions, river deltas and low areas. (Vieira and Furtado, 2005: 49).

According to the 1991-2012 Brazilian Atlas of Natural Disasters (UFSC- CEPED, 2013), despite the increasing frequency of droughts in Brazil, landslides represent, by far, the most serious type of disaster because they are most likely to result in the loss of human lives. Damage can have economic, environmental, and social dimensions, such as blocking traffic routes and limiting people's moviment. Moreover, they can spur supply problems, destroying urban landscape, therefore making these regions more vulnerable to new events, and tragically burying entire houses, provoking human fatalities.

Some extreme climate events are emblematic in the country's history and have profoundly marked the areas where they occurred. A prime example is the landslide that happened in the state of São Paulo in January of 1967, covering an area of about 30 km in diameter, in the region of Serra das Araras, on Via Dutra (Rosa Filho & Cortez, 2010). Figure 18 shows the disaster news.

This region was suffered from heavy storms after a long period of continuous rainfal.l Llandslides began to occur causing a massive destruction and more than 1,200 deaths in which only 300 bodies were found. Figure 19 shows an aerial view of the affected area. Two months later, in March, that process repeated near the city of Caraguatatuba (São Paulo), also killing 120 people and destroying 400 houses (Rosa Filho and Cortez, 2010).


DEZENAS DE MORTES NO MAIOR TEMPORAL DE TODOS OS TEMPOS

O GLOBO

ATAQUE CARDÍACO FULMINA SHASTRI

Figure 18: News January/1967
Source: Jornal Diário do Vale – 14/11/2011

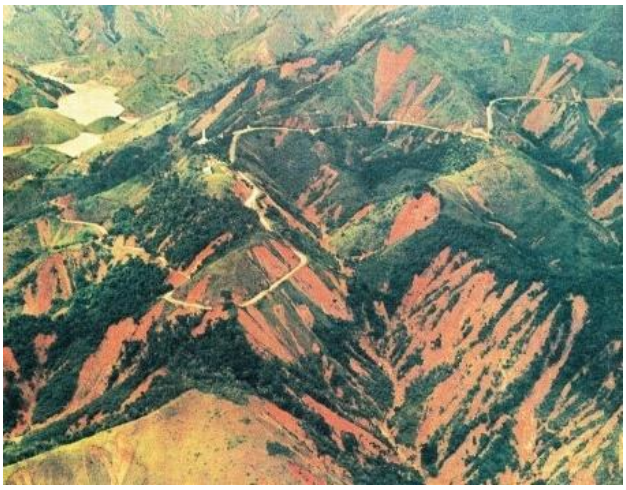

Figure 19: Serra das Araras after landslides
Source: Jornal o GLOBO

In the densest urban settlements that covers the hillsides of Brazilian cities, especially after the intense period of urban growth in the 70s, the risk of landslides has become more evident. The vulnerability increases because the poor and socially excluded don´t have access to the necessary technology for urbanization of this environment (Siebert, 2008).

Another serious environmental disaster due to extreme climate events took place in January of 1988 in the state of Rio de Janeiro, in the region of Nova Friburgo. Fifteen days of heavy rains resulted in the deaths of 570 people. Figures 20 and 21 show images of before and after affected area, where urbanization reaches all the way around the base of a 150m hill. It is possible to see the level of destruction when compare the street 7 de Setembro (marked with a red line) on the images of before and after the disaster(Rosa Filho & Cortez, 2010).

Figure 20: Nova Friburgo before landslide
Source: http://zonaderisco.blogspot.pt

Figure 21: The same area in Nova Friburgo after landslides
Source: www.zonaderisco.blogspot.pt

In this case study, we focus on a natural disaster that marked the history of South Brazil in recent years. It occurred in the state of Santa Catarina, in November 2008. Floods, landslides and mudslides have created disasterous situations for more than 1.5 million people, 80,000 become homeless or displaced, and 135 died. This event highlighted the socio-ecological vulnerability of the Itajaí Valley, where the consequences were greater. (Frank and Sevegnani, 2009, p.8).

A series of similar events took place in the following years. In March and May 2009, after a long period of drought, the states in the Northeast of the country (Maranhão, Ceará and Piauí) suffered with increasing rainfall intensity and frequency. In 2010, it was the turn of Angra dos Reis in Rio de Janeiro (January), Pernambuco (April) and Alagoas (June). Tragedies have gained ground in the media and have caught the attention of government and scientific community. In addition to traditional media such as radio, television, and the newspaper, the issue dominated discussions in social networks such as Twitter and Facebook, and the theme became a daily topic across the country. (BRAZIL, 2011, p.15).

However, although global warming has been pointed out as a factor contributing to the increase in the number of natural disasters, as the frequency and intensity of pluviometric events increases (IPCC, 2007), local biophysical and socioeconomic conditions are of great importance in this analysis. In addition to the geological and climatic conditions, there are exogenous processes that usually characterize natural disasters, mainly induced by human actions or governmental omissions that contribute indirectly to the intensification of the

phenomena. (Rosa Filho and Cortez, 2010; Vieira, 2004; Vieira and Furtado, 2005). Such situations ask for a reflection on the relationship between the various sectors of society and the natural environment, it also requires a broader understanding of the factors involved in the cause of these disasters. As stated by Frank and Sevegnani (2009, p.17), disasters are not only a problem for the region's development, but mainly a consequence of the development.

7.2 Case study methodology

The case study aimed to assess how the vulnerable inhabitants of Blumenau (Brazil), city located in Itajaí Valley, were prepared in the period 2009-2015 to face their climatic challenges. To achieve this objective, the research was developed in two phases. The first phase was the characterization of the case study and its vulnerabilities leading up to the 2008 disaster. The second phase was the assessment of the conditions generated by the social agents in the period from 2009 to 2015 to create or increase the SER of the local community for future climate change.

Procedures and techniques for conducting data collection varied according to the circumstances and/or the objectives of investigation and used documentary and bibliographic research, and interviews. Although each technique has a specific purpose, the methodology was based on the triangulation of the different techniques to reach the objectives. Hence, the analysis of the results in each phase of the research depended on the set objectives. Next, the procedures adopted in each phase of the case study are presented.

7.2.1 Data collection for the characterization of the case study vulnerabilities

Data collection for the first phase was based on documentary and bibliographic research. Documentary research is classified according to the source: primary sources include historical, bibliographic, and statistical data, cartographic material, and official archives. Secondary sources are generally printed in other works (Marconi and Lakatos, 2003).

Bio-physical data was obtained through primary sources such as official, historical, bibliographical, cartographic, statistical data, newspapers, and photographs. Population characteristics, geographic location, as well as geo-morphological and climatic profile were the main data collected.

The understanding of local vulnerabilities was based on the bio-physical characteristics and their relation with a set of complementary data, such as: the social, economic and political evolution of the region, the pattern of spatial occupation over time, the political-institutional context in which the 2008 disaster occurred, the history of the disaster in the region, and the

characteristics of the disaster. These data were obtained through documentary research and secondary sources, especially peer-reviewed literature.

The evolution and framework of public policies on climate change and disaster risk reduction was based on peer review literature and current legislation obtained from official government websites at international, national, regional and local levels.

In addition to understanding local vulnerabilities, the results obtained served as a basis for the subsequent analysis of the evolution of public policies during the study period.

7.2.2 The contribution of social agents for building the SER of the local community to climate change after 2008.

The objective of the second phase of this case study was to verify how the different social agents contributed to building the SER of the local community to climate change during the period of 2009 to 2015. This phase of the case study was organized in five steps.

1) Documentary research.

A documentary research was conducted to collect data on public policies developed by municipal authorities from 2008. Laws, regulations and norms were found on the departments' official websites and through access to official documents provided by city hall.

2) Interviews with representatives of public departments

Interviews were conducted with representatives of the main public departments of the local administration involved in the process of disaster risk reduction. The objective was to validate the documentary data, and to understand the real situation of the political-institutional evolution and the approach taken to face the local climatic challenges. The list of eight departments represented in the interviews is presented in Table 6.

Code	Department	Portuguese name and acronym
A	Foundation on the Environment	Fundação do Meio Ambiente – FAEMA
B	District Attorney General	Procuradoria Geral do Município – PROGEM
C	Secretary of Citizen's Defense	Secretaria de defesa do cidadão – SEDESCI
D	Secretary of Education	Secretaria de Educação – SEMED
E	Secretary of Public Works	Secretaria de obras públicas – SEMOB
F	Secretary of Urban Planning	Secretaria de Planejamento Urbano - SEPLAN
G	Healthcare Secretary	Secretaria de Saúde – SEMUS
H	Department of Urban Services	Secretaria de Serviços Urbanos – SESUR

Table 6: List of public departments in Blumenau whose representatives were interviewed.

During the planning of the interviews, in contact with local research groups, a similarity of objectives was identified between this work and an on-going research project by the research group “Management of Natural and Manmade Watershed Basins” (Gestão de ambientes naturais e construídos nas bacias hidrográficas - GEAMBH) from Regional University of Blumenau (Universidade Regional de Blumenau - FURB). The research project entitled: "The risk management of natural disasters in the municipality of Blumenau/SC from the perspective of the water resources policy of the Itajaí River Basin". This project had also planned to conduct interviews with representatives of the same selected public departments. As this group already had some scheduled interviews, it was decided to optimize the activity and to standardize the script of interviewers, presented in APPENDIX II, in order to contemplate the objectives of the two investigations. Thus, the GEAMBH researchers conducted this activity. The interviews with department representatives took place between September 22 and December 12, 2015. The conversations were recorded and later transcribed for easy analysis.

The first analyzes of the data took place during the design of the political-institutional framework after 2008, relating documentary data (laws, regulations and norms) with the description of the representatives of each department. The interviews were related to identify the structure and the dynamics adopted by the public administration in facing the local climatic challenges. The use of diagrams facilitated the understanding of the structure created and its dynamics of operation.

Thus, a second analyzes was conducted by N Vivo software, to determine the government vision of the institutional dynamics and its relationship with the other agents of the community. The objectives of the research and the interview script served as the basis for the codification of the units. The topics were classified as municipal risk management, local public policies and plans, relations between public policies, joint actions, national legislation, civil defense actions, recovery of affected areas, coordination between departments and participation of private entities. The units counting form was based on the presence or absence of certain elements (according to the theme), frequency of occurrence, association and opposition of units. The analysis was based on cognitive values, that is, how the respondents saw the situation. Thus, it was possible to identify, in addition to the individual vision of each interviewee, the general vision of the government.

3) Internet research:

An internet search sought to identify the opportunities for knowledge brokerage in DRR in Blumenau between 2009 and 2015. Official websites of the State Government, City Hall, Civil Defense, and the Regional University of Blumenau (FURB) were the main sources used. Also, two newspapers were consulted (one from the state capital and another from the city of Blumenau) which described the actions developed by these institutions. The full list of sources is in APPENDIX III. The words used for the search were "risk" and "disaster", both of which appeared in the response, not necessarily in that order. Results were classified as publications, audiovisuals, public events, programs and projects, and training courses.

4) Documentary research:

A documentary research was conducted to verify how the 2008 disaster aroused scientific interest on the subject, and which branches of knowledge generated contributions. Scientific publications, community actions, and scientific support for local government decisions were identified. The first step was to search on the official site of the National Council for Scientific and Technological Development (CNPq), research groups of the local university (FURB) linked to the environmental and transversal areas. The search was focused on research groups that developed investigations on climate change and/or hydrogeological disasters in their physical, social, environmental, technical, or economic aspects. In a previous search, thirteen research groups were found. In a second step, a search on the FURB website (www.furb.br) was conducted to identify the groups' scientific areas, the number of researchers and students (doctoral, master's, specialization, and undergraduates) involved, and the investigation themes (APPENDIX IV). Then, an additional search of the coordinators' CVs was conducted through the lattes platform of the National Council for Scientific and Technological Development[1](CNPq). Published papers, scientific events, research projects, and community actions related to the topic of climate change and hydro-meteorological disaster risks carried out between 2009 and 2015 were identified. As a complementary research, three questions were sent by e-mail to the coordinator of each research group. The content of the email is presented in the APPENDIX V. Only three responses were obtained.

5) Interviews with community representatives:

To understand if the local community saw changes in its ability to build SER after the 2008 disaster, interviews with semi-structured questions were elaborated to address community´s representatives. Previous research has sought to identify people directly related to

[1] www.lattes.cnpq.gov.br

recognized vulnerable groups in the community. The objective was to verify to what extent the community perceives the risks, identifies actions taken by public organisms to reduce their vulnerabilities and their participation in environmental education actions to increase knowledge and improve their adaptive capacity. Two key groups were selected: representatives of residents´ associations and agents of the Community Groups for Civil Defense (Núcleos Comunitários de Defesa Civil - NUDECs) in vulnerable areas of the city. The map developed by Samagaia (2010, p.123) that overlaps areas with concentrated poverty and areas at risk of hydrological disaster served as the basis for identifying the most vulnerable communities in the city. The first group (representatives of resident associations) was previously approached in a routine meeting with members of the FURB and local administration, and asked about willingness to contribute to the survey. In this occasion, ten of them, responsible for associations located in five vulnerable neighborhoods of the city, were willing to be interviewed. The second group (NUDEC) is part of the National Civil Defense Policy. Seven NUDECs were created in Blumenau after the 2008 disaster to promote cultural change over disaster risk. Their action normally takes place at two levels - Participation and Prevention. Although, at the time of the interviews, only two of them were still active. Table 7 shows the list of community associations whose managers were interviewed. The interviews were previously scheduled and were conducted in between 14/06 and 26/07/2016.

Most interviewees have lived there for more than 10 years and have a history of active participation in the communities where they live, following a number of hydro-meteorological events, including the 2008 disaster. The conversations were conducted based on the previously prepared script, but the interviewees had the freedom to express their opinion, their perceptions and recount memories lived in the place. The scripts of the interviews are in APPENDIX VI. Conversations were recorded and later transcribed to aid in the interpretation of the results.

The content of the interviews was analyzed using N VIVO software. The data were coded from common units. The coded units were based on themes according to each of the question formulated in the interview script (for example: climate and changes; climate and community; flood and community; knowledge, information, and learning; responsibility, community, city hall, civil defense; practical activities, participation, community, public power, university; among others). The form of counting of units was based on the presence or absence of certain elements (according to the theme), frequency of occurrence, association, and opposition of units. The analysis was based on cognitive values, that is, to what extent people knew about the subject and how they understood the situation. Data were

categorized by types of respondents (residents' association and Nudecs). Themes and categories guided the analysis. Then, for each theme, the relationships between the responses of the different groups were identified.

Institution	Name and acronym in Portuguese
Emil Wemuth Residents' Association	Associação de Moradores Emil Wemuth – AMEW
Maria Schumann Residents´ Association	Associação de Moradores Maria Schumann – AMMS
Association of Residents of left bank of Itajaí River	Associação de Moradores Margem Esquerda do Rio Itajaí – AMME
Belo Horizonte's Association of Residents	Associação de Moradores Belo Horizonte – AMBH
Coripós Residents Association	Associação de Moradores Coripós – AMC
Ina Valparaíso's Residents Association	Associação de Moradores Ina Valparaíso - AMIV
Leopoldo Hering's Residents' Association	Associação de moradores Leopoldo Hering – AMLH
Association of Residents Sunflower Land	Associação de moradores Loteamento Girassol – AMLG
Morro Hadlich Residents Association	Associação de Moradores Morro Hadlich (AMMH)
Unioun of Residents' Associations of Blumenau	União Blumenauense de Associação de Moradores-UNIBLAM.
NUDEC Coripós	NUDEC Coripós (NC)
NUDEC Nova Esperança	NUDEC Nova Esperança (NNE)

Table 7: List of resident associations whose managers were interviewed

The results obtained in this phase of the case study were first analyzed individually. Then through a triangulation of data, these analyzes contributed to the final interpretation of how the vulnerable residents of Blumenau (Brazil) were prepared to face their climatic challenges in the 2009-2015 period.

7.2.3 Assessment of Blumenau´s social capacity to build SER to extreme climatic events

With the list of enablers defined in chapter six, the Wheel of Social Capacity Assessment to build SER defined in section 6.4.2 was applied in case study. Five FURB researchers collaborated in this phase of investigation discussing the local process of building the SER to climate change, evaluating the analysis model proposed here, and the feasibility of its application in other case studies. The discussions took place at the FURB facility in three different moments, on August 29 and 30, 2017. Three researchers participated in the first

meeting. In the two others, personally conversations with one researcher occurred. The identification of each researcher is in the APPENDIX VII.

The work proposal was presented to the group using a multimedia resource. The objectives of the study and the development stages of the analysis model contextualized the discussion. It was not necessary to present the case study because the participants were very knowledgeable about the local situation.

As the enablers were presented, each one of the participants presented their doubts, reported their experiences and their perceptions regarding the local situation, and suggested adjustments for the better understanding and adequacy of the proposed model. Two of the participants at the end of the meeting declared the scores of each enabler for Blumenau from their own analysis. The meetings were recorded for later analysis. These discussions served as basis for the final assessment of the local situation.

The analysis of the local situation from the proposed tool was the last activity of the case study. From then on, it was possible to identify gaps and potentialities to be explored from local resources. Thereby, a final discussion was carried out that identified future paths to be taken by the community of Blumenau to increase their SER to climate change.

7.3 Characterization of the case study and its vulnerabilities

7.3.1 Bio-physical characteristics

Blumenau is a city located in the valley of the Itajaí River, in the southern Brazilian region, in the state of Santa Catarina. With an area of 520,000km² (40% urban and 60% rural), it has around 310,000 inhabitants (IBGE). The geography in the municipality is very rugged, characterized by high mountains in the south, along with valleys and streams in the northern region.

The humid subtropical climate and the physical characteristics make Blumenau historically vulnerable to floods and landslides. But these risks are also closely linked to human action and social contrasts that have produced serious social, economic, and environmental consequences (Siebert, 2008).

a) Geographic location

Blumenau is at Northeast of the State of Santa Catarina, Latitude 26º 55 '10 "South, Longitude 49º 03' 58" West, and altitude 21 meters above sea level. Figure 22 shows in red the location of Blumenau in the state of Santa Catarina (SC). The smaller image below shows the map of Brazil where the state of Santa Catarina is marked in black (Universidade

Federal de Santa Cararina - Centro Universitário de Estudos e Pesquisas sobre Desastres, 2011).

Figure 22: Location map of Blumenau, Santa Catarina, Brazil
Source: Universidade Federal de Santa Cararina - Centro Universitário de Estudos e Pesquisas sobre Desastres, 2011

From the Figures 23 (aerial view) and 24 (view in perspective), it is possible to perceive de form of urban settlement of the city Blumenau among the mountains and following the line of the river.

Figure 23: Aerial View of Blumenau
Source: Google Earth

Figure 24: View of Blumenau
Source: Jornal de Santa Catarina

b) Geomorphology

The city of Blumenau has a very rugged terrain, with large and numerous differences in elevations and slopes. Studies by geologists on the regional lithography reveal that the local hills are covered by a red soil, called "Archean granulite with weathering mantle." This type of soil has up to 12 meters deep and is supported by granitic rocks (Serra do Mar) with low permeability (Dias, 2009, p.17).

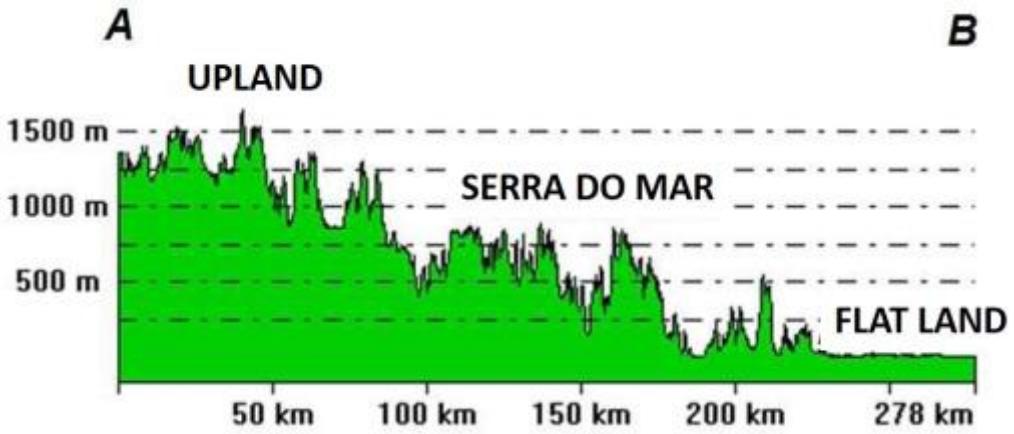

Figure 25: Profile altimetry AB showing the altimetry characterization of Geomorphological units of Santa Catarina.
Source: INPE, cited Dias, 2009, p.15

Figure 25 shows that the escarpment of the Upland da Serra Geral, with its more than 1500m of altitude and orientation parallel to the coast constitutes a real wall that complicates the internalization of clouds and causes precipitation of rain on the slopes of Serra do Mar.

In rainfall, the excessive water infiltrates very quickly and it is absorbed by deep alteration mantle of little permeable crystalline rocks. The result may be, on the one hand, the landslide in areas with altered vegetation and the accumulation of unconsolidated material, and on the other hand, the rapid flow of water towards the lowlands, where its accumulation in urban sedimentation plains, causes floods (Dias, 2009, p.17).

c) Climatic characteristics

According to the Brazilian Atlas of Natural Disasters 1991-2010: Volume Santa Catarina (UFSC - CEPED, 2011), the climate in the region is classified as mesothermal humid, with high temperatures in the summer. The average annual temperature is around 20,1ºC while the average minimum temperature is around 15,8ºC. The total annual local rainfall is 1596.2mm. The geographical position of Itajaí Valley, facing east (Atlantic Ocean) of the prevailing winds direction (south and north) favors the entry of moisture from the ocean towards the continent. Rain is evenly distributed throughout the year, as shown in Figure 26. There is two rainy seasons: one in spring and one in summer, with average rainfall of 130mm/month, and two periods of little precipitation: April and August, with about 80mm/month.

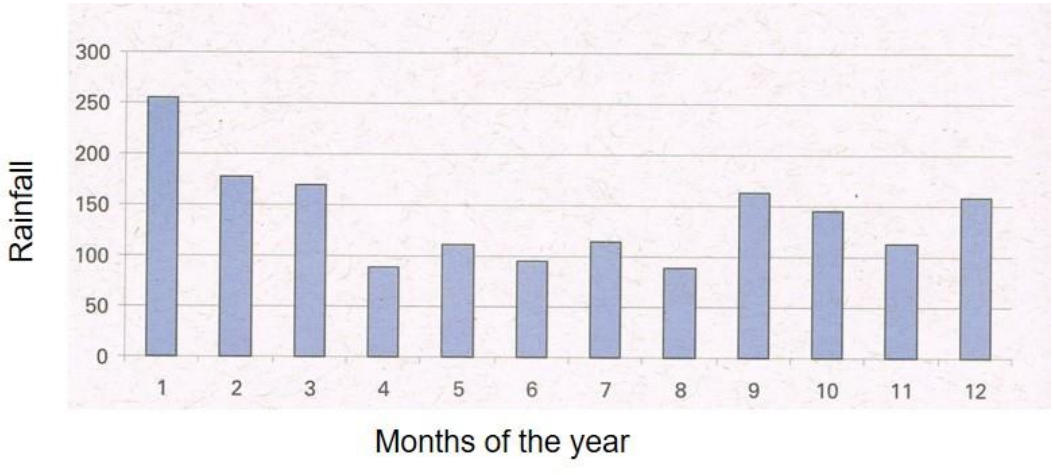

Figure 26: Distribution of the average monthly rainfall in Blumenau for the period 1988-2007
Source: Instituto de Pesquisas Ambientais (IPA) of the Universidade Regional de Blumenau (FURB)

7.3.2 Socio-spatial framework and vulnerability building

The Blumenau occupation began in the late nineteenth century with the arrival of German immigrants (1860) attracted by the possibility of becoming landowners. The initial development phase was based on the small family property, and the activities were based on agriculture and wood extraction. The city was established and developed according to the natural conditions, the navigability of the Itajaí river and its tributaries. The initial colonial lots had their tests (250m) facing the river and their depths (1000 m) towards the hills. All the urban dynamics took place around the banks of the river, which facilitated access and agricultural production (Siebert, 2009). In the next phase (1880-1914), yields from farming/extractivism and trade were channeled to other activities, especially textiles, that expanded in the later period (1915 to 1946). But, it was in the period after the second war (1947-1986) that industrial activity consolidated in the region (Mattedi, 1994).

The industrial development has brought economic development and consequently, the improvement of people's quality of life. This attracted a large contingent of workers both from nearby areas, and from more distant regions. This industrial contribution guaranteed until the mid-1980s, employment for the majority of local residents (Samagaia, 2010).

But, the 1990s national economic policies opened trade to the international market. Thus, local companies had to adjust to new technologies and new organizational models to cope with the global competition. This generated a dismantling of the textile industry. Then came many small outsourced companies to meet the demand of large companies. This new scenario changed work situation, such as: higher levels of exploitation, ever more flexible ties, a reduction in the jobs supply, wages and, consequently, access to the benefits of urban life. Thus, while the local economy slowly rebounded, the most impoverished populations had been drastically affected in their job opportunities, and being pushed to the outskirts of the city. Illegal occupations on hill slopes and valley, with poor buildings, self-built, without drainage, and with vegetation removal, have increased the vulnerability of populations to socio-environmental disasters. According to Siebert (2009, p. 48), "Socio-economic exclusion led to socio-spatial exclusion, characterizing a socio-environmental crisis". This crisis began with a disordered land occupation in areas considered vulnerable by the geological characteristics, and it consolidated throughout history. In a constant attempt to adapt the natural environment to human needs, people obstructed the waterway and the slopes were destabilized. Siebert (2012, p.7) synthetizes Blumenau's urban reality: "the urbanization model of the city to the present day is based on the occupation and landfill of the valley

bottoms, areas flooded by nature; on the cut of hills for streets and for buildings; on the rectification and piping of watercourses; and on vegetation suppression on the slopes”

Samagaia (2010), in her doctoral thesis analyzed the spatial dimension of poverty in Blumenau. The author identified the city areas today occupied by low-income families. They are located far from the central part of the city,

> "without adequate urban infrastructure, often occupied irregularly (residents do not have a purchase document or, in possession of them, are not properly registered in a notary's office); areas of environmental protection and areas of risk (usually land with great slope or fragile, exposed to landslides); and clandestine subdivisions (landowners sell land illegally, without infrastructure and without recognition of the responsible public bodies) (Samagaia, 2010, p.118).

The author, in his work, overlapped the areas of the city with concentration of poverty and areas of risk. Figure 27 shows in her map, the evident socio-spatial segregation of the city and the occupation of the risk areas by the poor populations.

This is a socio-environmental problem that began with the regional economic crisis of the industry. It was consolidated with the lack of housing policy for the low-income population, and aggravated by the economic policy adopted in a sequence of municipal administrations. Local governments sought to boost the economy by attracting new industries with the supply of land and tax exemption. This attracted more residents to the city in search of employment. The latter, without the financial conditions to establish themselves from the formal real estate market, ended up once again occupying areas of risk (Siebert, 2009).

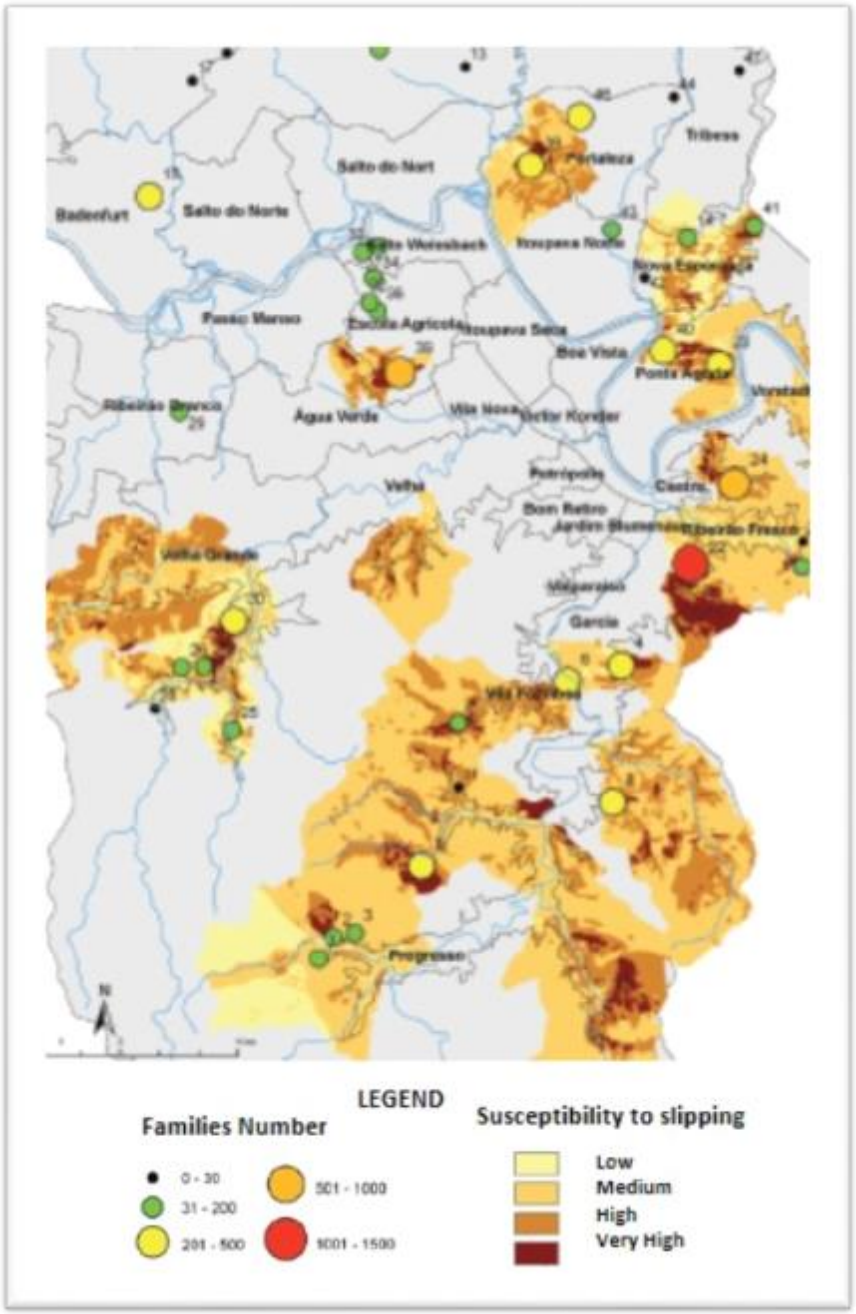

Figure 27: Overlapping of Areas of Poverty Concentration on Risk Areas
Source: Samagaia, 2010, p. 123

7.3.3 Political-institutional framework – from international to local

The international discussions on the balance of man-nature interaction, and on the limits of development began in the mid-1970s with the Stockholm Conference (1972) and Habitat I (UN Conference on Human Settlements, 1976). In 1987, the World Commission on Environment and Development published the Brundtland Report which defined the concept

of sustainable development. In 1990, the Intergovernmental Panel to Climate Change published its first Assessment Report. Two years later (1992), the international community adopted the United Nations Framework Convention on Climate Change (UNFCCC) as the global legal policy framework to reverse trends of changes in climate. In the same year, the II World Conference on Environment and Development, Eco-92, held in Rio de Janeiro consolidated the concept of sustainability with creation of Global Agenda 21. In 1995, linked to the UNFCCC, the first Conference of the Parties (COP) was created, and in 1996, the Habitat Agenda was launched at Habitat II conference in Istanbul.

At the beginning of the 21st century, evident global warming added new themes to the environmental agenda, and in 2000, the United Nations International Strategy for Disaster Reduction (UNISDR) was created. In 2002, the United Nations Conference on Sustainable Development (Rio + 10), was held in Johannesburg. Three years later (2005), the Kyoto Protocol was signed, with the commitment of voluntary reduction by the signatory countries of the greenhouse gases emission reduction. In the same year, the Hyogo Framework for Action on Disaster Risk Reduction of UNISDR was adopted.

In Brazil, the regulatory approach to urban and environmental issues began in the mid-twentieth century. It was a time-consuming and discontinuous process. The Law on Land Parceling (Brasil, 1979) has made an essential contribution to this process because it established the guidelines for creating new subdivisions and guidance for urban sprawl. But, with the 1988 National Constitution (Brasil, 1988), the municipalities became more autonomous over the territorial management. It defined the master plan as the basic instrument of urban policy. Thenceforth, the municipality is responsible for the control of land use and occupation, and it must create conditions for the development of its territory.

However, during those years, there were some setbacks, such as the demise of the National Housing Bank (BNH) in 1986, which generated a housing shortage of more than two decades, and the extinction of the National Department of Works and Sanitation (DNOS) responsible for the design and control of flood dams.

On the other hand, in 1988 the National Civil Defense System (SINDEC) was created (Brasil,1988) and in 1994, the National Civil Defense Council (CNDC) instituted the National Civil Defense Policy (PNDC). In the same year, the Ministry of Regional Integration (MIR) was responsible for some DNOS functions in flood containment. The creation of the Forest Code (Brasil, 1995) was a milestone in environmental regulation, since it established the permanent preservation areas (APPS), corresponding to the river banks, lakes, and lagoons, around hills, steep slopes, mangroves, among others. The Law 9.433 (Brazil, 1997) instituted

the management of water resources by the National Water Resources Policy (PNRH). It establishes the fundamental principles for the planned management of these resources.

The amendment of the Law on Urban Land Parceling (Brasil, 1999) and the Statute of the City (Brasil, 2001) were landmarks for urban development policy of the XXI century. The municipal master plan conditioned the other urbanistic instruments. City and property social functions were recognized, and legalization of irregular settlements was legitimized, thus enabling the land use regularization. In the same year (2001), the Residential Lease Program (PAR) was created to face the enormous deficit of the Brazilian housing deficit. Brazilian Agenda 21 was approved in 2002, and one year later (2003), the Ministry of Cities was created to coordinate public policies related to urbanization. In the same year, this ministry launched the Participatory Master Plan Campaign. It stimulated and guided Municipali Urban Plans for cities with more than 20,000 inhabitants and/or Metropolitan Regions. In the same year, the Ministry of National Integration (MIN) was created, which was subordinated to the National Secretariat of Civil Defense, and n 2005, the National Civil Defense System (SINDEC). Brazil's accession to the Kyoto Protocol resulted in creation of the Inter-Ministerial Committee on Climate Change (2007), and subsequently (2008), the National Plan on Climate Change (PNMC).

In regional context (state of Santa Catarina), disaster management policies began in 1959, with the development by DNOS of a flood containment system for the Itajaí Valley, made up of three dams. The works of the dams occurred between 1964 and 1992. In 1986, after the great floods (1983 and 1984), the Santa Catarina state government signed an international cooperation agreement with the Japan International Cooperation Agency (JICA). They projected a prevention system for the Itajaí River Basin. The project completed in 1988 was severely criticized by the academic community and it was not accepted by the government for lack of financial resources.

With the introduction of DNOS (1990), the flood control system oversaw the Regional Development Secretariat (SDR), and later was managed by the Ministry of Regional Integration (CEOPS, 2016). However, in the 1991-1994 administration, the regional government assumed and elaborated a broad proposal entitled "Global and Integrated Flood Defense Plan - Itajaí-Açu River Basin Ecosystem" (PLADE) with the purpose of obtaining external resources for the works provided by JICA.

Although Agenda 21 of Santa Catarina was completed in 2004, it does not address disasters or climate change, but there are recommendations for land regularization and the creation of housing policies and social inclusion.

In local level, the city of Blumenau, despite its floods history, had its first master plan in 1977, which sought to alter the natural disasters logic. The plan aimed to promote the decentralization of residential buildings, keeping only the commercial use in the center and less intensely in some arteries. Industrial use has remained scattered (Kreutzfeld, 2012).

The 1983 and 1984 floods were essential to a reassessment of disaster management. In the period of city reconstruction, the "Project Crisis" was created by the Regional University of Blumenau (FURB). Coordinated by Professor Beate Frank, the project aimed to develop non-structural measures for flood protection, encompassing time and level monitoring, hydrological forecasting models and flood risk charts (Frank, 1987, Pinheiro et al., 1987, Silva et al., 1988). This project gave rise to one of the most important institutions in flood prevention in the Itajaí River Basin, the Center of Operations of the Alert System (CEOPS, 1984). Its main function was to collect data, make forecasts and serve as a flood warning system. As a result, FURB was responsible for monitoring and forecasting the amount of rainfall and river level at five distinct points in the Basin. Professor Ademar Cordero (Doctor of Hydraulic Engineering from Università Degli Studi di Milano -1996) has been the director and one of the main researchers of the Center since its foundation (Silva, 2015).

In this period, residents and some economic sectors pressured the local administration to promote a reordering of the territory. The first revision of the Master Plan took place in 1989 to solve the challenges related to the last floods due to the occupation of areas of risk and of environmental preservation. This plan drew city growth guidelines in the north direction, but city kept west and south occupation trend. Although several service corridors were created in the main neighborhood penetration routes, to provide access to commerce and services, the city continued to develop in the central zone (Kreutzfeld, 2012).

The Itajaí Committee was established in 1997 as an advisory and deliberative regional body, to promote the management of water resources of the Itajaí River Basin and its tributaries (Frank & Bohn, 2000; Silva, 2015). In the same year, a new master plan revision was carried out. The review continued to induce north and west occupation due to the large availability of urbanization, outside areas susceptible to hydrological events and landslides. To this end, municipallity invested in new bridges and roads building. The development of new sub-centers and service corridors to meet neighborhood needs was not consolidated due to lack of investment (Kreutzfeld, 2012).

The 2006 Master Plan, which followed the participative orientation of the City Statute (2001), was planned to integrate investments, public services, and land occupation. The Blumenau 2050 project was created, addressing five action areas: Land Use; Circulation and

Transportation System; Interventions for Economic, Tourism, and Leisure Development; Housing and Land Regularization; and Sanitation and Environment (Kreutzfeld, 2012).

In this context, in 2006, the municipality started the elaboration of the Municipal Risk Reduction Plan (PMRR). A team composed of Civil Defense and Environmental Research Institute (IPA/FURB) carried out the task. Following the methodology suggested by the Ministry of Cities, in September 2008 fieldwork and technical stage of the plan was completed. During this period, the risk mapping was developed, highlighting 17 city areas that had suffered disasters occurrences between 1973 and 2008 (Silva, 2015).

Until the disaster of 2008, disaster risk management in Blumenau oversaw the civil defense, the fire department, and the municipal government. Between 1973 and 1983, local civil defense was composed of a committee of society people and public institutions. They met and decided at each new event, the local needs. Local directorate of Civil Defense was created by City Hall after 1983 flood. In this way, it was possible to organize records of occurrences of rains, floods and landslides that subsidized the mapping of risk areas. Three levels of risk were defined (high, medium, and low), to evaluate structural or non-structural measures that should be taken.

7.3.4 The history of disasters in Blumenau - SC

The history of Blumenau is marked by successive floods. From the beginning of the colonization in 1850 to 1997, 67 floods occurred, of which 11 events were until the year 1900, 21 in the 50 followed years (1900 to 1950), and 36 in the last 46 years of period (1950 to 1997). According Frank (1997, p. 2), it is observed that the discussion and possible adoption of preventive measures against flooding occurred always in the months or years that followed major flooding, namely 1911, 1927, 1957 and 1983. The floods that occurred shortly after these so-called "big" floods helped to keep alive longer mobilization, and in every post-flood period, there was a greater depth discussion on defense alternatives. But it was from the 2008 disaster that more concrete actions have been put in place. This flooding was not the highest peak (reached 11,52m), but its characteristics, with landslides and muslides showed the greatest consequences to Itajaí Valley.

In Blumenau (292,972 inhabitants), 103,000 people were affected, of which 5,209 were homeless (lost their homes and went to shelters), 25,000 were displaced (encamped in neighboring houses, relatives, or friends), 2,383 were injured or even seriously injured, and 24 died. More than 18,000 houses, 38 health facilities, 61 teaching units, hundreds of kilometers of roads and its pavements were damaged by landslides and floods (Frank and Sevegnani, 2009, p.113)

Figure 28: Bairro Garcia-Nov/2008
Source: Jornal de Santa Catarina

Figure 29: Bairro Progresso – Nov/2008
Source: Jornal de Santa Catarina

The disaster that befell people of Santa Catarina in November 2008, was undoubtedly the motivation for discussions on disasters risks in the country. At the time, expressions such as risk areas, risk mapping, risk management, and vulnerable communities had become part of the discourse of various sectors. (Brazil, 2011, p. 15)

However, in 2011 another major flood hit the city, with the river reaching the level of 13 meters, i.e. the greatest flood of the past 27 years. The rain caused lanslides and flooding in several cities in Santa Catarina. But, according to the Civil Defense, the numbers of affected people were different from 2008. While 60 municipalities have been reached, approximately 500,000 people were affected, and 14 cities have enacted emergency. There was only one death. According to Fraga (2009), the alert system to a flood possibility favored control measures and organization of civil society in the eminence of a disaster. Therefore, it seems that the Itajai Valley is now less vulnerable to major disasters. At least, between the two last events, it seems that their ability to adapt to face major floods, and recover quickly has increased. This may be the result of extensive discussion on disaster risk that settled in Brazil from 2008. But the growing human effort of public institutions to obtain accurate information about the risks, and ways to communicate these risks to the population maked this difference.

7.3.5 The characteristics of 2008 disaster

There is no record of a November with so much rain in the region as observed in 2008, when several historical records were broken. The rain event was characterized by having high intensity and long duration. As show in Figure 30, it is evident that most of the year 2008 the rain was below the expected average. But an anomaly occurred in October and especially in November, when a serie of rainy days occurred. In this month, at least during 6 days

precipitation exceeded 50 mm, while on the 22th and 23th, the daily totals recorded around 250 mm (never happened before), triggered the disaster (Pinheiro and Severo, 2010).

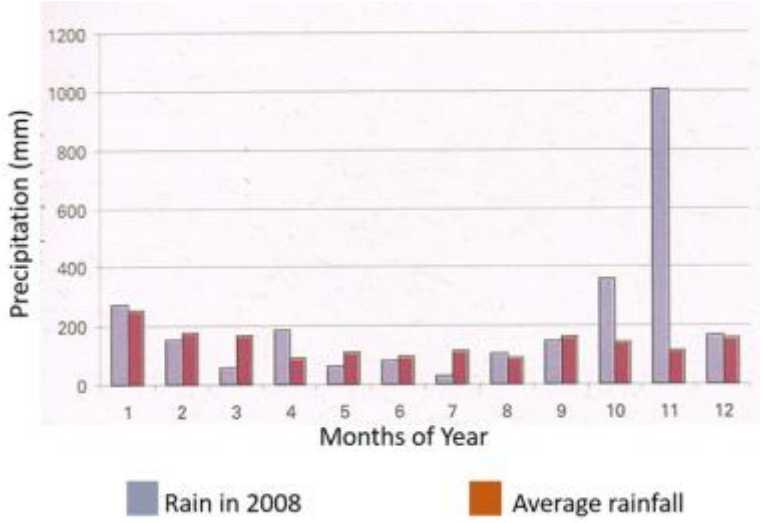

Figure 30: Distribution of the average monthly rainfall and the amounts recorded in 2008 to Blumenau. Source: Environmental Research Institute (IPA) of the Blumenau Regional University (FURB)

The continuous rainfall increased soil moisture, reducing the cohesion and friction thereof. Associated to the geomorphological characteristics of the region, the rain generated surface, and subsurface flows creating deep disabled drainages, and potentiating the slip of the slopes (Pinheiro and Severo, 2010, p.4). The structure of the rock, slope, and soil cover have the greatest interference in landslides, but the rainfall is the trigger of such events (Almound, 2009). However, in this case, a significant interference of human action determined the proportions reached in this disaster. The autonomous occupation of risk areas, without technical expertise to support it, was crucial.

In summary, it can be affirmed that the causes of the regional vulnerability are related to the disorderly occupation of fragile areas as a consequence of a flawed socioeconomic system. Although the area has biophysical characteristics that favor the occurrence of floods, mudslides and landslides, this would not mean by itself a hot spot of natural disasters. It is the presence of man in these areas that makes the occurrence of rainfalls a factor that triggers disasters. In this sense, the social system assumes great importance in the solution of this panorama. Public policies that focus on improving the economic conditions of the population, regulating and controlling land use, and improviding access to safer homes are essential to ensure the safety and well-being of citizens. But, as has been seen previously, it is also necessary to invest in improving the adaptive capacity of the community. Therefore, the next section analyzes what different social agents did in the years following this major disaster to ensure community security and increase their adaptive capacity.

7.4 The contribution of social agents for building the SER of the local community to climate change after 2008.

7.4.1 The evolution of political-institutional framework

The 2008 Disaster in the Itajaí Valley occurred in the light of the Fourth Assessment Report of Climate Change (IPCC, 2007), which confirmed the anthropogenic causes of global warming. The debate on environmental issues incorporated climate change at the World Conference on Environment and Development, which took place in Rio de Janeiro in 2012, known as RIO + 20.

In 2015, at COP 21, the Paris Agreement was signed with the accession of 111 countries, including China and the United States. Signing nations have committed to reducing GHG emissions and expanding carbon sinks to reduce the increasing risks and impacts of climate change. In this agreement, the themes discussed included increasing resilience and adaptive capacity and reducing vulnerabilities to climate change (UN, 2015). In the same year, the Sendai 2015-2030 Framework for Disaster Risk Reduction was signed, highlighting risk prevention, and building resilience. The document outlined guidelines and set goals; proposed a greater articulation between the different scales of actions; and defined the responsibilities of all stakeholders (UNISDR, 2015).

The experience of 2008 disaster, with dimensions never faced in Brazil, evidenced the weak institutional articulation. The national repercussion of the disaster has changed the way governments at all scales (national, state, and local) address natural disasters.

Following the Kyoto Protocol and the National Plan for Climate Change, in Brazil, Federal Law 12,187/2009 was approved, establishing the National Policy on Climate Change (Brasil, 2009). Since then, the country has committed itself to a voluntary reduction of GHG emissions by 36% by 2020. In the same year, the Brazilian Panel on Climate Change (PBMC) has been created to compile national scientific development on climate change; and the Federal Law 11,977/2009 was also approved, which creates the My House My Life Program (Minha Casa Minha Vida - MCMV). This law aimed to financing and producing social housing, and regularize urban settlements.

However, in 2011, a new series of landslides occurred in the Rio de Janeiro, killing 918 people. This was then considered the biggest climate disaster in the country's history and triggered new decisions about reducing the risk of natural disasters. In the same year,

Decree 7,513/2011 created the National Center for Monitoring and Alert of Natural Disasters (Centro Nacional de Monitoramento e Alerta de Desastres Naturais - CEMADEN).

In April 2012, Law No. 12,608/2012 was enacted. It establishes the National Policy for Protection and Civil Defense (Política Nacional de Proteção e Defesa Civil - PNPDEC); System and Council for Civil Protection and Defense (Conselho Nacional de Proteção e Defesa Civil - CONDEC); also, the Brazilian Code of Disasters (Codificação Brasileira de Desastres - COBRADE) was regulated, and the National Plan for Risk Management and Response to Natural Disasters (Plano Nacional de Gestão de Riscos e Resposta a Desastres Naturais) was created. This law guides risk and disaster management policies through prevention, mitigation, preparation, response, and recovery. It establishes: articulated action among all spheres of government; systemic approach; prevention actions; adoption of the hydrographic basin as unit of analysis and; planning based on research and studies and with the participation of civil society. The law specifies inspection and control instruments to avoid buildings in hazardous areas. One of the instruments is the Zoning Code of the Municipal Master Plan linked to the fulfillment of the requirements contained in the Geotechnical Chart of Aptitude for Urbanization (Vieira et al., 2016). Another important aspect to consider is that the Law No. 12,608/2012 amended the Law on the Guidelines and Bases of National Education. As of 2012, the principles of civil defense and protection have become mandatory in the curriculum of elementary education and secondary education (BRAZIL, 2012).

In 2015, Federal Law 13,089 created the Metropolis Statute to regulate metropolitan areas; and the National Plan for Adaptation to Climate Change (Plano Nacional de Adaptação à Mudança de Clima - PNA) was approved.

In the same way, the state of Santa Catarina has also turned its attention to the issue of climate change. In 2009, Santa Catarina state law 14,829 established the State Policy on Climate Change and Sustainable Development, and Law 14.675 established the new Santa Catarina Environmental Code. In 2012, the state prepared the Inventory of Greenhouse Gas Emissions of the Direct and Indirect Public Administration of Santa Catarina. In 2014, the meteorological radar was installed in the Itajai High Valley to monitor the climate of the Central-Eastern region of the State.

At the local level, according Secretary of Citizen's Defense, National Law No. 12,608/2012 that stablished National Plan for Risk Management and Response to Natural Disasters, leads the approach of the municipality to the confrontation of the local climatic disasters. However, after 2008, there was a significant evolution of municipal public policies. New sources of

funding enabled the conclusion of Municipal Risk Reduction Plan (PMRR) by early 2010. The technical data previously collected by Civil Defense served as a basis for the mapping of the Geological Hazard Areas and generated the Geotechnical Charter for Urbanization Aptitude, later required by Decree 9.853 / 2012. The PMRR also served as a basis for the elaboration of the Municipal Plan of Housing of Social Interest (PMHIS) between 2010 and 2012. However, according to Viera et al (2016), this last plan was not incorporated into the daily life of the community.

Complementary Law No. 747 of 2010, established the Environmental Code for the city of Blumenau. With this, environmental education was integrated into the educational programs of local schools, seeking to enhance the critical awareness of the city's environmental and social problems (Chicatto, Vieira, & Bohn, 2015).

The PMRR/Blumenau foresaw a new administrative structure of the Municipal Executive Branch of Blumenau (Complementary Law No. 870/2013). The interviews with representatives of the different departments were essential to understand the approach taken by the municipality in face of events climate change, the structure and extent of actions, the instruments of governance, and the relationships between public power, vulnerable communities, and scientific agencies. Figure 31 shows Municipal structure of Disaster Risk Reduction.

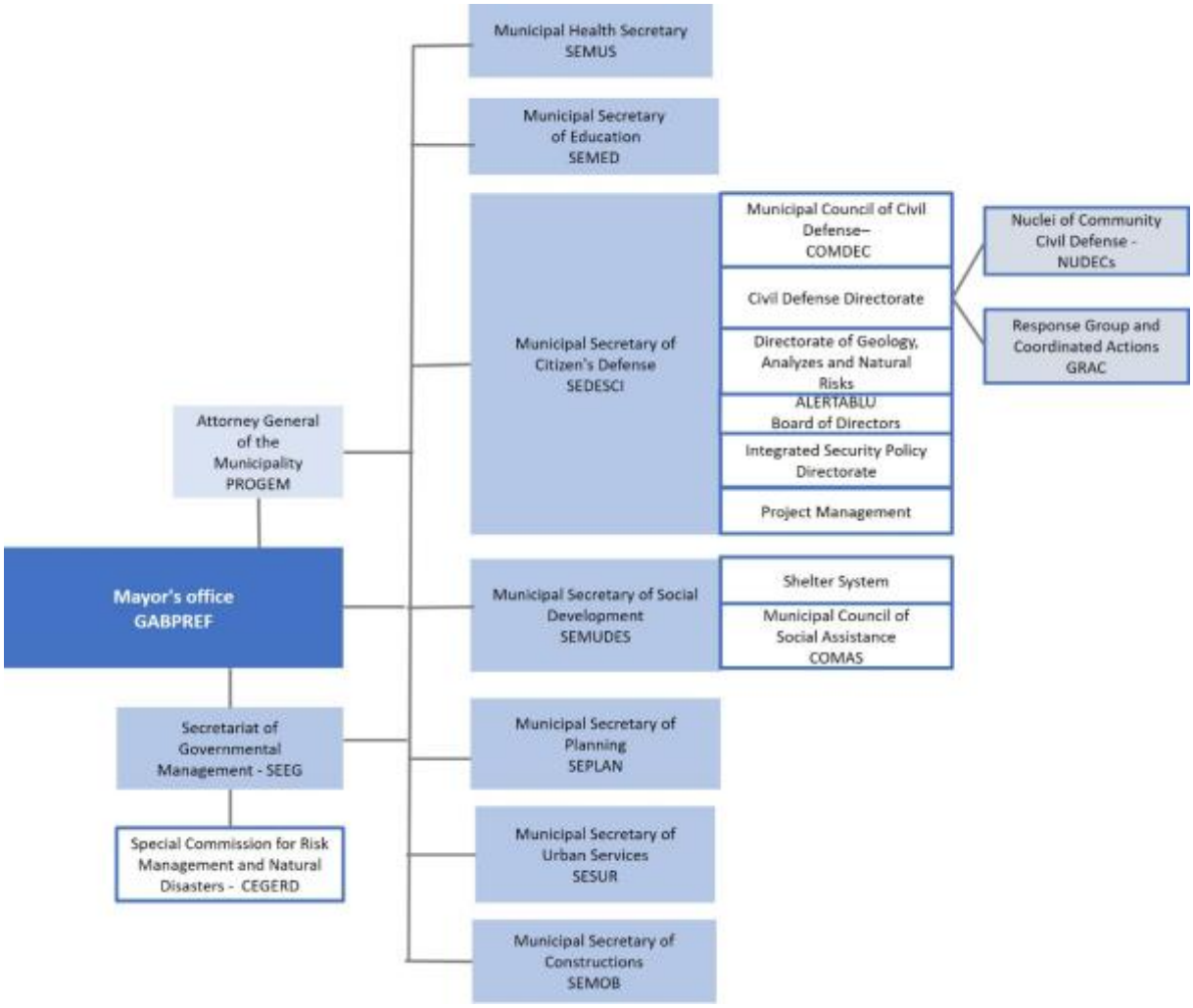

Figure 31: Municipal Structure of Disaster Risk Reduction

Public administration created a Secretariat of Defense of the Citizen (SEDECI), responsible for preparing strategies and guidelines for prevention and permanent protection against natural disasters. It has five board of directors: Directorates of Geology and Analysis and Mapping of Natural Risks; Directorate of Projects; Directorate of Alert System (ALERTABLU); Directorate of Civil Defense; and Directorate of Integrated Security Policies. Municipal Council of Civil Defense (Conselho Municipal de Defesa Civil - COMDEC), Nucleus of Community Civil Defense (Núcleos de Defesa Civil Comunitárias – NUDECs) and Coordinated Responses and Actions Group (Grupo de Respostas e Ações Coordenadas - GRAC) are linked to this secretariat. COMDEC is composed of civil society represented by class entities and by residents' association. It has monthly meetings and aims to: Monitor and identify adverse and abnormal factors can be the subject of disasters; Suggest solutions to prevent the Municipality against abnormal or adverse factors; Recommend or suggest specific and priority measures to the Public Administration to prevent, avoid or remedy

predictable calamities; Organize executive groups of continuous action, permanent or emergency, with a view to the execution of the approved plans and; Suggest objective measures to overcome the scourge.

All actions to reduce disaster risk in Blumenau are determined by the National Risk Reduction Plan (PNRR) and each of the secretariats interviewed has a specific function. Some of them work together. Table 5 shows relationship between municipal secretariat. Table 8 shows the relationship between the municipal secretariat. The secretariats that work together are marked in gray.

	SEDECI	***SEPLAN***	***SEMED***	***SEMUS***	***SESUR***	***PROGEM***	***SEMOB***	***FAEMA***
SEDECI								
SEPLAN								
SEMED								
SEMUS								
SESUR								
PROGEM								
SEMOB								
FAEMA								

Table 8: Relationship between the different Municipal Secretariats

SEDECI coordinates all actions to cope with disasters and works in conjunction with the other secretariats. Its actions are based on: risk analysis and mapping (DGEO[2]); Monitoring, alerting and alarm (AlertaBlu + Ceops[3]); Mechanisms of control and land use (Lei 751/2010[4]); Structural measures (security works); Public information and training (Defesa Civil na Escola[5]; NUDEC's); Preparing for an emergency (Plano de Contingência Inundações e Escorregamentos[6] and GRAC). This secretariat establishes partnerships with external partners such as the JICA Projects (Japan) and 50 Climate Partnerships (Germany).

Currently, all SEDECI action is established by General Guidelines for the Zoning of Susceptibility, Danger and Risk Associated to Geodynamic and Hydrodynamic Processes, Applied to Risk Management and Planning of Soil Use in the Municipality of Blumenau / SC (Blumenau, 2015).

SEMUDES is linked to the Municipal Council of Social Assistance (COMAS), responsible for coordinating the 60 shelters in the city. SEPLAN is responsible for urban policies, urban

[2] Geology Department
[3] CEOPS - Center of Operations of the Alert System of the Regional University of Blumenau (FURB)
[4] Lei 751/2010 - Complementary law establishing the Code of Zoning, Use and Occupation of the Soil in the Municipality of Blumenau
[5] Civil Defense at School Project – Educative project
[6] Contingency Plan - Floods and Landslides

planning, built heritage and inspection. It responds to the Municipal Master Plan (PDM), Land Use and Occupancy Code, and Building Code (under review). SEMUS is responsible for ensuring the supply of drinking water and medicines. SESUR is responsible for urban drainage and SEMOB for the containment of slopes. SEMED is involved in the training of Junior Civil Defense Agents and Disaster Simulation. CEGERD is linked to SEGG which coordinates the other secretariats.

The administrative structure presented before largely reflects the United Nations International Strategy for Disaster Reduction (UNISDR, 2009), but actions are being gradually implemented. Interviews pointed many barriers, especially financial ones, that limit the evolution of actions. One example is the removal of families from at-risk areas. So far, 2000 houses have been demolished and there is a need to demolish another 1500. But the Municipal Housing Plan of Social Interest (PMHIS) requires that all displaced families be included in government housing programs (MCMV) that cannot meet this demand. On the other hand, the projects of new edifications pass first by the Geotechnical Analysis for the Urbanization Aptitude. In case of any risk, the site is inspected by experts, and the measures to be adopted in the construction are defined or, the project is not feasible.

During the interviews, it was possible to identify the concern, mainly by representatives of SEPLAN, with other impacts of climate change, not extreme climatic events. Excessive summer heat is a growing concern. In this sense, the 50 Climate Partnerships Project have actions planned to address the heat islands.

In any case, Blumenau still has a lot to do, both in terms of DRR and in addressing other impacts of climate change. A good point in this process is that public administration is being structured for this.

7.4.2 Actions on disasters risk reduction (DRR) from 2009 to 2015

During the analyzed period, 67 actions of public agencies were found to intermediate knowledge about future scenarios, the expected impacts of climate change, and possible actions to reduce disaster risks. Table 9 present results, classified as publications, audiovisuals, public events, programs and projects, and training courses.

Among other actions, the Secretariat of Civil Defense, in partnership with CEPED/UFSC developed in 2010, a documentary of 77 minutes named: "Perception of risk: the discovery of a new vision". The video is the final product of an educational campaign developed between 2008-2009, in partnership with DEDC/SC. The goal of the campaign was to promote a culture of disaster prevention. Statewide, the campaign involved state public schools in

Santa Catarina, including the city of Blumenau, which received the educational material produced. Educational material and video are still available on the campaign website[7]. Some more significant actions are described below. The complete list is in APPENDIX V.

Type of action /Year	2009	2010	2011	2012	2013	2014	2015	Total
Publications	1	3	1	1	1	0	0	**7**
Audiovisuals	0	1	0	1	0	0	0	**2**
Public Events	2	4	9	4	5	4	7	**35**
Projects and programs	1	3	2	0	1	1	3	**11**
Training Courses	0	3	0	2	1	4	2	**12**
Total of Actions	**4**	**14**	**12**	**8**	**8**	**9**	**12**	**67**

Table 9: Actions of Knowledge Brokerage on DRR

In this period, Blumenau joined some international programs. One of them (2011-2012) was the International Strategy for Disaster Reduction Campaign (ISDR), a UN-linked entity. The campaign focused on the growing urbanization of the world and the problems of a disordered occupation, in opposition to the need to foresee risks and to create adaptation and coping tools for the construction of safer cities (United Nations, 2012). It had three lines of action:

- Communicate good practices and innovative experiences
- Undertake public activities
- Undertake risk management activities

In 2010, in agreement with the Government of the State of Santa Catarina, Japan International Cooperation Agency (JICA) was responsible for the “JICA Project” (2010-2012). It consisted of elaboration of the Project for Disaster Prevention and Mitigating Measures for the Itajaí River Basin; And from 2013, in agreement with the Brazilian Cooperation Agency (ABC), it was responsible for the Project to Strengthen the National Strategy for Integrated Management of Natural Disaster Risk (GIDES). Blumenau was chosen as one of the pilot cities for the project that aims to formulate strategies for risk assessment, urban expansion planning, prevention, recovery, and reconstruction of risk areas in Brazil.

Moreover, the City of Blumenau, signed a Memorandum of Understanding with Global Engagement to facilitate the exchange of experiences with its German partner city Weingarten (State of Baden-Württemberg). The "50 Municipal Partnerships for Climate Project” was initiated in the second half of 2015 and may have continuous action until the year 2018. This project addresses the themes of mitigation and adaptation to climate change with the objective of creating joint actions. Short-term workshops and missions of specialists

[7] http://www.ceped.ufsc.br/percepcao-de-risco-a-descoberta-de-um-novo-olhar/

will be developed (Dialog Global, 2014). As part of this project, Blumenau proposed to carry out environmental education actions, raise awareness in solid waste, use efficient and sustainable of resources in public institutions, and propose mitigation through the creation of the Energy Agency of the Valley.

Likewise, in 2010, FURB conducted a JICA-funded course called Multipliers in Mapping and Risk Management. It aimed at university professors, masters, doctors, and professionals related to the risk of natural disasters, the course discussed the conceptual and methodological foundations of risk management; the destructive processes in the Itajaí Valley, and the event of November 2008; mapping models of risk areas; general aspects associated with floods, landslides, and related processes; slope stability; and preventive plans for civil defense.

Another important initiative was the creation in 2012 of the Permanent Forum on Disaster Prevention in the Itajaí Basin as an attempt to integrate municipal, state, and civil society. Since then, it has been held twice a year and aims to bring together public and private organizations around the risk reduction of natural disasters, promoting a common basis for the definition and implementation of a permanent, guiding, and regulatory public policy.

In 2012, the Municipal Council of Civil Defense coordinated the presentation of ideas and the viability of actions with municipal education students in partnership with the Secretariat of Education and the Integrated Projects Council of the Municipality of Blumenau. From there came the programs of Civil Defense in the Schools and Junior Civil Defense Agents. The Civil Defense in Schools Program had great acceptance by the community and a gradual adhesion of public and private schools of the municipality. By 2015, it involved 10 schools each year. The activities were divided into four modules: 1) Basic Concepts of Civil Defense; 2) Perception of Risk; 3) Disaster; 4) Closing activities involving an exhibition and games. As support to the program, Civil Defense has developed and distributed a set of illustrated booklets covering various disaster risk topics (Chicatto et al., 2015).

The training of a group of Junior Civil Defense Agents aims to strengthen prevention and sustainability in the neighborhood, reducing the risks and vulnerability of children and adolescents, emergencies, and disasters. By 2015, the program involved four municipal schools in high-risk areas and trained 20 students in each. The students had two hours/class every 15 days, with theoretical and practical lessons. The program hopes to change the culture in communities as it multiplies knowledge and guides the community about prevention behaviors, risk factors, and personal, property, social and environmental damages reduction (Chicatto et al., 2015).

7.4.3 Formal knowledge production

Data collection on scientific production showed that the FURB has 13 research groups in different areas of knowledge with 31 research lines that can address social, environmental, technological, economic, or political issues related to the impacts of climate change, climate variability, and extreme climate events.

The results point out 104 researchers and 69 students involved in these investigations. APPENDIX VI shows a table with detailed results by area of knowledge. Contact with investigators via email was not satisfactory.

The search for scientific publications in GOOGLE Scholar involved the key words "Blumenau", "Risk", "Disasters" and “Climate Change”, and presented 134 finding. 58 scientific published works were identified in the period from 2009 to 2015: 4 doctoral theses, 9 Dissertations, 20 papers presented at conferences and 29 articles in scientific journals. The themes involve the analysis of public policies for risk management, biophysical aspects of risks, social-cultural aspects of the disaster, risk communication and risk perception. Some researchers are widely known in national scientific community, and even before the disaster they develop work on this subject. This is the case of Beate Frank, Lúcia Sevignani, Marcos Antônio Mattedi, Sandra Irene Momm, Cláudia Siebert, Rafaela Vieira, Noemia Bohn, Adilson Pinheiro, Ademar Cordeiro, Juarez José Aumond, Mário Tachini, Lauro Eduardo Bacca, and Dirceu Luís Severo, among others. Some academic works developed on the theme of the 2008 disaster provided subsidies for this investigation (Avila, 2015; Kreutzfeld, 2012; Samagaia, 2010; Santos, 2012; Silva, 2013).

Another approach of FURB is community extension programs (APPENDIX VII). Programs occur in four distinct and essential areas for building resilience: Environment, social communication, architecture and urbanism, and legal and social assistance. The communities recognize the importance of these programs and they want integrate actions promoted by FURB. They point out the need to approximate scientific knowledge to promote the increase of local knowledge and call for the expansion of these programs.

At the national level, publications related to climate change and their implications in various sectors of society and regions of the country. In May 2016, the Ministry of the Environment published the National Plan for Adaptation to Climate Change (PNAMC), but this theme has not yet been reflected in publications of scientific research developed by the groups surveyed.

7.4.4 Perception of the community regarding the implementation of public policies of Climate Change

The interviews with the ten associations of residents show the aware of people on changes in the climate, especially the changes in the period and the characteristics of the seasons. According the representative of Belo Horizonte resident´s association “the weather is coming out of the system. Last year did not have winter, and this year gave winter out of season, the autumn that was meant to be milder, was that winter cold”. In the same way, the representative of Ina Valparaíso’s Residents Association said: “I'm 70 years old, but the same cold now I had never seen. And the heat of the last year is only over now”. For them, the seasons are summing up to two: winter and summer, with colder winters and warmer summers. They also point out that the summers are getting drier and the rains are more concentrated in the spring.

All interviewees believe that this situation will worsen in the future. One of them said: “I'm almost sure it will get worse, because the man is no longer respecting nature, it's a lot of deforestation, a lot of river pollution, that help destabilize the climate” (AMBH).

They point out as the main concern the health of the population. The clear majority highlight respiratory problems arising from air pollution and some still show concern for vector-related diseases such as *Aedes Aegypti*. The main complaints are: the lack of sewage treatment, the pollution of the streams, and the lack of systematic collection of solid waste.

For them, there are lack of public awareness of environmental problems, and there is no interest on the part of the government in improving public infrastructure, such as basic sanitation and waste. “It is the community that throws garbage where it should not be thrown, deforest where it should not be cleared, builds where it should not be built, does not respect anything, then the contribution is directly from the humans” (AMLH). In a way, the interviewees perceived an evolution in the understanding of what is an area of risk of mudslides. Since the 2008 disaster, many civil defense actions occured in these areas, and losses, damages, and deaths have been responsible for raising awareness of risk areas. One respondent reported the remmoved by civil defense of many families from these areas, but according him in his community at least 30 people returned. Respondents demonstrated an interest in learning more about climate change, and they see the need for specific mechanisms targeted towards the general population to increase knowledge on climate change. The respondent of “AMME” said: “I think (knowledge) is very important, because we need to learn how to live with these adversities, such as floods and landslides”, and the

interviewed of “AMIV” said: “I think that awareness is a fundamental point, but it has to reach people”.

They pointed out that, as responsible for resident associations, they are often called to attend meetings, but these meetings were never related to climate change and adaptation. The lack of a simpler guideline of government agencies makes it difficult to understand the issues. During the recovery of the 2008 disaster, civil defense revived many enlightenment meetings with the population, but they had difficulties in conveying to people what had been discussed at higher scales. For them, lectures and events related to the theme should be directed to the community. They emphasize the actions of environmental education as essential, although the main concern shown by most respondents is the collection of solid waste and sewage.

Most of the interviewees pointed the municipal administration, Civil Defense, and the Environment Foundation (FAEMA) as responsible for addressing issues and promoting knowledge about climate change in the community, however some also mention FURB (local university). The interviewed of “AMME” suggested: "Through the schools, to make a Saturday of interaction, to make dynamics …to be learning and to be able to help in the future". The interviewees do not see themselves as channels of knowledge exchange in this area. They acknowledge the lack of knowledge and capacity for this task.

The lack of interest of the governors and councilors, who must have direct contact with the population that elected them, the lack of communication and the lack of answers are pointed out as great difficulties. The head of AMLH said: "We are very ill informed. Why does not anyone give us a booklet?" The head of AMHS said, "I think the neighborhood counselor would be the right person to help us." He would point out institutions that could help with those jobs on the street, on land, on riverbanks, in preservation areas ".

For some, people's low literacy makes them powerless to claim clear positions from government agencies. They complain about lack of information through the mainstream media such as open television channels and the internet. While acknowledging the high popularity of mobile phones, access to social networks is hampered in some places by the lack of internet and even telephone signal. For them, the simplest way to reach the population would be through educational programs on television.

Most respondents feel that their role in the residents' association is to check what is right and wrong in their community. They complain about the lack of supervision regarding deforestation, or the garbage dump on the slopes and riverbed.

For many, there is still no awareness of the need for educational programs aimed at vulnerable communities. Some projects as a "junior civil defense agent" have not yet reached

significant reach and need to be expanded. Most interviewees emphasized the good performance of local government in post-disaster recovery actions, but these actions lasted a few months. They underscored the need to maintain certain stocks throughout the year.

Interviews with representatives of the only two active NUDECs (Coripós and Nova Esperança) showed two different realities. The representative of NC is also the chairman of the Residents' Association (AMC), member of the Solidarity Nucleus of Civil Defense (NSDC) organized by Local Rotary Club and FURB. In this way, local community had access to some financing and specialized guidelines that made possible practice improvements, like the construction of a playground. The NC works mainly in waste collection and street cleaning. According to him, community involvement in collective activities is not satisfactory. The participants are always the same. As an example, he cited the first community activity: the first aid training promoted by the fire brigade. Since this same activity had already occurred in companies where people work, they were discouraged to participate. The main barriers pointed out by to broaden the Nudecs' performance refer to the lack of will to act of the populations and the lack of involvement of the public power in the community actions.

On the other hand, the NNE is more active. Its representative considers a good partnership with the Civil Defense and the Municipal Secretary of Works (SEMOB). The main focus of action of this Nudec is the collection and treatment of waste. Community got by local government a small vehicle to facilitate waste collection in areas where the access is very difficult. In addition, a group of volunteers acts in the waste separation for recycling. Used cooking oil is also collected and processed in soap, and is distributed free to the community. Typically, older people act in this activity. The NNE is responsible for coordinating work with a local shelter for homeless, for which they have received special Civil Defense training. In addition, a group of junior civil defense agents (between 15 and 20 students) operate on site. They assist in practical actions such as a fire simulation that was performed at school. Prior to this event, civil defense held talks for the community. Residents, students, parents, teachers, and church members participated in the activity. For the interviewee, some progress has been made in population safety and awareness of the areas at risk. But he stresses the need to create recreational spaces for young people, because after the disaster of 2008, many young drug users have emerged.

7.5 Assessment of Blumenau´s social capacity to build SER to extreme climatic events

The set of information collected in this investigation enabled the assessment of Blumenau's social capacity to build SER to extreme climate events. This evaluation was carried out jointly

with five FURB researchers who develop investigations into environmental themes. Some of them have also been involved in urban planning, disaster risk management and city's alert system operations center. The situation of Blumenau regarding the risks of disasters related to floods and landslides was discussed.

As it was previously identified, Blumenau follows an approach towards disaster risk reduction. Therefore, the analysis considered only the occurrence of extreme climatic events with local impacts related to floods and landslides. However, the proposed framework aims a broader analysis with a focus on transformative adaptation. In this sense, it would be interesting to apply it to the three levels of interventions: adaptation, mitigation, and disaster risk reduction.

The Figure 42 presents the Blumenau´s Wheel of Social Capacity Assessment for Building SER to climate change. Visually, it is possible to perceive a centalized governance model, a little participatory decision-making process, and weak stakeholder engagement in planning processes.

On the other hand, there is a clear development of specialized knowledge on the theme of disaster risk reduction, and an effort by some community segments to find new solutions to the challenges they face.

The compilation of the results obtained in the evaluation of each enabler from the group discussions is presented below. Thus, it was possible to identify how Blumenau has addressed the issue of hydrometeorological disasters, and what paths can be taken to improve their adaptive capacity and expand SER to climate change. After analyzing each set of enablers, a brief discussion is presented.

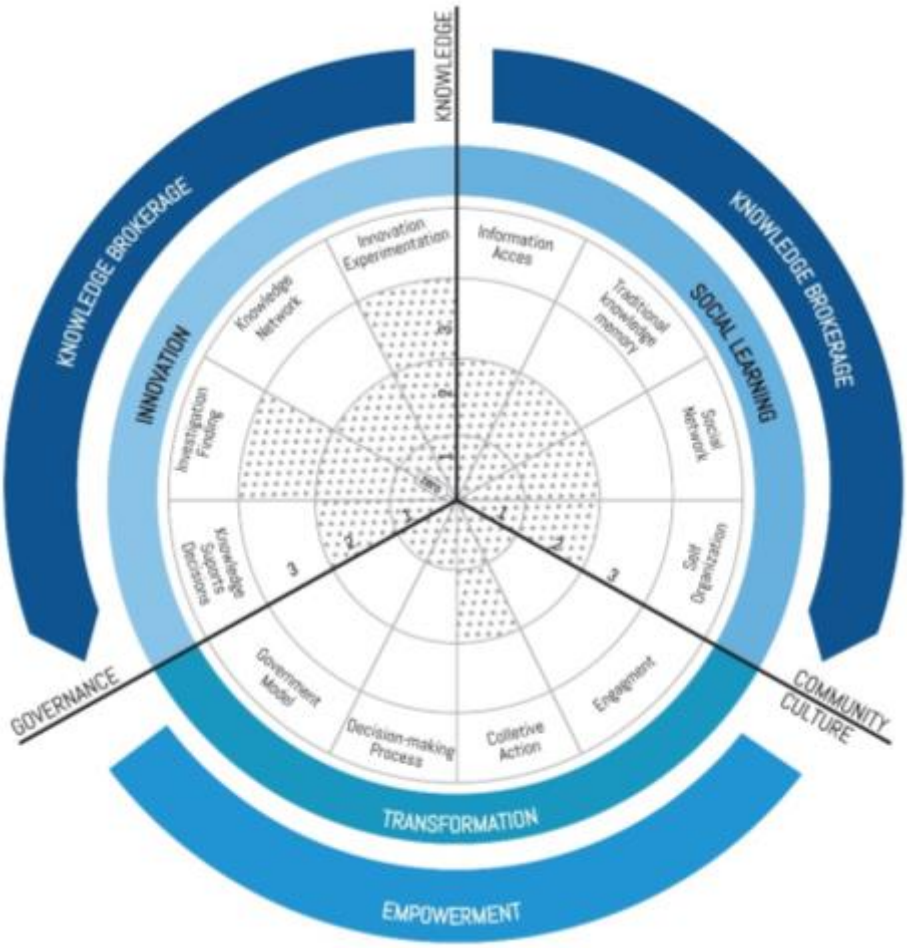

Figure 32: Blumenau´s Wheel of Social Capacity Assessment for build SER

7.5.1 Enablers of social learning:

Information Access: In analyzing whether the population has access to scientifically based information, it was noticed that AlertaBlu (extreme event monitoring and alerting system) is one of the most important mechanisms used for disseminating specialized information. CEOPS is responsible to provide the data. The system consists of a website and a mobile phone application. It contains a wide range of information, from weather forecasts, weather history, river levels, flood quotas, maps with landslide risk areas, tips on how to identify areas at risk, location of shelters in case of an event, and volunteer application form. During community interviews, people cited another mechanism of knowledge brokerage used after 2008: trainings and lectures regularly conducted by big companies to their employees. This is reflected in the daily experience. It is common to talk to anyone, like the cashier at the supermarket, and he knows the amount of flood that one should have attention to, what to do in a disaster, and how he can help the community in case of an hidrometheorological event.

However, there is no mass media or printed media program to disseminate information in order to increase the population's knowledge. This was one of the complaints made by representatives of the communities. Therefore, although AlertaBlu is a strong mechanism of knowledge brokerage, it is limited to those who have access to the internet. The lack of specialized information programs in the mass media makes the evaluation of this item considered at the intermediate level (2).

Local Knowledge: The valorization of local knowledge by the community was evaluated at an intermediate level (2). Blumenau has disaster rooted in its culture, and there is much historical material about past disasters. With each new event, the media promotes story-saving sessions and people discuss their past experiences. The historical archive of the city has photos, movies, newspaper articles and magazines, as well as books on the subject. When talking to people in the community, someone will always tell you about their past experiences and recalls some important attitudes toward dealing with disasters, such as the best commuting routes, or the most important supplies to have at home. Recently, some groups on social networks have created pages that address historical aspects of the city. As example are the Facebook groups: "Blumenau in the old days", “Blumenau and its history”, and “Blumenau Historical Collection”. This further increase in the community the memory of local knowledge. However, in the evaluation of this question, it was considered that there are no mechanisms that guarantee the integration of local knowledge in the formulation of public policies, since there are still possibilities to be explored in this sense, this enabler received an intermediate level evaluation (2).

Social Network: In assessing the use of social networks as a form of knowledge brokerage, it was verified that local institutions have used social networking services for prevention, warning, and recovery from extreme weather events. People can also subscribe to AlertaBlu to receive information via SMS or social networks. Interviews with residents pointed to social networks as the main means of communication today. Several groups use social networks to expose ideas and broaden collective consciousness. As example, are “Urban Acupuncture of Blumenau”, “Urban Sinergy”, and “Collective Blumenau”. However, this resource is not yet systematically exploited to increase community awareness of its climate challenges and ways to reduce its vulnerabilities. As such, Blumenau could strategically use social networks to prepare the community for climate change and its future consequences. Therefore, this item was evaluated at an intermediate level (2)

Self-organization: Community has some well-structured mechanisms of self-organization to face crisis situations. It has developed through various experiences, a series of autonomous

coping mechanisms. Each institution, such as churches, clubs, and associations already act in specific directions in case of an extreme event. As an example, the radio amateur club assists in communication between different locations in the city and with other cities. Motorcycle and jeep clubs access isolated areas to bring food and water, or rescue people. Churches and associations are responsible for collecting donations of food and clothing for shelters. There are groups of volunteers who provide social assistance to disaster victims, and others who are responsible for supporting reconstruction. In the last few years, some urban collectives emerged to broaden the community collective conscience, and pressure local government to meet their needs and desires. These collectives use social networks as a form of expression and often organize public demonstrations. In the last months, community discussed the construction of a new bridge over the river Itajaí. After many studies carried out by the Research and Urban Planning Institute of Blumenau (IPPUB), its location. The decision was confirmed in 2011 by the Urban Planning Council (Urban Planning Council-COPLAN) and the project was included in the Inter-American Development Bank's Mobility Program. A public tender with a jury formed by 19 representative entities of the society selected the project. But in a political decision, the current administration decided to change the location and design of the bridge by ignoring the studies of the road network, previous environmental, urban, and historical impacts. Thus, the local nucleus of the Institute of Architects of Brazil began the campaign "Bridge in Right Place". Its aim was make the government give upto build the new bridge in the center of the city, in the curve of the river Itajaí-Açu, a sensitive place of the historical point of view, geological, hydrological, and urban. Among many arguments, the opinion of experts on the effect of the pillars located in the curve of the river stands out. According to them, this interferes with the flow of water, bringing impacts such as increasing flood level and changing river flow velocity. A popular court action has halted the construction bidding process and the community expects a further discussion on the issue. In evaluating self-organization, the community's capacity to organize itself to find solutions appropriate to its needs was taken into account. This aspect was evaluated as level (2).

From these evaluation, it is possible to identify that Blumenau developed several forms of social learning. And this is reflected in new positions of the community in search of better ways to face their challenges. However, interviews with community representatives revealed that the opportunities created do not always reach who most need. This may happen due to the discontinuity of educational actions that were intensified soon after the 2008 disaster, and gradually weakened. In this sense, it is important to verify how advances in this area can be strategically targeted to reach the most vulnerable community.

7.5.2 Enablers of innovation:

Investigation and experimentation: Local research institutions carry out extensive research on the subject in different scientific areas, aiming at practical application to the community. Local scholars are focused on the understanding of the different dynamics of disasters, biophysical, urban, and sociopolitical issues involved in the causes, finding technical solutions to prevent and mitigate new disasters, discuss public policies, civil defense actions, social assistance to victims, and community perceptions of disaster risks. FURB has a tradition in directing its research to local issues and acting extensively with the community. The investigations developed by its researchers cover a variety of topics related to extreme weather events. Among the many examples, researchers such as Professors Ademar Cordeiro and Dirceu Severo (CEOPS) developed their own meteorological models for weather forecasting. In critical situations, different models are applied and confronted to ensure greater predictive effectiveness. And this methodology has helped the community to make important decisions, especially in the confirmation of major events such as Oktoberfest, which involve the entire community in times of heavy rainfall. Currently, FURB, through the Masters in Environmental Engineering (GEAMBH), the Master's Degree in Science and Mathematics Education, and the Research Group in Computer Graphics, Image Processing and Digital Entertainment, in partnership with several other institutions such as CAPES, Water Nacional Agency (ANA), and the Ministry of the Environment, is committed to develop a project to provide educational material of an interdisciplinary nature that enables the formation of students of Elementary and High School. The project called "Interactive Sandbox: understanding water out of the box" uses increased virtual reality to stimulate understanding of the water theme and its multiple dimensions. The educational material will be composed of virtual and augmented reality software with features of gamification, and an electronic book (e-book), composed of texts and videos, that will guide the student in carrying out the activities. It is intended to simulate in a conceptual way the different situations of a Permanent Preservation Area (APP) of a portion of the city (http://caixae-agua.blogspot.com.br/). Therefore, in the evaluation of research and experimentation, Blumenau fulliy contemplates this enabler (3).

Knowledge Network: Community usually establishes agreements with local and/or external knowledge agencies to address specific problems in a structured and planned manner. The community maintains several agreements with external institutions, such as: CEPED / UFSC, responsible for the Integrated Disaster Information System; INPE and Epagri, responsible for the generation of climatic scenarios for the three states of southern Brazil; Japan

International Cooperation Agency (JICA), responsible for flood mitigation projects; Brazilian Cooperation Agency (ABC), as pilot city for the Project to Strengthen the National Strategy for Integrated Management of Natural Disaster Risk (GIDES); and SKEW in cooperation with the Agenda 21 Working Group in the State of North Rhine-Westphalia (LAG 21 NRW) responsible for the "50 Municipal Partnerships for Climate Project". Even so, due political issues, according local researchers, the municipality does not exploit the full potential of integration between the university and local government. Therefore, as far as knowledge networks are concerned, this enabler was evaluated as an intermediary level (2).

Funding to investigation: Community captures resources from different national and international development agencies, integrating efforts to develop new solutions to their challenges. The municipality has become a reference in the search for better solutions for the reduction of disaster risks. In this way, local institutions have acquired the credibility to raise investment funds for new research. Local institutions are constantly participating in joint projects with external institutions, and with this, they enable their research projects. But at the national level, investment in research is undergoing an unprecedented crisis, which has been reflected in local research. However, there are significant efforts to attract external funding, such as the "50 Climate Partnerships Project", which brought to the city investments of around 800 thousand Euros, which are being invested in research and practical actions related to environmental education focused on disaster reduction, waste treatment and heat island decline. In November 2016, authorities from Blumenau, representatives of Civil Defense, Geology and International Relations went to Germany in search of a new partner for the Climate Change Mitigation and Adaptation Program. This program was developed by the City Hall and its partners: FURB, UFSC, Uniasselvi, the Urban Acupuncture Collective, the Brazil-Germany Chamber of Commerce and Industry of Santa Catarina, the Ministry of Foreign Affairs, the Chico Mendes Institute for Biodiversity Conservation, and Business Association of Blumenau (Acib). Therefore, considering the Brazilian reality of research funding, Blumenau fully contemplates the enabler (3).

Knowledge supporting decisions: Local government calls external experts to support timely technical decisions. He has invested in the expansion and improvement of his staff, hiring some specialized professionals in the themes pertinent to his needs, and created departments with specific technical functions, as is the case of Directorates of Geology and Analysis and Mapping of Natural Risks. It also received outside technicians for specific projects such as JICA, which was financed by state resources from Santa Catarina. However, according to local researchers, there is still some resistance from the government to seek new knowledge from the local university. In many situations, experts stand in the

opposite direction of government decisions and they are not heard. The most recent case is the change in the location of the new bridge which, despite many contrary statements by experts, still follows political guidelines. Another example reported in the discussions refers to the flood containment project carried out by JICA that did not take local knowledge into account when analyzing the area. In the view of the community and the experts of the Itaja Committee, the proposed project would have disastrous consequences for one of the communities of one of the tributaries of the river. This issue had to be resolved in court, which gave reason to the community and local experts. Thus, it was considered that Blumenau contemplates this enabler in an intermediary level (2).

The evaluation of this set of enablers shows the great potential of innovation of the local community. This is largely due to the solid body of Furb researchers who have invested in researches reallocated to the local reality, and the ability the community has acquired in seeking sources of funding for these researches. However, a difficulty has been identified in integrating locally produced scientific knowledge with governance mechanisms, that find the means to seek support from international researchers for local researchers. This issue has a political bias, and often ends up bringing solutions that are not appropriate to the local reality, because external experts lack the experience of the problem in its particularities, which are only perceived by those who closely follow the situation.

7.5.3 Enablers of transformation:

Engagement: For some specific themes, there are instrumental mechanisms of engagement, where representatives of local institutions and the community participate in an advisory way to formulation of public policies. An example is the participative budget (PB), which, although institutionalized since 1997, still presents a mismatch between the idea of PB and effective adherence to this policy as guiding government initiatives. According to Moura (2007), this was reflected in the lack of investment of financial resources, in the creation of tension between local representatives, and in the weakening and disrespect of the program among the population. On the other hand, Blumenau has adopted in its last revisions, the concept of Participative Master Plan, where the Planning Secretary's technicians discuss with representative entities of the community new ways of thinking about the city. Roundtables, workshops, and lectures have been developed since 2015 for a new revision of the plan. But it is observed that the engagement of stakeholders occurs due to the interests of specific groups or administrative responsibilities. The community does not participate because it does not consider itself with a voice to defend its interests and needs. Therefore, the development of this enabler was considered at an incipient level (1).

Collective action: Public power institutionalized some joint actions with the community, especially in the stages of preparation, coping and recovery of extreme events. It is usually the civil defense that makes this connection, performing various simulated actions in schools and vulnerable neighborhoods. The community is receptive to collective actions with clear objectives and defined coordination. Fire simulation, flooding and slope slip actions were successful, as well as clearing of hills and streams. However, other structured manifestations that rely on local government collaboration are still incipient. In any case, the community has a history of collective action that comes from the times of colonization, with collective financing, the creation of cooperatives, and in the organization of popular celebrations with assistance objectives. Oktoberfest is an example. The party was organized after the flood of 1983 to motivate people to develop the collective spirit and raise funds for the reconstruction of the city. This celebration takes place annually for 15 days of the year, with the involvement of the whole community. Today, this collective spirit is still present. It is increasingly evident the insertion of the collectives (cited above) into practical actions to transform the city. Increasingly people are engaging in these activities, widely recognized by the local community. However, engaging people in collective actions is largely linked to specific public actions, or to events promoted by associations and organized groups. In this way, the development of this enabler was considered at an intermediary level (2).

Participative decision-making process: Local government decisions are made primarily from needs and priorities raised by administrative technicians. Some are the opportunities for community participation, but the public consultation regarding the prioritization of actions is summarized. Slowly, by pressure from the community itself, new opportunities for participation are opening up, but they focus on more representative groups in the community, such as revisions of the master plan. Episodes of contestation has marked the community, which manifests itself from protests to try to be heard. This occurred, among other things, with the recovery project on the left bank of the Itajaí River, with the removal of trees on the banks of the River, and recently with the relocation of the new bridge. There is still a lot of resistance on the part of the local government for participatory deliberative processes. Community claims for more opportunities of participation. Recently, a social network (Minha Blumenau - https://www.minhablumenau.org.br/) was created for building more participatory processes in the decision making and public interest of the city. Therefore, Blumenau minimally contemplates this enabler, and its level of devevopment was considered incipient (1).

Descentrilized governance model: The governance model adopted in Blumenau concentrates power within the government's own administrative structure. Although some

government bodies have limited technical autonomy, major decisions are concentrated in the central public administration, and they are often driven by political and/or financial issues. There is some representation of different sectors of society and public and private institutions in the composition of some structures for the reduction of disaster risks, but even so, the decisions are basically focused on the mayor and his advisers. Therefore, the development of this enabler was considered at an incipient level (1).

The evaluation of this set of enablers shows a political-institutional resistance in enabling the community to participate more actively in the planning and implementation of public policies. This situation is widely disseminated in the Brazilian reality. Few communities have this right. The limitation in the level of involvement of different stakeholders in decision-making processes decreases government reliability and interferes with the willingness of the population to engage and becomes a vicious cycle. A change of attitude on the part of the community can reverse this situation, and some segments of local society are acting in this direction. Likewise, a political will is required to change this situation, and so far, unsustainable public administrations have shown no willingness to do so.

7.6 Synthesis

The results of the survey showed that Blumenau clearly adopted a risk reduction approach to dealing with extreme weather events. The concern is no longer focused solely on floods that have always hit the city. Its focus is on mudslides and landslides, whose events have grown in recent years and caused damage to the population and loss of life.

The city has been structured in this direction and several stakeholders are involved in the process. There is a line of action based on the guidelines of international organizations, with a large part of the actions aimed at disaster and recovery. Preventive actions have been limited to biophysical aspects and the creation of a database that supports future interventions, as the geological map of areas susceptible to landslides. Heavier interventions (dams) have been implemented with federal funding as a form of disaster prevention and mitigation.

There is a timid attempt by the community to engage in prevention process. This is due to the discontinuity of some programs, either for lack of institutional support, skilled people, or financing. Even so, the involvement of children in environmental education is expanding.

People generally perceive climate changes but do not relate floods to them. They are aware that much has already been done in this direction. Communities vulnerable to floods and landslides are aware of the risks they are experiencing, but they show little interest in

participating in prevention actions. In many cases, people are unaware of local government actions, and they feel a lack of public action.

There is a gap between the actions of the local government, the vulnerable communities, and the scientific body. So far, a greater approximation of local administration with international institutions than with local scientific institutions has occurring for exchange of technology and knowledge. The performance of FURB scholars is focused on scientific production without direct link with local power. Even so, some actions are carried out with vulnerable communities, especially through community outreach projects. The population perceives this gap, since they point to a lack of political will and opportunities for access to knowledge as barriers for the community to acquire skills to adapt.

Closer links between community, scientific body and public power are widely desired by both experts and the local community. However, successive public administrations have made no effort in this direction. Quite the opposite. Many projects that approached some agentes in one administration, were discontinued in the next. An example is the creation and subsequent disarticulation of the NUDECs, the community civil defense nuclei. This initiative is part of the national policy of civil defense, and aims to bring the community closer to the public power. Its main objective is to increase community knowledge and promote collective action in vulnerable areas. After 2008 disaster, seven Nudecs were established in Blumenau. At first, there was good public support. Information and training activities were developed. But, with the substitution of the responsible for the articulation of the rapprochement between the community and the public power, interests have changed and trust between the different actors has been lost. Thus, the project lost its strength, and five of the seven cores collapsed. With a simple political decision, the community missed a great opportunity to increase their knowledge, strengthen their ties and have the strength to fight with the public power for their needs.

On the other hand, it was possible to identify situations that prove the importance of a good governance to promote action sharing as a way to transform behaviors, generate new actions and increase resilience. An example is the case reported by Dr. Maurício Pozzobon in his experience as Director of Geology at the secretary of defense of the Citizen. Morro Coripós has always been vulnerable to landslides. Being located near the center of the city, the area was continually targeted by irregular settlements. This site has a history of disasters with many deaths, including in the 2008 disaster. After then, families at risk were removed, homes were destroyed, and electronic sensors were installed to monitor the behavior of the slopes and control of the risk of landslides. As a complementary activity, the geology department, together with civil defense, held a series of lectures in the community. The

purpose was to explain to the remaining residents the vulnerable situation of the site, the imminent risks and especially the importance of preserving the slopes. According to the technicians, the situation was stabilized and residents could stay there as long as new pressures on the area, such as new settlements or deforestation, were avoided. With this, the community became aware of the importance of preserving the site, and began to act in conjunction with civil defense in order to bar new settlements and prevent changes in the biophysical configuration of the hill. Since then, the situation has been controlled and there have been no more episodes of landslides.

Lastly, an important issue to consider is to return the focus of local approach to adaptation to climate change associated with disaster risk reduction. Blumenau needs to disassociate itself from the esteem of disaster, and move forward with an integrated approach based on the exchange of knowledge in climate change. Certainly, each involved have a contribution to make, either from their experience in previous episodes, or from the evolution of technological and scientific knowledge. To do so, it will be necessary to form knowledge brokers and identify a language that is accessible and clear to all involved.

8. DISCUSSIONS

The objective of this thesis was to analyze the process of building socio-ecological resilience (SER) to identify how local communities could reduce their vulnerabilities to climate change. To do so, this research defined the essential factors for a transformative process; discussed how to create or increase SER of vulnerable communities; defined a framework to evaluate how different social agents act in the process of building SER; and tested it in the case study, Blumenau, SC, Brazil.

This chapter conducts a discussion of the research findings, guided by the research questions and hypothesis of this research. The objective is to provide a synthesis view of how the set of findings address the research questions and how this thesis contributes to advance the scientific knowledge in this field. The chapter is structured around three sections.

The first section is guided by the research questions presented in Chapter I. Responses to questions are provided taking stock of the theoretical development, but also of the case study, of the research experience, and the literature reviewed.

The second section responds to the hypothesis that capacity of local communities to reduce their vulnerabilities to climate change depends on the interactions of knowledge, governance mechanisms and community culture.

Finally, the third section discusses the idea of SER as adaptation approach to Climate Change. This is the major contribution of this thesis to scientific knowledge and it resulted from the reflexive and iterative process during the analysis of results and the writing of the document.

8.1 Addressing the research questions:

i) What makes a transformative process of adaptation to climate change?

A transformative adaptation process occurs when new skills and capabilities are developed, and institutions, organizations, communities, and individuals are better able to understand their vulnerabilities, and seek new and creative solutions to reduce them. These new skills and capabilities empower people to share the responsibility to adapt. The sharing of responsibilities of adaptation to climate change may induce changes in social systems and consequently transformations in SES. **This thesis navigated under this perspective identifying action sharing as a necessary condition for transformative processes of adaptation to climate change.** Stakeholder engagement and participation, knowledge brokerage and social learning, and individual and collective action, here called action sharing, are the social dynamics identified as motivating changes in the social system. These social dynamics are interrelated and interdependent. As spaces and opportunities for engagement and participation in public decisions are created, the possibility of knowledge exchange and social learning opens up. The local specificity of adaptation requires the interaction between scientific and expert knowledge, and local knowledge. The consequent knowledge exchange creates dynamic social learning, through participatory process. In the same way, they create new networks that can generate initiatives for collective actions to work toward a common goal. This gives credibility, relevance, and legitimacy to decisions that are eventually made.

Three social dimensions are envolved in action sharing: *knowledge*, as the driver of change; *governance mechanisms* that ensure environment to support the process; and *community culture* that defines values, and influences attitudes and behaviors. The interaction of the three is what determines a community's ability, or lack of, to build resilience to climatic challenges.

These results contribute to the advancement of scientific knowledge as they indicate key elements for triggering a deliberate process of social transformation. The differential of this approach lies in the importance of interaction and interdependence between these three elements as an essential factor to trigger a transformative process. In the reviewed literature, these elements are widely discussed in an adaptive decision-making process, but they are usually addressed independently and disconnected. In this way, the empowerment potential of the community is weakened and people do not feel co-responsible in the process of adaptation. In the other hand, integrating them brings to the discussion characteristics intrinsic to human dynamics, and specific particularities of context that determine the

complexity of approaching climate change situations. With these conditions combined, the potential for transformation widens.

ii) How can vulnerable communities increase SER to climate challenges?

The increase of the SER for climate change depends on how the interactions between the three social dimensions involved (knowledge, mechanisms of governance and community culture) can contribute to create the social dynamics capable of promoting social learning, innovation and transformation in social system, and thus improve the adaptability of local communities by reducing their vulnerabilities to climate change. **This thesis contributes to the advancement of scientific knowledge by identifying the enablers of social learning, innovation and transformation of the social system, which may be relevant to enhance the social capacity of vulnerable communities to build SER in the changing climate.**
Although the literature identifies many of these enablers as characteristics of a resilient system, in this study they arise from the interaction between different social dimensions, as a result of knowledge brokerage and focused for community empowerment. This set of interdependent and co-related enablers supports dialogue between different stakeholders, and favors a systemic and integrated vision, creating the necessary conditions for the development of flexible adaptive capacity, and increasing the resilience of communities vulnerable to climate change.
By identifying these enablers and establishing assessment parameters for each one, this thesis helps local communities to assess their social capacity to create the SER. From this assessment, they can identify limitations of the approach taken so far, potentials to be explored, and then, decide based in scientific arguments the best approach to adaptation to climate change at local level.

iii) How can Blumenau (Brazil) prepare the community to tackle climate change?

The analysis of Blumenau's Wheel of Social Capacity Assessment for Building SER, showed that some enablers can be leveraged to increase the adaptive capacity of the community, and to develop SER to climate change. Engagement, a more participatory decision-making process, and a decentralized governance model are essential for Blumenau to create conditions for expanding community knowledge and increasing adaptive capacity. Other enablers also have potential to be developed. Improving access to quality information, valuing and including local knowledge in knowledge brokerage processes, strategic use of social networks for community empowerment, and technical support for self-organization can

contribute significantly to the social learning. Likewise, expanding participation in knowledge networks and integrating local knowledge into decision-making can enhance social innovation. Finally, the planning and implementation of collective actions between government, community and scientific body can generate the necessary transformations in the social system to increase SER.

This thesis presents some suggestions for actions that can contribute to help the government of Blumenau (Brazil) to prepare the community to tackle climate. These are:

a) Promote a shift from disaster-focused approach to a more positivistic view that looks at climate change as an opportunity for change. During the research, there was a fatalistic tendency of the community to face its climatic challenges and a certain conformism with the situation. In this sense, it is important that the climate change planning team take the initiative to address this issue from a more constructive perspective as a great opportunity to focus on more sustainable planning solutions.

b) Integrate mitigation and DRR into adaptation policy. Despite some isolated manifestations during the interviews (representative of the secretariat of urban planning), Blumenau has so far assumed a DRR approach. In this way, most of the actions are directed towards the prevention, preparation, response and recovery of disasters. But this approach is no longer enough. It is time to think about an adaptation "with" climate change that integrates all the answers to this new reality, including mitigation and DRR.

c) Establish effective and ongoing coordination by local authorities to maintain NUDECs and Residents' Association as active partners of vulnerable communities. From the disaster of 2008 until the completion of this thesis, these integration mechanisms between local government and the community went through a period of implementation, growth and subsequent weakening. It is important that these social instruments recover their role and expand their performance in the community. The associations of residents have representation throughout the city and they can be a strong channel of environmental education. NUDECs, however, are located only in the most vulnerable areas, so they can specifically address issues of vulnerability reduction and resilience. As the local government recognizes the importance of these mechanisms, it can offer an active coordination for these groups and empower their representatives to act effectively as agents of change with the communities. Like this, a network of contacts is initiated, social learning is promoted, and the first step of building SER is achieved.

d) Create new opportunities for knowledge brokerage such as lectures, workshops, active networks and coordinated collective actions. The research showed a gap in the promotion of environmental education among vulnerable communities. Most discussion spaces on the subject of climate change are restricted to the academic or governmental environment. As new discussion spaces open up, with appropriate language and creative participatory methodologies, and the community is invited to participate, people are better able to learn more about the topic and demystify certain understandings. The use of social networks can be adopted by any social agent: Government, teaching institutions, public and private organizations, and groups of people. All it needs is to have creativity and use scientific knowledge as a basis, in a simple language, accessible to the community and with a constructive approach, highlighting what can be done and the advantages that this brings. The expansion of knowledge can generate a new perception that everyone is responsible for new answers and that each one can do his part.

e) Bring public power to the local scientific body and promote partnerships to increase knowledge and improve decision-making. The contact with the researchers revealed their deep dissatisfaction with the consecutive local governments that do not seek partnerships to take advantage of the knowledge produced in the institutions of the region in support for their decisions. One of the limiting factors may be the need for investments, but there are different forms of integration. One possibility lies in opening up government to action-research opportunities, where government and researchers go together to find new ways to solve their most pressing issues. In this way, both social learning and innovation will be stimulated. These surveys can be funded by institutions at both the federal and state levels, as findings can be replicated in future situations. But for this, a great barrier to be faced is the political resistance of transformation.

f) Strengthen social movements that fight for the creation and inclusion of mechanisms of democratic participation that support the decision-making process of adaptation. This is a crucial point to promote the transformation necessary to increase the resilience of the community and it depends essentially on political will. In this sense, Blumenau has found its ways of claiming for more participatory spaces. The engagement of different sectors of the community can give the support necessary for this struggle to become a conquest.

8.2 Responses to the hypothesis of thesis

The hypothesis posed in this study is that capacity of local communities to reduce their vulnerabilities to climate change depends on the interactions of the three social dimensions involved in the process of building SER: knowledge, governance mechanisms and community culture.

To assess this hypothesis, this study analyzed social dimensions necessary to develop in vunerable communities the capacity to learn, innovate and transform social system. These skills and capabilities empower people to share responsibility to adapt. Thus, knowledge is the key element and the trigger of this process. Then, who would be the agents involved? The government (responsible for laws, rules and public policies) and community (until recently seen as a passive agent in the adaptation process). However, for different skills to be developed, not only the availability of knowledge and the presence of the agents involved is sufficient. A favorable environment is required for knowledge exchange. Thus, mechanisms of governance can create a favorable environment; and community culture can define individual and collective values and beliefs for people to interact in this process.

This thesis relates the three social dimensions: knowledge, governance mechanisms, and community culture. The analysis of these interactions generated a conceptual model that synthesizes this thesis: Knowledge is the key element of SER-building process. Through knowledge brokerage, the community can change its attitudes, values, beliefs, practices and consequently its culture. Social learning, as a result of this interaction, can empower community. In the same way, through knowledge brokerage, governance mechanisms can be improved and innovations can emerge. These dynamics generate a transformative process capable of providing new subsidies for adaptive flexibility and building SER. Therefore, the hypothesis that guided this thesis proved to be true insofar as it showed the importance of each of the dimensions in the development of the abilities to increase the adaptive capacity of the communities, and mainly, in the interdependence of the three dimensions in this process.

8.3 SER as adaptation approach to Climate Change

The question that permeated the development of this study was whether the concept of SER could be adopted as an adaptation approach to climate change. This doubt arose as the literature began to discuss the need for new approaches to adaptation, with a systemic, procedural and transformative view, concepts that are widely discussed in the theory of resilience. In order to answer this question, it would be necessary to identify how these

concepts integrate adaptation and resilience. It was from this perspective that this thesis developed.

The successive interpretations of concepts and their relations generated a conceptual model that is the main contribution of this thesis. By synthesizing the integration between adaptation and SER in a conceptual model, **this thesis contributes with scientific literature when it shows how SER can be adopted in a proactive and strategic approach to adaptation to climate change.** For this, it is necessary to observe some aspects that are the basis of the concept of resilience, that is, the process must promote social dynamics geared to social learning, innovation and the transformation of the social system. In this sense, the approach should foster capacity building so that public and private institutions, community and individuals can find creative solutions to increase their adaptive capacities and reduce their vulnerabilities to climate change. This approach can be a sustainable alternative for vulnerable communities with limited financial resources because it is based on the transformation of the social system rather than on costly structural works. However, it involves political will and community engagement, which are quite complex to manage.

Finnally, with these outcomes, this thesis can make contributions to explore practical ways to: Encourage local communities to seek knowledge about climate change adaptation to become empowered and pressure authorities to create spaces for engagement and negotiation between different interests and actors in adaptation planning; Stimulate decision-makers to develop transformative strategies that address the causes of vulnerability and guide them to implement adaptation policies appropriate to local social-ecological realities. Provide guidelines to Brazilian policy-makers for the development of public policies of climate change adaptation based on the building of SER of local communities to enhance knowledge exchanges and empower communities to assume their responsibilities in future climate challenges.

9. CONCLUSIONS

This dissertation began with the argument that, in recent years, researches have proven that previous and continuous forecasts of the impacts of climate change on some regions have been ongoing. In this regard, concerns are focused on the very vulnerable areas, with poor people who have their livelihoods based on fragile ecological systems. Poverty and lack of basic infrastructure combined with lack of information may limit people's ability to adapt and often need to resort to ineffective responses that worsen the situation.

In this context, there is a consensus in the academic world on the need to change the way to think and adapt to climate change. With this, the adaptation happens to be understood in a broader and systemic approach, within a process-oriented and transformative view. It addresses the causes of vulnerability and transforms the structure and dynamics of the social system.

From the above, this study analyzed how the concept of resilience could be integrated in the process of adaptation to climate change. In this sense, this study reviewed the concepts of adaptation, transformation and social-ecological resilience, and integrated them in the process of buiding SER. The results of this study generated a framework for assessment of the community social capacity to build SER to climate change and it was applied in the case of study (Blumenau). During the course of these studies, it emerged some conclusions presented below.

First, the analysis of the evolution of adaptation concept concluded that, the complexity of this concept is one of the factors by which it differs from theory to practice. Adaptation over the last years has come to be understood in the academic environment as a systemic, iterative, and integrative process. However, the literature shows this in a fragmented way. Thus, these characteristics are not reflected in planning and implementation of the

adaptation. In putting the definition of adaptation in these terms (procedural, systemic, iterative and integrative) can contribute to making adaptation planning clearer, and its implemention more effective. Adaptation is procedural, because the impacts of climate change are continuous, crescent, and surrounded by uncertainty, and responses must be implemented in a scale of time and space. It is systemic, because it involves cause and effect relationships, where several elements of the system are involved, interconnected with each other, responding differently to the same impact. It is iterative, because it needs to be continuously reviewed. Each action causes a reaction in more than one element of the system. But some actions, while improving specific aspects of the system, can harm the system as a whole. The interactivity can help in correcting these distortions in a timely manner so, that benefits are greater than losses. And finally, it is integrative, because it must address the various challenges of climate change, involving long-term changes (climate change), climate variability and extreme weather events. Likewise, adaptation becomes the main response to climate change as it is local and directly linked to the most basic level of society: the individual, the community, the institutions and the local society. If all the above aspects are taken into account, it should integrate into its scope the various levels of possible responses: mitigation, adaptation and disaster risk reduction.

Second, when analyzing how a transformative process of adaptation occurs, the social dynamics necessary to trigger a process of transformative adaptation were identified and it was concluded that these dynamics should be explored together and integrated. Action sharing defines the set of these actions: engagement, knowledge brokerage and collective action. They are concepts widely discussed in literture, but the interaction between them is the triggering element of transformations in the social system. Some examples of this were identified in the results of the case study. The community of Blumenau is receptive to collective actions and integrates whenever it is called, but these actions mostly do not have a knowledge brokerage component. In this sense, the actions are punctual and do not reflect a social learning capable of generating transformations. In the same way, actions focused on knowledge brokerage, depend on the engagement of people to generate positive results in the community. Blumenau held several events of knowledge brokerage DRR, but the people engaged mostly were those directly related to the topic discussed, which ends up limiting the scope of action to a specific group. In this sense, a special effort is needed to identify and engage the community, especially those who can become agents of transformation in their environment. A good example are the simulated actions taken in schools and vulnerable areas. These actions involved the three components of action sharing: the people engaged because they were largely involved in the importance of the action, there was an exchange

of knowledge between civil defense technicians and population, and this was done through collective action, causing learning were effective, and cited by the interviewers as very positive

Third, in analyzing the process of building resilience, it was concluded that the increase in adaptive capacity depends on the interaction between the social dimensions involved: knowledge, governance mechanisms and community culture. However, this interaction should focus on social learning, innovation, and community empowerment to generate a transformative process and build BE. Each of these dimensions has its role in this process and if one of them is not focused in that direction, the transformation does not happen and the increase in resilience is impaired. In Blumenau, it is possible to perceive that in this interaction, the mechanisms of governance are not articulated for these objectives. The resistance of susceptible governments to openness to the community has limited their actions to punctual structural measures. As there are governance mechanisms that integrate the population and academia in the planning and decision-making processes for adapting to climate change, creative solutions and social innovations that require less investment and reach the population as a whole can emerge.

Fourth, when analyzing Blumenau as a case study, it was concluded that there is a search by some sectors of the community to find ways that can promote changes in structures and social dynamics, especially what refers to the mechanisms of governance hitherto instituted. This is a trend in many Brazilian municipalities and has been promoted in social networks. Blumenau has a diversity of social groups that are articulated by several causes, including self-organization and public manifestations. This may also be the beginning of a turn towards a deliberate process of adaptive transformation to climate change. As these actions gain strength to influence political stances to the point of bringing about changes in governance mechanisms, the decision-making process can become more participatory and deliberative. This is a collective gain. And the climate change issue, so important for the region, can take on the necessary relevance, generating the much-needed sharing of responsibilities in the adaptation process.

Fifth, it was also concluded that Blumenau does not adequately explore the different sources of knowledge (scientific and local) it has to improve the adaptive process and increase resilience to climate change. On the one hand, the FURB concentrates a scientific knowledge in this area that can not be ignored and concentrate on the academy. On the other hand, the experience of so many hydrometeorological events gave the local population a personal and particular knowledge that can not be restricted to book reports or informal

conversations. There is a need to articulate these two types of knowledge through knowledge brokerage mechanisms so that they can effectively contribute to the formulation of public policies and the implementation of innovative solutions to future climate challenges.

Finally, as a final conclusion of this thesis, it can be said that the construction of socio-ecological resilience in vulnerable communities can be an appropriate approach to adaptation to climate change. It is a systemic process, iterative and integrated, and transformative. It involves the various stakeholders and includes in its scope social learning, innovation and community empowerment. In doing so, it develops the adaptive capacity of the community to reduce its vulnerabilities and acquires the necessary strength to change the social system, transforming its dynamics and structures.

9.1 Limitations and Future Developments

The development of this study showed some aspects that need to be better developed and that were not approached in this work. The interdisciplinary character of this research involves concepts discussed in different areas of knowledge, but in different ways. In this sense, it is essential to clearly define the adopted concepts in each approach for adaptation. This was especially felt at the time of the interviews and focus group conducted in the case study. Therefore, it would have been very useful to have a glossary of the terms and concepts used in this research, and which is a suggestion for other research of this type to be developed in the future.

In the same way, it is very important to simple and clear language, in a constructive approach to communicate climate issues to the general population. Contact with the population of Blumenau has revealed a somewhat fatalistic view of climate change, and the perception that these changes will happen in the distant future, which leads them to believe that this discussion is not urgent. Therefore, how to communicate and inform the population constructively about climate change would be an issue of great importance to be addressed in future research.

In addition, there is a difficulty on the part of public policy makers in identifying creative forms of knowledge brokerage. Therefore, given the importance of the subject, it is necessary to develop a broader study of mechanisms of knowledge brokerage and stakeholder engagement, knowledge broker training, and adequate language to facilitate the understanding of simple people from vulnerable communities. This can contribute significantly to the process of creating and increasing SER.

Lastly, this study was limited to assessing the applicability and efficiency to wheel a real case (Blumenau), and to verify the evolution of public policies and community actions from a

specific event (disaster 2008). However, this evaluation is somewhat limited because the local measures adopted in Blumenau since then have not been decided from this tool, but adopted from the available knowledge in the place and time of them. It would be very important to proceed with a later stage of this work, developing a joint research-action between researchers, public power and community to develop a set of actions based on this tool. In this way, the effectiveness of the tool could be proven.

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APPENDIX I

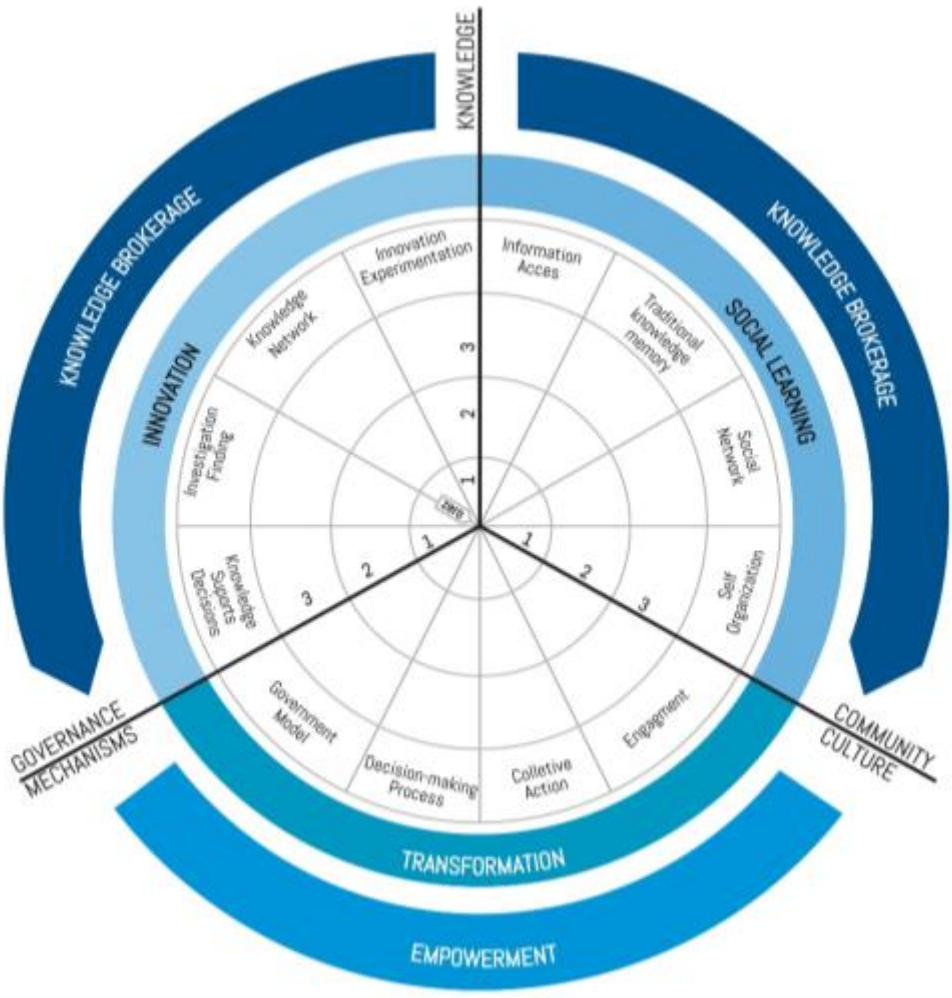
Form of the Assessment of the Social Capacity to build SER

Assessment of the Social Capacity to build SER		
Local:		
Focus:		
Type of Impacts:		
Scores:	(0) It does not contemplate; (1) It minimally contemplates; (2) It contemplates in large part; and (3) It fully contemplates.	
Enablers of social learning (interactions between knowledge and community culture)		
Enabler	**Description**	**Evaluation parameter**
Information Access	How community has acess to specialized information on adaptation to climate change?	Community uses information channels with user-friendly attributes to disseminate information and improve knowledge, such as: mass media (TV and radio) print media (pamphlets, brochures, newspapers and posters); electronic media (internet support services and sms); and community channels (extensive offices, neighbors / friends, local administration and local meteorologists). The sources of information considered important are: researchers, meteorological agencies, indigenous knowledge and development agencies.
Local Knowledge	How local knowledge integrates climate change adaptation process?	Three approaches to create synergies among knowledge systems: (a) integration of knowledge, (b) parallel approaches to developing synergies across knowledge systems, and (c) co-production of knowledge.
Social Network:	How does the community use social networks to enhance adaptive capacity?	The local community has developed mechanisms that use social networks (operational, personal and strategic) to improve its adaptive capacity.
Self-organization	How does community react when it faces situations in which the public power does not give the adequate answers to their needs?	Community has well-structured and continuous mechanisms of self-organization to find suitable solutions to various situations in which the public power has not attended to their needs and expectations.

Enablers of innovation (interactions between knowledge and governance mechanisms)		
Enabler	**Description**	**Evaluation parameter**
Investigation and experimentation:	How does the community research and experiment new ways to meet its challenges?	Local research institutions carry out extensive research on a diversity of scientific areas, reserches integrate local knowledge, and they include practical application to the community.
Knowledge Network	How does the adaptation planners interact with other sources of knowledge?	Adaptation planners participate in knowledge networks with different research agencies (local, national, and international), develops joint projects, and gets support to manage its climate challenges creatively, planned and systemiatically.
Funding to investigation	How does the community seek funding to develop appropriate solutions to its climate challenges?	Community capture funding to develop research, attracts funds from different national and international development agencies, integrating efforts to develop new ideas to face their climatic challenges.
Knowledge supporting decisions	How specialized knowledge supports local decisions?	Science can contribute in science-policy process: (1) framing and problem definition, (2) scientific assessment of climate impacts, vulnerabilities and risks; and (3) assessment of adaptation options and their implementation.

Enablers of transformation (interactions between governance mechanisms and community culture)		
Enabler	**Description**	**Evaluation parameter**
Engagement	How is community involvement in formulation of local public policies?	The existence of highly motivated people who drive the development process adaptation strategies; an institutional structure with interdepartmental and intersectoral cooperation; institutional power structure that influences the involvement of internal stakeholders; and cooperation or contestation of external stakeholders
Collective action	How is the integration between public power and community coping with community problems?	Community develops three types of connections: bounding, bridging and linking.
Participatie decision-making process	How are decisions made in local government?	Existence of participative spaces with a fully democratic deliberative process of adaptation that envolves: influence, inclusion and deliberation
Governance model	What is the local governance model?	The existence of a strong polycentric governance model, which integrates multiple sectors and scales, including private and non-governmental organizations.

Wheel of Social Capacity Assessment for build SER to Climate Change



APPENDIX II

ROTEIRO SEMIESTRUTURADO DE ENTREVISTA COM ÓRGÃOS DA ADMINISTRAÇÃO PÚBLICA DE BLUMENAU/BRASIL

Órgãos visitados:

- Fundação do Meio Ambiente (FAEMA)
- Procuradoria Geral do Município (PROGEM)
- Secretaria de defesa do cidadão (SEDESCI)
- Secretaria de Educação (SEMED)
- Secretaria de obras públicas (SEMOB)
- Secretaria de Planejamento Urbano (SEPLAN)
- Secretaria de Saúde (SEMUS)
- Secretaria de serviços Urbanos (SESUR)

a) Questões comuns a todos os órgãos selecionados:

1) Quais são ações da Secretaria em relação à gestão municipal de risco de desastres?
Número de colaboradores (diretos) na Secretaria:

2) Perguntas específicas:

- A lei 12.608/2012 institui a Política Nacional de Proteção e Defesa Civil (PNPDEC) dispondo sobre o Sistema Nacional de Proteção e Defesa Civil – SINPDEC. Você já ouviu falar dessa lei?
- Como está articulado o SINPDEC (Sistema Nacional de Proteção e Defesa Civil) na Secretaria? Existem entidades privadas articuladas com a secretaria em relação ao Sistema Nacional de Proteção e Defesa Civil?
- Existem planos específicos de implantação de obras e serviços para a redução de riscos de desastres existentes no município?
- Quais as ações realizadas na fase de recuperação de áreas atingidas em desastres naturais? Articula-se com outra secretaria?
- Quais as dificuldades encontradas quando se deve isolar e interditar uma área atingida? Quando/como se dá a remoção de escombros?

3) Relação do órgão entrevistado com as demais secretarias:

Assinalar a pontuação que for mais conveniente para cada secretaria de acordo com a seguinte classificação:

(0) Nenhuma Articulação; (1) Baixa Articulação; (2) Média Articulação; (3) Alta Articulação.

	SEDECI	***SEPLAN***	***SEMED***	***SEMUS***	***SESUR***	***PROGEM***	***SEMOB***	***FAEMA***
SEDECI								
SEPLAN								
SEMED								
SEMUS								
SESUR								
PROGEM								
SEMOB								
FAEMA								

APPENDIX III

Resultado da pesquisa de ações sobre risco de desastres que foram desenvolvidas por instituições públicas na região do Vale do Rio Itajaí no período de 2008 a 2015.

a) **PUBLICAÇÕES**:

Título 1: **Desastre de 2008 no Vale do Itajaí. Água, Gente e Política**
Autores: Beate Frank e Lúcia Sevegnani, L. (Org); Carla Tomaselli (Colab)
Editora: Fundação Agência de Água do Vale do Itajaí. Colaboração - FURB.
Patrocínio: Caixa Econômica Federal
Ano: 2009

Título 2: **Comunicação em Desastres: A atuação da Imprensa e o Papel da Assesseria Governamental**
Autores: Ana Paula de Assis Zenatti e Soledad Yaconi Urrutia de Sousa
Editora: UFSC/CEPED
Apoio: Governo do Estado de Santa Catarina (Departamento Estadual de Defesa Civil) e Associação Catarinense de Imprensa.
Ano: 2010

Título 3: **Comunicação de riscos e de desastres**.
Edição: Ministério da Integração Nacional. Secretaria Nacional de Defesa Civil. Universidade Federal de Santa Catarina. Centro Universitário de Estudos e Pesquisas sobre Desastres.
Ano: 2010.

Título 4: **Mudanças climáticas e emergências. Prevenção e Práticas de Desenvolvimento Solidário e Sustentável**
Edição: Caritas Regional Santa Catarina
Ano: 2010

Título 5: **Manual de Deslizamento: Um Guia para a Compreensão de Deslizamentos**
Autores: Juarês José Aumond | Paulo R. Rogério
Editora: EDIFURB
Apoio: Centro de Apoio Científico em Desastres (CENACID) da Universidade Federal do Paraná
Ano: 2011

b) FILME:

Título 1**: Percepção de Risco, a Descoberta de um Novo Olhar**
Género: Documentário
Tempo de duração: 77 minutos
Direção e Idealização: Sandra Alves e Vera Longo
Ano: 2010

c) EVENTOS:

Evento 1: **Noções Gerais de Defesa Civil e Percepção de Desastres.**
Promoção: Defesa Civil Estadual com o Centro de Estudos e Pesquisas sobre Desastres da Universidade Federal de Santa Catarina (UFSC).
Local: Blumenau
Descrição: Aulas e at**ividades extraclasse para** estudantes da 7ª série de 39 escolas municipai**s.** O objetivo é criar uma cultura de prevenção entre os estudantes e suas famílias. Os participantes recebem kits educativos com livro, histórias em quadrinhos e um documentário sobre o tema. O projeto é inspirado numa campanha mundial lançada em 2006 pela Organização das Nações Unidas (ONU). Blumenau é o primeiro município catarinense a implantar o projeto em escolas municipais.
Data: Segundo semestre/2009

Evento 2: Lançamento do Cartaz Campanha Cidades mais seguras 2010/2011
Promoção: CEPED/UFSC/Defesa Civil/Ministério da integração nacional
Data: Outubro/2010

Evento 3: **Seminário Estadual Sociedade e Meio Ambiente: Ações e Políticas de Prevenção e Respostas Pós-Desastre 2008.**
Promoção: Universidade Regional de Blumenau (FURB) e Universidade Federal de Santa Catarina (UFSC)
Local: Blumenau - FURB.
Data: 22/11/2010
Descrição: Seminário com especialistas nas áreas ambientais, prevenção de desastres e de intervenções em situações de risco. Evento aberto à comunidade em geral.

Evento 4: **2º Seminário JICA**
Local: Blumenau
Promoção: Governo do Estado de Santa Catarina em cooperação com a Agência de Cooperação Internacional do Japão (JICA)
Objetivo: Troca de experiências e tecnologias em gestão de desastres. Mostrar, através de palestras, os estudos relativos à prevenção. Ao longo do dia, sete assuntos foram abordados por especialistas da equipe JICA, UNIVALI, FURB, Universidade Federal de Santa Catarina (UFSC) e Secretaria de Estado de Desenvolvimento Sustentável.
Data:23/11/2010

Evento 5: **6º. Seminário Nacional de Habitação, Meio Ambiente e Sustentabilidade**
Promoção: Federação Nacional de Arquitetos (FNA).
Objetivo: Abordar temas como processo de urbanização, mudanças climáticas e situação de vulnerabilidade, ocorrência de desastres e ocupação do solo em áreas de risco.
Local: Assembleia Legislativa do Estado de Santa Catarina
Data: 25/11/2010

Evento 6: Seminário "**Ações de Regularização Fundiária Urbana e de Redução de Riscos de Desastres - uma abordagem interdisciplinar**".
Promoção: Ministério Público de Santa Catarina, MPSC
Objetivo: ampliar os subsídios e capacitação para a discussão de questões relacionadas à ocupação territorial, seu planeamento e a política de regularização fundiária, aproximando essas políticas públicas das ações de prevenção e combate aos desastres. Para os painéis e palestras foram convidados especialistas de diversas áreas que contribuem para a discussão integrada e interdisciplinar do tema em sectores interligados, porém distintos:
- Direito urbanístico diante da atual realidade de planeamento inadequado das cidades e da ocupação desordenada dos perímetros urbanos;
- Planeamento urbano voltado às ações da defesa civil e à preparação para desastres e catástrofes correlacionados à ocupação de áreas de risco;
- Políticas públicas voltadas ao resguardo de direitos fundamentais, como a vida, a dignidade humana, o acesso à moradia digna e à inclusão soco espacial.

Local: Florianópolis
Data: 18 e 19 de agosto de 2011

Evento 7**: Palestra Metodologias de Mapeamento das Áreas de Riscos de Desastres Hidrológicos (inundações e escorregamentos)**
Autor: Masato Kobyiama
Local: UFSC - Florianópolis
Ano: 2011

Evento 8: **O Sistema de Justiça e a Prevenção aos Riscos de Desastre**.
Promoção: XXX Semana de Estudos Jurídicos da FURB.
Objetivo: Apresentação dos trabalhos do grupo de pesquisa em Direito da FURB e discussão sobre o tema do Projeto de Pesquisa “O Sistema de Justiça e a Prevenção aos Riscos de Desastre”.

Local: FURB Blumenau
Data: 29/08/11

Evento 9: **1º Simulado de Preparação para Desastres**.
Local: Blumenau-SC
Promoção: Defesa Civil Nacional
Data: 21/11/2011
Descrição: O órgão pretende capacitar os moradores de áreas de riscos diante das ações da natureza. Aproximadamente 500 moradores das ruas Cristina, Frederico Kôrte e João José Garcia Júnior, no Bairro Velha Central, participaram do evento.

Evento 10: **Campanha Nacional Cidades Resilientes**
Promoção: Secretaria Nacional de Defesa Civil, do Ministério da Integração Nacional.
Duração: o biênio 2011-2012
Descrição: É uma adaptação brasileira à Campanha da Estratégia Internacional para Redução de Desastres (EIRD), entidade ligada à ONU. Está pautada na crescente urbanização mundial e nos problemas decorrentes de uma ocupação desordenada em contraponto à necessidade de prever riscos e criar ferramentas de adaptação e de enfrentamento para construção de cidades mais seguras. No contexto brasileiro, a Campanha se sustenta nos governos locais e riscos urbanos. Pretende ampliar a participação local na gestão de risco, incentivando a formação de uma cultura de prevenção de riscos de desastres. A campanha apresenta três linhas de atuação:
- comunicar boas práticas e experiências inovadoras
- empreender atividades públicas
- empreender atividades de gestão de risco

Evento 11: **Cerimônia de Entrega dos Certificados de adesão aos municípios do estado da Campanha Mundial para a Redução de Desastres - Desenvolvendo Cidades Resilientes**
Promoção: Governo do Estado de Santa Catarina/ Secretaria de Estado da Defesa Civil.
Objetivo: Comemoração da Semana Nacional de Redução de Desastres (10 a 15 de outubro/2011) e ao dia Internacional de Redução de Desastre (12 do Outubro)
Data: Outubro/2011

Evento 12: **Workshop Mudanças Climáticas, Desastres Naturais e Previsão de Ris**co
Promoção: Semana de Ensino, Pesquisa e Extensão da UFSC, encontro integrado à Semana Nacional de Ciência e Tecnologia.
Local: Reitoria UFSC- Florianópolis
Data: 19 a 22 de outubro de 2011.
Descrição: A equipe do CEPED/ UFSC preparou um estande interativo para atender o público infantil, adultos e especializado que passa pela tenda da ciência nos quatro dias de feira. Além das apresentações no estande, realizaram-se três minicursos:
- Intervenção em áreas de risco por critérios geomorfológicos, geológicos e geotécnicos;
- Comunicação de Risco e Desastre
- Psicologia e Desastres: gestão de risco, prevenção e mobilização comunitária

Evento 13: **Simpósio da Defesa Civil**
Promoção: Governo do Estado de Santa Catarina
Local: Blumenau
Data: 16/02/2012

Evento 14: **Apresentação Pública do Plano Diretor com ações do governo do Estado para a prevenção e mitigação de desastres na Bacia do Rio Itajaí.**
Promoção: Governo do Estado de Santa Catarina
Local: Florianópolis
Data: 17/02/2012

d) PROJETOS:

Projeto 1: **Plano de Encostas**
Promoção: Prefeitura Municipal de Blumenau
Objetivo: O projeto tem os mesmos objetivos do Plano de Enchente, que prevê a desocupação de áreas alagadas conforme o Rio Itajaí-Açu sobe. O novo plano tem mecanismos para monitorar o risco de deslizamentos e retirar as famílias em tempo.
Data: 2009

Projeto 2: **Promoção da Cultura de Riscos de Desastres - PCRD**
Promoção: cooperação técnica entre a Secretaria Nacional de Defesa Civil (SEDEC) e o Centro Universitário de Pesquisas e Estudos sobre Desastres da Universidade Federal de Santa Catarina (CEPED/ UFSC), e da parceria com a Revista Com Ciência Ambiental

Descrição: Projeto de carácter nacional que está sendo implantado em todos os estados da nação. O **PCRD** foi concebido e estruturado em seis ações principais. Abaixo são apresentados os resultados do projeto até agora considerando-se cada uma das ações:

- ✓ Oficina de Capacitação em Comunicação e Percepção de Riscos de Desastres: Já foram realizados em nível nacional, 15 oficinas com 540 participantes no total.
- ✓ Caderno Especial na Revista Com Ciência Ambiental – Percebendo Riscos, Reduzindo Perdas; 16 edições entre Maio/10 e agosto /2011, com 10 mil exemplares mensais distribuídos em Santa Catarina
- ✓ Secção Especial na Revista Com Ciência Ambiental – Cidades Seguras: 8 edições
- ✓ Veiculação de Campanhas de Prevenção: 100 matérias no diário catarinense, com as seguintes fontes: Defesa Civil (8); outras fontes oficiais, como MI, MCT prefeituras e governos estaduais (11); Especialistas, categoria representada por professores, pesquisadores e cientistas (60) e População diretamente afetada pelo desastre (21).
- ✓ Anuário Brasileiro de Ocorrência de Desastres: disponibiliza uma pequena sequencia histórica de desastres entre os anos de 2007 e 2010 no link: *Ocorrência de Desastres* (http://defesacivil.gov.br/desastres/desastres.asp).
- ✓ Pesquisa-ação em Comunicação e Percepção de Riscos: Questionários aplicados em 11 estados com um total de 1041 participante. Ainda não foi aplicado no Estado de Santa Catarina

Data: 2010 a 2014

Projeto 3: **Planejamento Nacional para Gerenciamento de Riscos (PNGR**)
Promoção: Ministério da Integração Nacional
Realização: Centro Universitário de Estudos e Pesquisas sobre Desastres (CEPED), da Universidade Federal de Santa Catarina (UFSC).
Descrição: O projeto foi dividido em três etapas a serem concluídas em 2012. A partir das informações da primeira fase do mapeamento, será construído um banco de dados informatizado com os desastres naturais ocorridos no país.
A segunda fase, que começou paralelamente à primeira, inclui cadastro de novos desastres no banco de dados, formando um arquivo atualizado com dados pluviométricos, históricos e socioeconômicos. A terceira e última etapa é a que vai contar diretamente com a ação e colaboração das prefeituras, dos órgãos de Defesa Civil municipais e de organizações não-governamentais. Será a vez de treinar e capacitar profissionais para aplicar o material desenvolvido na atuação direta à prevenção, no ensino para jovens em escolas públicas e privadas e nas ações municipais para controlar a ocupação em áreas de perigo.
Data: outubro de 2010

Projeto 4: **Projeto JICA**
Promoção: Governo do Estado de Santa Catarina e Agência de Cooperação Internacional do Japão (JICA)
Objetivo: Estudos preparatórios para o Projeto de Prevenção de Desastres e Medidas Mitigadoras para a Bacia do Rio Itajaí.
Período: 11/2010 a 05/2012.

Projeto 5: **Sistema Nacional de Alerta e Prevenção de Desastres Naturais**

Promoção: Governo Federal
Período de Implantação: gradativamente entre os anos de 2011 a 2015.

Projeto 6: **Centro de Operação do Sistema de Alerta (CEOPS)**
Organização: Furb / Blumenau
Objetivo: Estudo que levanta a informação e divulga as cotas de enchente das ruas de Blumenau. Está sendo elaborado desde novembro/11, com visita a campo e medição dos picos de cheia. Destaca que estado de emergência passou de 12,5m para 7,5 metros.
Acesso**:** http://ceops.furb.br/
Data: A partir de novembro de 2011

e) CURSOS:

Curso 1: **Multiplicadores no Mapeamento e Gerenciamento de Riscos**
Promoção: Financiado pela JICA, Agência de Cooperação Japonesa e organizado pelo Departamento de Ciências Naturais da FURB.
Objetivo: Com o objetivo de formar multiplicadores para mapeamento de áreas de risco de desastres naturais e voltado a professores universitários, mestrandos, doutores e profissionais ligados a questão de riscos de desastres naturais, o curso discute desde segunda-feira, 15 de março aspectos como os fundamentos conceituais e metodológicos do gerenciamento de riscos; os processos destrutivos no Vale do Itajaí e o evento de novembro de 2008; modelos de mapeamento de áreas de risco; aspectos gerais associados a enchentes, inundações e processos correlatos; estabilidade de encostas e planos preventivos de defesa civil
Local: - Blumenau/SC
Data 19/03/2010

Curso 2: **Pós-graduação Gestão em Defesa Civil**
Promoção: Universidade de São José (USJ) e Centro Universitário de Estudos e Pesquisas sobre Desastres (CEPED) da UFSC
Descrição: cursos à distância como Gestão de Riscos e Desastres para psicólogos.
Ano: 2010

Curso 3: **Comunicação de Riscos e de Desastres**

Promoção: Secretaria Nacional de Defesa Civil, o Centro Universitário de Estudos e Pesquisas sobre Desastres da Universidade Federal de Santa Catarina, CEPED UFSC, e a revista.

Objetivo: Curso a distância. Procura estabelecer diálogos entre o poder público, agentes de defesa civil, profissionais e sociedade civil para fortalecer as ações de prevenção e preparação. Sob o enfoque da Comunicação de Risco se mostra como uma ferramenta para construção de redes de proteção, com participação da mídia e profissionais de comunicação.

Ano: 2010

APPENDIX IV

FURB Research Groups

Área Científica	Grupo de pesquisa	Linha de Pesquisa	Pesquisadores	Estudantes			
				D	M	E	G
Ciências Agrárias	Manejo de recursos florestais	Conservação da natureza	3		1	1	
		Produção florestal sustentável	5		1		2
		Regeneração e dinâmica de florestas	3		2		
Ciências Biológicas	Recuperação de Áreas Degradadas	Ecologia da Paisagem Aplicada à Restauração Ecológica	1				1
		Restauração Ecológica	9		1		6
Ciências Exatas e da Terra	Grupo de Estudos Climáticos e Hidrometeorológicos	Inovações Tecnológicas no Tratamento do Meio Ambiente: Deslizamentos e Mudanças Climáticas	3				
		Mecanismos de Desenvolvimento Limpo e Mercado de Carbono	1				
		Sistema de Informações de Conforto do Ambiente Construído e Mudanças Climáticas	6				
Ciências Humanas	Grupo de Pesquisas de História Ambiental do Vale do Itajaí - GPHAVI.	História Ambiental	5				2
		História Ambiental e Desenvolvimento Regional	4				3
	Núcleo de Estudos, Pesquisas e Extensão sobre Movimentos Sociais - NEPEMOS	Políticas Públicas e Participação Social	6		2		1
	Núcleo de Políticas Públicas	Ecodecisão e Territorialidade	6	3	3		
Ciências Sociais Aplicadas	Grupo de Estudo e Pesquisa do Habitat - GEPHabitat	Arquitetura e Sustentabilidade	6				
		Conforto Ambiental	1				3
		Paisagem e Ambiente	2				
	Análise ambiental e ecodesenvolvimento	Análise Ambiental e geoprocessamento	4				
		Educação para o ecodesenvolvimento	5	2	3		2
		Planejamento urbano e sustentabilidade	3		1		
		Técnicas de Análise e Avaliação Urbana e Regional	5	1	2		1
	Direitos Fundamentais, Cidadania e Novos Direitos	Sustentabilidade Socioambiental, Ecocomplexidade, Políticas Públicas Sanitárias e Ambientais	4				
	Núcleo de Pesquisas em Desenvolvimento Regional	Desenvolvimento geográfico desigual	6	2	1		
		Processos de planejamento e desenvolvimento territorial	11	1			
	Núcleo de estudos urbanos e regionais	Habitação de interesse social: prática projetual e diálogos com a história	2				
		Gestão Ambiental Urbana	2				
		Planejamento Urbano e Sustentabilidade	8				
Engenharias	Saneamento e hidrologia ambiental	Modelização Hidrológica	2		1		
		Processos Hidrológicos	2	2			1
		Saneamento ambiental	4	5	7		
	Gestão de ambientes naturais e construídos em bacias hidrográficas	Gestão de riscos de desastres	8				2
		Gestão integrada de recursos hídricos	4				2
		Gestão urbana e ambiental	5				1
TOTAL : 6	13 GRUPOS DE PESQUISA	31 LINHAS DE PESQUISA	134	16	25	1	27

Table 7: FURB research groups

APPENDIX V

PROGRAMAS DE EXTENSÃO FURB

- **Grupo de Pesquisa e Extensão de Gestão de Ambientes Naturais e Construídos em Bacia Hidrográfica (GEAMBH**)

Programa: Cidadania pela água na bacia hidrográfica do rio Itajaí

1) Projeto: Prevenção e mitigação aos riscos de desastres.

Objetivo: organizar nos anos de 2015 e 2016 quatro fóruns e preparar duas vídeo-aulas de capacitação em defesa civil, com o objetivo de contribuir para a construção de uma cultura de prevenção e mitigação aos riscos de desastres e consequente ampliação da capacidade de resiliência das comunidades da Bacia do Itajaí à ocorrência de eventos extremos.

- **Curso de Comunicação Social - Publicidade e Propaganda**

Programa: Comunicação e comunidade

Visa manter relacionamento constante com a sociedade, profissional e social, de tal modo que alguns problemas sociais recebam atenção produtiva por parte da instituição, além de possibilitar novos meios e processos de produção, inovação e transferência de conhecimentos, permitindo a ampliação do acesso ao saber e o desenvolvimento social da cidade.

1) Comunicação para o Desenvolvimento Social,
2) Informação e Cidadania,
3) Programa Televisivo Plug-In.

- **Cursos de Arquitetura e Urbanismo e Engenharias Civil e Elétrica**

Programa Construir: parceria para o desenvolvimento com qualidade de vida.

Tem como objetivo propiciar o desenvolvimento socioeconômico e ambiental na comunidade, através de serviços, projetos e assessoria técnica para a execução de equipamentos comunitários de qualidade, menor custo e ambientalmente corretos, beneficiando comunidades e entidades sem fins lucrativos, na prática inter e multidisciplinar.

1) Projeto Planejar: Produção Arquitetônica;
2) Projeto Estruturar: Produção Complementar;
3) Projeto Conscientizar: Conscientização e Cidadania

- **Cursos de Direito e Serviço Social**

Programa GRACO: Gestão de Riscos e Participação Comunitária.

Objetiva assessorar e capacitar as organizações comunitárias da cidade de Blumenau na prevenção e enfrentamento das problemáticas decorrentes das condições de risco e vulnerabilidade social e seu impacto nas tradicionais formas de gestão dos conflitos interpessoais e coletivos, bem como contribuir para com a construção e o fortalecimento da autonomia e da cidadania da sociedade civil organizada.

1) Projeto Formação e Capacitação Jurídica Comunitária;
2) Projeto Assessoria e Capacitação Comunitária3
3) Projeto Participação Juvenil e Gestão de Riscos

APPENDIX VI

E-mail enviado para os coordenadores de grupos de pesquisa da FURB

Caros coordenadores de grupos de pesquisa da FURB,

Estou a realizar minha tese de doutoramento na Universidade de Lisboa no programa de Alterações Climáticas e Políticas de Desenvolvimento Sustentável e tenho Blumenau como meu estudo de caso.

Estou a pesquisar o processo de construção da resiliência socioecológica e a troca de conhecimento como elemento chave neste processo.

Por isso, tomo a liberdade de entrar em contato convosco. Gostaria de saber como o conhecimento científico produzido pelos grupos de pesquisa da FURB chegam até a comunidade e interagem com decisores de políticas públicas.

Em meus levantamentos de dados, identifiquei que o grupo de pesquisa que você coordena tem linhas de investigação que podem abordar temáticas de caráter social, ambiental, tecnológico, econômico ou político voltadas aos impactos das mudanças climáticas, da variabilidade climática e de eventos climáticos extremos.

Sendo assim, peço a sua colaboração ao responder a 3 perguntas.

1) O seu grupo de pesquisa tem desenvolvido investigação em temáticas voltadas para as mudanças climáticas, variabilidade ou eventos extremos? Se, sim, quais?

2) De que forma as pesquisas desenvolvidas pelo seu grupo se relacionam com a comunidade em geral, seja na valorização do conhecimento local, seja na divulgação de resultados obtidos e na oportunidade de troca de conhecimento?

3) Como você vê a integração entre o conhecimento científico produzido na FURB e as instituições públicas responsáveis pela formulação de políticas? O conhecimento atua como suporte de decisão? Há incentivos ao desenvolvimento de novas pesquisas e inovação? Existe algum mecanismo de troca de conhecimento entre estes dois agentes?

Agradeço imensamente a sua contribuição e me coloco a sua disposição para qualquer dúvida!

Obrigada.

Kátia Virgínia Cañellas

APPENDIX VII

ROTEIRO DE ENTREVISTAS SEMIESTRUTURADAS COM A COMUNIDADE

a) ASSOCIAÇÕES COMUNITÁRIAS/ DE MORADORES:

Identificação da Associação:
Nome do Respondente:
Atribuição na associação:

1. Vc percebe que o clima na sua região está mudando? Se sim, quais as mudanças no clima que vc sente mais?

2. Vc acredita que essa situação pode se agravar no futuro?

3. Vc identifica problemas e ameaças relacionados ao clima que afetam diretamente a sua comunidade? Se sim, quais?

4. Vc considera que sua comunidade contribui de algum modo para agravar esse fenômeno? Se sim, como? Se não, por quê?

5. Como vc avalia o seu conhecimento em relação a essa problemática? Vc considera importante ter esse conhecimento? Quem vc acha que deveria gerir essas informações?

6. Quem vc considera responsável em abordar os problemas de origem climática nas comunidades? Por quê?

7. Esse problema está integrado nas atividades ou projetos institucionais de sua associação?

8. Como vc avalia os principais programas públicos existentes sobre essa temática, tendo em conta as demandas e os fatores de vulnerabilidade socioambiental da sua comunidade?

9. Os membros da comunidade são chamados em algum momento a participar nesses programas públicos?

10. O que vc considera importante abordar nessa problemática e quais instituições deveriam estar envolvidas?

b) NUDECS:

Identificação do Núcleo:
Nome do Respondente:
Atribuição:

1. Quais são as atribuições dos NUDECs?

2. Que atividades tem sido realizada junto à comunidade?

3. Que tipo de treinamento/ informações vcs recebem para realizar essas atividades? Que é o responsável por esse treinamento?

4. Vc considera que seu conhecimento está adequado às necessidades da comunidade ou já identificou algumas deficiências no treinamento que recebeu?

5. Quais as principais barreiras e dificuldades que vcs enfrentam junto à comunidade? Que avanços vc considera que já foram alcançados?

6. Como vc avalia o envolvimento da comunidade em ações do NUDEC? Que tipo de pessoas são as mais engajadas: velhos, jovens, donas de casa.... São sempre as mesmas pessoas que participam, ou depende do tipo de ação?

7. Na sua opinião como vc avalia a atuação do seu NUDEC? Vc identifica algum aspecto que precisaria mudar? (Relação com a comunidade, com as instituições públicas...) se sim, quem vc acha que poderia ajudar nisso?

APPENDIX VII

FURB Researchers that participate in Framework discussion

- Dr. Claudia Siebert: Architect and Urbanist, PhD in Geography, Federal University of Santa Catarina (2006). Retired professor of architecture and urbanism at FURB, she also worked as Director of Urban Planning in Blumenau.

- Dr. Noêmia Bohn: lawyer, Ph.D. in Social Relations Law, in the sub-area of Diffuse and Collective Rights by the Pontifical Catholic University of São Paulo (2003) and postdoctoral fellow at the Unite Mixte de Recherche Territoires, Environement, Télédetéction et Information Spatialisée at the Maison de la Télédetéction (2006-2007). Served as Legal Advisor of the Management Committee of the Itajaí River Basin (Itajaí Committee)

- Dr. Ademar Cordeiro: Civil engineer, PhD in Hydraulic Engineering from the Polytechnic of Milan / Università Degli Studi di Milano (1996). Coordinator of the Operation Center of the Alert System (CEOPS).

- Dr. Juarês José Aumond, geologist, Ph.D. in Civil Engineering from the Federal University of Santa Catarina (2008).

Dr. Maurício Pozzobon: Biologist, PhD in Forestry Engineering, Federal University of Paraná (2013). He served as Municipal Secretary of Geology and as Director of Geology, Analysis, and Natural Risks in the city of Blumenau