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Par

ISSAKA OUSMAN GAOH Aboubacar

Institutional Assessment of Climate Services for Disaster Risks Management Decision-making in Niger

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DOCTORAL THESIS

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West African Science Service Centre on Climate Change and Adapted Land Use

Field: Human and Social Sciences

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Specialty: Climate Change and Disaster Risks Management

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Publicly defended on 06th May, 2025 before the jury composed of:

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Doctoral Thesis

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UNIVERSITY OF LOME

FACULTY OF HUMANITIES AND SOCIAL SCIENCES

Climate Change and Human Security

Climate Change and Disaster Risks Management

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Dedication

To

My mother Zeinabou Kabani, and my father Issaka Ousman

Elise Mamata, my late sister

You stay remembered

May your soul rest in peace!

Acknowledgment

Glory be to the Almighty Allah, the Merciful, who provided me the strength, motivation, and health to complete this journey!

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Executive Summary

In the context of recurrent extreme climate events in Niger, adaptation policies promote climate services (CS) to support climate risk management by strengthening institutional and CS capacity. However, the constant occurrence of climate-related disasters and their impacts raises concerns about the existing institutions and CS implementation. This dissertation examines the institutions and CS capacity for disaster risk management (DRM) decision-making. Using a qualitative approach, data were gathered from 242 scholarly sources, 19 in-depth interviews, 75 community-level interviews, and 47 policy documents and analyzed through Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), qualitative document analysis, institutional mapping, and analysis. Findings identified three policy-oriented priority areas, including development of CS, use-adoption-uptake of CS, and evaluation of CS. A multi-layered institutional framework operates across upstream and downstream decision-making levels. The national framework for climate services (NFCS) and regional climate outlook forum (RCOF) represent science-policy interfaces linking CS producers and decision-makers. Institutions such as national direction of meteorology (NDM), African centre of meteorological applications for development (ACMAD), AGRHYMET regional climate centre, and Niger basin authority (NBA) deliver diverse CS, including daily, seasonal, and decadal forecasts, alerts, and six early warning systems (EWS). Flood-related CS dissemination is coordinated by the general direction of civil protection (GDCP) and the ministry of humanitarian action and disaster risk reduction (MHA/DRR), while drought-related implementation falls under national platform for food crisis prevention and management (NMPMFC) and early warning system coordination unit (EWS/CU). As part of the gaps, CS implementation is essentially external agenda-setting and project-driven, leading to critical funding gaps, limited sustainability, and weak project takeover. The infrastructure gap, especially in the weather observation network (WON), affects CS production. Actors-level gaps persist, with inadequate last-mile communication, limited accessibility, and format impeding effective implementation. This study recommends enhancing institutional coordination, fostering science-policy interfaces, establishing a sustainable CS funding mechanism, and densifying the WON. It also advocates leveraging technological advancements to implement impact-based EWS.

Key Words: Climate services, disaster risks management, adaptation policies, flood, drought, Niger

Résumé

Dans le contexte de récurrence des événements climatiques extrêmes au Niger, les politiques d'adaptation promeuvent les services climatiques (SC) pour soutenir la gestion des risques climatiques en renforçant les capacités institutionnelles et les SC. Cependant, l'augmentation constante des catastrophes et leurs impacts soulève des questions quant aux institutions actuelles et la mise en œuvre des SC. Cette thèse examine les institutions et les capacités des SC pour la prise de décision en matière de gestion des risques de catastrophe (GRC). Basée sur une approche qualitative, les données collectées inclues 242 sources académiques, 19 entretiens, 75 entretiens semi-directif et 47 documents de politiques, puis analysées à l'aide de la méthode PRISMA, de l`analyse qualitative de documents, d'une cartographie institutionnelle. Les résultats mettent en évidence trois domaines prioritaires de politiques notamment le développement des SC, l'utilisation, l'adoption et l`appropriation des SC, et l'évaluation des SC. Un cadre institutionnel à plusieurs niveaux fonctionne en amont et en aval de la prise de décision, comprenant le cadre national pour les services climatiques (NFCS) et le forum régional sur les prévisions météorologiques (RCOF) servant d'interfaces science-politique et relient les producteurs de SC et les décideurs. Des institutions telles que la direction nationale de la météorologie (NDM), le centre africain d'application de la météorologie au développement (ACMAD), le centre climatique régional (AGRHYMET) et l`autorité du bassin du Niger (NBA) fournissent divers SC, notamment des prévisions quotidiennes, saisonnières et décennales, des alertes et six systèmes d'alerte précoce. La dissémination des SC pour les inondations est coordonnée par la direction générale de la protection civile (GDCP) et le ministère de l`action humanitaire et de la gestion des crises de catastrophes (MHA/DRR), tandis que l'intégration des SC pour la sécheresse relève du le mécanisme national de prévention et de gestion des crises alimentaires (NMPMFC) et de la cellule d`alerte précoce (EWS/CU). Parmi les lacunes, la mise en œuvre des SC est essentiellement fixée par un agenda externe et axé sur des projets, ce qui entraîne des déficits de financement, une durabilité limitée et une faible appropriation des projets. Les lacunes en matière d'infrastructure, en particulier dans le réseau d'observation météorologique, affectent la production des SC. Les lacunes au niveau des acteurs persistent, avec une communication inadéquate, une accessibilité limitée et un format empêchant une intégration efficace. Cette étude recommande de renforcer la coordination institutionnelle, de consolider les interfaces science-politique, d'établir un mécanisme de financement durable des SC et de densifier le réseau d'observation météorologique. Elle préconise également de tirer parti des avancées technologiques pour développer des systèmes d'alerte précoce basés sur les impacts.

Mots Clés : Services climatiques, gestion des risques de catastrophes, politiques d`adaptation, inondations, sécheresse, Niger

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Chapter Three

Abbreviations and Acronyms

ACMAD: African Centre of Meteorological Applications for Development

CCA: Climate Change Adaptation

CIF: Climate Investment Fund

CIS: Climate Information Services

COP: Conference of Parties

CS: Climate Services

DRM: Disaster Risks Management

DRR: Disaster Risks Reduction

EM-DAT: Emergency Events Database

EWS: Early Warning System

FANFAR: Reinforced cooperation to provide operational flood forecasting and alerts in West Africa (FANFAR) Project

FAO: Food and Agriculture Organization of the United Nations

FEWS NET: The Famine Early Warning Systems Network

GDACS: Global Disaster Alert and Coordination System

GDCP: General Direction of Civil Protection

GFCS: Global Framework for Climate Services

I3N: Initiative Nigeriens Nourish Nigeriens

INDC: Intended Nationally Determined Contribution

IPCC: Intergovernmental Panel on Climate Change

ISDR: International Strategy for Disaster Reduction

LCDs: Least Developed Countries

MHA/DRR: Ministry of Humanitarian Action and Disaster Risks Reduction

MHEWS: Multi-Hazards Early Warning System

NAP : National Adaptation Plan

NBA: Niger Basin Authority

NC-CC : National Communication on Climate Change

NDC: Nationally Determined Contribution

NDM: National Direction of Meteorology

NFCS: National Framework for Climate Services

NGO: Non-Governmental Organization

NMHSs: National Meteorological and Hydrological Services

NMPMFC: National Platform for Food Crisis Prevention and Management

NPHA/DRR: National Policy on Humanitarian Action and Disaster Risks Reduction

PRISMA: Preferred Methodology for Reporting Systematic Literature Review and Meta-Analysis

SAICU-GTN: Système d`Alerte aux Inondations pour la Commune Urbaine de Gaya, Tanda et Niamey V

SATH-NBA: The Satellite-Based Water Monitoring and Flow Forecasting for the Niger River Basin

SFDRR: Sendai Framework for Disaster Risks Reduction

SLAPIS: System Local d`Alerte Précoce pour les Inondations de la Sirba

SLR: Systematic Literature Review

SPI: Science-policy Interface

UNDRR: United Nations Office on Disaster Risks Reduction

UNFCCC: United Nations Framework Convention on Climate Change

UNISDR: United Nations International Strategy on Disaster Risks Reduction

WIS: Weather Information Service

WMO: World Meteorological Organization

Statement of No Plagiarism

To the best of my knowledge, I confirm that my dissertation is entirely original and does not infringe upon anyone else's ideas, methods, copyrights, or quotations. I have appropriately credited the work of others referenced in my research, which aligns with established academic referencing standards.

I affirm that this is the ORIGINAL Dissertation, incorporating the revisions recommended by the examiners. I take full responsibility for any disputes or issues of plagiarism that may arise from this PhD dissertation.

Moreover, I acknowledge the use of Grammarly and Quillbot writing assistant software to improve my dissertation's clarity, correctness, and delivery.

Aboubacar ISSAKA OUSMAN GAOH

Lome, 19th March 2025

GENERAL INTRODUCTION

General Introduction

1.1. Context of the Study

Climate change rapidly progresses, and climate-related risks exacerbate (Mechler *et al.*, 2019). The latest assessment report by the IPCC has warned with high confidence about the severity and recurrence of extreme climate events worldwide in the coming years (IPCC, 2022). Floods, droughts, heavy rainfall, and climate-sensitive disease outbreaks continue to strike worldwide and are expected to worsen in the most vulnerable countries (IPCC, 2022) leading to loss of lives, destruction, and damage to infrastructure and livelihood (UNDRR, 2022). The EM-DAT international disaster database indicates that over the last twenty years (2002-2021), 793 flood events and 137 instances of droughts represented 55% of climate hazards in Africa, with 14,053 and 20,821 deaths, respectively (CRED, 2022).

Hence, climate risk governance has become critical as countries are making efforts toward achieving sustainable development goals and fulfilling their pledge to reduce disaster risk as enshrined in the Sendai Framework by 2030 (UNISDR, 2015). In the wake of climate change adaptation and DRM, CS have gained interest over recent decades as promising solutions to uncertain climatic conditions (Pathak & Lúcio, 2018; Vaughan & Dessai, 2014a), a powerful tool recognized by the Sendai Framework in reducing climate-related disasters (Tarchiani *et al.*, 2021).

The GFCS marked momentum in the international agenda toward enabling countries to manage climate risks by developing and incorporating science-based climate information and prediction into planning, and policy (WMO, 2014). CS involve producing, translating, transferring, and using climate knowledge and information in climate-informed decision-making and climate-smart policy and planning for effective climate risk management (Vaughan, 2016; WMO, 2014).

The development and use of CS have been instrumental in managing climate risks in many cases since their emergence. At the same time, many countries are still lagging in this movement, particularly the most vulnerable. While this situation is attributed to various factors, the African continent suffers from the long-standing problem of a lack of weather and climate observations. This persistent limitation of information affects the capacity of countries to predict and adapt to extreme events (WMO, 2022c).

Literature highlights a dearth of studies investigating the institutional lens of CS in Niger. The study attempts to contribute to the growing CS field to fill this research gap while also contributing to inform practice for effective climate-informed decision-making in Niger. This general introduction outlines the global and national context of CS for DRM. It states the research problem research questions and objectives. The section elucidates the added value of the study, highlighting the contributions of the findings. The section presents the study area and concludes with an overview of the research methodology and the dissertation outline.

1.2.2. Climate Services for Disaster Risk Management

To effectively face climate variability and long-term climate change, it is essential to provide timely, accurate, and actionable CS to government organizations and communities for effective climate-informed decision-making (Grossi & Dinku, 2022). CS consist of the collection of climate data; generation and provision of a wide range of information on past, present, and future climate; development of products that help improve the understanding of climate and its impacts on natural and human systems; and the application of these data, information, and products for decision-making in all walks of life and at all levels of society (Grossi & Dinku, 2022). Depending on users' needs, these data and information products may be combined with non-meteorological data, such as agricultural production, health trends, population distributions in high-risk areas, road and infrastructure maps for the delivery of goods, and other socioeconomic variables (WMO, 2016) to provide tailored services (**Figure 1.1**).

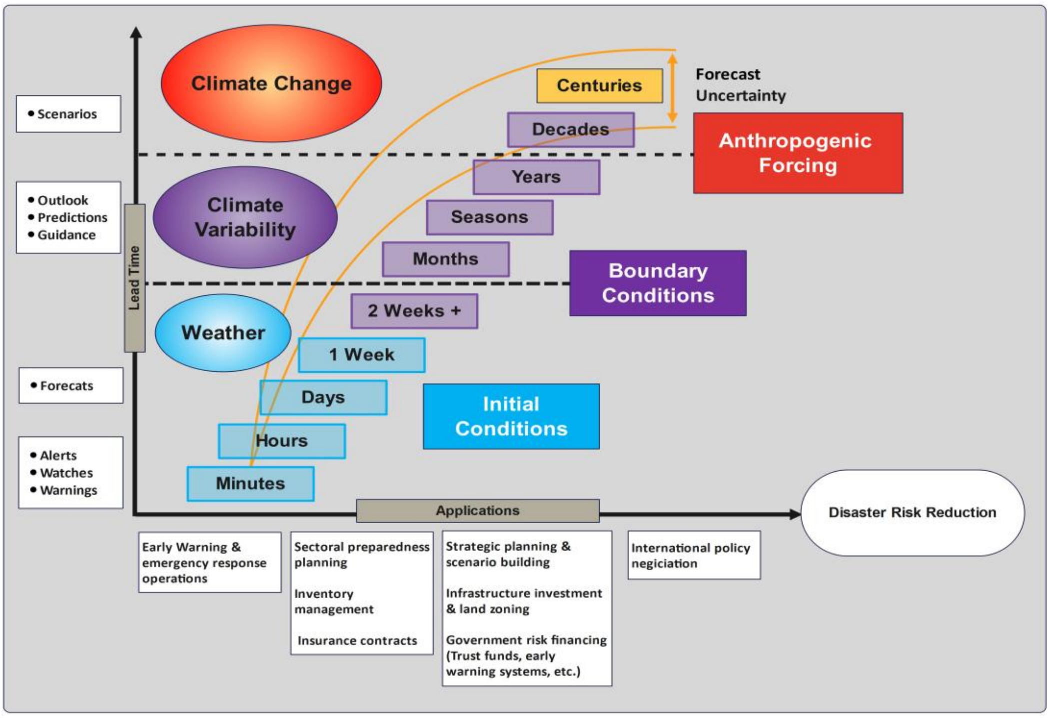

Figure 1. 1: *Seamless hydrometeorological and climate services (Adapted from NOAA & WMO)*

1.2.3. Development of the Concept and Approaches of Climate Services

The Intergovernmental Panel on Climate Change (IPCC) has established a comprehensive and authoritative understanding of climate change, significantly raising awareness about its impending crisis. As a result, various institutions have been mobilized to tackle the pressing issues associated with climate change globally. One of the pioneering institutions is the World Meteorological Organization (WMO), which has emphasized the centrality of climate data and its translation into useful CS.

Literature links the emergence of the concept of CS to the establishment of the Global Framework for Climate Services (GFCS) following the Third World Climate Conference in 2009 (Hewitt et al., 2012a; Medri et al., 2012; Vaughan & Dessai, 2014b). The GFCS was established to enable countries to face climate-induced disasters by developing science-based climate information and predictions and incorporating them into planning, policy, and practice (WMO, 2014). It targets five goals to ensure its effective implementation, including: 1. Reducing the vulnerability of society to climate-related hazards through better provision of climate information; 2. Advancing the key global development goals through better provision of climate information; 3. Mainstreaming the use of climate information in decision-making; 4. Strengthening the engagement of providers and users of climate services; 5. Maximizing the utility of existing climate service infrastructure. In this line, the GFCS bridges the interfaces between science, policy, and society for a resilient system to climate risk. It defines CS as "Providing climate information in a way that assists decision-making by individuals and organizations. A service requires appropriate engagement, along with an effective access mechanism, and must respond to user needs" (WMO, 2014).

Five key components shape the functioning of GFCS namely (i) Observation and monitoring to improve the collection and dissemination of climate data and information, including historical data, current observations, and future projections. (ii) Climate services: to develop and deliver tailored CS that are relevant and useful for decision-makers and help them anticipate and manage climate risks and opportunities. (iii) Research and modeling: to improve the understanding of climate processes and their impacts and to develop improved climate models and forecasting tools. (iv) Capacity building: to build the capacity of individuals and institutions to use and apply climate information through training and education programs. (v) Governance and coordination: to provide a platform for coordination and collaboration among various stakeholders involved in CS and to ensure effective governance and management of the initiative. The framework recommends that countries establish their National Framework for

Climate Services (NFCS) to foster synergy between institutions and actors in developing and providing CS based on the users` needs to ensure effective DRM.

1.2.4. The Need for Climate Services for Disaster Risk Management

The development of CS offers a reliable decision-support mechanism in efforts toward CCA (Leal & Jacob, 2020). The adoption of a comprehensive resilience agenda and the shift in focus within the DRR community from "managing disasters' to "managing risks' provide unique opportunities for better integration of CS into DRR decision-making at both strategic and tactical levels (Street et al., 2019). The literature highlights a broad spectrum of CS, with the Early Warning System (EWS) being the most important in DRM. An EWS is intended to be a comprehensive system of climate-related information provided to decision-makers (individuals or institutions) for informed preventive and protective actions (Trtanj & Houston, 2021). EWS encompasses essential monitoring, forecasts, and predictions that provide advanced warnings to decision-makers, enabling preventive action in managing and mitigating the impacts of hazardous climate events (Aguirre-Ayerbe et al., 2020; Apergi et al., 2020). The Yokohama Action Plan promoted EWS and the effective dissemination of information through mass media as critical factors for successful disaster prevention and preparedness. In this regard, developed countries have pledged to provide financial assistance to establish and strengthen EWS in disaster-prone developing countries, particularly those in the least developed, landlocked, and small-island developing States, which led to the establishment of the Trust Fund for the Decade to finance such initiatives.

Nevertheless, essential capacity gaps have been identified over the years in establishing and developing effective EWS, especially within the least developed countries (LCDs) (WMO, 2020b). To address this problem, the Climate Risk and Early Warning Systems (CREWS) initiative, pioneered by WMO members, has invested US$ 40 million in projects in LCDs to enable the establishment of EWS (WMO, 2023a). Recently, to support the most affected countries by climate-induced disasters, the UNFCCC Warsaw International Mechanism for Loss and Damage, launched at COP 28 in 2023, also promoted EWSs as a critical measure for averting loss and damage associated with the adverse effects of climate change (WMO, 2023b).

While the urgent need for EWS has been established above, there was limited understanding of which components are essential to make EWS effective. Thus, back in 2005, the World Conference on Disaster Reduction adopted the Hyogo Framework for Action 2005-2015, which highlighted the dire need for: "early warning systems that are people-centered, in particular systems whose warnings are timely and understandable to those at risk (...) including guidance on how to act upon warnings (...)" (Para. 17, ii.d.9). Out of the need to provide countries with clear guidance for more effective EWS, the third International Conference on Early Warning (EWC III) in Bonn in 2006, experts and scientists from various backgrounds developed a Checklist of Core Elements that need to be met by an effective and people-centered EWS (ISDR, 2006). These elements include Risk Knowledge, Monitoring and Warning Service, Dissemination and Communication, and Response Capability. For effective governance and institutional arrangements to thrive, it is essential to adopt an early warning approach that considers the perspectives and needs of local communities while also considering gender and cultural diversity (WMO, 2018a).

Given the amplification of climate-induced disasters and the growing demand for Early Warning Systems (EWS), the Sendai Framework for Action, established at the end of the Hyogo Framework, marked a pivotal transition from a single-hazard EWS to a Multi-Hazard Early Warning System (MHEWS) (Golding, 2022). MHEWS adopts a proactive and holistic approach in its design, extending beyond the traditional elements of an Early Warning System (EWS) to enhance the development and communication of the MHEWS (Luther *et al.*, 2017). A MHEWS addresses hazardous events' single and combined risks (Amaratunga *et al.*, 2021).

Thus, following the 7th Session of the Global Platform for Disaster Risk Reduction, which emphasized the importance of strengthening Early Warning Systems (EWS) for Disaster Risk Reduction (DRR), the Third Multi-Hazard Early Warning Conference (MHEWC-III), held in Bali in 2022, also highlighted the critical need for countries and international organizations to collaborate on the effective development of Multi-Hazard Early Warning Systems (MHEWS). Hence, in 2023, the United Nations initiative, labeled "Early Warning for All," has come to build upon the previous efforts. Indeed, given the increasing recognition of the importance of EWS and the ambition to make them for All, the executive action plan 2023-2027 planned an important investment of USD 3.1 billion (WMO, 2023a).

These initiatives respond to the constant call to equip the most vulnerable countries with efficient CS systems that enable them to face climate-related disasters effectively. Thus, like other underdeveloped countries in West Africa, the need for CS is particularly pronounced given the stakeholders' engagement in recognizing the importance of facing climate risks (Sultan *et al.*, 2020).

1.2.5. Climate Services for Disaster Risks Management in the Niger Context

CS has become a significant area of interest within the field of climate variability and change and risk management in Niger (DNM, 2016). In the context of increasing exposure and vulnerability of communities and the need for relevant strategies to face climate uncertainties, CS has become appealing to researchers, experts, and decision-makers. Thus, various facets of the subject have been under scrutiny among scholars.

Indeed, the need for CS, particularly seasonal forecasts for the onset of the rainy season among farmers, has been pressing over the last two decades, given their importance in positively impacting agricultural production (Sultan, 2007). The adoption of CS has been at the heart of understanding users' needs and the benefits of using them, as they are touted to enable coping with climate risks and positively impact farmers' income and livelihood. By adopting an ex-ante agro-economic approach to study the impact of 10-day and seasonal forecasts on farmers' cropping practices and income, Roudier *et al.* (2016) have demonstrated that when only seasonal forecasts are available, the income benefit is close to zero. Conversely, in more than 75% of cases, the availability of 10 days of forecast induced a slight positive income change among farmers with low adaptive capacity, while it led to a change of approximately +15% for farmers with access to fertilizers and more arable land. The authors have highlighted that combining both CS is far more beneficial, though it appears a bit riskier than relying solely on 10-day forecasts. Roudier *et al.* (2016) arguably attributed these income changes to the modifications of farmers` cropping practices due to adopting CS.

Researchers have recently shown a relationship between the use of climate information and farming investments. The adoption of CS enabled optimal resource allocation by farmers (Maman Bizo *et al.*, 2024), thereby adjusting their investment for the upcoming rainfall season and increasing the annual production of about 64 bunches (equivalent to 10 bags of 100 kg millet) while improving income generation of about 73,000 FCFA from the average farmland of 3 ha per farmer (Seydou *et al.*, 2023). Therefore, adequate access to and uptake of CS is crucial in this context.

The dissemination of CS is arguably effective, as studies have reported comprehensive access through various channels: 98.4% via national and local radio, 72.8% via television, and 96.5% via the Internet (Seydou *et al.*, 2023). Contrarily, in other cases, access is not widespread or is determined by various factors. Despite the limited studies on determinants of adoption in Niger (Partey *et al.*, 2018), previous studies have discovered reliability and religion as factors affecting access and adoption among farmers (Sultan, 2007).

Besides the importance of CS for agriculture, there is broad recognition of its benefits in managing extreme climate-related hydrological events, such as floods, which pose serious challenges to the population. One of the most significant current discussions concerns the approaches to producing and disseminating CS for local populations, relying on local and indigenous knowledge to cope with climate uncertainties (Arsenault *et al.*, 2023). Tarchiani *et al.* (2020) explored the potential for linking available technical capabilities with local skills through a participatory approach to produce and disseminate flood early warnings. This approach operates capacity and calibrates them locally through risk thresholds, field observations, and potential impacts using flood scenarios. This involved a co-development strategy between experts and users and has been proven efficient in dealing with extreme flood events (De Filippis *et al.*, 2022).

1.2. Research Problem Statement

Situated in the Sahel, Niger has an exceptionally arid climate. Indeed, most of the country has a desertic environment, and the southern strip has a tropical climate with a single short rainy season from June to September and a long dry season from October to May (CNEDD, 2000). Characterized by significant inter-annual variability in rainfall, the country's climatic situation has resulted in recurrent and frequent dry years since 1968 (CNEDD, 2006).

Thus, several droughts have impacted Niger, including 1973, 1984, 2005, 2008, 2010, and 2011, accompanied by disastrous food crises (Boureima, 1993; CARE, 1998; GFDRR, 2019; Youssoufou, 2015). This situation has negatively impacted the food market and caused food crises, namely that of 2005, which is considered one of the most impactful across the country (Aker, 2010).

Following decades of droughts, like the rest of Sahelian West African countries, Niger has been experiencing more abundant rainfall since the late 1980s and 1990s, leading to severe flooding (Nouaceur, 2020). Floods and droughts remain the main hazards that continue to affect Niger as a consequence of high exposure and increasing vulnerability of the population and changing climate conditions (Descroix *et al.*, 2013). The country generally experiences flooding during the monsoon season, particularly towards the end of the season (WMO, 2022c), a phenomenon that is observed to increase as the case of 2024 (Reporterre, 2024).

Extreme climate events are characterized by their increased frequency and severity, causing devastating impacts on both human and natural systems, which leads to humanitarian crises that increasingly call for public action and interest from Non-Governmental Organizations (NGOs) and international donors. Thus, for decades, these NGOs have increased their intervention to complement public action in disaster management at all levels due to the inadequacy of public action and the considerable deficiency concerning the capacity for forecasting, reflection, coordination, and communication (Olivier de Sardan, 2008).

In the aftermath of the devastating floodings in 2012 and the drought, the government established the Nigeriens Nourish Nigeriens initiative (i3N), which became the heart of the national public governance for food security in the context of climate change (HC3N, 2012, 2016). Hence, most of the new projects and investments are implemented in line with this policy, which is "to ensure that the people of Niger are free from hunger and malnutrition in the long term and to guarantee them the conditions to participate fully in national production and to improve their incomes" by 2035 (HC3N, 2012, 2016). The revised Nationally Determined Contribution (NDC) was recently submitted, emphasizing the need for investments and national contributions regarding climate action, focusing on adaptation policy. Thus, various other strategies and plans were developed under international agendas, particularly the Paris Agreement and the Sendai Framework, to enhance the governance of climate risks. These efforts are thus deployed to reinforce national capacity at institutional, infrastructural, and human resource levels to address climate risks.

As part of the national climate adaptation policies, CS have become a significant intervention area (CNEDD, 2020, 2021; DMN, 2016). Thus, many interventions have been implemented to disseminate CS for risk-informed decision-making focused on strengthening institutions and CS capacity and enhancing community uptake for effective integration of CS in risk decision-making (DMN, 2016). Regarding CS capacity, a recent evaluation of states members' capacities, calculated as a percentage of functions satisfied by National Meteorological and Hydrological Services (NMHSs), Niger is flagged to fulfill the Basic Level of Provision (WMO, 2023c). In parallel, another recent report classified Niger among 20 African countries reported to have established a Multi-Hazard Early Warning System (MHEWS) (WMO, 2023b) to face climate-induced hazards.

The institutional and policy level is characterized by various institutions including the National Directorate of Meteorology (NDM), the African Centre of Meteorological Applications for Development (ACMAD), the Regional Climate Centre for West Africa and the Sahel (AGHRYMET), and the African Centre of Meteorological Applications for Development

(ACMAD). Thus, they provide various decision-making tools, from daily to decadal and seasonal forecasts and early warnings.

These institutions and their coordination framework, along with the implementation of CS capacity, are envisioned to enhance the preparedness of the country to face disaster risks in a comprehensive and proactive approach (CNEDD, 2021, 2022; DMN, 2016). Hence, these efforts should be reflected in the reduction of impacts related to climate-induced disasters over the years.

However, the recurrence of flood and droughts and their impacts raise questions about the effectiveness of current institutional mechanisms and the existing capacity of CS for disaster risk decision-making.

1.3. Research Questions

General research question: How do existing institutional frameworks and climate services capacity support disaster risk management decision-making in Niger, and what gaps impede their development and implementation?

Specific Research Question 1: What are the main policy-oriented priority areas in climate services for disaster risks management?

Specific Research Question 2: How is the status quo of institutions and climate services capacity for disaster risks management?

Specific Research Question 3: What gaps impede the development of climate services and their implementation for disaster risk management decision-making?

1.4. Objective of the Dissertation

The general objective of this dissertation is to assess climate services for disaster risks management decision-making in Niger at the institutional level as a contribution to improving the understanding of the institutional landscape and challenges that impede their implementation. The dissertation is structured around three operational-specific research objectives:

Specific Objective 1: To review policy-oriented priority areas of climate services for disaster risks management

Specific Objective 2: To map institutions and climate services' capacity for disaster risk management decision-making

Specific Objective 3: To examine gaps impeding the development and implementation of climate services for disaster risk management decision-making

1.5. Added Value of the Study

Disaster risk remains a cross-cutting issue across the main climate-sensitive areas, namely water, energy, food, and health, amid the current climatic conditions in Niger. The significance of the current study lies in its contribution to improving understanding of the institutional framework and CS capacity supporting DRM, as well as prevailing gaps impeding their effective implementation. The findings could be valuable information for decision-makers to enhance their overall climate action (SDG 13) and the implementation of the Sendai Framework for Disaster Risks Reduction (SFDRR), particularly the overall disaster risk governance. Additionally, these findings represent a contribution to the implementation of the National Framework for Climate Services (NFCS) as recommended by the WMO. The findings also represent valuable input to inform donors about priority areas for CS to guide future investments and interventions. Both stakeholders will benefit from updated information on existing gaps that need to be addressed to effectively develop and integrate CS into DRM decision-making in Niger. Concerning the scientific community, the findings constitute a starting point for further investigations.

1.6. Conceptual Framework

The conceptual framework defines the variables and concepts and illustrates their expected relationships. By mapping out these levels, the section operationalized variables and concepts from their abstract assumptions into measurable observations (Babbie, 2020).

1.6.1. Climate Services (CS)

CS aim to provide people and organizations with timely, tailored climate-related knowledge and information that they can use to reduce climate-related losses and enhance benefits, including the protection of lives, livelihoods, and property (Vaughan & Dessai, 2014). In their practical application, irrespective of the sector, according to the WMO documentation they may include weather forecasts (Nowcasting, very short-range forecasts, Short-range forecasts, Medium-range forecasts, and Long-range forecasts); climate forecasts (Monthly, seasonal, sub-seasonal, and decadal forecasts on rainfall and temperature), Early warning system, Warning and Alert. As a matter of example, in agriculture the prediction of the onset and offset of the rainy season, dry spells, and rainfall amounts, are produced to allow farming decision-making.

For DRM, one of the leading CS remains EWS, which allows decision-makers (organizations or individuals) to face the risks of flooding or drought.

1.6.2. Risks/Uncertainty

Among its various definitions, the concept of risk may refer to a set of scenarios and their associated consequences and probabilities (Kaplan & Garrick, 1981). The notion of risk, therefore, involves both uncertainty and some kind of loss or damage that might be received. Symbolically, we could write this as: risk = uncertainty + damage.

In the context of climate change, the concept of risks equates climate risk with disaster risk, identifying its components as hazard, exposure, and vulnerability, noting that the ability to capture the dynamic nature of exposure and vulnerability makes for more successful adaptation and risk management policies and practices (Viner et al., 2020). It is largely acknowledged in the literature that the outcomes of risks may be estimated, while it is difficult to reliably estimate the probability of uncertainty.

1.6.3. Vulnerability

The concept of vulnerability has its roots in the study of natural hazards and poverty (Janssen & Ostrom, 2006). In the context of climate change, particularly climate extreme events, vulnerability pertains to the degree to which a human or natural system is susceptible to being impacted by a disaster or hazard (IPCC, 2001). The concept has been a powerful analytical tool for describing states of susceptibility to harm, powerlessness, and marginality of both physical and social systems, and for guiding normative analysis of actions to enhance well-being through reduction of risk (Adger, 2006). Vulnerability represents a key element in the domain of climate change and DRM, which demonstrates the degree of preparedness and resilience of a human or natural system (UNDRR, 2024).

1.6.4. Disaster Risk Management (DRM)

The IPCC in its special report on managing the risk of extreme events and disasters to advance climate change adaptation (CCA) defined DRM as the processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, and sustainable development (IPCC, 2012)

In this perspective, DRM encompasses all strategies and decision-making undertaken by state-led institutions or individuals to mitigate the risk of disastrous climate-related events. Thus, in this dissertation, the primary assumption is that the development of CS serves as a strategy and decision-support tool to address climate-related disasters, including floods and droughts. In this regard, CS are conceived as the application of DRR to mitigate the risks associated with the impacts of climate-related events. CS are developed and implemented through a policy mechanism and are intended to be acted upon by the users in the context of climate risks.

The character and severity of impacts from climate extremes depend not only on the extremes themselves but also on exposure and vulnerability (IPCC, 2012) (**Figure 1.2**). In the context of extreme climate change, considering the broader challenge of sustainable development, combining adaptation to climate change and disaster risk management provides a more holistic and effective approach to reverse the adverse impacts of climate-induced disasters.

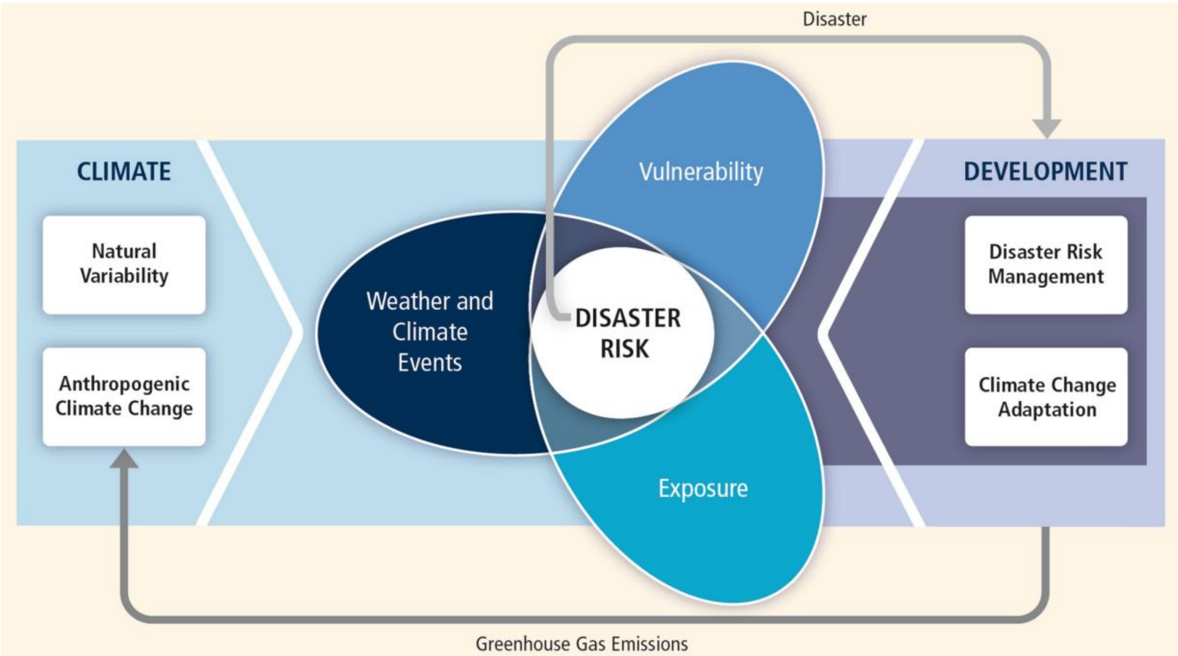

Figure 1. 2: *Relationship Between Climate Change – Extremes Events – Impacts and Management Strategies (IPCC, 2012)*

Climate change adaptation (CCA) emphasizes preparing for and responding to the long-term impacts of projected climate patterns, while disaster risk management (DRM) focuses on policies and strategies to reduce and manage risks associated with short-term climate hazards, such as floods, droughts, and dry spells. Given the complexity of climate change, relying on a standalone approach will not yield sufficient outcomes. An integrated strategy combining both CCA and DRM is essential for effectively addressing the multifaceted challenges of climate change.

In this context, the global initiatives established after 2015, specifically, SDG 2030, the Sendai Framework for Disaster Risk Reduction (SFDRR) 2030, and the Paris Agreement, have driven efforts toward achieving policy coherence. (Mysiak et al., 2018; Street et al., 2019; Yamazaki-Honda & Japan, 2022). Conceptually, it seems appropriate that Disaster Risks Reduction (DRR) is an appropriate delivery mechanism for CCA; however, this does not always transfer to the operational level (Booth *et al.*, 2020) and is developed in separate policy domains (Street *et al.*, 2019). Policy coherence is an attribute of policy that systematically reduces conflicts and promotes synergies between and within different policy areas to achieve the outcomes associated with jointly agreed policy objectives (Nilsson *et al.*, 2012). At the national scale, the National Adaptation Plan (NAP) supplement on synergy and coherence between DRR and CCA proposes several pathways to coherence (UNDRR, 2020b) to foster adaptative capacity and prevent and reduce climate risks effectively. This approach ensures states formulate their policies considering the national context and actively engage all relevant stakeholders to foster an environment enabling comprehensive DRM.

Disaster Risk Reduction (DRR) and Disaster Risk Management (DRM) are two fundamental concepts and approaches stemming from the broader climate change policy context. While they are frequently used interchangeably, they serve different purposes and focus. DRR refers to the policy objective of DRM, and its goals and objectives are defined in DRR strategies and plans (UNDRR, 2023). Eslamian and Eslamian (2021) have discussed the concept and practice of disaster management as a process that follows four phases, including mitigation, preparation, response, and recovery, based on the definition of ISDR (2009). By integrating the aspect of risk, the evolution of the concept of DRM extends beyond DRR, adding a management perspective that encompasses prevention, mitigation, preparedness, and response.

Thus, DRM is considered the application of disaster risk reduction policies and strategies, encompassing actions to prevent new disaster risks, reduce existing disaster risks, and manage residual risks. Thus, in its approach, DRR focuses on policies and strategies to reduce the underlying drivers of risk. DRM focuses on the practical implementation of DRR policies and strategies (PreventionWeb, 2021). The concept and practice of DRR/DRM have constantly evolved from a narrowed technical discipline to a comprehensive approach to climate risk governance endorsed by the international community (Wei *et al.*, 2021). Various non-legally binding agendas were established to operationalize this concept, with the Sendai Framework for Disaster Risk Reduction (SFDRR) being the latest international framework. In this context, DRM has marked a paradigm shift from a response and relief-centric approach to a proactive and holistic process of climate risk governance (Babu, 2021).

1.6.5. Capacity

Generally, the literature on climate change emphasizes the concept of capacity building, which pertains to the ongoing process through which individuals, organizations, and societies acquire, enhance, and sustain their abilities to establish and realize their developmental goals over time (UNDP, 2007, as cited in Lennar *et al.*, 2018). Furthermore, capacity building is recognized as the fifth pillar of the GFCS, a critical element in implementing the framework (WMO, 2014). As it was described,

> The approach to Capacity Development under the Framework is to help strengthen existing capabilities needed to enable all countries to manage climate risk effectively. Areas included are governance, management, human resources development, education and training, leadership, partnership creation, science communication, service delivery, resource mobilization, and infrastructure (WMO, 2014).

In a previous effort, Dinku *et al.* (2018) assessed the CS capacity, explicitly focusing on the National Meteorological and Hydrological Services (NMHS) capacity to supply CIS, as they defined it. The NMHS, in this case, refers to the National Direction of Meteorology (NDM). In this dissertation, the concept of capacity refers to the perspective of WMO (2014), considering it in all possible facets of CS for DRM (**Figure 1.3**), including the state of EWS, their adequacy, and additional institutional capacity in the field of CS for DRM in Niger.

1.6.6. Gap

Like the concept of capacity, the gap may refer to something missing or a desired situation. Likewise, in the literature, gap analysis is a recurring aspect of this concept. From the policy process perspective, implementation gaps represent the mismatch between expectations and outcomes (Abdullahi & Othman, 2020). In the Paris Agreement, the gap concept highlights the need to support countries in effectively identifying gaps in adaptation policy (UNFCCC, 2015). Adaptation gaps are defined as “the difference between actually implemented adaptation and a societally set goal, determined largely by preferences related to tolerated climate change impacts and reflecting resource limitations and competing priorities” (UNEP, 2014, 2021). The IPCC (2022) Sixth Assessment Report (AR6) has constantly mentioned the adaptation gaps as a critical need to address in the face of increasing climate-related risks. In the GFCS, the concept of gap is closely linked to that of capacity, with recurrent mentions of capacity gaps (WMO, 2014). Thus, like capacity development, the gap concept is considered an essential element to be addressed for the effective implementation of CS across different application sectors. In this research, the concept of gap is drawn from different aspects discussed in this section, considering it as impeding factors to the effective development and implementation of CS for DRM. As such, in the current case, the gap is considered inherent in the process of CS implementation for DRM (**Figure 1.3**).

1.6.7. Science-policy Interface (SPI)

Moving beyond a mere theoretical understanding, the IPBES perspective remains a significant definition of an SPI. This concurs with some perspectives, which consider the IPCC the prime advanced, structured, and institutionalized SPI, particularly in the climate policy process (Engels, 2005; Siebenhüner, 2014) to inform climate change decision-making (Howarth & Painter, 2016). This lies in the IPCC mandate to "to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation [...]" (IPCC, 2013a as cited in Minx *et al.*, 2017). From these perspectives, in the context of the current dissertation, SPIs are conceived as official platforms dedicated to developing CS and supporting integration into DRM decision-making. In this case, two so-called SPIs are identified, namely the National Framework for Climate Services (NFCS) and the Regional Climate Outlook Forum (RCOF) (**Figure 1.3**)

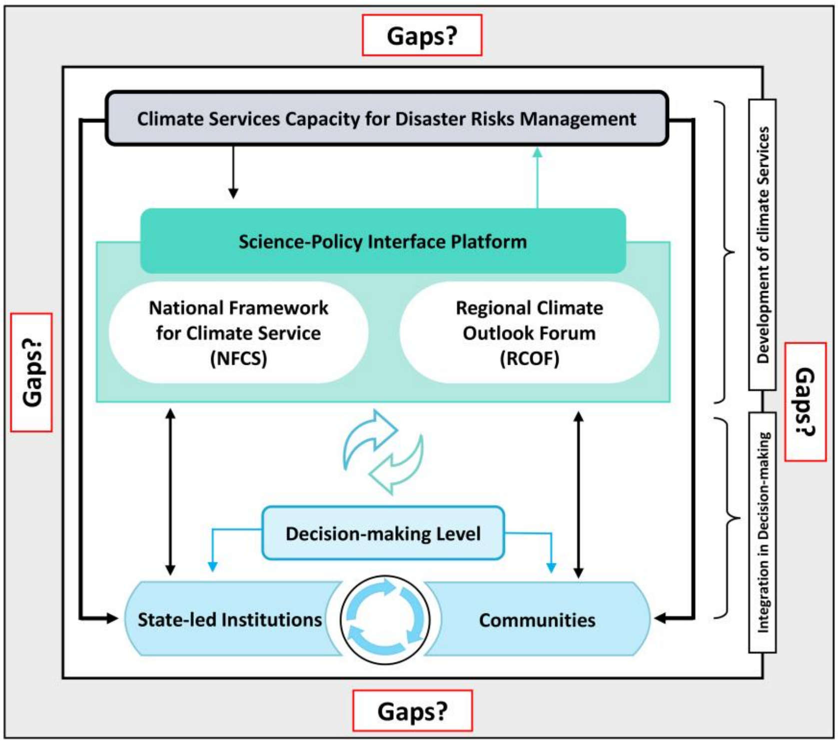

***Figure 1. 3**: Research Conceptual Framework*

1.7. Presentation of the Study Area

Situated in West Africa, Niger is a landlocked Sahelian country located between the Sahara Desert and Africa south of the Sahara. It extends between latitudes 12°N and 23°N and longitudes 0°E and 16°E. It shares borders with Algeria and Libya to the north, Chad to the east, Nigeria and Benin to the south, and Burkina Faso and Mali to the west. It has an area of 1,267,000 km², two-thirds covered by desert.

1.7.1. Demography and Socioeconomic Aspects

According to the latest census conducted in 2012 (INS, 2012), Niger has a population estimated at 17 129 076 inhabitants. The country has one of the highest population growth rates in the world (3.9%) and a fertility rate estimated at 7.2 children per woman, the highest in Africa, with an estimated population of 26.31 million in 2024 (INS, 2024).

1.7.2. Ecology-Environment-Climate

The climate of Niger is hot and dry, characterized by two main seasons a short rainy season from June to early October and a long dry season from November to May. The rainfall regime is characterized by high Spatio-temporal variability (DMN, 2018). As cited in the ANADIA report, Hess *et al.* (1995) and Bello (1996) found variability in the rainfall regime ranging from 20 to 80 percent in the Sahelian zone. There is a decreasing gradient in the rainfall regime from north to south, with cumulative rainfall varying between 824 mm in Gaya in the southwest and 15.9 mm in Bilma in the northeast (DMN, 2011).

The climate risk profile, developed based on climate change scenarios (RCPs), which projected climate parameters and impacts across sectors until 2080, has highlighted the country's increasing vulnerability to climate change. Thus, based on this scenario, temperature in Niger is projected to rise by between 2.0 and 4.6 °C by 2080, compared to pre-industrial levels, with higher temperatures and more temperature extremes projected for the southwest of Niger (GIZ, 2021).

Precipitation trends are highly erratic, with projections ranging from a slight decrease to a more substantial increase in annual precipitation sums. Future dry and wet periods will likely become more extreme (GIZ, 2021).

1.7.3. Case Study Zones

Case study research scientifically investigates a real-life phenomenon in depth and within its environmental context (Ridder, 2017). This study adopts a case study as an effective data collection strategy (Marrelli, 2007) to enrich the findings regarding the gaps in integrating climate into disaster risk decision-making. The choice of this case is intended to provide insights from the beneficiaries of climate services, specifically the population living in flood-prone areas of the Niamey region. Five neighborhoods are concerned: Kombo, Lamordé, Kirkissoye, Nogaré, and Zarmagandey. The focus is on the 2020 flooding event, which caused losses and damages to the riverine population. Overall, 16 participants were interviewed in Kirkissoye (male: 11, female: 5), 15 in Kombo (male: 10, female: 5), 16 in Lamordé (male: 9, female: 7), 15 in Nogaré (male: 11, female: 4), and 13 in Zarmagandey (male: 5, female: 8).

In the Seasonal Climate Outlook Forum (RCOF 2020), rainfall amounts were expected to be higher than the average cumulative total for the 1981-2010 period over the Sahelian and Sudanian zones. Experts have then warned and called for measures to be taken in the face of the high likelihood of inundations. These recommendations clearly stated:
Given the above-average cumulative rainfall expected over the Sahelian strip, the shorter-than-average duration of dry spells, and the excess runoff from rivers, the risk of flooding is high. To mitigate these risks to people, animals, crops, and material assets, we recommend:

- Closely monitor alert thresholds at various sites at high risk of flooding;
- Strengthen communication of seasonal forecasts and awareness-raising among vulnerable communities by involving state actors and the various disaster risk reduction platforms in the communication and crisis management chain,
- Prevent uncontrolled occupation of flood-prone areas, particularly in urban areas,
- Strengthen the monitoring and intervention capacities of agencies in charge of flood monitoring, disaster risk reduction, and humanitarian aid,
- Ensure regular cleaning of drainage channels,
- Conduct simulation exercises as part of preparing flood response plans.

On September 6th, 2020, the high rainfall destroyed the dike in Lamordé. As a result, the whole zone got flooded. As the rainfall season continues, the flooded areas spread to other zones. On September 15th, the five zones were completely flooded, affecting 48,507 people and 6,928 households, destroying and forcing the population to evacuate. The flood also impacted public services, including schools, universities, and healthcare centers within the affected zones.

This situation occurred while CS were meant to be implemented to face flooding. These included the diffusion of alerts through National Television and Radio, SMS Alerts via Cell phones, and, more importantly, the SLAPIS EWS, which was implemented and covered the zones. A field survey was conducted in January 2024 within the five areas most affected by the flooding. Fifty-five (75) participants were interviewed using a semi-structured interview guide comprising traditional leaders, farmers, civil servants, students, and traders. The interview's main focus was understanding the gaps in implementing CS for population decision-making during the flood event. The purposeful and snowball sampling methods were employed to recruit participants based on specific criteria, including those who lived in the area in 2020, had a minimum primary level of education, and owned a telephone. Thus, a paper-based semi-structured interview guide was designed to collect the data. First, participants were identified, and based on their indication, additional participants were identified to proceed with interviews in the following areas, using a snowball strategy.

1.8. Outline of the Dissertation

General Introduction presents the context global and national of the study. The research problem states the need for investigation in the wake of the increasing recurrence of extreme climate events and their impacts in Niger and outlines research questions and objectives. The theoretical framework discussed the policy process, science-policy interface, and actor-oriented interface theories. The conceptual framework defines the concepts and their presumed interconnections. The section presented the study areas and the outline of the dissertation.

Chapter One identified policy-oriented priority areas in the field by adopting the PRISMA method. The analysis drawn from 242 scientific studies identified three policy-oriented priority areas including the development of CS, use-adoption-uptake of CS, and evaluation of CS. Major CS addressed included early warning systems, (sub)seasonal forecasts, and impact-based warnings. The co-production approach emerges as a cross-cutting component in the CS value chain in response to the inadequacy of the top-down approach to CS promotion. The chapter concludes with a recommendation for further investigation on the institutional lens of CS from a science-policy interface perspective. As an avenue for future research agendas, this perspective offers a valuable analytical lens and entry point given its importance to institutions and CS capacity to understand intricate facets of the decision-making process.

Chapter Two mapped institutions and CS capacity for DRM, using a qualitative research approach combining 47 policy documents, 19 key informant interviews with stakeholders, and participant observation analyzed through institutional mapping, institutional analysis, and qualitative document analysis. Findings evidenced a multi-layered institutional framework, which encompasses several institutions at the upstream and downstream decision-making processes. The National Framework for Climate Services (NFCS) and the Regional Climate Outlook Forum (RCOF) emerged as primary science-policy interfaces, bridging CS producers and decision-makers. The institutional layering also encompasses NDM, ACMAD, AGHRYMET, and NBA as the leading provider of CS in several formats and levels ranging from daily forecast, seasonal forecast, and alerts to EWS such as FANFAR, SLAPIS, SAICU-GTN, SATH-NBA, and GDACS. Regarding the implementation of CS for DRM, the GDCP, and MHA/DRR coordinate the dissemination process for floods as a sudden-onset disaster. In contrast, the NMPMFC, through the EWS/CU, coordinates the implementation of droughts as a slow-onset disaster, including its consequences and food insecurity. Although there is notable progress in establishing institutions and CS capacity, the overall trend of flood and drought occurrence and their impacts remains upward, suggesting gaps in institutions and CS implementation. The chapter recommends enhancing institutional coordination, expanding EWS coverage and capacity building, and formalizing mechanisms to integrate climate services into DRM decision-making processes.

Chapter Three examined the gaps that impede the development and implementation of CS for DRM, employing a qualitative methodology based on 19 in-depth interviews, 75 semi-structured interviews, and a review of 47 policy documents. From the policy process perspective, the implementation of CS appeared to be primarily driven by an external agenda-setting with a project-driven approach, resulting in several ramifications. The primary issue is the funding gap, marked by acute dependence on external funding and the lack of state-led funding mechanisms. These gaps affect the sustainability of CS interventions, the limited geographical scope, and the lack of takeover. The infrastructural gap depicted a deficiency in equipment capacity, particularly regarding the weather observation network, which affects the production of CS due to its sparsity and difficult access in areas affected by armed conflicts. From the actor-oriented perspective, results highlighted gaps between CS providers and beneficiaries, which are shaped and influenced by several interface encounters including inadequate last-mile communication, CS format, and limited accessibility.

The General Conclusion concludes the dissertation with a general discussion of research findings. It then outlines the theoretical and empirical contributions of the study and states the limitations of the study. The section concludes by proposing avenues for future research.

CHAPTER 1: SYSTEMATIC REVIEW OF POLICY-ORIENTED PRIORITY AREAS OF CLIMATE SERVICES FOR DISASTER RISKS MANAGEMENT AND RESEARCH GAPS

Chapter 1: Systematic Review of Policy-Oriented Priority Areas of Climate Services for Disaster Risks Management and Research Gaps

2.1. Abstract

CS are key for mitigating and managing the impacts and risks associated with climate-induced disasters. While evidence over the past decade underscores their effectiveness across various domains, particularly agriculture, to enhance their potential, it is crucial to identify priority areas and existing research gaps for future research agendas. As a contribution to this effort, this chapter employs the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to review the state of the art, which yielded 242 peer-reviewed articles, book sections, and reports from 2013 to 2023 after the screening process. Findings revealed flood, drought, and food insecurity as major climate-related disasters addressed in the literature. Major CS addressed included EWS, (sub)seasonal forecasts and impact-based warnings. Grounded in the policy processes theoretical perspective, the main focus identified and discussed three prevailing policy-oriented priority areas: (i) development of climate services, (ii) use-adoption-uptake, and (iii) evaluation of climate services. In response to the limitations of the prevalent supply-driven and top-down approach to climate services promotion, co-production emerges as a cross-cutting critical aspect of the identified priority areas. Despite the extensive research in the field, more attention is particularly pronounced from the science-policy interface perspective. This perspective offers a valuable analytical lens as an entry point for further investigation. Hence, future research agendas would generate insightful evidence by examining this critical aspect, given its importance to institutions and climate services capacity, to better understand intricate facets of developing and integrating CS into DRM.

Key Words: climate services, disaster risks management, systematic review

Cite: Gaoh, A., Laube, W., Abbey, G. and Waongo, M. (2024) Mapping Climate Services for Disaster Risk Management: A Systematic Review and Research Gaps from a Policy Process Perspective. *American Journal of Climate Change*, **13**, 314-360.

2.2. Introduction

The widespread impacts of climate change and the need to make communities climate-resilient are at the heart of many countries' development and adaptation agendas. In this vein, researchers and experts continue to call for urgent and increased efforts to develop sound CS systems that mitigate and manage climate-induced disaster risk worldwide. Great scientific endeavors and investments have been made to develop and promote them, and the concept of CS has been placed at the heart of the international adaptation agenda following the World Climate Conference in 2009. Despite abundant research and investments, the impacts of climate change on human and natural systems continue to rise, and additional efforts towards more effective CS for DRM are increasingly important.

There is an increasing need to develop a deeper understanding of the production, dissemination, and implementation of CS, particularly in collaboration between scientists and decision-makers, to enhance climate-informed decision-making. This systematic literature review represents an evidence synthesis work summarizing the key findings of scientific literature about CS for DRM published from 2013 to 2023. This chapter answers the question of what are the policy-oriented priority areas in CS for DRM? and leads to identifying potential research gaps as an entry point for future research agendas. In doing so, we adopted a systematic literature review grounded in the policy process's theoretical perspectives.

2.3. Theoretical Approach: Policy Process

The theoretical framework that informs this Essay is rooted in the linear model of the policy process and the interactive model of policy implementation to explore the landscape of CS for DRM. Grounded in the policy process perspective, the framework provides a lens (Larsen & Adu, 2021; Grant & Osanloo, 2014) to capture policy-oriented priority areas.

Policies emerge due to social needs or problems (Ozgur & Kulaç, 2017). In an attempt to provide a comprehensive definition of policy, Birkland (2010) synthesized a set of attributes of policy such as problem-solving oriented, made in the public interest, interpreted, and implemented by public and private actors; goal-oriented or oriented state, ultimately made by government or via the interplay of government and nongovernmental actors. These elements are widely considered substantially instrumental to policy-making, a view that many scholars accept.

The linear model, widely known as a staged, sequenced model, represents one of the most traditional theories for understanding policy formulation and implementation, according to Sutton (1999), and remains a valuable starting point for understanding policy-making processes (Ozgur & Kulaç, 2017). According to this model, the policy process is allegedly characterized by a well-ordered arrangement of steps, translating a rational trajectory from problem identification to solution implementation, including agenda setting, which refers to the identification and framing of potential issues to be addressed by decision-makers, decision phase defining the formulation of the policy, and implementation phase in which policy is put in action and evaluation in which the impacts and performance of the implemented policy are assessed to determine its success or failure (Grindle, 1991; GültekiN, 2014). This lingering model provides an objective analysis of options and a clear separation between policy and implementation (Sutton, 1999; Thomas & Grindle, 1990).

In practice, a proposed reform is added to the government's agenda, a decision is made on the proposal, and a new policy or institutional arrangement is implemented, either successfully or unsuccessfully (Grindle, 1991). Mostly, there is a strong focus on policy formulation and decision-making, while the implementation phase receives less attention. However, since the outcomes of policy initiatives are often determined by a lack of political will, poor management, or shortage of resources (Sutton, 1999) but not necessarily depending on the policy or decision itself, a proper analysis of a policy process needs to include policy implementation and feedback loops between implementation and policy making.

Although linear policy models have helped shift attention from policy formulation and political decision-making to implementation, they are, according to Sutton (1999), oversimplifying and overlooking the complexity of policy processes, which are not necessarily linear; steps within the process may overlap or coincide. Furthermore, linear models are criticized for overlooking the influence of power dynamics and the diversity of actors that shape agenda-setting, decision-making, and implementation by focusing solely on the logic and rationality of these steps.

In contrast to the traditional linear model, several instrumental elements influence policy outcomes, from agenda setting to implementation, in the interactive models of policy processes. In a seminal work, Sutton screened the contributions of several disciplines, including political science, sociology, anthropology, international relations, and management studies, to provide an overview of interactive models of policy processes. Against the conventional understanding of policy as a linear process, they argued that policy is not simply about analyzing a problem, appraising possible responses, selecting a response rationally, implementing the chosen action, and evaluating the outcome (Clay & Schaffer, 1984). Instead, they suggested that the policy process is more complex and chaotic, shaped by multiple purposes and unintended consequences. This perspective challenges the traditional ″practitioner perspective″, which views policies as ″objective entities″ that result from decisions made by a rational authority and reorganize bureaucratic action to solve particular problems and produce a known (or desired) outcome (Clay & Schaffer, 1984).

The perspective emphasizes the complexity and unpredictability of policy-making, highlighting that it is not merely a matter of rational implementation of decisions through selected strategies. Such processes can be understood using concepts such as policy narratives, policy communities, and change management, which have been developed by various scientific disciplines. Policy processes should be both dynamic and processual. Different steps in a given policy process are likely to be reshaped or affected by the interests and reactions of various actors, thus affecting the outcomes (Grindle, 1991; Thomas & Grindle, 1990). Considering implementation as the most crucial component of the process, the interactive model places it at the center of the policy process analysis.

2.4. Materials and Methods

2.4.1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

Initially used in psychology and health science (Durach *et al.*, 2017; Higgins & Green, 2020; Moher *et al.*, 2014), the systematic literature review (SLR) is now recognized as a standard methodology for summarizing and identifying key scientific contributions in many scientific fields (Pahlevan Sharif *et al.*, 2019; Schmid, 2020; Tranfield *et al.*, 2003), including climate change adaptation (Berrang-Ford *et al.*, 2015; Shaffril *et al.*, 2021) and disaster risk management. According to Snyder (2019) traditional literature reviews are often criticized for being opaque in their selection and evaluation of literature and tend to lack a rigorous methodology, which can result in significant bias in the review process.

SLR is beneficial in research fields that involve complex questions and employ a wide range of conceptual and epistemological approaches and diverse information sources (Shaffril *et al.*, 2021). Unlike traditional review, according to Higgins and Green (2020), SLR provides a comprehensive and organized way of reviewing the existing literature, in which the methodology is transparent and replicable. The current review methodology adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher *et al.*, 2014) (**Figure 2.1**). The process is organized into seven steps drawn from the

PRISMA statement checklist (Page *et al.*, 2021), including data collection, data analysis, and data synthesis. How these were performed is described in the following sections.

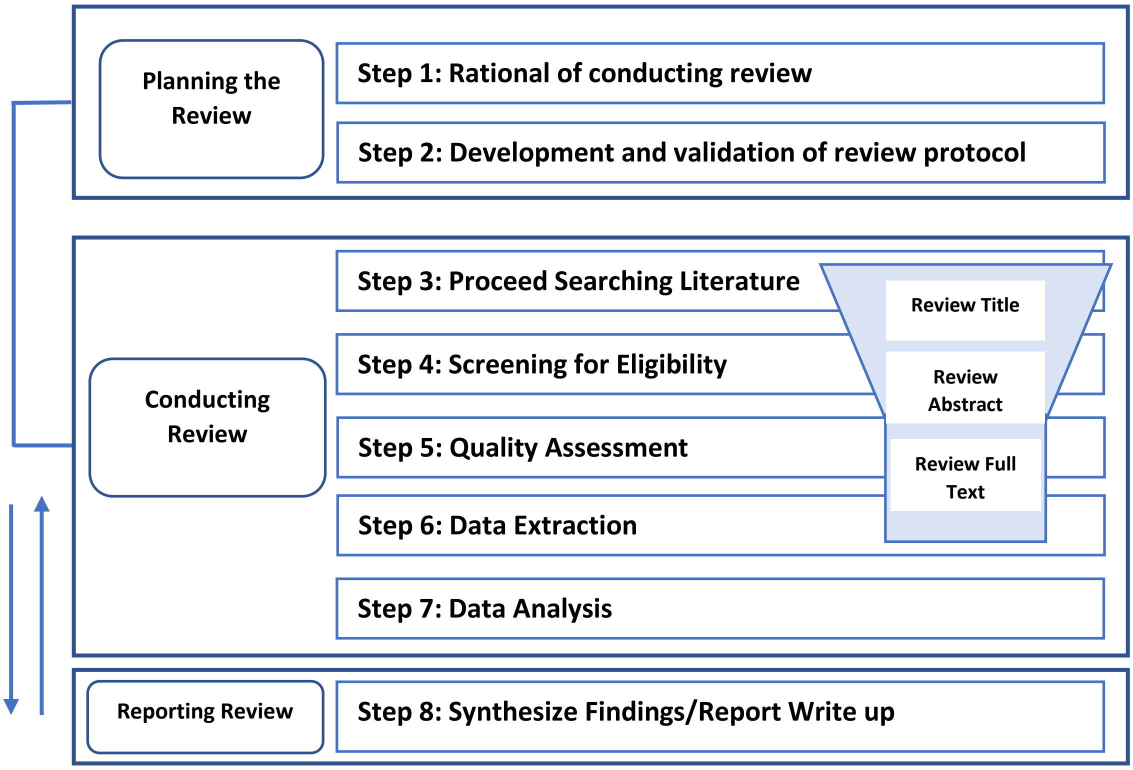

Figure 2. 1*: Steps of Systematic Literature Review Adapted from (Xiao and Watson, 2019)*

2.4.2. Data Collection: Review Concepts and Search Strings

Given the cross-cutting aspect of the subject of inquiry and out of the need to ensure a rich and comprehensive review, the data collection was performed by relying on multidisciplinary sources as recommended in the Cochrane Handbook (Bramer *et al.*, 2017), including Research4life, Tylor and Francis online, Google Scholar, ScienceDirect, and JSTOR using a search string (**Figure 2.2**) that refined search results to retrieve articles that were most relevant to the review topic. Records were directly saved into Zotero through the web importer extension in Google Chrome.

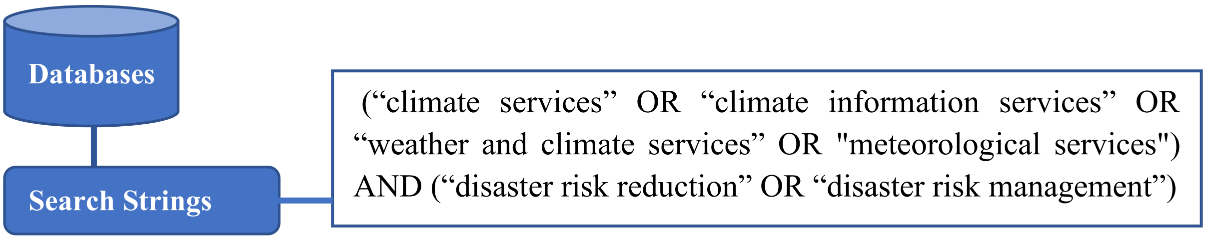

Figure 2. 2*: Review Concepts and Search Strings*

To collect records not captured in databases, a snowball search strategy was employed in ResearchRabbit to identify additional studies related to the initial one imported. This step was achieved by searching for literature citing the initial hit and relevant papers cited in these texts.

2.4.3. Inclusion and Exclusion Criteria

Based on the inclusion and exclusion criteria (**Table 2.1**), a three-stage screening was performed to identify the final sample from 2168 records. Thus, (1) duplicates were removed, and titles were scanned against eligibility criteria. (2) abstracts were screened, and (3) the full content was evaluated. Records collected from databases (1460) and records collected through ResearchRabbit (998) resulted in an initial sample of 2168. Within this sample of 2168 records, the initial screening process eliminated a substantial number of studies due to their minor focus on CS for DRM. Within the sample, some papers combined literature, interviews, and questionnaires; these papers were then considered as satisfying the inclusion criteria because they did not rely solely on a literature review. In the final step of the screening, 46 studies (32 from the set of five databases and 14 from ResearchRabbit) were excluded from the 288 papers, resulting in a sample of 242 included in the review.

Table 2. 1: *Inclusion and Exclusion Criteria*

Inclusion criteria	Exclusion Criteria
(weather) (climate) (meteorological) information services, disaster risk management (reduction)	Editorials, working papers Grey literature, blogs, unpublished papers
(Peer-reviewed) research journal	Systematic Review and scoping review
Book chapter (section)	Mini Review, communication
Timeframe (2013-2023)	Publication beyond this timeframe
Publication language (English)	Publication not in English
(Official Report) Issued by the Government or institutions dealing with climate services for DRM/DRR	News, Policy briefs, Conference papers

Note. Developed by author

2.4.4. Data Extraction, Coding, and Analysis

To proceed with data processing (**Figure 2.3**), the records were consolidated into a single database using Zotero 6.0.26. Duplicates were removed, and initial filtering was performed. The data were then exported to Microsoft Excel for further sorting and organization, facilitating the continued screening and generation of graphs and tables. Data analysis was conducted in descriptive and thematic/content analysis (Tranfield *et al.*, 2003). The former provides a comprehensive account of the sample included in the review, whereas the latter offers a qualitative thematic/content analysis (Creswell & Creswell, 2018), drawing on key conceptual patterns emerging from the reviewed literature. Thematic/content analysis was employed to identify conceptual patterns (Braun *et al.*, 2019; Braun & Clarke, 2013; Flick, 2014), and eligible records were imported into ATLAS.ti 23 for analysis. This process facilitated the identification of key themes and patterns in the data. After organizing the data, two coding processes were employed, including open coding and axial coding (Adu, 2019; Auerbach & Silverstein, 2003; Saldaña, 2016). At the first stage of open coding, relevant data were condensed to generate initial units of analysis (codes). The axial coding completed the first stage, which involved grouping and connecting codes and placing them in new categories. This allowed to come up with sub-priority areas.

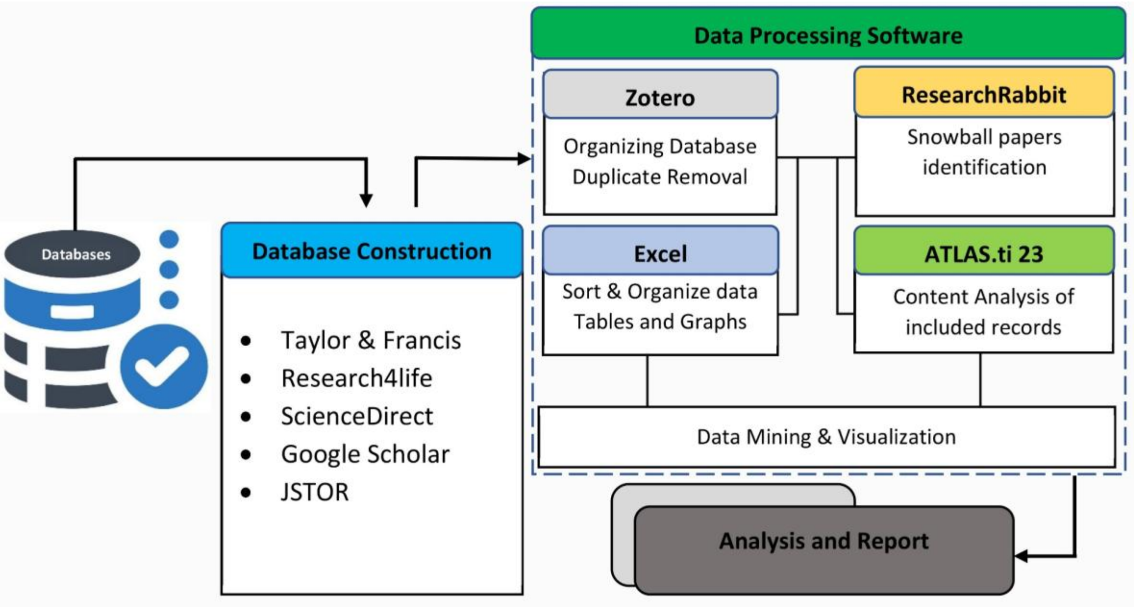

***Figure 2. 3**: Data Extraction, Coding, and Analysis*

As part of the data collection, screening, and extraction process, a specific checklist (**Table 2.2**) was utilized. This checklist contains meta-data, based on which relevant information was identified and captured for the analysis. By following this procedure, each study was reviewed per this metadata checklist.

***Table 2. 2:** Checklist of meta-data for the review*

Item ID	Description of Item
Title	Portrays the title of the paper/document included in the review
Objective	Described the objectives of the study
CS/WCS/CIS/MS/DRM/DRR	Key concepts used in bibliographic search
Key Words	Main concepts of the research
Milestones	The main findings achieved in the study
Abstract	Summary of information contained in the paper
Authors	Authors who contributed to the production of the study
Global/Region/Country	Geographical scope and situation of study
Document Type	Type of document included in the study
Journal	Journal in which the paper is published
Disaster Type	Type of climate-related disaster in the study
Sector	Sector of focus in the study

*CS: Climate Services, *WCS: Weather and Climate Services, *CIS: Climate Information Services, *MS: Meteorological Services, *DRM: Disaster Risk Management, *DRR: Disaster Risk Reduction

Note. Developed by author based on literature

2.4.5. Quality Appraisal

The ROBIS (McGuinness & Higgins, 2020) (https://www.riskofbias.info/) tool was applied in this review to assess its quality. This process included (1) Relevance Assessment, which evaluated the relevance of the studies concerning the review's objective. (2) Identification of concerns with the review process, which identified potential issues or concerns with the process of the review itself, particularly regarding the PRISMA methodology. (3) Bias Risk Judgment, the final step that involves making an overall assessment of the review's reliability (Whiting *et al.*, 2016).

Within these three stages, four key domains are examined, including (i) Study Eligibility Criteria, which assessed the criteria used to select studies for inclusion (**Table 2.2**) and ensured that the selection process is unbiased and consistent. (ii) Identification and Selection of Studies, evaluating the methods used to identify and select studies for inclusion in the review. It ensured that all relevant studies were considered and that the selection process was transparent and replicable. (iii) Data Collection and Study Appraisal, which examined the methods used for data collection and the appraisal of studies by ensuring that the data collected is reliable and that the quality of the studies included in the review has been appropriately evaluated. (iv) Synthesis and Findings, the final domain that evaluated the way findings have been synthesized to ensure that the conclusions drawn are backed by the data and are presented clearly and understandably.

The assessment was conducted into five (5) batches, with the risk of bias for each batch of studies included, detailed in (**Figures 2.4; 2.5; 2.6; and 2.7).** As displayed in these figures, each of the 242 included studies was assessed according to this method to ensure the reliability of the review. Concerning the assessment of the studies batch 5, is placed in (**appendix 10**).

Overall, after the assessment, most of the studies included in the review were found to have a low to moderate risk of bias, indicating a high level of reliability of the review.

Figure 2. 4: Studies Batch 1 Risk of Bias

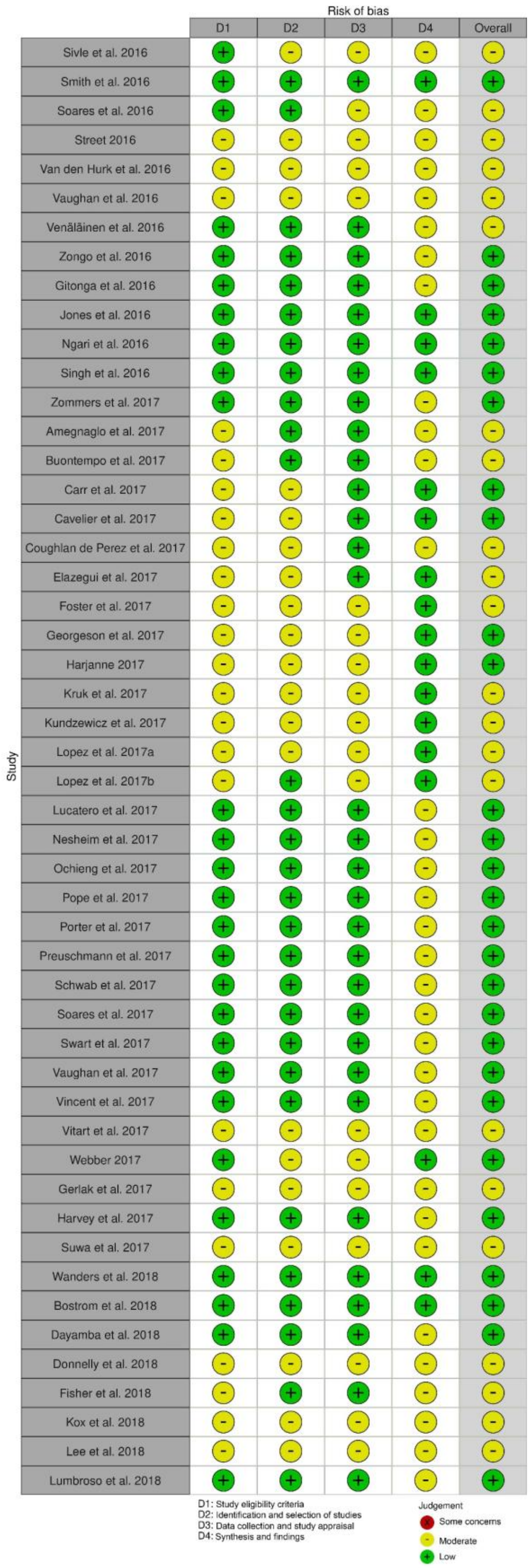

Figure 2. 5: Studies Batch 2 Risk of Bias

Figure 2. 6: Studies Batch 3 Risk of Bias

Figure 2. 7: Studies Batch 4 Risk of Bias

2.5. Results and Discussions

From 2458 records collected, 2216 studies (including duplicates and irrelevant) were removed through the screening process, resulting in a final sample of 242 (**Figure 2.8**) based on the eligibility criteria (**Table 2.1**). The reviewed record of 242 studies included 201 (83%) journal articles, 33 reports (13 %), and 9 (4%) book sections, all related to CS and DRM (**Figure 2.9**).

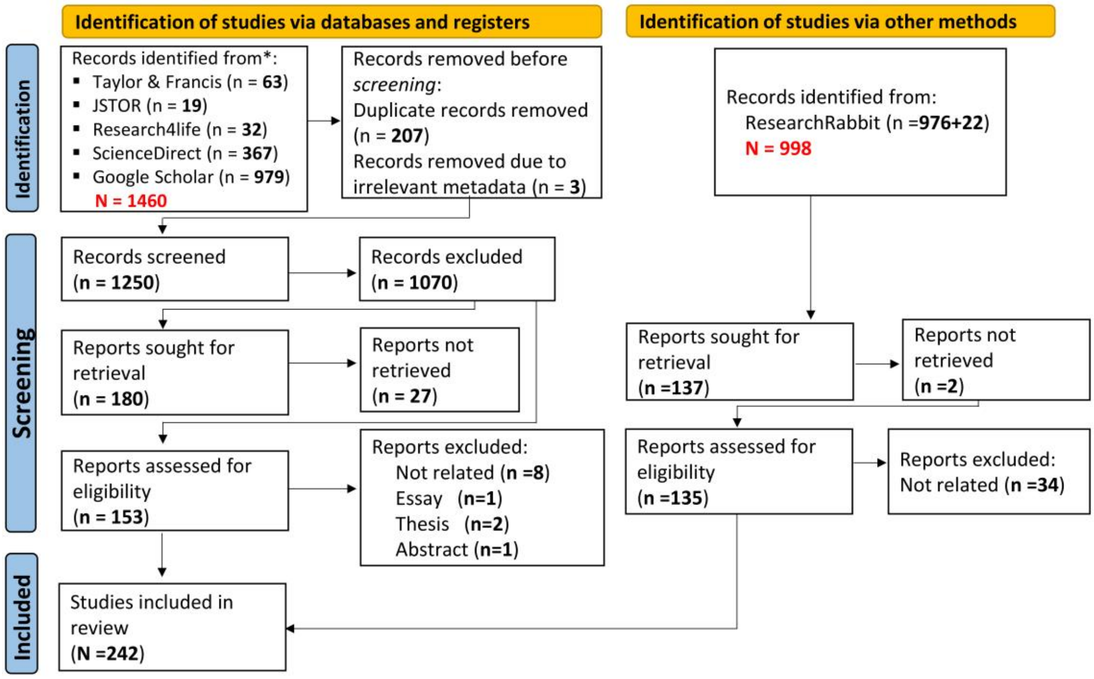

Figure 2. 8: *PRISMA Flowchart of Studies Included in the Review*

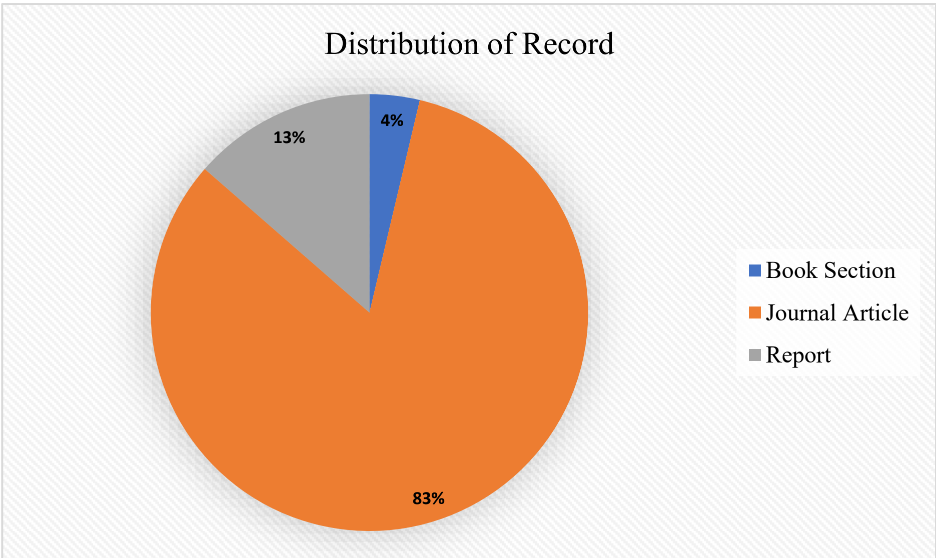

Figure 2. 9: *Distribution of Studies Included*

2.5.1. Assessment of Studies on Climate Services for Disaster Risk Management

Literature production has increased substantially over the ten years (2013-2023) covered by this review (**Figure 2.10**). The temporal evolution portrays that the highest production occurred in

2020, followed by 2021, 2019, and 2017, while the lowest scientific literature production was identified in 2013 (considering that this work concerned the early publication of 2023).

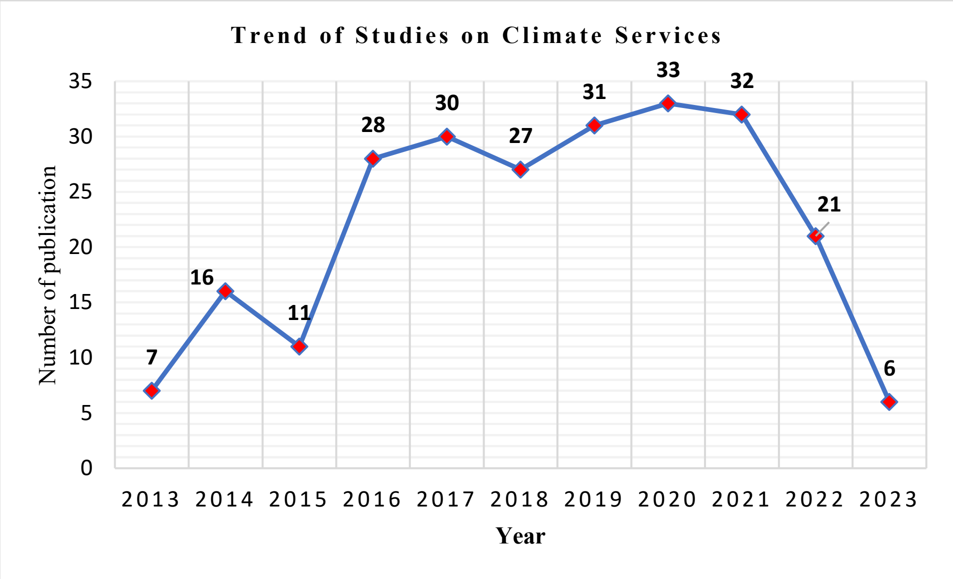

Figure 2. 10: Trend of Studies on Climate Services

Among the literature surveyed, Climate Services has the highest number of publications (n=48) followed by the International Journal of Disaster Risk Reduction (n=14) and Climate Risk Management (n=11), summarized in (**Table 2.3**)

Table 2. 3: Number of Publications per Journal

Journal	**Publication**
Climate Services	48
International Journal of Disaster Risk Reduction	14
Climate Risk Management	11
Weather, Climate, and Society	9
Bulletin of the American Meteorological Society	6
Climatic Change	6
Hydrology and Earth System Sciences	6
Climate and Development	5
Environmental science & policy	4
Frontiers in Climate	4
Frontiers in environmental science	4
Sustainability	4
Advances in Science and Research	3
Earth Perspectives	3
Journal of meteorological research	3
Weather and Climate Extremes	3
Wiley Interdisciplinary Reviews: Climate Change	3
Climate	2
Environmental Development	2
Frontiers in Marine Science	2

Journal	**Publication**
Geoforum	2
Global Environmental Change	2
Natural Hazards and Earth System Sciences	2
The Journal of Agricultural Science	2
Water	2
Agriculture	1
Area	1
Atmospheric and Climate Sciences	1
Climate Policy	1
Copernicus	1
Current Journal of Applied Science and Technology	1
Current Science	1
Earth and Space Science	1
Earth’s Future	1
East African Journal of Science, Technology and Innovation	1
Ecological Economics	1
Environmental Hazards	1
Frontiers in Sustainable Food Systems	1
Gender, Technology and Development	1
Geomatics, Natural Hazards and Risk	1
Geoscience Communication	1
Geoscience letters	1
International Journal of Climate Change Strategies and Management	1
International Journal of Disaster Resilience in The Built Environment	1
International Journal of Disaster Risk Science	1
International Journal of Environmental Research and Public Health	1
International Journal of Water Resources Development	1
ISPRS International Journal of Geo-Information	1
Journal of Contingencies and Crisis Management	1
Journal of Environment and Earth Science	1
Journal of Flood Risk Management	1
Journal of geophysical research. Atmospheres	1
Journal of Hydrology	1
Journal of Hydrometeorology	1
Journal of Integrated Disaster Risk Management	1
Journal of Public Affairs and Development	1
Meteorological Applications	1
Meteorology and Climatology	1
Meteorology Hydrology and Water Management. Research and Operational Applications	1
One Earth	1
Open Access Library Journal	1
Political Geography	1
Procedia. Economics and finance	1
Proceedings of the International Association of Hydrological Sciences	1
Proceedings of the National Academy of Sciences of the United States of America	1

Journal	Publication
Progress in Disaster Science	1
Science Advances	1
Science Bulletin	1
South African Journal of Science	1
Tropical Conservation Science	1
Tropical Cyclone Research and Review	1
Urban Climate	1
Water Resources Research	1
Total	**200**

Noted. Designed by author based on analysis of included studies

Concerning reports produced by institutions involved in climate services and disaster risk management, the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) has the highest record (n = 7), followed by the World Meteorological Organization (WMO) and the World Bank (**Table 2.4**). (**Table 2.5**) summarizes publishers of books sections included in the review where Springer totalizes the highest (n=6).

Table 2. 4: *Literature Publication per Institution*

Institution	Publication
CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)	7
World Bank	4
World Meteorological Organization (WMO)	4
Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED)	3
Alliance of Biodiversity International and CIAT, CARE International, and World Agroforestry (ICRAF)	1
Building Resilience and Adapting to Climate Change (BRACC)	1
CARE International	1
CICERO Center for International Climate and Environmental Research	1
Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA)	1
European Union (EU)	1
Konrad-Adenauer-Stiftungand, University of Nairobi, African Drylands Institute for Sustainability	1
Kulima Integrated Development Solutions and the University of Leeds	1
Stockholm Environment Institute (SEI)	1
UK aid/Weather and Climate Information Services for Africa (WISER)	1
UK Climate Resilience Programme	1
UK Department for International Development (DFID)	1
United Nations University Institute for Water, Environment and Health (UNU-INWEH)	1
WASH Cluster Somalia	1
World Meteorological Organization (WMO) & National Oceanic and Atmospheric Administration (NOAA)	1
Total	**33**

Noted. Designed by author based on analysis of included studies

Table 2. 5: Publishers

Publisher	Publication
Springer	6
Elsevier	1
Routledge	1
World Scientific Publishing Co. and APEC Climate Center	1
Total	**9**

Noted. Designed by author based on analysis of included studies

Looking at the geographical coverage of studies included, the highest percentage of publications addresses Africa at 36.4%, Europe at 24.8%, Asia at 16.1%, and Oceania at 1.2%. Some studies covered more than one geographical zone, as highlighted in (**Figure 2.11**). The last category concerns studies focusing on a global scale, accounting for 10.7%.

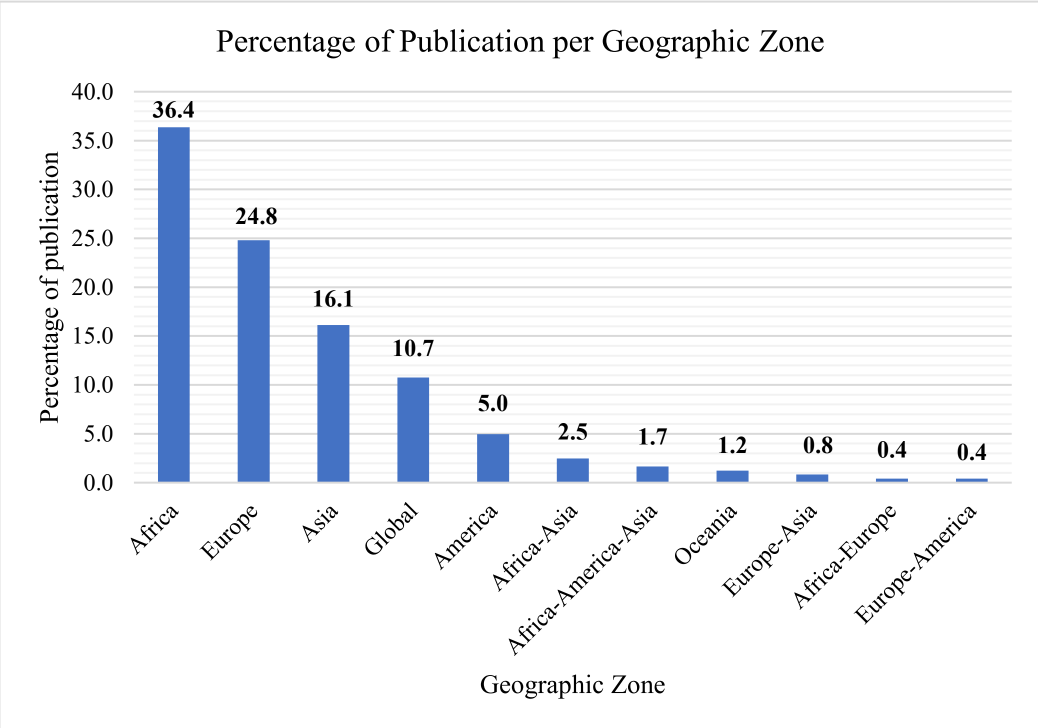

Figure 2. 11: Distribution of Literature Production per Geographical Zone

2.5.2. Profiling Climate-Induced Disasters Addressed in the Systematic Review

The extensive array of scientific literature on CS for DRM and its broad coverage across various fields, including agriculture, water resources management, and urban development, demonstrates the growing interest in this field. Over the past decade, scientific production has been abounding with increasing interest from scholars of various backgrounds and perspectives. By systematically reviewing literature from 2013 to 2023, this work mapped scholarly research priorities in CS for DRM. This section begins by presenting climate-induced disasters in the literature and the typology of CS. The second section delves into analyzing identified policy-process-related priority areas in the literature.

Flooding stands out prominently in this review as one of the most common climate-induced disasters. Simultaneously, drought also emerges as another frequently occurring disaster (**Figure 2.12**). These findings align with evidence indicating that hydro-climatic extreme events have increased in magnitude globally due to climate change (IPCC, 2022). In Africa, over the last twenty years (2002-2021), the Centre for Research on the Epidemiology of Disasters (CRED) indicated the occurrence of 793 floods and 137 droughts (CRED, 2022), which impacted more than 52 million people in 2022 according to the Global Center on Adaptation (GCA, 2022). Furthermore, food insecurity appears in the third position in the explored literature as a consequential outcome of the interplay of the first two (CRED, 2022). In Asia, recent evidence indicates that 81 climate-related disasters occurred in 2022, with over 83% being floods and storms (WMO, 2022a).

As a widespread phenomenon observed globally, particularly in the southern regions, drought worsens, increasing impacts and damages (Aadhar & Mishra, 2021; Ha *et al.*, 2023) and in Monsoon regions (Kim *et al.*, 2020). Other climate-related events in the literature include cyclones and storms (**Figure 2.12**). In Europe, more frequent and hotter heatwaves are expected, while in some parts, droughts will increase, and flooding will occur in other zones (Guerreiro *et al.*, 2018). The occurrence and impacts of drought and flood are well documented, as appeared in (Lehner *et al.*, 2006), in which these events have been projected to increase.

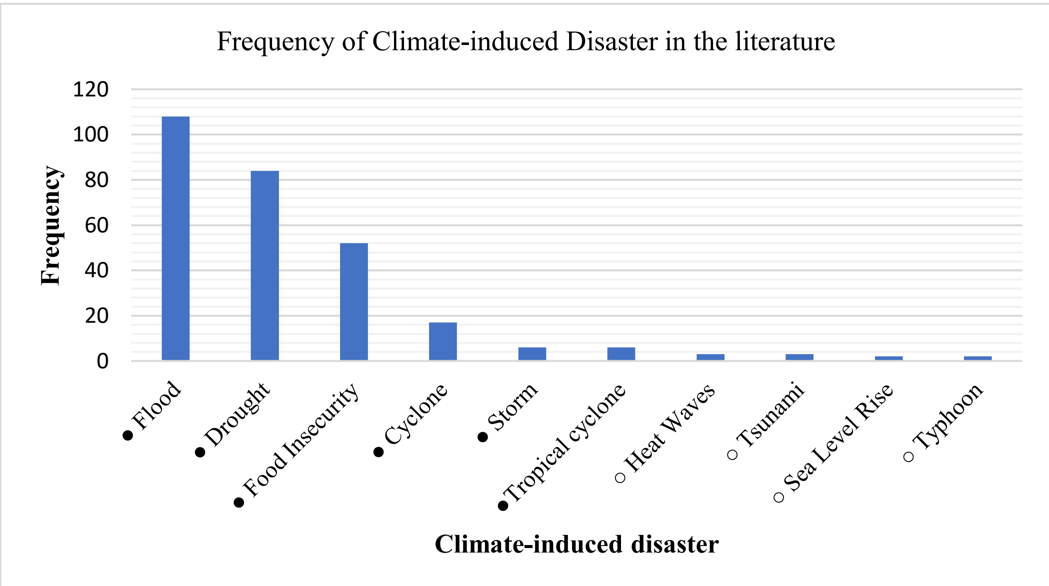

Figure 2. 12: *Frequency of Climate-induced Disaster in the Literature*

2.5.3. Profiling Climate Services for Disaster Risk Management

CS has rapidly and progressively expanded as a field of interest among various actors, depending on their logic and research interests (Vaughan & Dessai, 2014b). The urgent need to mitigate and face climate-induced disasters has sparked attention to the role CS play in the DRR cycle in managing this societal risk (Hewitt & Stone, 2021). This has led to the need for the development of various typologies of CS (Bessembinder *et al.*, 2019) to support decision-making for a wide range of end-users. A wide variety of CS are developed to meet the needs of both supply and demand sides (Visscher *et al.*, 2019). Throughout the reviewed literature, the various CS for DRM encompasses a range of essential components that aim to enhance preparedness, response, and resilience in the face of climate-induced disasters.

These services are broadly categorized into three key areas: climate information, impact assessment, and decision support. CS provide reliable and timely data on weather patterns, climate variability, and long-term climate projections. This includes meteorological data, such as temperature and rainfall patterns, as well as climate modeling and forecasting. Impact assessment services analyze the potential consequences of climate-related hazards on various sectors, including water, infrastructure, agriculture, health, and ecosystems. These assessments help understand vulnerability and risk exposure, facilitating the development of targeted disaster reduction strategies. Decision support services utilize climate information and impact assessments to inform policy and decision-making processes. They involve developing user-friendly tools, such as risk mapping and early warning systems, which enable stakeholders to make informed choices and take proactive measures in disaster risk reduction.

By combining these types of CS at different scales, policymakers, communities, and individuals can better anticipate, prepare for, and respond to climate-induced disasters, ultimately minimizing their impacts and building resilience in a changing climate.

In summary, CS for DRM identified within the literature include meteorological services, weather information, warnings, forecasts (such as seasonal climate forecasts and sub-seasonal to seasonal forecasts), early warning systems (e.g., flood early warning and cyclone early warning), and Impact-Based Warning Systems (**Figure 2.13**).

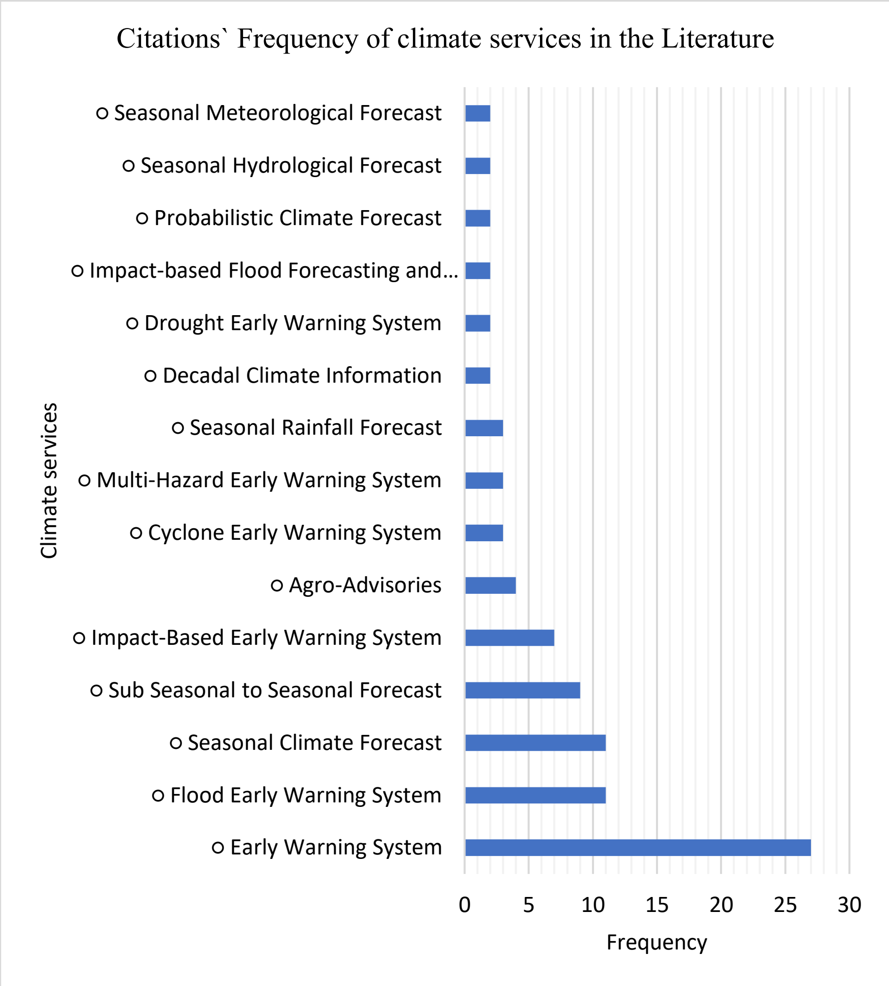

Figure 2. 13: *Citations Frequency of climate services in the Literature*

2.5.4. Policy-Oriented Priority Areas on Climate Services for Disaster Risks Management

The analysis of the reviewed literature identified three major and interconnected policy-oriented priority areas, including (i) development of climate services, (ii) use-adoption-uptake of climate services, and (iii) evaluation of climate services (**Figure 2.14**).

These priorities are integral to disaster risk management and climate change adaptation, both of which fall within the realm of climate change policy, aiming to encourage science-based and climate-informed policy development (Larosa & Mysiak, 2020). Broadly considered within climate change policy, adaptation is viewed not as a single activity but rather as a continuous process and ongoing policy cycle to understand risks, develop adaptation options, and assess them (Leal & Jacob, 2020). In the same vein, authors argued for the concept of adaptation services, which complement climate services in the context of risk management. This standpoint on adaptation services aligns with the definition of CS as providing climate information in a manner that supports decision-making (WMO, 2014). Similarly, CS support all phases of disaster risk reduction (Street et al., 2019).

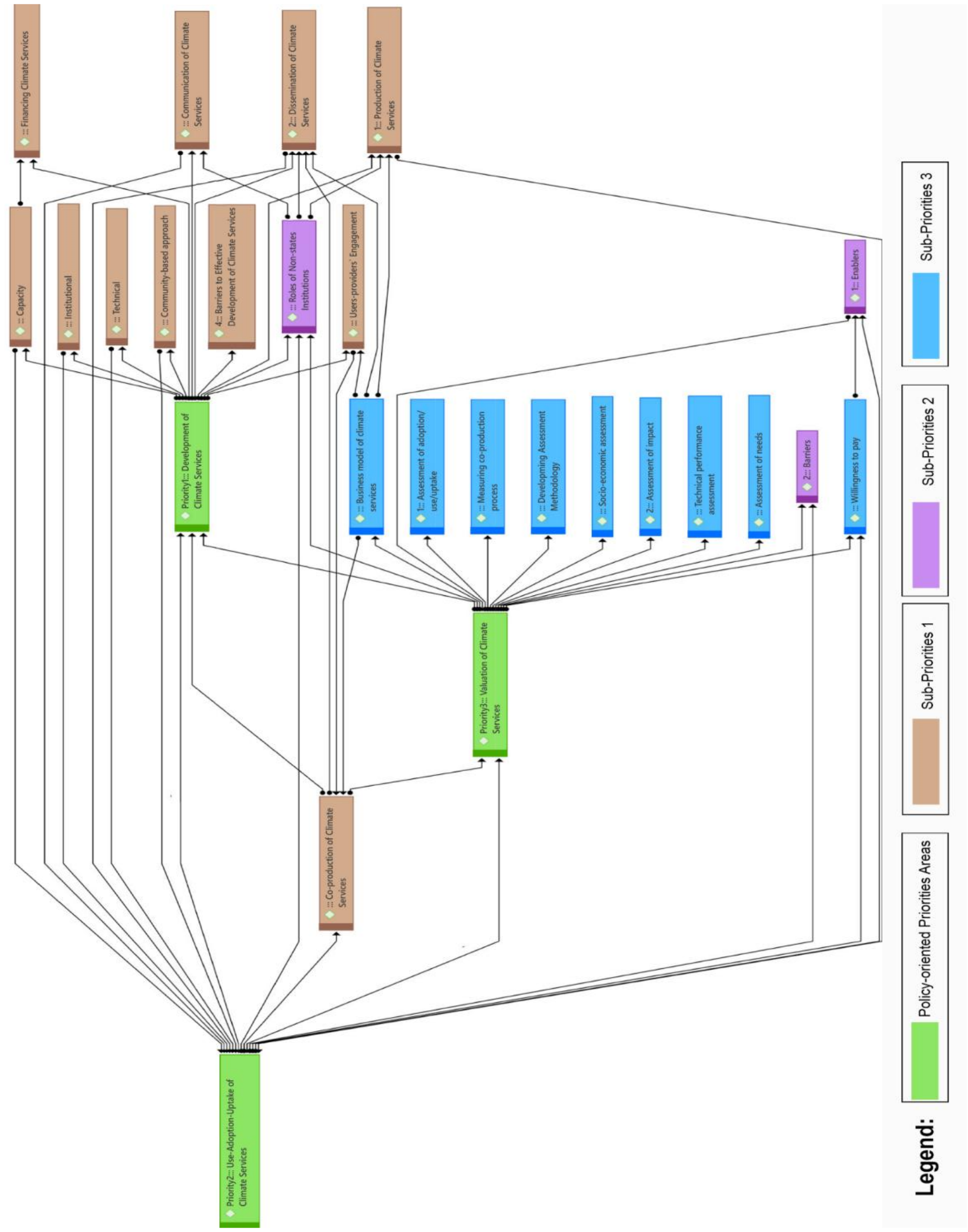

Figure 2. 14: Identified Policy-Oriented Priority Areas

2.5.4.1. Priority 1: Development of Climate Services

The development of CS provides reliable decision support in efforts to adapt to climate change (Leal & Jacob, 2020). In parallel, as part of their role in decision-making, CS have been proven to support a better understanding and anticipation of disaster risk.

In the explored literature, the development of CS revolves around various aspects, namely (1 production: co-production; users-providers` engagement), (2 dissemination: communication; community-based approach; roles of non-state institutions (NGOs and Private sector), (3 barriers to development: institutional; technical; capacity). To foster effective dissemination, many projects employ a community-based approach, which goes beyond a simple top-down approach by involving the community at the heart of the dissemination process. This has brought non-state actors on board, as it falls within the realm of their developmental interventions. Non-governmental organizations have made significant efforts in this regard (Jones *et al.*, 2016; Kirbyshire & Wilkinson, 2018) in implementing CS programs, bringing a new breath of life to the field.

By recognizing the widespread impacts of climate change and variability, which became an existential threat to humanity as well as the humanitarian perspective to addressing societal needs to face its impacts, these stakeholders recognized the need to build a strong and effective CS system (Coughlan de Perez & Mason, 2014), This has marked a renewed interest in funding projects to support countries in their effort to build a sustainable CS system from NGOs and non-state actors, especially in sub-Saharan Africa (Harvey et al., 2019). In this context, they are considered key actors, given the recognition of a "missing middle" of two-way brokering, translation, and validation where NGOs and other non-state actors can support innovation and experimentation, particularly in two-way forms of engagement with local actors and knowledge holders (Knudson & Guido, 2019).

2.5.4.2. Priority 2: Use-Adoption-Uptake of Climate Services

The second priority area, extensively documented in the explored literature, represents the use-adoption-uptake of CS. Beyond methodological considerations, this conceptual variation focuses mainly on understanding two key elements: enablers and barriers (Antwi-Agyei *et al.*, 2021). Interestingly, these elements can sometimes be found within a single factor, which can both enable and hinder. CS are produced to support users' decision-making processes (Vaughan & Dessai, 2014b), which suggests that tailoring these services to meet users' needs significantly shapes their adoption (Buckland & Campbell, 2021). This highlights the positive impact of co-design on the use and uptake of CS (Buckland & Campbell, 2021).

Several factors influence the adoption of CS, including gender (Carr & Onzere, 2018), awareness and perception of CS (Zongo *et al.*, 2015), institutional membership (West *et al.*, 2018), institutional design (Vedeld *et al.*, 2021), and institutional coordination and communication (West *et al.*, 2018). These factors are closely linked to the concepts of salience, legitimacy, and credibility, which influence the usefulness of CS to end-users (Cash *et al.*, 2002; Clifford *et al.*, 2020). To achieve salience, legitimacy, and credibility, it is crucial to manage boundaries between disciplines, scales, and forms of knowledge(Cash *et al.*, 2002).

Furthermore, several factors are related to the roles of non-state institutions or actors in providing and creating favorable conditions to enhance the usability of climate services. One such aspect is the agency of non-state actors, particularly the emergence of NGOs. These organizations act as brokers in disseminating CS, creating an enabling environment that enhances utilization (Harvey et al., 2019). Consequently, as discussed in the literature, the enablers and barriers are arguably attributed to the approaches adopted during climate service implementation. In most cases, barriers are considered to reflect a supply-driven approach in which users have limited input in the process.

In contrast, the adoption of a bottom-up, participatory, or co-production approach is reflected in the enablers, as the users' needs are at the heart of the approach, in addition to the continuous interactions throughout the process.

2.5.4.3. Priority 3: Evaluation of Climate Services

The evaluation of climate services has been widely explored in the dedicated literature (Vaughan *et al.*, 2019). Indeed, the literature focuses on assessing CS as an integrated element of the value chain. Scholars identified this priority out of the need to make the processes more effective by evaluating various dimensions of climate services specifically 1 Assessment of use-adoption-uptake(Amwata *et al.*, 2018; Soares & Dessai, 2015), 2 Assessment of impact, socioeconomic assessment; willingness to pay for climate services (Ouédraogo *et al.*, 2018; Paparrizos *et al.*, 2021), 3 technical performance assessment, 4 Assessment of needs (Vincent *et al.*, 2017), 5 developing assessment methodology (Tall *et al.*, 2018; Vogel *et al.*, 2017), 6 Measuring co-production (Visman *et al.*, 2022), 7 Business model of CS for fostering adoption and boosting the market for climate innovation (Larosa & Mysiak, 2020).

Developing assessment methodologies is becoming a critical element, given the need for robust metrics and indicators to effectively evaluate CS and ensure that evaluation constitutes a cornerstone of the value chain (Dinku, 2018). The importance of this aspect is emerging towards the co-evaluation approach as it appeared in priorities as a shift towards a more comprehensive approach that involves the entire value chain, the actors involved, and their logic in the field (Lugen, 2020), which is at the heart of co-production.

2.5.5. The Emergence of Co-production Approach to Climate Services Implementation

The co-production approach is gaining prominence as a central theme in the field of CS (Daniels *et al.*, 2020). The traditional method of CS delivery has largely been characterized by a supply-driven approach, where the process flows predominantly in one direction (ICPAC, 2021). Thus, despite numerous calls for useful CS to support policy, most endeavors were consistent with this linear model (McNie, 2013). The supply-driven or top-down approach is mostly characterized by the availability of data technology and production rather than by specific user needs (Hewitt et al., 2012a; Lourenço et al., 2016).

The approach has faced criticism for failing to sufficiently address the needs and capacity of end-users (Sultan *et al.*, 2020), which may result in the production and provision of CS that are irrelevant or impractical for local decision-makers. This is particularly problematic in developing countries, where local capacities and needs often differ significantly from those assumed by global models. In contrast, a demand-driven and bottom-up approach begins with users' needs and develops tailored CS to meet those needs. This approach can lead to more relevant and usable CS, although it requires a deep understanding of user needs and the capacity to meet those needs, which can be challenging to achieve in practice (Lourenço *et al.*, 2016), which does not deter its use.

The approach has been continuously improved, and over the last few decades, the co-production (which focuses on demand-driven) approach has emerged and been widely adopted in implementing CS programs (Jacobs & Street, 2020), serving as both the antithesis and the solution to the linear model (Tangney, 2022). This approach is rooted in the theory and practice of knowledge co-production, which involves the joint creation of knowledge by experts and non-experts, ensuring that diverse perspectives and experiences contribute to the understanding and resolution of complex issues (Jasanoff, 2004). The process emphasizes the collaborative and interactive approach to producing knowledge among scientists, policymakers, stakeholders, and the public, aimed at addressing complex societal issues (Jasanoff, 2004).

Applied to the CS process, it brings together diverse knowledge sources and experiences to jointly develop new, combined, and relevant knowledge and systems, enabling their intended use in specific decision-making contexts (ICPAC, 2021). The process of co-producing knowledge and building the necessary skills and capacity of different user groups, both to guide the production and tailoring of CS (to meet context-specific needs) and to be able to apply that information (Leal, 2015). To enhance efficiency and effectiveness (Vaughan & Dessai, 2014b), the CS sector must focus on improving its production methodology (Weichselgartner &

Arheimer, 2019), which involves the shift to a co-production paradigm (Bremer *et al.*, 2019; Vincent *et al.*, 2018). Co-production can be highly effective in fostering dialogue and collaboration throughout the value chain, assisting in the development of services grounded in credible, relevant, and trustworthy knowledge (Hewitt & Stone, 2021). This revealed its critical importance as an impetus towards the effective development of CS for DRM.

Furthermore, co-production emerged as a cross-cutting aspect across the three main priority areas identified in the current work, namely, (Development, Use-adoption-uptake, and Evaluation of climate services). Indeed, the process lies in the effective engagement of users (Daly & Dessai, 2018) and that of providers, which can be considered as the two faces of the same coin. Since CS should be decision-driven and reflect end-users' needs, their engagement in the production process remains critical (Baulenas *et al.*, 2023).

However, Bremer *et al.* (2019) are against the narrow acceptance of the process, instead framing it as multifaceted. Most importantly, co-production has implications for the evaluation of CS. As users and providers are actively involved in the production process, they are also part of the evaluation through the evolving idea and method of co-evaluation of CS (Delpiazzo *et al.*, 2022), which is recognized as central for co-development (Tarchiani *et al.*, 2021) and framing of CS (Lugen, 2020).

An example of a practical and proven application of the co-production approach is described in the Tandem Framework (Daniels *et al.*, 2019, 2020). To ensure the effectiveness and long-term sustainability of CS this approach integrates the key components of the value chain, aligning with the three major priority areas outlined in the current review. Applied throughout the different aspects, the approach involves, for instance, co-design (Daniels *et al.*, 2020; Santos & Swartling, 2020), and when it comes to evaluation, considered in terms of co-evaluation (Delpiazzo et al., 2022; Street et al., 2019). In this regard, co-production brings a new perspective to the (co)-evaluation of CS, providing a methodological approach to assess the impacts of the co-production of CS with a focus on the user's feedback (Englund *et al.*, 2022).

2.5.6. The supply-driven and co-production approaches vs. linear and Interactive Policy process? A reflection on the implications of the theoretical framework

The interactive model of policy implementation and the linear model of the policy process are combined in the theoretical framework used in this study. This theoretical lens offers a prism through which the three main areas of specified priority are analyzed. Thus, as revealed in the analysis, the field of climate services has historically been dominated by a supply-driven approach characterized by a top-down production method. This approach aligns with the linear model of the policy process, where experts develop policies or services that are then implemented. However, this approach has drawbacks, notably in terms of climate services.

The top-down character of the supply-driven strategy might result in misalignment and a certain level of discrepancies between the services offered and the real needs of end-users. This imbalance presents a high likelihood of leading to underutilization of climate services or slowing down the uptake process, which limits their potential to face and manage disaster risks. The co-production approach has evolved in response to these limitations and is gaining momentum in this field. Co-production entails active collaboration between service suppliers and end-users throughout the process, from development to evaluation.

This strategy, therefore, remains consistent with the interactive model of policy implementation, which emphasizes the importance of iterative learning and feedback loops. Thus, by customizing climate services to end users' unique needs and settings, co-production ensures these services are more relevant and widely adopted. However, co-production is not without challenges. Indeed, it requires a significant commitment of time and resources and a change in the balance of power such that end users are more actively involved in the process.

Thus, this emerging approach initially provides a theoretical pathway to understanding the interplay of different actors involved in the process and institutional layering, which have significant implications for the development of services and their integration into disaster risk management. From a practical perspective, co-production provides a concrete enabling environment for actors to better engage and overcome barriers and discrepancies.

2.6. Conclusion and Implications

CS for DRM are increasingly under scrutiny, and the body of literature in this area has seen significant expansion over recent decades. This chapter systematically reviewed 242 records, including peer-reviewed papers, book sections, and reports from 2013 to 2023. Upon initial examination, the comprehensive analysis highlighted major climate-induced disasters, including floods, droughts, and food insecurity, as the main climate-related disasters addressed. Regarding the typology of climate services, as addressed in this work, several studies provide empirical evidence indicating that EWS, SFs, and IBWs are identified as the top research priorities.

Informed by a theoretical framework that combines a linear policy process model and an interactive policy implementation model, this paper identified three major policy-oriented priority areas. Firstly, (i) development of climate services, which encompasses various sub-priorities, namely production, co-production users-providers ‘engagement, dissemination, communication, community-based approach; roles of non-state institutions; Barriers to development; institutional; technical; capacity. Secondly, (ii) Use-Adoption-Uptake of Climate Services with much more focus on Enablers and Barriers. As a sub-priority, the Roles of non-state institutions acting as providers and users of climate services are also highlighted. Thirdly, (iii) Evaluation of climate services emerged as a high-priority area within which assessment of use-adoption-uptake, assessment of impact, socioeconomic assessment, willingness to pay, technical performance assessment, assessment of needs, developing assessment methodology, measuring co-production, and business model of climate services emerged as sub-priorities.

Reflecting on the theoretical framework, the co-production approach is emerging as a cross-cutting theme across these major priorities in response to the dominant supply-driven or top-down approach in CS production, implementation, and dissemination.

A rigorous and effective review of prior, relevant literature is a crucial component of any future academic project, laying a solid foundation for advancing knowledge. It facilitates theory development, closes areas where a plethora of research exists, and uncovers areas where research is needed (Webster & Watson, 2002). As a fundamental goal of literature reviewing (Müller-Bloch & Kranz, 2015), the current work, in addition to mapping priority areas, identifies potential research gaps in the field of CS for DRM.

The present systematic review of the literature on CS for DRM reveals a substantial need for further investigation from the SPIs perspective. This aspect is pivotal to formulating and implementing effective policies regarding CS for DRM, particularly in the interplay between institutions and CS capacity. Studying and understanding these aspects from the SPIs would enhance understanding of the intricacy of the mechanisms through which CS can inform and influence policy decisions. Practically, addressing this gap is imperative to enhance DRM strategies' efficacy and foster a synergistic relationship between scientific inquiry and policy-making processes.

As in many other sectors, such as biodiversity governance, in this field, scientists, experts, and decision-makers often operate in different spheres with distinct languages, priorities, and timelines. The SPIs serve as a bridge, translating scientific findings into digestible knowledge for policymakers and facilitating dialogue to ensure that CS are effectively integrated into disaster risk decision-making. SPIs are social processes encompassing the relations between scientists and other actors in the policy process, allowing for exchanges, co-evolution, and the joint construction of knowledge to enrich decision-making (Van Den Hove, 2007). They involve two-way communication between producers and users of scientific knowledge, recognizing that science and policy are two separate but interconnected worlds (Pielke, 2007) (Pielke, 2007). This dynamic interaction is characterized by the exchange of different types of expertise, values, and interests, shaping the use of knowledge in decision-making (Stirling, 2008).

Given the commonalities shared by these definitions of SPIs, they appear to be an integral part of the policy process. Regarding CS under scrutiny in this work, SPIs entail implications for institutions and CS capacity and their development and integration into DRM. SPIs' perspective should play a crucial role in understanding the institutional logic that underpins the development and integration of CS and the disaster risk decision-making process. Consequently, this endeavor can inform theoretical research practice to unpack more insights concerning the development of CS and their integration into DRM. It can also inform policy practice in the quest for a deeper understanding of the intricate facets that influence the effectiveness of decision-making processes in the field.

While this research presents valuable insights, it is important to acknowledge certain limitations. The most significant of these is the absence of a meta-analysis, which could have offered a more quantified and comprehensive understanding of the issue at hand. This omission may affect the depth and breadth of the findings, highlighting the need for further exploration in future studies.

CHAPTER 2: INSTITUTIONS AND CLIMATE SERVICES' CAPACITY FOR DISASTER RISKS MANAGEMENT DECISION-MAKING IN NIGER

Chapter 2: Institutions and Climate Services' Capacity for Disaster Risks Management Decision-making in Niger

3.1. Abstract

In the wake of the increasing recurrence of floods and droughts that frequently threaten population lives, livelihoods, and food security, CS for DRM has become of great importance for policy and decision-making issues in Niger. This chapter examines institutions' frameworks and CS capacity for DRM decision-making. It employs a qualitative research approach combining a review of 47 policy documents, 19 key informant interviews, and participant observation analyzed through institutional mapping, institutional analysis, and qualitative document analysis. Findings revealed a multi-layered institutional framework composed of several institutions at the upstream and downstream decision-making processes. The National Framework for Climate Services (NFCS) and the Regional Climate Outlook Forum (RCOF) emerged as main science-policy interfaces, bridging CS producers and decision-makers. The institutional layering encompasses the national direction of meteorology (NDM), the African center of meteorological applications for development (ACMAD), the AGHRYMET regional climate center, and the Niger basin authority (NBA), mainly providing CS in several formats and levels, including daily forecast, seasonal forecast, alerts and six early warning systems (EWS). Concerning the implementation of CS for DRM, the general direction of civil protection (GDCP) and the ministry of humanitarian action and disaster risk reduction (MHA/DRR) coordinate the dissemination process for floods as a sudden-onset disaster, while the national platform for food crisis prevention and management (NMPMFC), through the early warning system coordination unit (EWS/CU), coordinates the implementation for droughts as a slow-onset disaster, including food insecurity. Although there is a notable process in the establishment of institutions and CS capacity, the overall trend of floods and droughts occurrence and their impacts remains upward, which suggests challenges in the implementation process. Based on these insights, the chapter recommends enhancing institutional coordination, expanding EWS coverage, and enhancing mechanisms to integrate CS into DRM decision-making processes.

Key Words: climate services, disaster risks management, institution, climate policy, capacity, Niger

3.2. Introduction

Institutions can be defined as a triad of rules, social structures, and organizations in the context of climate change adaptation (Leal, 2015). In their formal facet, institutions pertain to regulatory and legal frameworks, political structures, rules, and standards enacted and enforced by those structures (Holmes Jr *et al.*, 2012). Thus, in the context of climate change, institutions have a central role in the governance of the crisis (Bremer *et al.*, 2021). They represent the multitude of means for holding society together, giving it a sense of purpose, and enabling it to adapt (O'Riordan & Jordan, 1999). Since the first IPCC Assessment Report (AR1) in 1990, the role and place of institutions at both global and local scales have emerged as a significant concern in the quest to create an enabling environment for effective climate action.

In the same way, climate change represents a threat to human and natural systems (Field *et al.*, 2014), it presents significant challenges for public institutions. As its effects touch every area of the economy and society, responding effectively necessitates collaboration among various governmental and non-governmental entities. Additionally, the long-term nature of climate change demands the ability to strategize, execute, and maintain a reliable commitment to progressively more ambitious policies across different political cycles (World Bank, 2021). Climate change governance uses institutions to address governance failures, strengthen incentives, and build capability for climate action (World Bank, 2025).

At the global scale, the IPCC was established as the prime advanced, structured institution in the climate policy process (Engels, 2005; Siebenhüner, 2014) to assess and inform climate change decision-making at all levels (Edenhofer *et al.*, 2025; Howarth & Painter, 2016). This is reflected in the IPCC mandate "to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation [...]" (IPCC, 2013a as cited in Minx *et al.*, 2017). Jointly, the WMO provides governments at all levels with scientific information that they can use to develop climate policies (WMO, 2022b).

Following the droughts of 1970-1980, like most Sahelian countries, Niger sets up national food crisis prevention and management systems under the aegis of the Comité Inter-États de Lutte contre la Sécheresse au Sahel (CILSS) (Delcombel, 2008). In Niger, most of the disasters that occur are generally attributed to a failed rainy season, which leads to long dry spells and drought, or due to important floods event that wash away crop areas. Thus, the DRM emerged as a political issue. As a matter of fact, political power is closely linked to its ability to manage food crises, as in the case of the first president of independent Niger, Hamani Diori, who was overthrown by a military coup following the famine of 1973-1974 (Crombé & Jézéquel, 2007). Furthermore, this situation is regarded as a political and humanitarian concern, especially in light of the 2005 food crisis, which resulted from a failed rainy season and a locust invasion (Michiels *et al.*, 2008). Although a problematic climate triggered the crisis, public management constituted an amplifying factor that exacerbated its effects. Indeed, tensions and conflict have characterized the crisis management between decision-makers, public institutions in charge of management, and donors (Olivier de Sardan, 2008). This was so confusing that even the agreement to characterize the crisis as a disaster involved many tensions (Delcombel, 2008). Disaster prevention, particularly flooding, has long been incorporated into urban development policy by constructing gutters and similar infrastructures (Simeu-Kamdem & Mama, 2018). This is especially true in urban areas, which most need public interventions. This has been the same situation regarding food insecurity management, which is also viewed from a public policy perspective as a developmental issue (Olivier de Sardan, 2008).

As the global climate change agenda evolves, at the local scale, states are called to establish national institutions that reflect the international framework. A recent example is the NDC, a national process drawn from the overall Paris Agreement, institutionalized at COP 15 (Rayner *et al.*, 2021). In addition to the role of institutions in governing climate risks, adequate capacity is also critical for effective climate action. The establishment of the GFCS by the WMO represents excellent progress, particularly with the call for countries to establish their NFCS to coordinate efforts in developing and providing CS (Hewitt et al., 2012b; WMO, 2014). In the context of adaptation, CS emerged as a critical decision-support tool for communities and decision-makers, particularly for DRM (Street et al., 2019).

CS consist of the collection of climate data; generation and provision of a wide range of information on past, present, and future climate; development of products that help improve the understanding of climate and its impacts on natural and human systems; and the application of these data, information, and products for decision-making (WMO, 2016). While there is an increasing call to establish adequate CS capacity, in 2021, at the regional level, the Hydromet report of the Economic Community of West African States (ECOWAS) (2021) ranked Niger with Essential Category of CS provision. In another WMO study, Niger fulfilled the Basic Level of CS Provision (WMO, 2023c). At the same time, in the WMO MHEWS report (2023b) Niger is among the 20 African countries reported to have implemented and operationalized an MHEWS.

Table 3. 1: Categorization of CS Provision

	Observations & Monitoring	Research, Modeling & Predictions	Climate Service Information System	User Interface Platform	Capacity Development
Basic	Operate and maintain adequate national observing systems, suitable for basic hydrometeorological purposes	Conduct weather forecasts and warnings (up to 7-10 days ahead)	Conduct basic climate diagnostics and analysis	Interacts with users, to meet requests (for weather forecasts and information and for basic climatology questions)	Participate in training, as required, for data management, QMF, data rescue, basic analysis (using, e.g., CDMS)
Essential	Operates expanded surface climate and weather observation network	Performs national weather and climate research	Conduct advanced statistical analysis (diagnostics; homogeneity testing and adjustment, etc.)	Interact with users in one or more sectors to identify their requirements	Participate in training for specialization in climate services
Full	Adopt long- term strategy for managing observing network and its change	Downscale climate prediction and projection products	Develop and/or provide, in a multidisciplinary context, specialized (tailored) climate analysis, prediction and monitoring products	Provide climate information relevant to policy development and National Action Plans	Conduct, or provide expertise to, training of climate services and prediction specialists

Note. (Dinku, 2018)

Adequate institutional mechanisms, resources, and a comprehensive understanding of the country's current disaster risk governance system are essential foundations for developing effective and implementable DRR policies and strategies (UNDRR, 2021a). Improving understanding of the role and contribution of CS constitutes a critical step to prioritizing investments and enhancing countries` ability to manage climate-related risk (Vaughan & Dessai, 2014b). In Niger, in the wake of the increasing recurrence and severity of climate-induced disasters, significant efforts have been made to understand the vulnerability of communities to climate risks, adaptative capacity, and impact analysis. Yet, in the context of the increasing need for effective public policies, there is a need for institutional analysis (Vaughan *et al.*, 2016), especially from a science-policy interface perspective, given its implication for institutions and the capacity of CS for DRM decision-making (Gaoh *et al.*, 2024). This chapter examines institutions and CS capacity for DRM decision-making.

3.3. Materials and Methods

3.3.1. Research Design

This chapter employed a qualitative research approach, which implies an inquiry process of understanding a social or human problem based on building a complex, holistic picture formed with words, reporting detailed views of informants, and conducted in a natural setting (Creswell, 1994). It represents an inductive, interpretive, and naturalistic approach to the study of people, cases, phenomena, social situations, and processes in their natural settings to reveal in descriptive terms the meanings that people attach to their experiences (Yilmaz, 2013) aligning with a constructivist epistemology, which suggests that knowledge is constructed through interactions between the researcher and the participants (Lincoln & Guba, 1985).

This approach is appropriate for exploring the complex and dynamic nature of institutional settings, allowing to delve into the contextual realities of decision-making processes that shape CS for DRM decision-making in Niger (Creswell & Poth, 2018).

3.3.2. Sampling Strategy

A purposeful sampling strategy was employed to achieve an in-depth analysis of the issue under investigation. This technique is based on the scientific prerequisite of selecting participants who can help inform the central phenomenon in this study (Creswell, 2016). Unlike in random sampling for the quantitative approach, the determination of the sample size is contingent upon the principle of theoretical saturation of information, which consists of collecting data until reaching redundancy (Merriam & Tisdell, 2016), then the sample size is likely adequate for the analysis (Creswell, 2016). Thus, this strategy is employed to select relevant documents and participants, ensuring that the collected data is rich, focused, and representative of the key institutions involved in CS for DRM (Patton, 2015).

3.3.3. Data Collection Methods

In this chapter three methods were used to collect the information based on the types and sources of data: Qualitative document review, In-depth Key Informant Interview (Yin, 2011), and Participant Observation (PO).

The document review consisted of 47 policy documents obtained through official requests at the surveyed institutions, and institutional repositories, which were cross-checked before analysis.

Additionally, regarding interviews, which consisted of face-to-face discussions with experts and officials, 19 in-depth interviews were conducted with key informants. Upon the agreement of the participants, some of the interviews were recorded and later transcribed for the sake of analysis. However, other participants did not agree to be recorded; in these instances, memos were used to capture the information shared by the informants.

Moreover, a semi-structured interview guide was designed to collect information about the state of the EWS, based on the indicators of an EWS, which includes four key elements (KE) (**Table 3.2**), namely (KE1) Risk Knowledge, (KE2) Monitoring and Warning Service, (KE3) Dissemination and Communication, and (KE4) Response Capability. Each KE contains a checklist of three open-ended questions related to the design of an EWS. Furthermore, additional information from official records on the development and implementation of these EWS was reviewed to complement this analysis.

Table 3. 2: *Key Elements of Early Warning System*

Key Element	Description	Questions	Description
KE1	Risk Knowledge	Q1	Are the hazards and the vulnerabilities well known?
		Q2	What are the patterns and trends in these factors?
		Q3	Are risk maps and data widely available?
KE2	Monitoring and Warning Service	Q1	Are the rights parameters being monitored?
		Q2	Is there a sound scientific basis for making forecasts?
		Q3	Can accurate and timely warnings be generated?
KE3	Dissemination and Communication	Q1	Do warnings reach all of those at risk?
		Q2	Are the risks and warnings understood?
		Q3	Is the warning information clear and usable?
KE4	Response Capability	Q1	Are response plans up to date and tested?
		Q2	Are local capacity and knowledge made use of?
		Q3	Are people prepared and ready to react to warnings?

Note. (UNISDR, 2006)

The combination of these methods to collect data pertains to the triangulation of multiple data sources to enrich and ensure the reliability of findings (Creswell, 2016; Merriam & Tisdell, 2016).

Furthermore, participant observation was employed to collect additional data in the frame of the Regional Outlook Forum (RCOF) held in 2023 in Niamey. The participant observation was conducted from 24 to 27 April 2023. The event consisted of an annual forum gathering experts, CS providers, users, and decision-makers to produce the seasonal climate outlook for the upcoming rainy season. During the forum, the researcher participated in the different Working

Groups, including Climatology, agrometeorology, and Hydrology. Various discussions of participants were captured using memos.

Furthermore, the plenary sessions allowed to capture information using memos. The final step of the forum consisted of presenting the conclusion and interactions with users of CS and decision-makers. Information regarding participants' interactions, processes, and thoughts was also captured during these steps.

3.3.4. Data Analysis Methods

3.3.4.1. Institutional Mapping (IM)

Mapping presents a good metaphor for exploring institutional links because there are some parallels between this exercise and geographical mapping (Green, 2007 as cited in ; McFadden *et al.*, 2010). Adopted in this study, IM represents an approach to understanding the ways in which different local contexts (institutions) vary in their mandated roles, responsibilities, and plans, and how these differences shape the delivery of CS for DRM (SHEAR, 2021) within a specific sector or domain of governance (IWRM, 2024). Adopting this approach gives insight into institutional and governance structures […], and the roles of the stakeholders and institutions involved in CS for DRM (McFadden *et al.*, 2010).

3.3.4.2. Institutional Analysis (IA)

Institutional analysis (IA) covers both formal and informal institutions. Formal institutions, such as government agencies, typically have a legally defined role, structure, and, in some cases, a set of procedures (GESAMP, 2001). IA, drawing on frameworks such as the Institutional Analysis and Development (IAD) framework (Ostrom, 2005), is employed to systematically assess the rules, norms, and decision-making processes that shape institutions involved in a particular sector's governance. The IAD framework focuses on the interactions within institutional settings, examining the "action arenas" where participants engage, make decisions, and influence outcomes based on a set of rules and norms (Ostrom, 2005). This approach enables the exploration of institutional arrangements and the capacity of CS for DRM.

3.3.4.3. Qualitative Document Analysis (QDA)

Qualitative Document Analysis (QDA) is a systematic procedure for reviewing or evaluating documents (Bowen, 2009). QDA aims to scrutinize policy and strategy documents issued by national institutions in the realm of CS and DRM through a systematic analysis process (O'Leary, 2017).

The triangulation of data sources, documents, interviews, ensures a comprehensive understanding of the institutional landscape and enhances the reliability and validity of the findings (Babbie, 2007; Creswell & Creswell, 2018; Denzin & Lincoln, 2005; Merriam & Tisdell, 2016).

The analysis was performed using ATLAS.ti 2024 as a way to ensure evidence-based research. Qualitative Thematic/Content Analysis is a systematic procedure that applies rigorous steps, including coding, categorization, and generating patterns as the unit of analysis, extracted from data collected (Bowen, 2009; Braun & Clarke, 2006). This procedure applies an inductive analytical approach as a way to ensure data analysis is rooted in the participants' perspective (Flick, 2018) through an In Vivo coding approach (Adu, 2019; Saldaña, 2016), which is grounded in the raw data, capturing the meaning portrayed by empirical indicators (Adu, 2019).

3.4. Results and Discussions

3.4.1. Climate Change Policy Context: Climate Change Adaptation, Disaster Risk Mana gement, and Climate Services

The IPCC AR6emphasized the importance of implementing a synergic policy framework regarding CCA and DRM for effective climate policy (IPCC, 2022). In Niger, the National DRM policy, which complement the National Adaption Plan (NAP) is framed as per the international and continental climate-related policies agendas (**Figure 3.1**).

As aligning CCA and DRR has become a key aspect of the international CC policy framework (Valente *et al.*, 2022), at the international level, these concerned 1) the United Nations Framework Convention on Climate Change (UNFCCC) 1992; 2) the United Nations Sustainable Development Goals (SDGs) 2030 Agenda; 3) the Paris Agreement (PA) 2015; 4) The Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030. At the continental level, two main agendas are concerned: 1) the African Union (AU) 2063 Agenda and 2) the Africa Regional Strategy for Disaster Risk Reduction (ARSDRR) 2004.

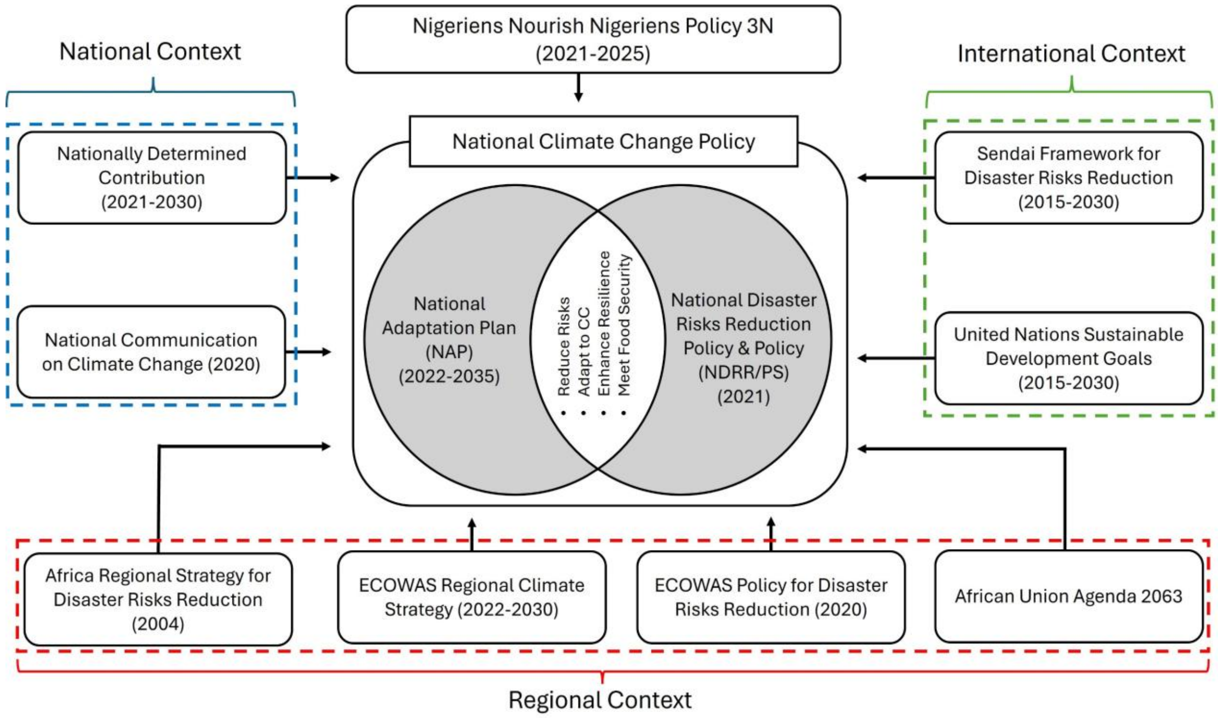

Figure 3. 1: *Niger DRM and CC Policy Context*

Regarding the UNFCCC, Niger signed the convention on 11 June 1992 and ratified it on 25 July 1995. Following these processes, Niger was committed to developing its National Communication on Climate Change (NC-CC). Four NC-CCs were developed, which took stake of climate change situation including vulnerability, adaptation needs and measures. Thus, the first NC-CC started in 1998 and was completed in 2000. The three subsequent NC-CCs were presented in 2009, 2016, and 2020, respectively. Concerning the SDGs 2030, in 2017, Niger enacted the Strategy for Sustainable Development and Inclusive Growth (SSDIG) 2035, from which is drawn the National Plan of Economic and Social Development (PDES) 2017-2021, updated to 2022-2026. The Nationally Determined Contributions (NDC2) coordinates the national climate actions, including mitigations and adaptation policies.

Furthermore, through the ratification of the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030, Niger has committed to elaborating a holistic national policy for DRR to tackle climate risks. Following this commitment, the National Strategy for Disaster Risk Reduction (NS-DRR) 2022-2030 was implemented in 2021. On the other hand, like the policies and agendas detailed above, the national DRM policy aligns with the African Union 2063 Agendas and, most importantly, the Africa Regional Strategy for Disaster Risk Reduction (ARSDRR) 2004. As climate risk reduction has become integrated into all national agendas, so has the interest in investing and developing CS. This nexus has made CS a cross-cutting issue in national climate change policy. Thus, the synergistic approach between CS, DRR, and CCA addresses the need for institutional coherence, which facilitates the reduction of existing fragmentation and conflicts within the existing DRR and CCA agendas by strengthening resilience (Street et al., 2019). The interconnected elements of climate policy have demonstrated their effectiveness in addressing multi-level governance challenges in Kenya, with the integration of other governance aspects, such as land restoration (Smucker *et al.*, 2020), also aligning with broader development policy. In another context, the evidence demonstrated the possibility of combining more SDGs, CC, and DRM for effective climate policy goals (Kluza *et al.*, 2024), highlighting the importance of geographical context.

3.4.3. The Science-Policy Interfaces in the Development and Integration of Climate Services for Disaster Risks Management

3.4.3.1. The National Framework for Climate Services (NFCS)

In Niger various institutions and stakeholders engaged in the generation of CS for climate risks decision-making (**Figure 3.2**). Thus, the diversity of actors and institutions led to the establishment of the National Framework for Climate Services (NFCS) in 2016 to bridge the gap between climate information developed by scientists and service providers on the one hand and the practical needs of users on the other hand (DMN, 2016). The NFCS represents a typical example of an institutional arrangement for national CS (WMO, 2017), which reflects the recommendation for countries to enhance the effective production and delivery of CS for decision-making (WMO, 2014). Thus, many other countries, such as Tanzania, have already established their NFCS (Kijazi *et al.*, 2021). This reflects one of the main goals of the GFCS, aiming to strengthen, coordinate, and support the effective (co) development and provision of relevant user-driven CS for climate risks decision-making (Hewitt et al., 2012a; Kijazi et al., 2021; WMO, 2014).

Going beyond this standpoint, findings analysis reveals how, in its functioning, the NFCS may be considered as an SPI for the production and integration of CS for DRM. As an SPI, the NFCS emphasizes the collaboration between CS producers, scientists, decision-makers, and users, making the co-production of CS a key aspect of its mission. The NFCS interfaces the leading producers of CS and national sectoral actors and institutions, aiming to co-produce CS that meet the priority needs of decision-makers and end-users.

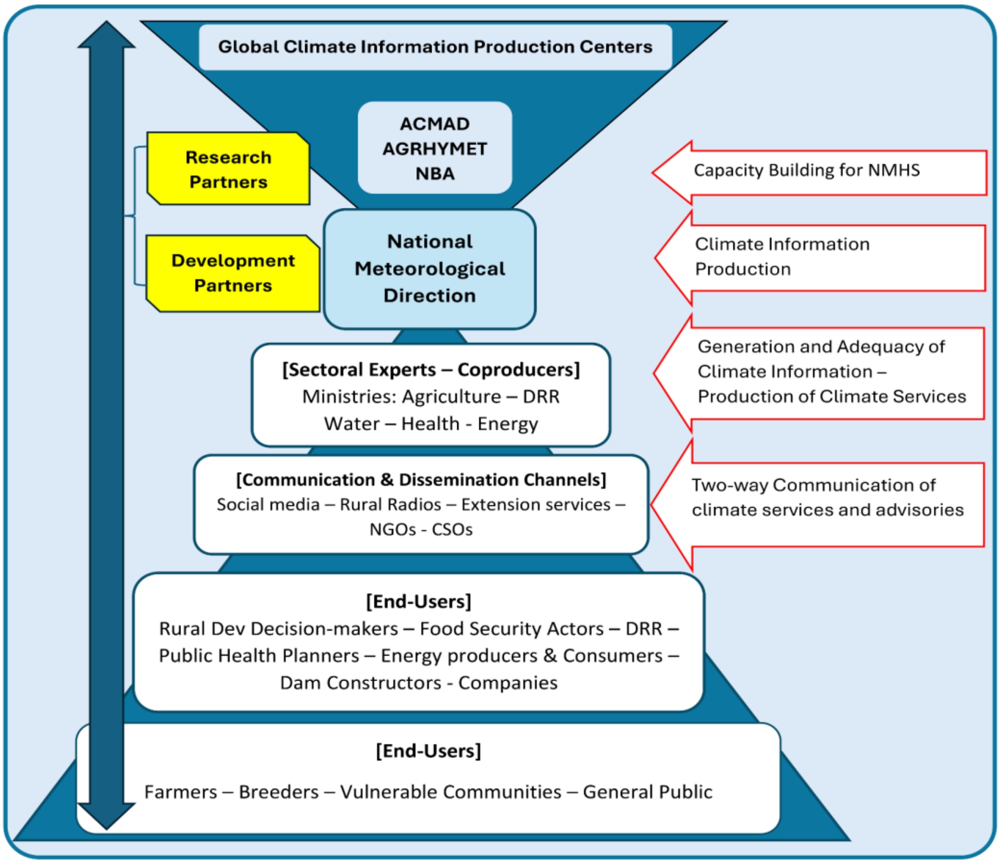

Figure 3. 2: *National Climate Services Value Chain adapted from (DMN, 2016)*

By translating climate information into actionable services, the NFCS enables policymakers to make informed decisions. The NFCS, through its structured, participatory, and interdisciplinary approach, functions as an SPI, ensuring that scientific climate information is not only developed but also coproduced and integrated into climate risk policy and decision-making processes.

The NFCS features an Interdisciplinary Working Group on Climate (IWG-C), which brings together experts and stakeholders from diverse sectors, including agriculture, water resources, health, and DRM. This interdisciplinary and multi-sectoral collaboration promotes knowledge exchange between scientists, technical experts, and policymakers, ensuring that CS are decision-driven and aligned with policy needs. The IWG-C is structured around seven sectoral Thematic Groups (TG), each dedicated to a specific climate-sensitive area to support the implementation of the NFCS.

The IWG-C facilitates communication between these thematic groups (TG) to ensure effective collaboration, serving as an interface for dialogue and coordination among actors in different climate-sensitive sectors. As such, each group is responsible for coordinating efforts and producing sector-specific CS through periodic meetings to validate information and co-develop bulletins and policy briefs such as climate and health, climate and water resources, and climate and DRR for decision-makers.

The TG within the IWG-C focuses on co-developing sector-specific CS, such as risk indicators and warnings, which are crucial for effective DRM. Through the IWG-C and TG, the NFCS actively engages stakeholders through workshops, consultations, and collaboration sessions to align CS with user needs. This user-centric and participatory approach ensures that the services developed are relevant and that policymakers are equipped with the necessary products and knowledge for decision-making, thereby enhancing the integration of climate information into climate risk policy processes. While the NFCS focuses on a national scale, another platform, the Regional Climate Outlook Forum (RCOF), represents a broader perspective as it extends beyond the national scale. The following section presents the RCOF and its functioning.

3.4.3.2. The Regional Climate Outlook Forum (RCOF)

According to WMO (2020a), the RCOF represents a multi-national and multi-institutional collaborative platform focused on a well-defined region, that is regularly convened to produce consensus-based, user-relevant seasonal climate outlook products for the upcoming season in real-time to support climate-related risk management in climate-sensitive sectors of critical socioeconomic significance for the region in question, and thereby contribute to sustainable development at the regional and national scale.

The Regional Outlook Forum (RCOF) represents the second SPI platform identified in the production and implementation of CS for DRM. The current analysis is based on the 10th RCOF organized in Niger in 2023.

The RCOF is co-organized by the AGRHYMET Regional Center for West Africa and the Sahel, the ACMAD, the National Directorate of Meteorology (NMD), and West African meteorological agencies, with the close involvement of the World Meteorological Organization (WMO).

Results suggest that the RCOF is structured into several steps to develop CS for decision-makers. These include the Pre-Forum, the Forum, the Dialogue with Users, and the Communication of the Seasonal Forecast (SF). In this case, its main goal was to develop a seasonal climate forecast for decision-making in the West African States.

The Pre-Forum involves capacity building for experts on forecasting approaches, methodologies, and tools used for this purpose. The preliminary data preparation and different models used are ensured during this phase.

The Forum represents the platform of forecast production, where experts from partaking institutions are clustered into three working groups (WG), including climatology, agrometeorology, and hydrology, each WG develops CS regarding the specific aspect of the season. The co-development of the seasonal forecast is consensus-based among experts, according to the approach adopted and the experts' experience. This approach is reportedly employed in other regions and has allowed to building robust CS that has helped decision-makers (Graham *et al.*, 2012).

Dialogue with users as part of the process, the dialogue with users represents a feedback loop where both CS producers and users, including farmers organizations, private sectors, and decision-makers, gather as a platform of interaction to discuss the CS produced and possible room for improvement from the users' perspective. This step sets the stage for communicating the seasonal forecast. Users` engagement has been identified as one of the main goals of the RCOF, though the approach is diversely conceived according to regions and institutional settings (Daly & Dessai, 2018).

The Communication of the seasonal forecast: the seasonal forecast produced is communicated to the general public, and policy recommendations are formulated for decision-makers regarding the priority actions to implement in the face of the season. This communication ensures that the forecast reaches the last mile.

Several institutions disseminate the seasonal forecast to decision-makers regarding disaster risk decision-making at the sectoral level. At the interface of CS producers and decision-makers, these institutions translate the forecast into digestible information for them. As stated during an interview with a senior officer of the EWS/CU,

> "The Prime Minister also receives information about seasonal forecasts but needs more context-specific understanding. Thus, we proceed to what is known in technical terms as downscaling. The PM does not necessarily need to know what is happening in Togo, Mali, or Senegal. He just needs to know what is going on in Niger, and even in Niger, you have to specify in different areas of the country to tell him what is expected during the season. […]`". (Interview with EWS/CU senior officer, 09.05.2023, Niamey)

3.4.4. The State of Climate Services Provision

In terms of CS capacity for DRM, findings revealed three leading providers. They develop and disseminate various CS for the sake of climate risks decision-makers. The main provider remains the National Direction of Meteorology (NDM), which has the state's official mandate, as in most countries (FAO, 2020) at the national level to collect, process, and produce CS for decision-making which positions the institution at the center of the DRM decision-making (WMO, 2009). Similarly, in Kenya, Shilenje and Ogwang (2015) have demonstrated the central role of the National Meteorological Agency in the provision of CS, which provides similar CS as those described in (Ngari *et al.*, 2016).

The African Centre for Meteorological Applications for Development (ACMAD) represents a continental institution with the mandate of capacity building and CS provision for decision-making (**Table 3.3**). Indeed,

> In its missions, ACMAD pulls together the meteorological databases and data in Africa, […] to complement (not to replace) national meteorological and hydrological services and assist them in areas where they probably lack. […] It monitors weather and climate on a continental scale and, where possible, alerts those areas when nature is not going to be friendly in the near future. ACMAD goes into research, investigating what could have been the cost of certain climate-related phenomena and communicating it to national meteorological and hydrological services throughout the continent." (Interview, ACMAD Agent, Niamey, 12.06.2022)

Like ACMAD, other sub-regional CS providers jointly produce CS in response to the needs of DRM decision-makers and other stakeholders. They include NBA, which hosts the SATH and provides hydrological data and services on the Niger River Basin. The institution issues technical notes, Alerts, Forecasts, bulletins, and monthly bulletins to supply the national DRM decision-making mechanism. AGHRYMET produces, shares, and disseminates CS and EWS (FANFAR) for DRM decision-making in the same mission.

Table 3. 3: *ACMAD Climate Services Provision and Frequency*

Climate Services Providers	**Climate Services provided**	**Frequency**
African Centre for Meteorological Application for Development (ACMAD)	Continental Multi-hazard Outlook (Vigilance map: Heatwave, Rainfall, Wind, Meningitis, Dust) and Policy Brief for decision-makers	Quarterly 5 Days
	Nowcasting	Daily
	Short-Range Weather Forecast	Once a Week
	Weekly Weather Forecast	Weekly
	Heatwave	Weekly
	Data Service	Daily
	Long-Range Forecasting Service	Monthly, Annually, seasonally
	Climate Monitoring Services	Decade, Monthly
	Decadal Climate Bulletin	10 Days
	Interactive Web Platform for Climate Services	Online

Note. Compiled by author based on field data analysis

3.4.4.1. The State of Early Warning System for Disaster Risk Management in Niger

The state of the art of available EWS in Niger has identified six (6) systems (**Table 3.4**), detailed in the following sections. These systems primarily address flood and drought hazards, including various induced impacts, with a geographical scope that ranges from limited regional zones to the entire country.

***Table 3. 4:** Available Early Warning Systems in Niger*

EWS	Geographical Scope	Hazard	Host Institution	Funding	Implemented
SLAPIS	SIRBA River	Flood	DGRE/DH - MH/A	Italian Cooperation	2018
FANFAR	National	Flood	SMHI&AGHRYMET	European Commission	2018
GDACS	National	Flood, Wildfire, Drought	UN, EU	European Commission	2004
SAICU-GTN	Gaya, Tanda, Niamey V	Flood	MHA/GC	UNDP	2019
SATH-NBA	Niger River Basin (Niger)	Flood, Drought	NBA	Netherlands + BAD, NBA (ClimDev)	2013
FEWS NET	National	Food Insecurity	USAID	USAID	1985

Note. Compiled by author based on interview and documents analysis

3.4.4.1.1. The Famine Early Warning Systems Network (FEWS NET)

The Famine Early Warning Systems Network (FEWS NET) (https://fews.net/) (**Table 3.8**) represents a global system established in 1985 by the United Nations (USAID) to provide early warning information and analysis of current and future acute food insecurity to inform decisions on humanitarian planning and responses in 30 of the world's most food-insecure countries (ReliefWeb, 2024), including Niger. The system operates nationwide, alerting humanitarian organizations and government decision-making bodies to potential food insecurity issues that could lead to widespread famine, enabling them to implement proactive measures to address and alleviate the situation.

3.4.4.1.2. Sirba Local Flood Early Warning System (SLAPIS)

The Sirba Local Flood Early Warning System (SLAPIS) is an integrated EWS (**Table 3.4**) that aims to promote decision-making and behavioral changes from reactive to proactive the levels of the community, and decision-makers, for the reduction of flood risk in the Communes of Sirba (**Figure 3.3**), which is the main tributary of the Niger River and the primary source of floods in the region) (slapis-niger.org, n.d.). Implemented in 2018 in the frame of the ANADIA 2.0 project in Niger, the system covers the zones crossed by the Sirba River.

3.4.4.1.3. The Flood Alert System for the Urban Commune of Gaya, Tanda, and Niamey V (SAICU-GTN)

The SAICU-GTN was developed and implemented in 2019, funded by the United Nations Development Programme (UNDP), to address the recurring risks of floods (**Table 3.4**). Like the SLAPIS, this system covers zones located on the Niger River, including the Municipalities of Gaya and Tanda in the Region of Dosso and the municipality V of Niamey (**Figure 3.3**). The system is hosted by the Ministry of Humanitarian Action and Disaster Risk Management (MHA/DRM) and monitored by a specific unit, which provides warnings to authorized institutions and actors, including the GDCP, through the Operational Watch Center, Alert and Crisis Management (OWCACM). The system is based on an interactive web platform that displays warnings about rainfall amounts and river flows.

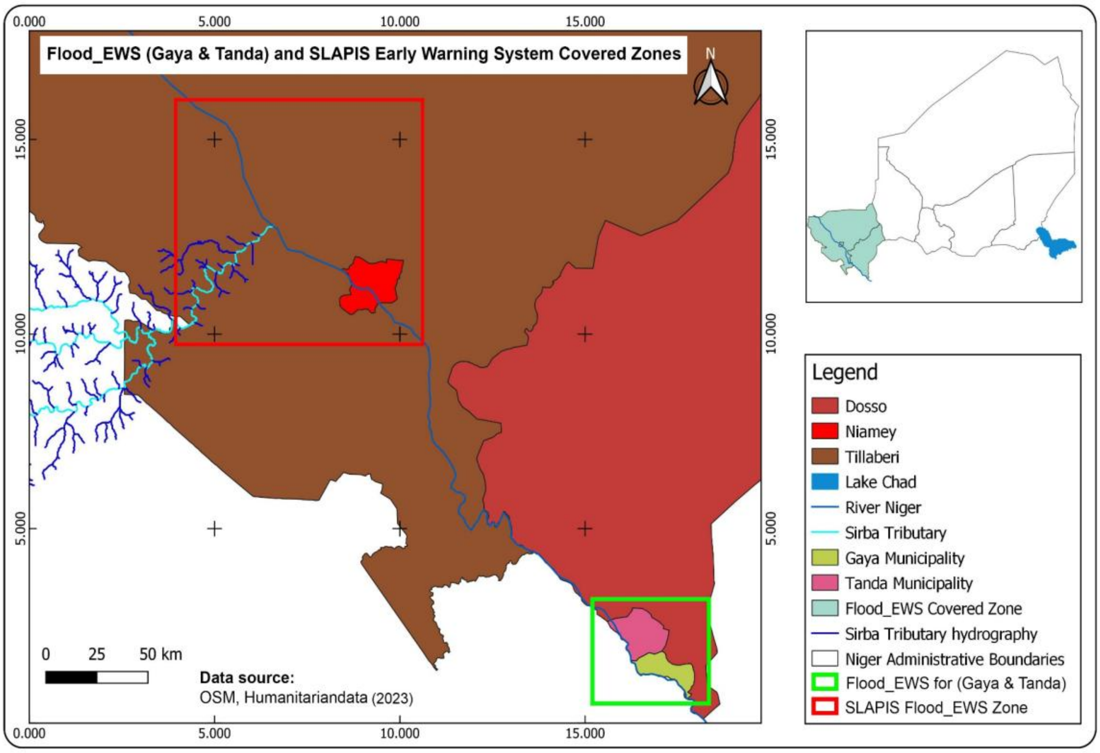

Figure 3. 3: Geographical Scope of the SLAPIS and SAICU-GTN

3.4.4.1.4. Reinforced cooperation to provide operational flood forecasting and alerts in West Africa (FANFAR) Project

The FANFAR project, funded by the European Union (**Table 3.4**), represents an EWS implemented in West Africa, with contributions from the participating institutions in the domain of CS for DRM. Hosted by the Swedish Meteorological and Hydrological Institute (SMHI) and the Regional Climate Centre for West Africa and the Sahel (AGHRYMET), the system is developed to provide decision-makers with timely and relevant information on flood risk. In Niger, it covers all the zones of the Niger Basin and the entire country (**Figure 3.6**).

3.4.4.1.5. The Satellite-Based Water Monitoring and Flow Forecasting for the Niger River Basin (SATH-NBA)

The Satellite-Based Water Monitoring and Flow Forecasting for the Niger River Basin SATH-NBA is an EWS project funded by the Dutch Ministry of Foreign Affairs and Niger Basin Authority (NBA). Implemented by the same institution, it covers the Niger River Basin for all the countries that share the water body, including Niger (**Figure 3.4**). The system monitors rainfall information and river floods to inform decision-makers to anticipate extreme flood events (http://www.sath.abn.ne/). It also includes the provision of information and monitoring of drought and desertification.

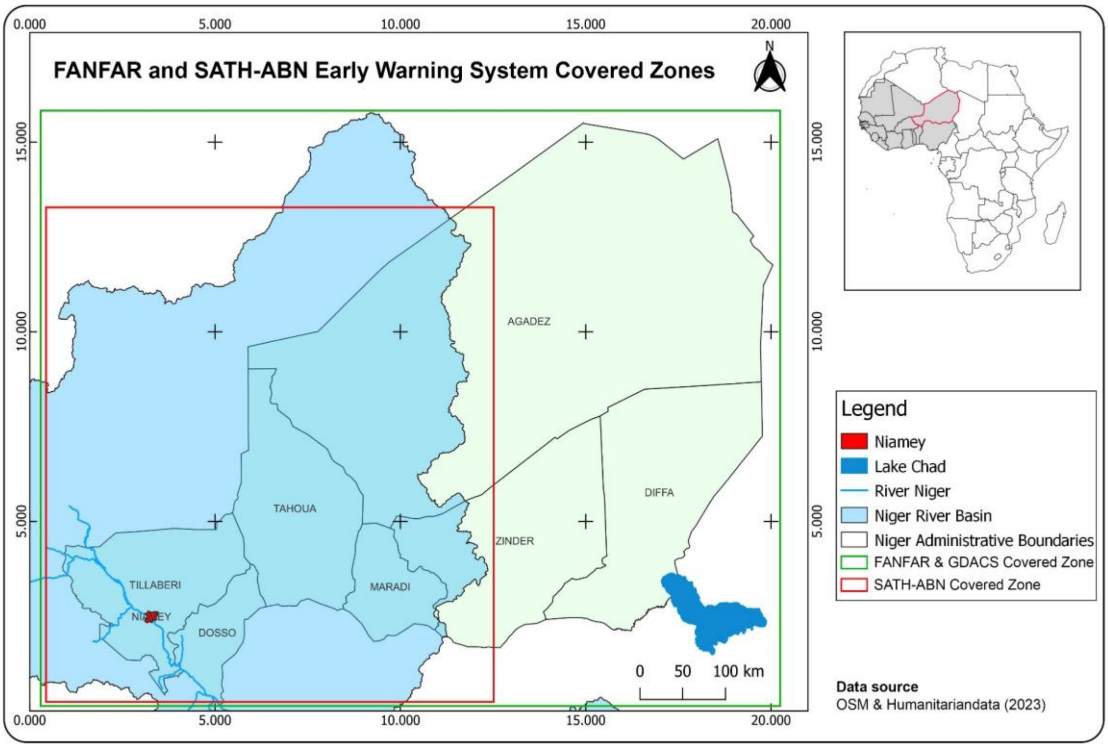

Figure 3. 4: Geographical Scope of the FANFAR and SATH-NBA

3.4.4.1.6. Global Disaster Alert and Coordination System (GDACS)

The Global Disaster Alert and Coordination System (GDACS) is a worldwide EWS established in 2004, funded by the European Union Commission to consolidate and strengthen the network of providers and users of disaster information worldwide to provide reliable and accurate alerts and impact estimations after sudden-onset disasters and to improve the cooperation of international responders in the immediate aftermath of major natural, technological and environmental disasters (Groeve *et al.*, 2006). The system generates multi-hazard disaster monitoring and alerts for earthquakes, tsunamis, floods, volcanoes, and tropical cyclones. It is mainly designed to assist humanitarian responders with their decisions in the early onset or after a disaster by providing, for instance, near-real-time flood alerts with an initial estimate of the consequences (De Groeve *et al.*, 2007). As a global system, its geographical coverage extends to the entire Niger (**Figure 3.4**) and provides information on the hazards listed earlier.

3.4.4.2. Adequacy of Available Early Warning Systems in Niger

Only the main EWS, including SLAPIS, SAICU-GTN, FANFAR, and SATH-NBA, were concerned with the adequacy analysis. Thus, based on the (UNISDR, 2006) definition of an EWS, a series of questions containing key elements of an effective EWS was included during the fieldwork to explore their adequacy from the institutional standpoint, complemented with relevant literature related to the identified EWS. The following sections detail the analysis of the adequacy of the identified EWS concerning the (UNISDR, 2006) definition.

3.4.4.2.1. Sirba Local Flood Early Warning System (SLAPIS)

The SLAPIS is one of the most recent EWS implemented in Niger, which met the adequacy of the (UNISDR, 2006) definition. As described in (**Table 3.5**), the implementation of SLAPIS met all the KE, addressing induced impacts on human lives, livestock, livelihood, and crop activities. Indeed, overall, the system is developed by integrating local observations with meteorological and hydrological forecasts through a risk information system, an integrated information and communication mechanism, a mapping of flood-prone zones, local plans of risk reduction, and sensitization and awareness creation (Tarchiani *et al.*, 2019). Indeed, concerning the KE1, this system includes a solid knowledge of flooding risk and detection over the scope of all the communities along the Sirba River.

Thus, a flood scenario level of vigilance is developed based on a river flow threshold, with corresponding flooding severity and potential impacts on the population. The scenario is operationalized through a color scale that describes the level of risk ranging from green, portraying a normal situation; yellow, portraying a risk of increasing river flow without a high likelihood of damage, especially on cropping activities; orange, describing a risk of increasing river flow with significant impact on the population, and red portraying a high severity level with a high likelihood of inducing losses and damage in the area (Tarchiani *et al.*, 2019). For the KE2, the system relies on accurate data caption within the covered areas through hydrometric stations installed along the rivers, upstream and downstream, which feed the system with timely and accurate data. This monitoring is based on locally collected data and an advanced hydrological model (GloFAS), upgraded to (Niger Hype) for more accuracy and precision in flood forecasting (Tarchiani *et al.*, 2019). The system also includes a manually installed color scale at the village level, using the same flooding scenario, which allows for visual monitoring of the river flow level at the community level. This increases a clear and smooth understanding of the warnings by the local community since they are directly involved in the value chain through the Community Early Warning System and Emergency Response (CEWS/ER), trained and empowered to read information embedded in the color scale, thereby spreading it to the Vulnerability Observatory (VO) under the aegis of the municipality.

Furthermore, regarding the warning services, the system comprises an interactive Web Platform, which provides four levels of information, including timely observation and forecasts, the level of vigilance, flood scenario, and vigilance bulletin, all accessible to the population and authorized institutions (Tarchiani *et al.*, 2019), which concur to the KE3. Integrating flood risk scenarios and warning systems into the local community plan through a participatory approach enables an adequate response capacity, KE3, in the SLAPIS EWS. This involves an interactive process, which brings all the actors, including the municipality, traditional and taping, into the active role of the population itself.

3.4.4.2.2. The Reinforced cooperation to provide operational flood forecasting and alerts in West Africa (FANFAR) System

The FANFAR EWS is designed based on knowledge of flood risks from various institutions, including meteorological and hydrological departments, and other risk management stakeholders particularly the Regional Climate Centre for West Africa and the Sahel (AGHRYMET) providing practical knowledge of risks of flood. The archived data and patterns of climate-induced disaster within West Africa also enhances the baseline of solid knowledge risks KE1 in the FANFAR system (Lienert *et al.*, 2020).

Concerning the KE2, the system is fueled with data from the institutions from participating countries through their respective WON. These data ensure the accuracy of information disseminated to decision-makers through a user-friendly web platform, with a flood forecasting scenario built on four models, including Burkina Faso HYPE, Niger HYPE, West Africa HYPE and Worldwide HYPE.

As of KE3, information and warnings are disseminated based on a color scale of risk severity, including green describing the normal trend and yellow, orange, and red, respectively, for severity levels 1, 2, and 3. The alert system generates information that is disseminated through the web platform, email, and File Transfer Protocol (FTP). By integrating flood forecasting and alert systems into the web platform, FANFAR simultaneously met both aspects of KE2 and KE3. The co-design workshops throughout the system's development and implementation have enhanced users' information uptake. This process has also created enabling conditions for a better response capacity in KE4, as the integration of users' needs and perspectives is met and has increased the system's reliability.

3.4.4.2.3. Flood Alert System for the Urban Commune of Gaya, Tanda, and Niamey V (SAICU-GTN)

This system was designed to meet the requirements of an effective people-centered EWS. Regarding the KE1, this system is built on a solid understanding of the flood hazard in Tanda, Gaya, and Niamey V, including the patterns of their vulnerability and addressing impacts on humans, livestock, and crop areas. Indeed, before the design of the system, a baseline study was conducted to document flood-prone areas, vulnerable populations, and infrastructure at risk. Furthermore, a mechanism of post-disaster data collection is integrated into the system as a feedback loop to enhance the system's effectiveness as part of the KE1.

The interactive web platform provides real-time flood risk mapping within the communities hosted at the MHA/DRR including five levels: the date of observation, observed and forecast precipitation, a display of the risk of pluvial inundation, observed and forecast river flow, and a display of the risk of fluvial inundation within the areas. The information on the flood risk is determined by a precipitation threshold with three levels of risk within the next 72 hours, including (Low risk, Moderate risk, and High risk) for pluvial flood. The same method of information applies to the risk of fluvial flood, which is determined by a threshold of river flow with three levels of risk (Low risk, Moderate risk, and High risk).

For the KE2, the system is fed with locally collected hydrological data from installed stations and climate data provided by the NBA, which ensure accurate results (Daughtry *et al.*, 2012) based on the Soil and Water Assessment Tool (SWAT) model simulation model that predicts the impact of management decisions on water and sediments (Arnold *et al.*, 1998) and an existing and tested hydrodynamic model (HEC-RAS 1D) (Kashfy *et al.*, 2020; Pandya *et al.*, 2018). As it was reported in an interview with the developer via Monde Afrique, the system accurately predicted the 2020 flooding

> "[T]his system takes into account satellite-based rainfall data over the catchment area and water levels measured by automatic stations on the river. Every three hours, it calculates the water level for five days ahead. When we implemented the system, the maximum ever reached was

> 640 cm. Moreover, when the system predicted more than 640, I did not believe it. When the dike was full, it predicted it would break." (Prevost, 2020).

The dissemination and communication (KE3) of the warning's information is ensured in the covered local communities, framed by the National Alert Code Mechanism, which involves local authorities as intermediaries to spread the information to those at risk when the warning is enacted. The system is configured to send alerts to a list of authorized actors. The alert is then downscaled through the Community Early Warning System and Emergency Response (CEWS/ER), led by the municipality in collaboration with the Vulnerability Observatory (VO) within the affected areas. To ensure meeting the KE4, the entire system is integrated into the local community's DRR plan, which involves various stakeholders, including municipalities, traditional authorities, humanitarian actors, and the local population.

3.4.4.2.4. The Satellite-Based Water Monitoring and Flow Forecasting for the Niger River Basin (SATH-NBA)

Regarding the KE1, the SATH-NBA is a system for river flow forecasting and drought integration, which combines a Meteosat-based (operated and supplied by EUMETSAT) climatic data collection system, the Energy and Water Balance Monitoring System (EWBMS) with a large-scale hydrological model (LSHM) (https://sath.abn.ne).

The system is designed on a comprehensive network of hydrological stations, complemented with satellite monitoring to enhance accuracy. Concerning KE2 and KE3, the interactive web platform provides two levels of information, including Agrometeorological data (Daily actual evapotranspiration, Daily precipitation, Drought and Climate monitoring) and hydrological data and forecasts (River discharge, Water level, upstream Precipitation, and Evapotranspiration). The water level generates information on flood risks based on a color scale, including (green as the normal situation, yellow alert, orange alert, and red alert).

The communication of information and alerts is operationalized through the web platform, Radio and TV, the Research Centre, universities, the National Direction of Meteorology, the Direction of Hydraulic Resources, Civil Protection, EWS/CU, and other stakeholders involved in the DRM. The data and information generated through the system are translated into digestible services for decision-making including technical notes about hydrological situations, forecasting bulletins, warnings, articles, and monthly hydrological bulletins.

Table 3. 5: Adequacy of EWS

Key Element	Description	SLAPIS	FANFAR	SAICU-GTN	SATH-NBA
KE1	Risk Knowledge	Q1 ☒	Q1 ☒	Q1 ☒	Q1 ☒
		Q2 ☒	Q2 ☒	Q2 ☒	Q2 ☒
		Q3 ☒	Q3 ☒	Q3 ☒	Q3 ☒
KE2	Monitoring and Warning Service	Q1 ☒	Q1 ☒	Q1 ☒	Q1 ☒
		Q2 ☒	Q2 ☒	Q2 ☒	Q2 ☒
		Q3 ☒	Q3 ☒	Q3 ☒	Q3 ☒
KE3	Dissemination and Communication	Q1 ☒	Q1 ☒	Q1 ☒	Q1 ☒
		Q2 ☒	Q2 ☒	Q2 ☒	Q2 ☒
		Q3 ☒	Q3 ☒	Q3 ☒	Q3 ☒
KE4	Response Capability	Q1 ☒	Q1 ☐	Q1 ☒	Q1 ☐
		Q2 ☒	Q2 ☐	Q2 ☒	Q2 ☒
		Q3 ☒	Q3 ☒	Q3 ☒	Q3 ☒

Note. Developed by author based on interviews and documents analysis

3.4.5. Decision-making Process of Climate Services Implementation for Flood Risks Management

In Niger, the policy responses to climate change have resulted in the establishment of a dense institutional landscape that aims to deal with all possible implications of the crisis. In the current case, the major focus is on CS for DRM institutional arrangement. This translates the instrumental role of establishing effective legal and institutional frameworks as crucial to climate governance (Oulu, 2021).

The National Platform for Disaster Risk Reduction (NPDRR) was implemented in 2012 to meet the various DRM policy goals. At the decision-making level, the NPDRR coordinates stakeholders involved in DRM governance, including state and non-state actors, in enacting national DRR strategies and policies at national, regional, and local scales. However, operationally, the analysis revealed two main decision-making mechanisms for flood and drought.

The institutional arrangement of CS and DRM is structured around a multi-layered network of institutions organized into four main stages: knowledge, monitoring and observation, dissemination, and response (**Figure 3.5**). The policy focus of this institutional arrangement focuses on the management of flooding and its impacts on populations and socioeconomic sectors.

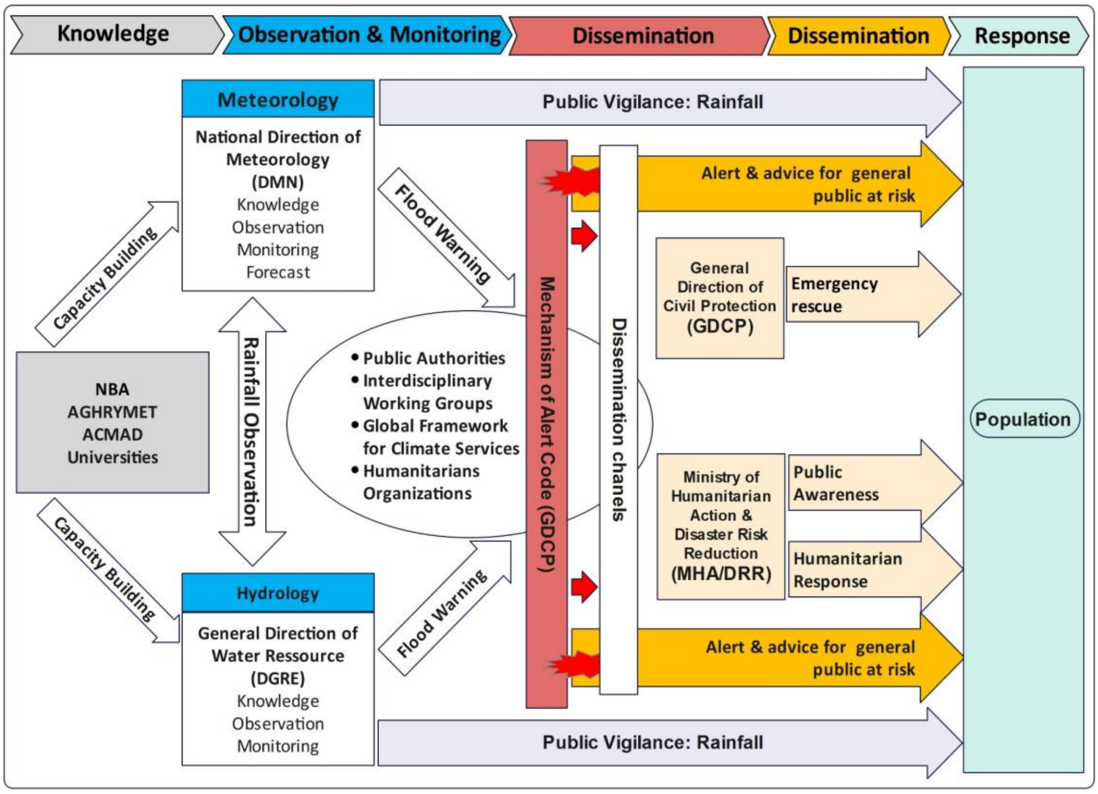

Figure 3. 5: Climate Services for Disaster Risk Management Institutional Mapping adapted from (MHA/DRR-MAH/GC, 2022)

3.4.5.1. Knowledge (Capacity Building)

The set of institutions under the knowledge section primarily provides capacity building within institutional arrangements. Based on the review of official records and institution profiles, five major institutions are identified with the role of providing knowledge in the value chain. These include the Niger Basin Authority (NBA), the regional climate center for West Africa and the Sahel (AGHRYMET), the African Centre of Meteorological Applications for Development (ACMAD), Universities, and the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL). This role of capacity building goes beyond knowledge dissemination in that these institutions are also CS providers, with data, equipment, research, and project implementation.

3.4.5.2. Weather Observation and Monitoring

Based on the available weather observation network (WON), the National Direction of Meteorology (NDM) officially ensures the systematic observation of weather and climate at the national and local scales. As part of its mandate, the NDM is the leading CS provider for climate risk decision-making. In parallel, the general direction of water resources (GDWR), under the Ministry of Hydrology and Sanitation (MH/S), ensures the collection and monitoring of hydrological data about the risk of flooding, particularly on the Niger River. These institutions represent the National Hydrological and Meteorological Services (NHMS) and provide flood warnings for stakeholders and populations for flood risk management. These stakeholders are diverse in their roles and missions, including national authorities, interdisciplinary working groups, the GFCS, and humanitarian organizations. All these institutions and stakeholders partake in the national mechanism of the alert code, which ensures the dissemination of warnings at the national and local scales for community climate risk management.

3.4.5.3. Dissemination of Climate Services

The dissemination of CS, particularly for flood risk management, is organized through the national alert code mechanism (**Figure 3.6**), which constitutes the official legal framework governing flood alert dissemination. The decision-making process is organized under the aegis of the Ministry of the Interior (MI), operationalized via the Operational Watch Center, Alert and Crises Management (OWCACM) coordinated by the General Direction of Civil Protection (GDCP) at the national level under the *LAW N° 2017-006 of March 31, 2017, determining the fundamental principles of the organization of civil protection and the Decree N° 2018-538/PRN/MISP/D/ACR of July 27, 2018, defining the national alert code.*

Similarly, as it is legally framed (Article 5) at the decentralized levels, governors, Prefects, and Mayor, respectively, at regional, departmental, and municipal levels, enact the diffusion of the alert. To this end, (Article 6) determines the actors' roles in the process: "*Alert messages are prepared on the basis of information provided by technical institutions at the various administrative levels. When the mayor triggers the alert, he immediately informs the prefect, who immediately reports to the governor. The latter informs the Minister in charge of civil protection or the designated Minister as soon as possible*."

The means and channels of diffusion of the alert messages are then defined under (Article 7), including radio and television broadcasting services, Cell phone operators, Traditional community media, Local authority equipment, and Internal networks providing information to the public at stations and airports.

The GDCP is mandated to manage post-disaster focused on emergency rescue at the national level framed through the *Decree N°2017-876/PRN/MISP/ACR/MAH/GC of November 10, 2017, determining the conditions for the development of emergency response organization plans (ORSEC)*. As it was highlighted

> "Civil protection is, in a way, the armed wing of the mechanism and the ministry of humanitarian action because when a disaster occurs, first aid and interventions are carried out by civil protection to secure the affected populations and their property, that is the role of civil protection." (Interview, Agent of EWS/CU, 09.05.2023, Niamey)

To this end, the emergency rescue involves stocktaking and risk analysis, as well as actual and potential losses and damages to humans and infrastructure. The plan also implies a synergy between DRM institutions in executing the emergency responses at the national and local scales, particularly the MHA/DRR. Thus, as portrayed in the institutional arrangement, the MHA/DRR has two prominent roles in dissemination, including public awareness and humanitarian response post-disaster, especially in the context of flooding.

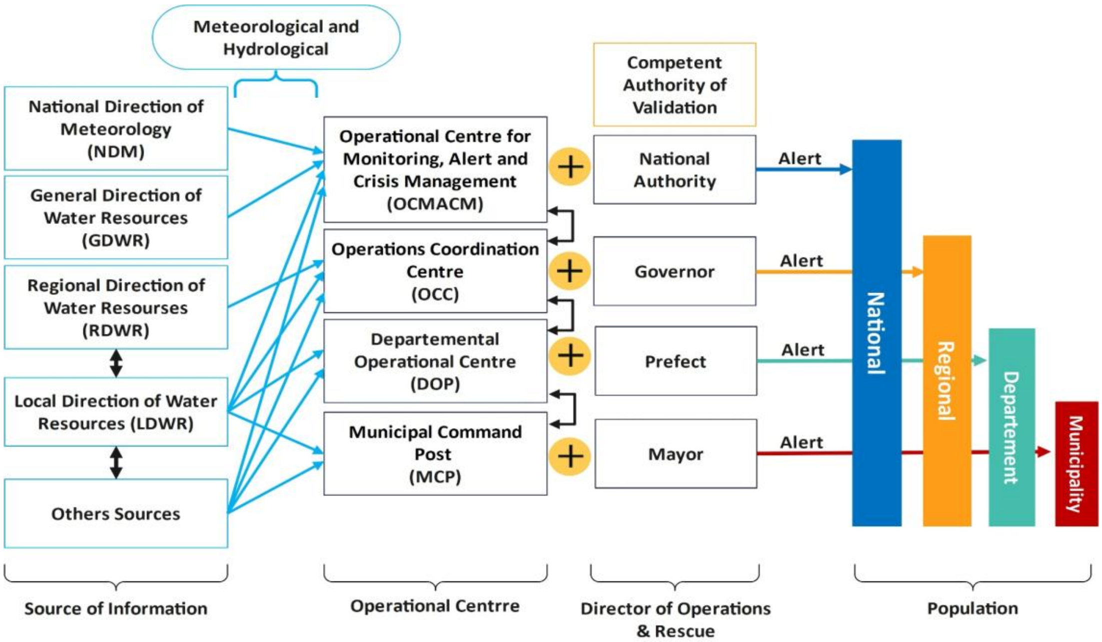

Figure 3. 6: Dissemination of Alert Messages adapted from (DGPC, 2020)

3.4.5.4. Response Process

Once the alert messages reach the last mile, the population at risk acts upon the information received to decide before the event occurs. The response is organized in various ways. At first glance, upon receiving the alert, the population should make relevant decisions by following the advice and warnings embedded in the Alert to minimize the risk to their lives and property. Local authorities are actively involved in the process by providing updates on the situation on the ground and deploying municipal resources to aid in the rescue and support the affected population. In the event of a flood, the GDCP conducts rescue operations in conjunction with the MHA/DRR, ensuring humanitarian relief to the affected population. At the decentralized level, the Community Early Warning System and Emergency Response (CEWS/ER) and the Vulnerability Observatory (VO) are engaged both before and in the post-disaster situation.

Their roles go from the local response activities to the dissemination of information at the local level.

3.4.6. Decision-Making Process of Climate Services Implementation for Food Crisis

In the institutional architecture of DRM policies in Niger, the National Platform for Food Crisis Prevention and Management (NMPMFC) focuses on issues related to the governance and management of food crises, which are the corollary of climatic disasters, notably floods and drought. As it was echoed during an interview with an agent of the institution:

> "The management is based on the crises that arise. Institutionally, the EWS/CU, which is an integral component of the NMPMFC, deals with slow-onset crises, such as drought. A food crisis does not just happen suddenly. It has indicators, and it is these indicators that we monitor until the crisis hits. So, it is different from sudden-onset crises like floods." (Interview, EWS/CU Agent, 13.10.2023, Niamey)

Set up in 1998 following several years of drought in Niger, the NMPMFC represents the decision-making framework for the prevention, mitigation, management, and early recovery from the impact of crises affecting populations (NMPMFC) in Niger (**Figure 3.7**). As its name implies, the mechanism focuses on two main aspects: prevention and management. The first aspect is oriented to the ex-ante decision-making, and the former is oriented to the ex-post (including the course of the occurrence) of the disastrous event and its consequences. Thus, regarding the decision-making process, governance of the system is ensured by the Permanent Secretariat comprising the Early Warning System Coordination Unit (EWS/CU), the Food Crisis Unit (FCU), and the Social Nets Unit (SNU) as the core institutional tentacles. In this architecture, when it comes to the integration of CS into decision-making, the EWS/CU plays a pivotal role at the interface between CS providers and decision-makers in that it partakes at the same time in the development process of CS.

Thus, the EWS/CU represents a knowledge brokerage interface in the integration of CS for food crisis decision-making. Indeed, before the beginning of each rainy season, CS providers organized the seasonal climate outlook forum, which determines the course of the season in terms of rainfall amount, the onset, end, and potential dry spells or drought events. The outcomes of the forecasts are then translated into more digestible information for decision-makers by brokering from technical languages to understandable information. This may take the format of a policy brief or technical notes to smooth the decision-making process.

> "We need to do what we call downscaling. The Prime Minister does not need to know what is happening in Togo, Mali, or Senegal. He just needs to know what is going on in Niger, and even

in Niger, we have to specify according to different areas of the country to tell him what is expected. Therefore, this work differs from what was done during the production of the regional seasonal climate forum, which was global forecasting, and now we have to tell him. Moreover, as I was saying, it is also political. […]. There are notes for decision-makers and communication in the form of a bulletin." (Interview, EWS/CU agent, 09.05.2023, Niamey)

As echoed by the EWS/CU agent, the process also involves active communication.

> "Another very critical aspect is communication. Everything we do is aimed at decision-makers, to make them aware of the situation and help them make the right decisions. On the other hand, the general public and partners also need to know what is going on. Moreover, to achieve this, we need to communicate [...]. For example, I am preparing a technical note on the recent seasonal forecasts for this year. This note will not be the same as what will be aimed at the general public. The Prime Minister just needs to understand the situation, and it is a very succinct document that will enable him to make decisions. I do not need to dwell on the curves generated. Does he need to know how to go from 35 degrees to 7 degrees? That is not his problem. He is a decision-maker and needs a consistent, highly synthetic document." (Interview with an agent EWS/CU, 09.05.2023, Niamey)

The communication of the forecasting is organized at two levels: the Joint Committee of Concertation, which involves all the stakeholders, including the donors, and the Restricted Committee of Concertation, which involves the main state actors and institutions (**Figure 3.7**). The EWS/CU, therefore, ensures the role of prevention following the above-described approach at the institutional level.

At the population level in the regional, departmental, and local scales, the prevention implies a decentralized approach through the Vulnerability Observatory (VO), which is led by the local authorities (Governor, Prefect, Mayor) and the Community Early Warning System and Emergency Response (CEWS/ER). The VO represents a coordination framework ensuring the mediation between the community decision-making process and the national NMPMFC (**Figure 3.7**). The VO interfaces knowledge exchange between stakeholders and the analysis of the local situation regarding food crisis as well as negotiating the implementation of actions and strategies for the prevention and management of the food crisis. To this end, the CEWS/ER participates in the data collection for the NMPMFC after validation at the communal, departmental, and regional committees. At the same time, the VO plays the role of a feedback loop regarding the ongoing situation and the local food crisis management, ensuring the monitoring of the situation.

Overall, through the various roles they play, these actors interface the two-level decision-making processes, including the top-down (government) and bottom-up (community), regarding the integration of CS in food crisis management.

Furthermore, in the context of ex-post food crises in the aftermath of a widespread flooding or drought event, as mentioned earlier, the food crisis unit (FCU) and social nets unit (SNU) play a key role in the decision-making process. In their mandate, these two structures are complemented by other stakeholders at national and local levels. As one of the direct impacts of the food crisis remains the deterioration of the population's food and nutritional situation, these actors ensure the building back through relief actions and strategies. Generally, their role involves the distribution of foodstuff as part of the relief packages to the affected population, most often with the support of programs led by non-governmental organizations (NGOs) and humanitarian organizations.

The NMPMFC works with several institutions to undertake its activities in the prevention, anticipation, mitigation, response, and early recovery from the impact of food, pastoral, and nutritional crises. As part of the Interdisciplinary Working Group (IWG), these institutions produce information needed for the analyses carried out by the EWS/CU, which interfaces the operational implementation of the interventions. The NMPMFC ensures the implementation and coordinates responses in the form of food assistance and support for livelihoods in the context of sudden-onset events and provides further input to the structures responsible for the overall coordination of emergency responses to these shocks, such as the MHA/DRR.

3.4.6.1. Dissemination of Information for Decision-making

As described in (**Figure 3.7**), As a slow-onset crisis, the drought and its direct impacts, including food insecurity and famine, are monitored for an extended period. Based on the institutional mechanism established following the local, departmental, regional, and national levels hierarchy, a permanent monitoring operation is organized based on a set of parameters, particularly within the identified most vulnerable zones.

The main channel for disseminating and communicating information on food security situations is the "Monthly Information Bulletin." This report is drafted based on data from food security information systems, from the Early Warning System Technical Interdisciplinary Working Group (EWS/IWG) (their monthly reports), and information collected by field agents from all technical services. The data is initially verified and enriched by the food security early warning system committees at department/urban commune and regional levels to validate this information. They are then transmitted monthly to the Early Warning System Coordination Unit (EWS/CU).

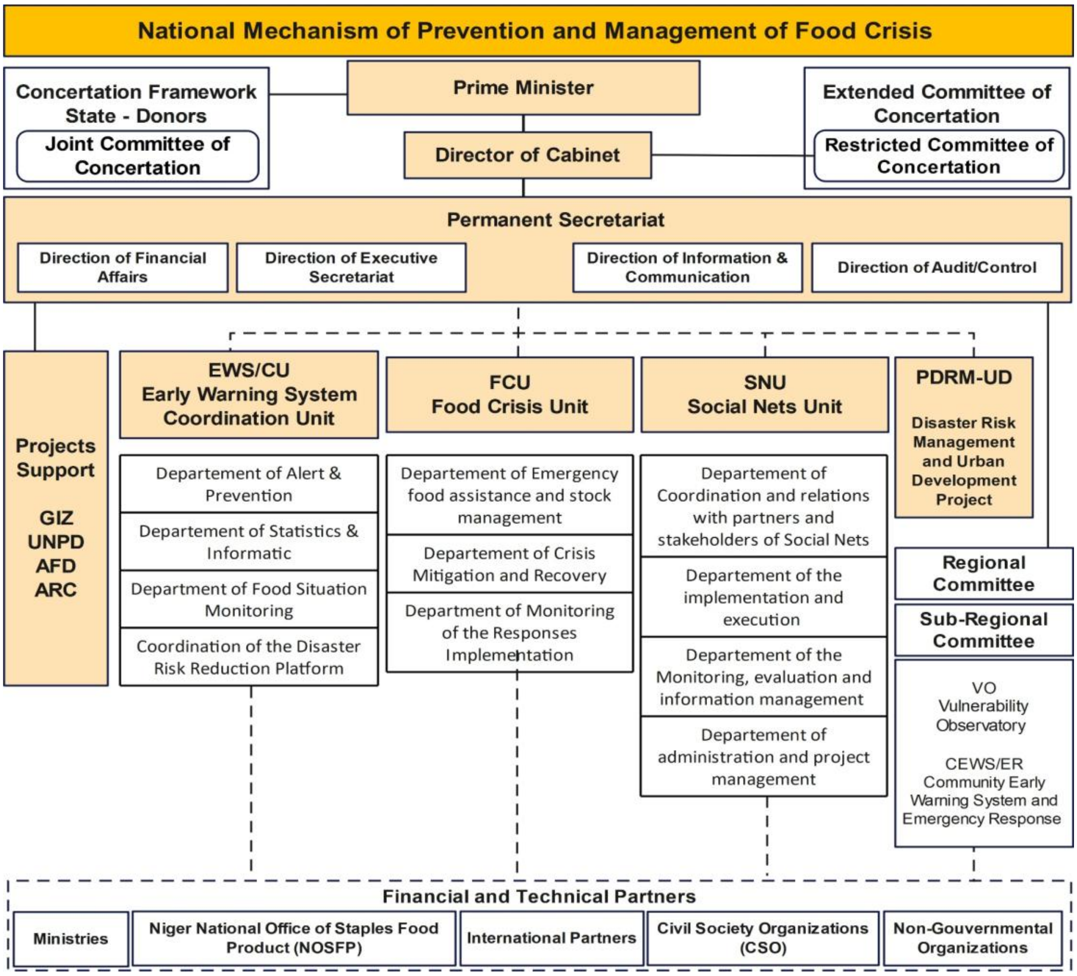

Figure 3. 7: National Mechanism of Prevention and Management of Food Crisis (SAP/CC, EWS/CU)

3.4.7. Analyzing the Disconnect of Rising Flood and Drought Impacts

CS are critical for effective climate-smart decisions to reduce the impact of climate-related disasters (WMO, 2014). It is widely acknowledged that limited or ineffective institutional mechanisms and capacity often hamper the effective implementation of climate risk policies, strategies, and projects (UNDRR, 2020). Investments in climate risk governance by establishing institutions and implementing CS create an enabling environment to address the impacts of extreme climate events effectively (IPCC, 2022; WMO, 2023). Per international frameworks, Niger has channeled efforts into climate risk governance as highlighted in this chapter. From establishing the legal frameworks for effective institutional mandate and coordination to developing CS, particularly forecasts, alerts, EWS, and MHEWS, the policy goal of these investments was meant to enhance preparedness, response, and adaptive capacity at national and sub-national levels, reduce risks, and address food insecurity. Therefore, reduced impacts should reflect the efforts being made. However, a paradox has emerged amid the rising flood and drought impacts over the past 20 years (2004-2024).

Relying on the aggregated data from the Inundations Data Base (BDINA), United Nations Office for the Coordination of Humanitarian Affairs (UN/OCHA), and Ministry of Humanitarian Action and Disaster Risks Reduction (MHA/DRR) on flood impacts, analysis shows a rising though sawtooth impacts pattern over the last 20 years. The annual number of houses destroyed by floods (**Figure 3.8**) reveals a significant rising trend. The years 2004 to 2011 show a relatively low and erratic number of destructions, while there is an apparent increase from 2012, which marked one of the deadliest floods in Niger. Around 2018, there was another phase of increase, with 2020 marking a severe pick in the number of houses destroyed.

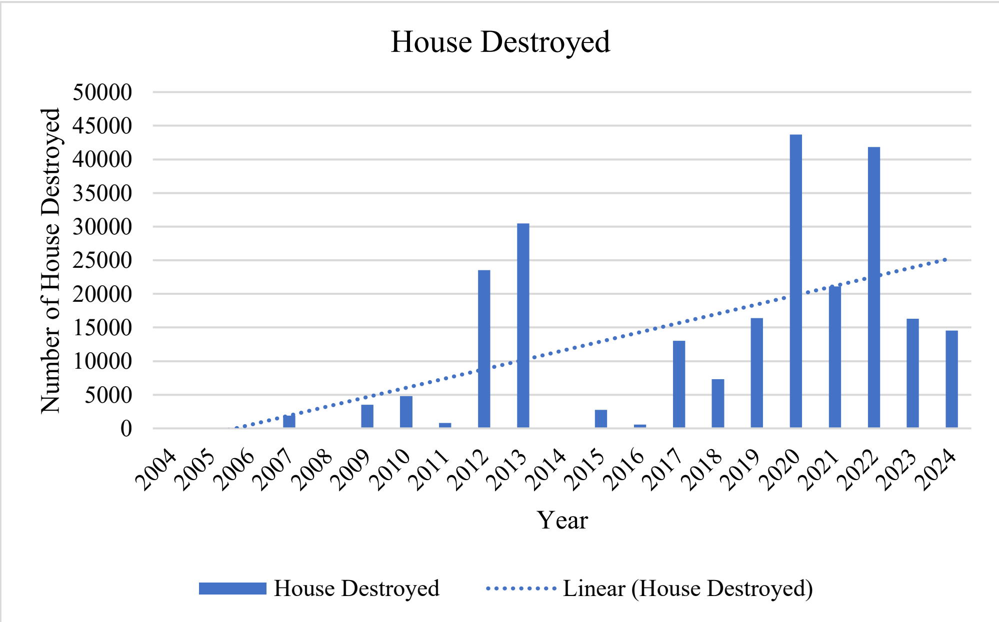

Figure 3. 8: Flood Impacts 2004-2024 (House Destroyed)

Livestock losses show significant peaks in certain years, with the highest peak in 2020, with an overall trend that is rising (**Figure 3.9**).

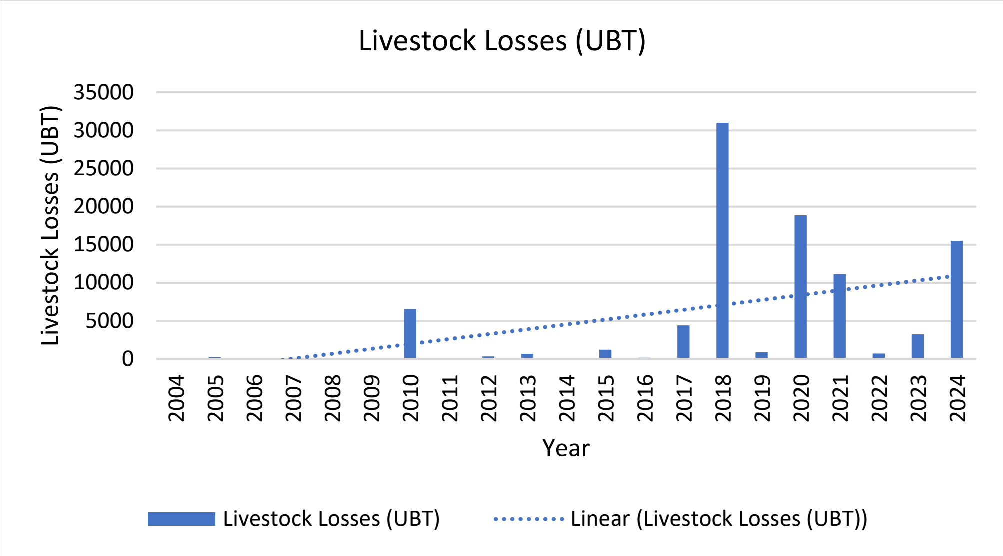

Figure 3. 9: *Flood Impacts 2004-2024 (Livestock Losses)*

The damage to crop area shows fluctuations over the years, while peaks were observed in 2012, 2015, and 2020 (**Figure 3.10**). However, the overall trends are slightly upward over the period (2004-2024).

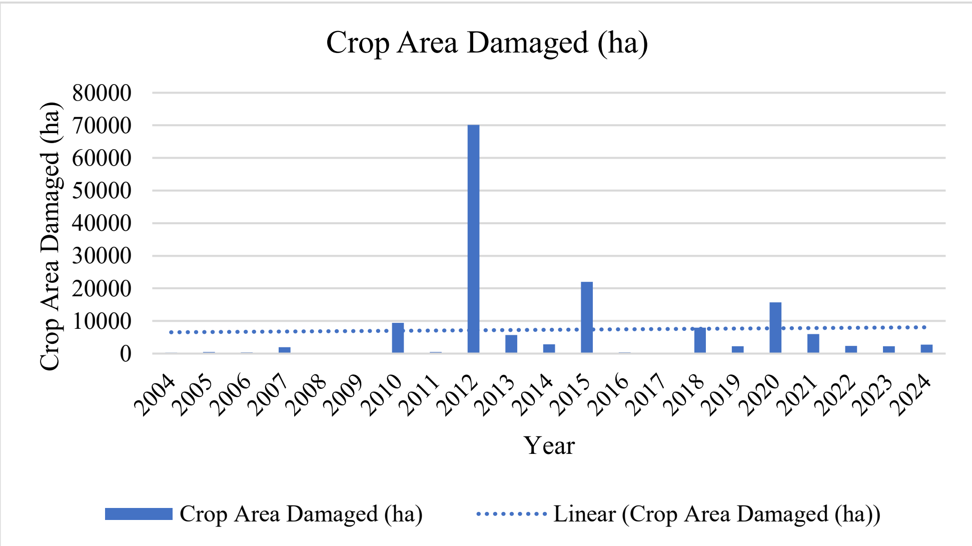

Figure 3. 10: *Flood Impacts 2004-2024 (Crop Area Damaged)*

Regarding the impacts on the locality affected and people affected, over the 20 years, data highlight an increasing number of casualties (**Figure 3.11**). The data show a peak of people affected in 2012 and 2020, which represents the most disastrous flooding in the last two decades. This does not hide a relative variability, which is significantly noticeable, with some years more impacted than others. Thus, despite a fluctuation in the flood impacts, the overall pattern is significantly on the rise.

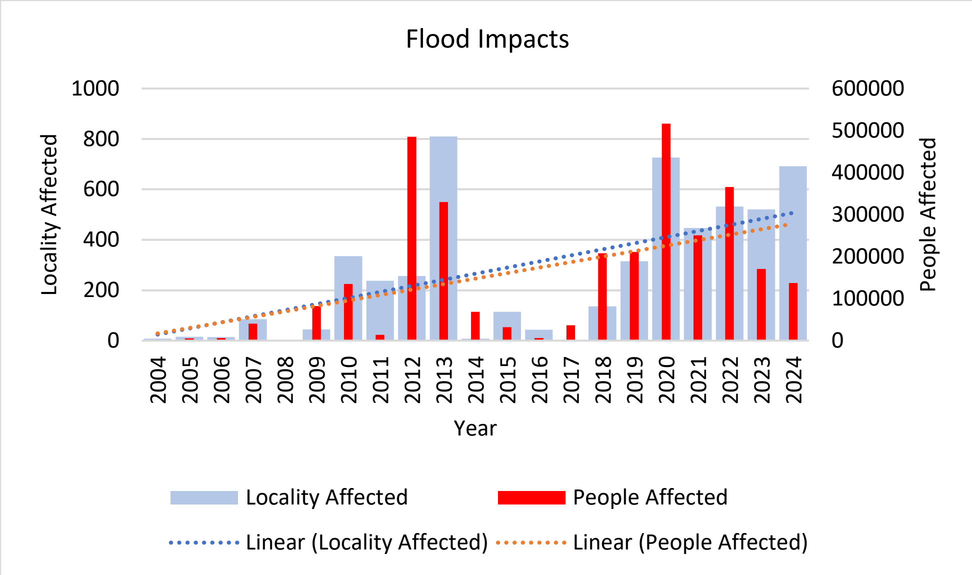

Figure 3. 11: *Flood Impacts_2004-2024 (Locality Affected-People Affected)*

Furthermore, from 2004 to 2024, analysis of flood impacts highlights a noticeable upward trend concerning the localities affected. The impacts show significant year-to-year variability, highlighting some years experiencing high increases. Moreover, regarding the death toll, the data portrays an increasing trend, as indicated by the linear approximation (**Figure 3.12**). In contrast, data show that some years experience higher loss of life than others, but the overall trend is increasing.

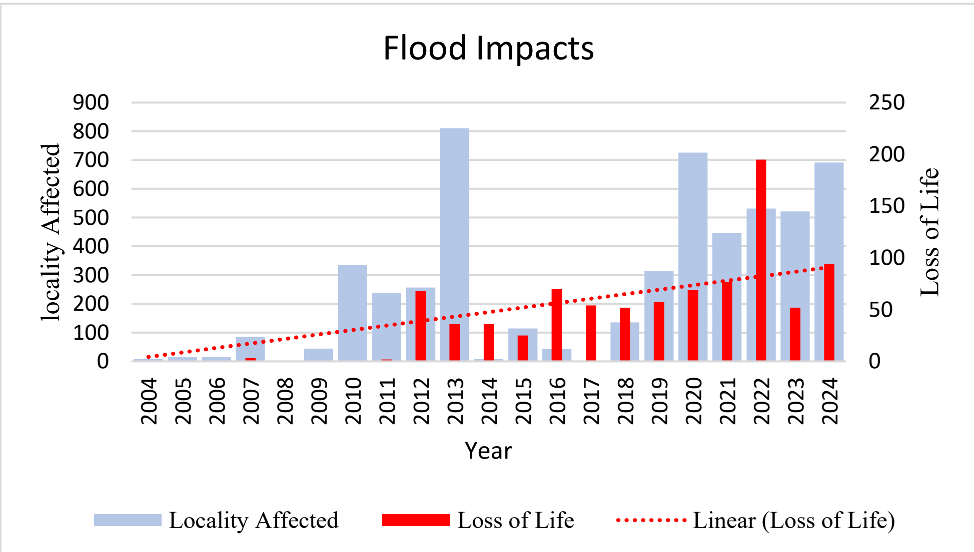

Figure 3. 12: *Flood Impacts_2004-2024 (Loss of Life)*

Concerning the impacts of droughts, based on the EM-DAT database from 2005 to 2022, the analysis of drought impacts focused on two key aspects: the Consumer Price Index (CPI) and the number of people affected by droughts. Thus, regarding the first aspect, (**Figure 3.13)** portrays an upward trend, indicating an increasing number of people impacted by drought. At the same time, the pattern of the (CPI) shows an upward trend. This illustrates the dual impact of droughts on both economic factors (CPI) and population. The upward trends in both metrics suggest that droughts are becoming more frequent and severe. Consequently, the increasing CPI suggests that droughts have a significant economic impact, which reflects high inflation caused by the food shortage as one of the direct impacts of drought.

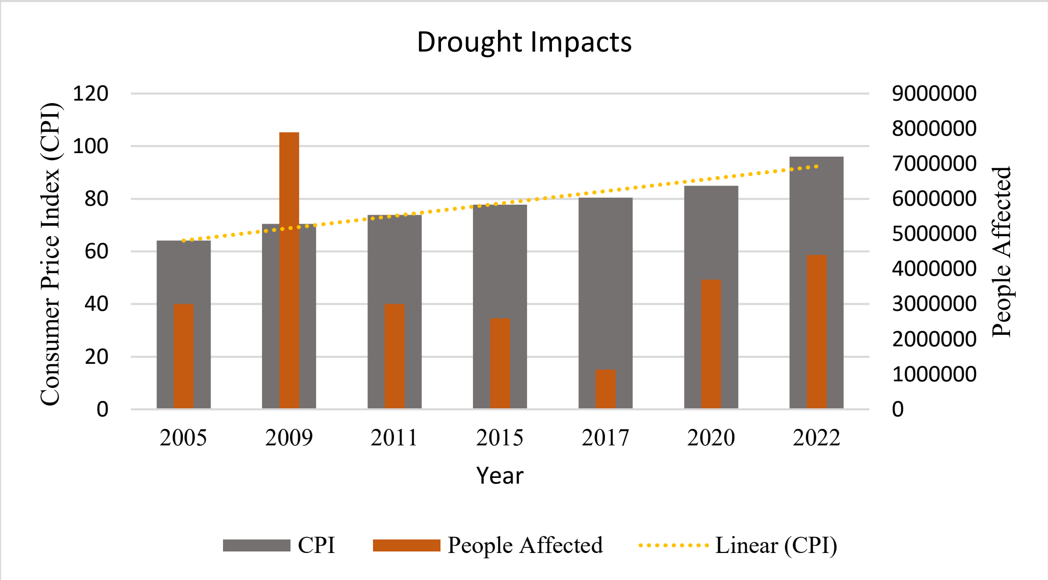

Figure 3. 13: Drought Impacts_2005-2022 (People Affected-Consumer Price Index)

This background raises questions about the institutional decision-making mechanisms and implemented CS capacity, particularly development, and integration into disaster risk decision-making in Niger. Indeed, policies implemented, the institutional framework in place, and existing CS capacity aim to address climate risks, however, the trends of extreme events occurrence and their impacts do not reflect the current status quo.

3.4.8. Policy Recommendations

The findings of this chapter have various policy implications, particularly for improving the coordination, capacity, and integration of CS into DRM strategies.

Findings call for strengthening institutional coordination by harmonizing the mandates and roles of the different institutions involved in CS and DRM to reduce redundancy, avoid fragmentation, and ensure efficient resource allocation.

Findings demonstrated disparities in geographical coverage of EWS. Hence, there is a need to expand and strengthen the coverage of EWS, particularly in underserved and high-risk areas. Additionally, capacity-building programs should be developed to train local authorities and communities for the effective use of EWS for timely decision-making.

Findings shown that Community Early Warning Systems and Emergency Response (CEWS/ER) and local involvement in EWS through the Vulnerability Observatory (VO) are already established. As such, policies should support scaling up where they are not operational and enhance (CEWS/ER) approaches.

3.5. Conclusion

The purpose of this chapter was to address the research question: what is the status quo of institutions and CS capacity for DRM decision-making? The findings indicated that significant progress has been made in the development of institutional frameworks and CS capacity for DRM decision-making in Niger.

Regarding policy goals, CCA and DRM aimed to reduce climate-related risks, adapt to climate change, strengthen the population's resilience, and meet food security. When it comes to institutional arrangement, the findings emphasized the complex institutional landscape where multiple stakeholders operate across national, regional, and local levels. Institutions such as the National Direction of Meteorology (NDM) and General Direction of Civil Protection (GDCP) are involved in producing and disseminating CS, particularly for flooding, while Community Early Warning Systems and Emergency Response (CEWS/ER) ensure last-mile dissemination of warnings and feedback from local communities.

Furthermore, findings identified the National Framework for Climate Services (NFCS) as a crucial institutional mechanism for the production and dissemination of CS into policy-making. The NFCS functions as a science-policy interface (SPI), promoting the co-production of CS, ensuring that climate information is relevant and user-driven, and enabling dialogue between CS producers, decision-makers, and end-users. Similarly, the Regional Climate Outlook Forums (RCOF) is also highlighted as key SPI platforms.

Regarding CS capacity, a wide range of CS are provided besides six (6) EWS addressing various climate-induced hazards like floods and droughts. Thus, EWS such as SLAPIS and FANFAR play a key role in providing timely and accurate warnings of flood risks, while others, like FEWS NET, monitor food security crises due to droughts. These EWS are aligned with international standards and designed, making them adequate to foster a proactive approach to disaster risk reduction at the national and local levels. Most EWS, particularly SLAPIS, SAICU-GTN, and SATH-NBA, meet the key elements of effective EWS: knowledge of risks, monitoring and warning services, dissemination and communication, and response capabilities.

Concerning the geographical coverage, while FEWS NET and FANFAR, provide nationwide coverage, SLAPIS and SAICU-GTN cover specific flood-prone areas like river basins and urban municipalities.

Though CS are disseminated through various channels by providers, the legal framework remains the alert code mechanism governed by Decree No. 2018-538/PRN/MISP/D/ACR, establishing the national alert framework. It outlines a clear, structured process for the dissemination of alerts at different administrative levels (national, regional, departmental, and municipal). The framework specifies the roles and responsibilities of local authorities (mayors, prefects, governors) and technical institutions in activating and communicating alerts.

CHAPTER 3: ANALYSIS OF GAPS IMPEDING THE DEVELOPMENT AND IMPLEMENTATION OF CLIMATE SERVICES FOR DISASTER RISKS MANAGEMENT DECISION-MAKING IN NIGER

Chapter 3: Analysis of Gaps Impeding the Development and Implementation of Climate Services for Disaster Risks Management Decision-Making in Niger

4.1. Abstract

As part of the national climate adaptation policies, CS have emerged as a significant area of climate action. Several projects have been implemented to disseminate CS for effective risk-informed decision-making, focusing on strengthening institutions, CS capacity, and enhancing community uptake. However, evidence comes to question the effectiveness of existing mechanisms in light of the recurrence and upward trend of the impacts induced by extreme events. This chapter examines the gaps impeding the implementation of CS for DRM decision-making in Niger. Grounded in the policy process, science-policy, and actor-oriented interface perspectives, the study employs a qualitative methodology that includes 19 in-depth interviews, 75 semi-structured interviews, and a review of 47 policy documents. From the policy process perspective, the implementation of CS remains essentially driven by an external agenda-setting approach and project-driven, resulting in several ramifications. The primary issue is the funding gap, marked by acute dependence on external funding and the lack of state-led funding mechanisms. These gaps affect the sustainability of CS interventions, the limited geographical scope, and the lack of takeover. The infrastructural gap depicted a deficiency in equipment capacity, particularly regarding the weather observation network, which affects the production of CS due to its sparsity and difficult access in areas affected by armed conflicts. From the actor-oriented perspective, results highlighted gaps between CS providers and beneficiaries, which are shaped and influenced by several interface encounters. These gaps included inadequate last-mile communication, CS format, and limited accessibility.

Key Words: climate services, disaster risks management, climate policy, gap analysis, Niger

4.2. Introduction

Insufficient availability, accessibility, and application of climate services to manage climate-related risks led to the implementation of the GFCS (WMO, 2014). In the same vein, the Sendai Framework further identified weak governance, limited institutional coordination, priority in post-disaster response, and inadequate EWS for preparedness, mostly in Least Developed Countries (LDCs) (UNISDR, 2015). In the wake of the projected recurrence and amplification of extreme climate events, the development of adequate CS is widely recognized and promoted to reduce and manage disaster risks (IPCC, 2022). As CS are increasingly promoted, an increasing interest is also noted among scholars to investigate various issues in the field. As CS represents a public policy interest, from a policy process perspective, previous studies have highlighted three prevailing policy-oriented priority areas: development of CS, use, adoption, uptake of CS, and evaluation of CS (Gaoh *et al.*, 2024). The debate has been active on what CS are, where they are most effective, and how they should be designed to deliver best societal benefits (Vaughan *et al.*, 2018).

Over the past years, Niger has faced recurrent floods and droughts, inducing food insecurity, claiming lives, and damaging properties. In the context of a dire need for effective adaptation solutions, CS have emerged as a significant policy intervention (DMN, 2016). Many interventions were implemented to disseminate CS for risk-informed decision-making in this quest to address climate risks. Consequently, interventions were dedicated to strengthening institutions and CS capacity and enhancing community uptake to integrate CS in climate risks decision-making effectively.

However, evidence interrogates the effectiveness of existing institutions and CS capacity to cope with climate risks. Indeed, in recent floods, 81,944 people were affected, and 3,300 hectares of cultivated land were washed away (OCHA Niger, 2022). Simultaneously, 2.5 to 3.3 million people were affected by severe food insecurity (ReliefWeb, 2022) due to erratic and delayed rainfall, long dry spells, and flooding that led to losses and damage to crops (IFRC, 2022).

Over recent years, as the interest in CS is growing, scholars have attempted to investigate several aspects related to CS in Niger. Most studies generated evidence on the access, use, and socioeconomic benefits of adopting CS, particularly in the agriculture sector. In a study on the impact of seasonal forecasts on farmers' cropping practices and income, Roudier *et al.* (2016) have demonstrated that relying solely on seasonal forecasts yields minimal benefits for farmers' income. In contrast, when 10-day forecasts are accessible, more than 75% of farmers with low adaptive capacity experienced a slight positive income change. Farmers who had access to fertilizers and more arable land experienced income increases of nearly 15%. Authors have pointed out that utilizing both types of CS is significantly more advantageous despite being somewhat riskier than relying exclusively on 10-day forecasts. Roudier *et al.* (2016) arguably attributed these income changes to the modifications of farmers` cropping practices due to adopting CS. According to Maman Bizo *et al.* (2024), the adoption of CS enables optimal resource allocation by farmers, thereby adjusting their investment for the upcoming rainfall season and increasing the annual production of about 64 bunches (equivalent to 10 bags of 100 kg millet), while improving income generation of about 73,000 FCFA from an average farmland of 3 ha per farmer (Seydou *et al.*, 2023). These studies highlighted how effective access and uptake of CS benefits the agriculture sector. In a case study investigating the impacts of CS on farmers` vulnerability reduction in Southern Niger, Seydou *et al.* (2023) reported comprehensive access of around 98.4% through national and local radio, 72.8% through television, and 96.5% via the Internet.

Furthermore, regarding access to CS, prior studies have discovered reliability and religion as factors affecting access and adoption among farmers (Sultan, 2007). In addition to the importance of CS for agriculture, there is broad recognition of their benefit in managing extreme climate-related hydrological events, namely flood, which poses serious challenges for the population.

One of the most significant current discussions concerns the approaches to the production and dissemination of CS for the local population relying on local and indigenous knowledge to cope with climate uncertainties (Arsenault *et al.*, 2023). In a study on the role of co-production in disseminating flood EWS, Tarchiani *et al.* (2020) have demonstrated the possibility of connecting the available technical capabilities with local skills through a participatory approach to produce and disseminate flood early warnings.

Despite the emergence of literature on CS in Niger, there is still a need for further investigation into the challenges that affect the effective development and integration of CS into DRM decision-making.

As a contribution to this effort to shed light on the current issue, this chapter is dedicated to analyzing the gaps impeding the development and integration of CS for DRM decision-making. Moreover, as noted in the literature, most of the studies relied on a quantitative approach to investigate the access, use, and economic benefits of CS for farmers. The current endeavor relies on a qualitative approach grounded in the policy process, science-policy interface, and actor-oriented interface theoretical perspectives. The research findings are drawn from two cases, including an analysis of the gaps impeding the development and integration of CS at the institutional level and integration at the community level.

The results of this case study are primarily based on in-depth interviews conducted with actors at institutions identified as having a role in the CS and DRM domains. This is complemented by the review of official policy documents issued within the framework of CS implementation for DRM.

The second case study focuses on analyzing gaps in the integration of CS at the community level, using the 2020 flooding in Niamey as a case study. To this end, as described in the methodology, the case study encompasses five communities affected by the events. The outcomes reflect data collected in these communities through in-depth interviews with participants living within the areas, based on their knowledge and experiences of the event and how they utilized the delivered CS.

1.3. Theoretical Approach

The theoretical framework adopted in this dissertation is grounded in three interconnected theories: the policy process, the science-policy interface, and the actor-oriented interface perspective. The Theory of Policy Process provides insights into the mechanisms that underpin the decision-making processes of CS for DRM and the roles of various actors in these processes. The SPIs are considered a critical facet of bridging scientific knowledge and policy-making. It elucidates how CS are developed and integrated into disaster risk policy and decision-making and the challenges associated with this process. As an analytical framework for understanding development interventions, Norman Long's Actor-Oriented interface perspective elucidates the agency of beneficiaries and actors at different interfaces in implementing CS for DRM.

1.3.2. Science-Policy Interface

The process of formulating policies is often intricate; actors involved in policy-making navigate an interplay of multiple stakeholders and their interests, which frequently clash (Burton *et al.*, 2019). In this context, it becomes crucial for actors, particularly researchers and policymakers, to navigate and learn how to integrate their perspectives into the policy process effectively. This context has led to the emergence of the concept of the science-policy interface (SPIs), as stated by Burton *et al.* (2019), which are defined as social processes that encompass relations between scientists and other actors in the policy process and allow for exchanges, co-evolution, and joint construction of knowledge intending to enrich decision-making (Van Den Hove, 2007) and represent space where scientific knowledge converges with decision-making processes (Gluckman *et al.*, 2021) in the quest to create a common ground to collaborate to resolve practical problems in society (Afrin & Rahman, 2022).

The emergence of studies on science-policy interface issues and the renewed interest among scholars and decision-makers stems from long-lasting philosophical, sociological, and political questions concerning the roles of science in society (Van Den Hove, 2007), where the cleavage between scientists and policy-makers is pointed out as the triggering factor of failure in science-informed decision-making. In this context, SPIs represent a central element of the policy process, which has various implications for different stages and knowledge production. Gluckman (2018) identified three categories of roles at the science-policy interface: knowledge generation, knowledge synthesis, and knowledge brokerage.

Knowledge production or generation is of great interest to scholars and practitioners because of the need to develop socially relevant knowledge. Based on Gibbons's (1994) comprehensive work, two main approaches are widely acknowledged. Mode 1 knowledge production is the traditional and well-established model for generating knowledge within academic institutions, which is characterized by a linear, discipline-driven, and academically oriented approach to knowledge creation. Mode 2 knowledge production, on the other hand, is a more collaborative, context-driven, and transdisciplinary approach to knowledge generation. Widely considered as a mechanism for transferring research evidence into policy and practice (Ward *et al.*, 2009), at its simplest level, knowledge brokering facilitates the flow of information from one side to another according to Shaxson and Gwyn (2010), as well as transforming it (Meyer, 2010). These actors primarily include scientists, policymakers, boundary organizations, and other stakeholders, such as project beneficiaries (Burton *et al.*, 2019).

In light of the complexity of knowledge production and decision-making, Neßhöver *et al.* (2013) identified three instrumental propositions to the effective science-policy interface, including framing research and policy jointly, promoting inter and transdisciplinary research, and multi-domain working groups that include both scientists and policy-makers from various fields and sectors, put in place structures, and incentive schemes that support interactive dialogue in the long-term. Whereas these elements seem to address practical issues arising at the interfaces of science and policy, Van den Hove (2007) identified a range of points of intersection between science and policy, which induce some theoretical considerations that need to be addressed, as defined by the author earlier as science-policy interfaces. The Author described 15 normative requirements guiding the design, implementation, and evaluation of science-policy interfaces, which reflect the main elements including outputs, processes, actors, and context.

1.3.3. Actor-oriented Interface Theory

The emergence of the sociology of development has exposed the weakness of determinist theories. Long Norman, through his various empirical research, has introduced a new school of thought in analyzing new aspects of development interventions. As the pioneer of the actor-oriented perspective, he reiterated the relevance of this approach to understanding development intervention and their impact on the lives of local populations (Long, 1991, 2003).

This perspective emphasizes the role of social actors and the various types of knowledge involved in a given situation. This approach is grounded in the constructionist perspective that involves "[…] making and remaking of society through the ongoing self-transforming actions and perceptions of a diverse and interlocked world of actors" (Long, 2003), considering development interventions and their outcomes are socially constructed phenomena. This perspective highlights a negotiation process where various actors engage in a contest of meaning, knowledge, cultural interactions, and power dynamics. Thus, development interventions and their outcomes regarding social change and implications emerge from the interplay of different actors. To bring about change or transformation within a given social context, one needs to acknowledge that one will not land in a "vacuum" but will introduce innovations in the context of a development earmarked by existing social structures, social relations, cultural values, and forms of knowledge.

In his diverse research on rural development issues, Long, by emphasizing the process of intervention, highlights the fact that: "[…] All forms of external intervention necessarily enter the existing lifeworlds of the individuals and social groups affected, and in this way, they are mediated and transformed by these same actors and structures."(Long, 2003). Societies are the product of a long history with a specific cultural background and various features in a complex interaction of actors. Furthermore, wherever a new idea comes from, and whatever its importance, it will be influenced or mediated by both social actors and their environment, which refers to the concept of "*lifeworlds*" that includes situated actions, interactions, and meanings.

The centrality of social actors in Long`s approach is critical for understanding social change and development. Moreover, by recognizing such aspects, the author focused on “human agency,” self-organizing processes in intervention, and what he calls mutual determination of the so-called internal and external factors and relationships (Long & Liu, 2009). The fact is that an actor with the attribute of human agency is considered to have the knowledgeability and capability to process social change that occurs within the frame of a given external intervention (Long, 2003). They can actively process experiences in any situation in their situated lifeworld. This concept helps to understand interface encounters through the interplay of actors by highlighting that actions are determined by structure and actors' knowledgeability and capability (Long, 2003).

The interplay of these actors, ranging from local farmers to the other agents who have a stake in the development process, results in a confrontation where conflicts often occur due to the interface situation. The interlocking relationships of actors simultaneously result in what Long qualifies as "battlefields of knowledge" due to the different types of discourses, power, and knowledge domains within a particular social arena. Thus, Long highlights the importance of social interface analysis when exploring and understanding surrounding issues and the diversity of conflicts inherent to development intervention. From the (Long, 1991) perspective, looking at interface situations thoroughly helps understand all these questions. The author defines social interface as: “[…] a critical point of intersection between different life worlds, social fields or levels of social organization, where social discontinuities based upon discrepancies in values, interests, knowledge, and power, are most likely to be located.” (Long, 2003). The author states, “Interface analysis aims to elucidate the types and sources of social discontinuity and linkage present in such situations and to identify the organizational and cultural means of reproducing or transforming them.” (Long, 1999). Thus, adopting the "interface approach" is a response to the dire need to develop an adequate analytical approach to understand the relationships between policy, implementation, and outcomes.

Contrary to most standpoints, which tend to establish a linear link between policy objectives, means of implementation, and outcomes as natural. By adopting this approach, the whole process is conceived as an inseparable set of understanding. In addition, the "interface approach" contributes to the development of a relevant comparative analysis of the process of the responses of a given population (targeted and non-targeted) to a specific intervention by aiming to explore how different groups deal with a new situation resulting from external intervention. Despite criticism about the narrow and repetitive character and its abstract system of interpretation (Olivier De Sardan, 2013), the adoption of the "actor-oriented approach" intends to overcome the simplification and theoretical gap in the analysis of social change and rural development through an analytical framework that puts the focus more on "interface situations" between implementing agencies and local groups and actors (Long, 1991).

4.3. Materials and Methods

4.3.1. Research Design

This chapter adopted an exploratory qualitative research design, allowing a rich understanding of the subjects being investigated (Leavy, 2017). Creswell (1994) defines qualitative research as an inquiry process of understanding a social or human problem based on building a complex, holistic picture, formed with words, reporting detailed views of informants, and conducted in a natural setting. To meet the research objective, this chapter particularly employed a case study research design (Priya, 2021). Creswell (2014) emphasized the in-depth exploration of multiple data sources, while Patton (1980) highlighted the flexibility and triangulation of data sources. In the same perspective, Yin (2011) has stressed empirical inquiry within real-life contexts and methodological rigor, while Merriam (2009) has focused on the interpretive nature of case studies in understanding complex phenomena, in the current case, the gaps impeding the development and implementation of CS for DRM decision-making.

4.3.2. Data Collection Methods

4.3.3. Participants/Sampling Strategy

Overall, a purposeful sampling strategy is employed in this chapter. This strategy is known in qualitative research as well suited to achieving in-depth and comprehensive analysis of the case under investigation (Creswell & Creswell, 2018) without generalizing to all cases (Patton, 1980). Unlike in random sampling for the quantitative approach, the sample size is determined upon the assumption of theoretical saturation by collecting data until reaching redundancy (Creswell, 2016; Lincoln & Guba, 1985; Merriam & Tisdell, 2016).

The target population for this research included Key informants (KI) at different institutions listed in (**Appendix 6**). A document review of officials' records obtained at the institutions listed above complemented this initial data source. Furthermore, in the case study, the target population was the local population residing in the flood-prone areas of Niamey's Municipalities 1 and 5.

4.3.4. Criteria for the Selection of Participants

To reflect the qualitative nature of this case study, the sampling approach employs a purposeful sampling strategy. To this end, a set of criteria is defined to select participants for the study. At first glance, the case study area encompasses five neighborhoods: Kombo, Nogaré, Lamordé, Zarmagandey (Municipality 5), and Kirkissoye (Municipality 2). These zones were the most severely affected during the 2020 flooding and are considered among the most flood-prone areas in Niamey. Regarding participants, the defined criteria concern those living in the area during the 2020 flood event. Another aspect concerns these areas being directly concerned during the 2020 event. The data were collected through Key Informant Interviews (KI), Qualitative Document Review, and participant observation.

4.3.6. Validating the Accuracy of Data and Findings

A clear and detailed description of the methodology, including data collection and data analysis, represents the first step in establishing the trustworthiness of the research process (Braun & Clarke, 2006). Additionally, the coding, categorization, and pattern generation tools available include steps in the ATLAS.ti 24. In addition, to ensure the accuracy of the data, details of the participants' profiles (individuals) and institutions, as well as complete information about the documents explored, are provided. This includes maintaining detailed records of the entire analysis process, ensuring the validity and reliability of the findings, and addressing any potential biases or limitations throughout all aspects of this research.

4.3.7. Data Analysis Methods

In qualitative inquiry, a code is often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and evocative attribute for a portion of language-based or visual data. The data can consist of interview transcripts, participant observation field notes, journals, documents, literature, artifacts, photographs, videos, websites, and other relevant materials. (Saldaña, 2009). Coding is a reflexive and iterative process in which research plays a central role and arises from the researcher's interaction with the data collected (Mohajan & Mohajan, 2022). Qualitative coding, which is a sub-category of qualitative analysis, is a systematic, subjective, and transparent process of reducing data to meaningful and credible concepts that adequately represent the data and address the research problem, purpose, or questions (Adu, 2013, as cited in Adu, 2019) as a process of reducing and analyzing data, it involves several strategies. This study employed three main interrelated strategies for data coding: open coding, axial coding, and selective coding. Open coding involves an inductive process through which data are broken down into salient concepts, representing units of analysis. It represents the initial steps of generating codes. Axial coding involves analyzing the data to create categories based on interrelated codes after generating the initial codes. This develops a more comprehensive understanding of the data being coded. Selective coding is applied as the third step to group categories identified in the axial coding into overarching themes or patterns.

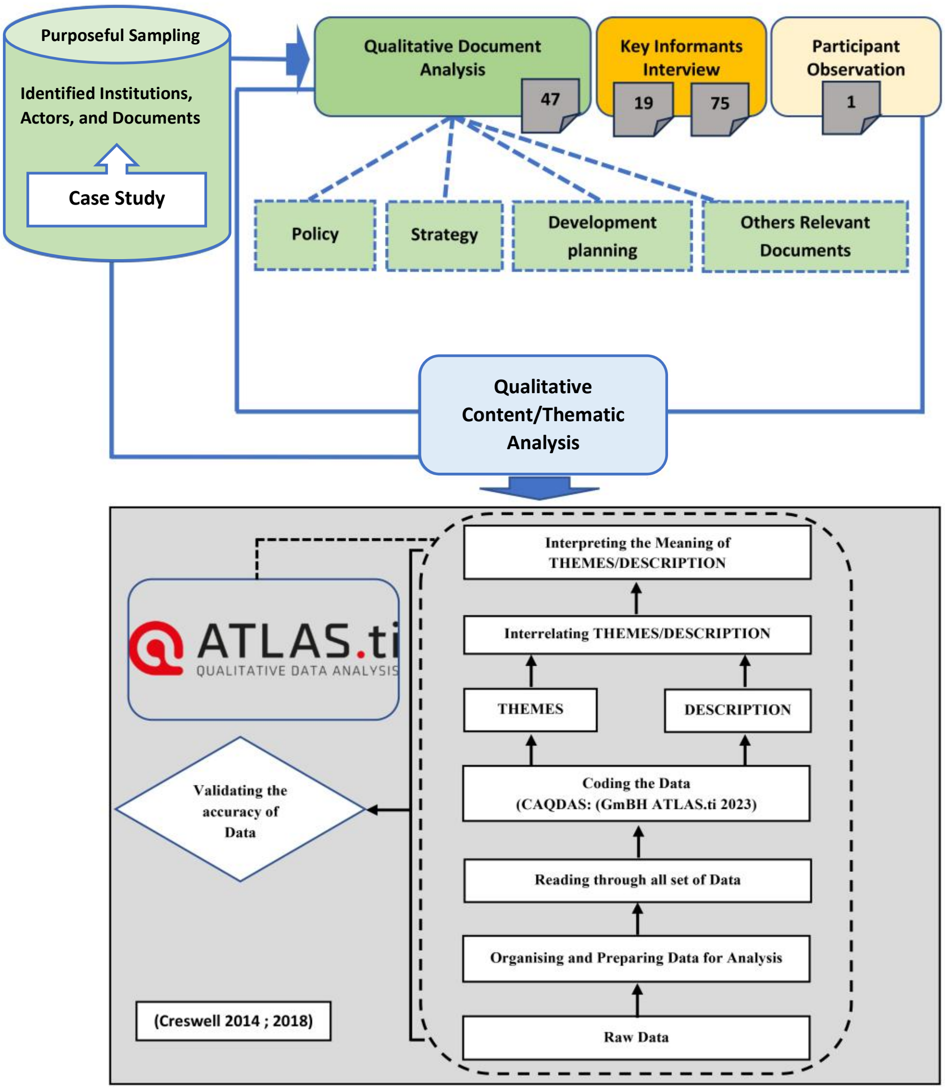

Figure 4. 1*: Graphic Representation of Data Collection and Analysis Approach*

The qualitative approach examines non-numerical data collected in this research to identify patterns, themes, and meanings. It consists of an iterative process (Bazeley, 2013) that involves organizing, categorizing, and interpreting data to develop insights into the research question and objective. The qualitative data collected were analyzed using the following steps, applying content and thematic analysis (Braun & Clarke, 2021), which was performed with **ATLAS.ti 24** (Friese, 2012) as Computer Assisted Qualitative Data Analysis (CAQDAS). It consists of a systematic procedure that applies rigorous steps, including coding, categorization, and generating patterns as the unit of analysis, extracted from data collected to answer research questions and objectives (**Figure 4.2**). Applied in this case, the Content/Thematic Analysis involved examining data described in previous sections, including official records and In-depth key informant Interviews, to identify recurring themes, patterns, or categories constituting analysis units.

The recorded interviews were systematically transcribed using the transcription option Multimedia Transcripts in ATLAS.ti 24. The data were then loaded into the software to proceed with coding. The Open Coding Approach was applied through in vivo coding as the initial step. The axial coding was applied through Apply Codes. To generate themes and patterns, codes were grouped into code groups. This entire process was rooted in the Qualitative Data Analysis (Creswell, 2014). This procedure applies an inductive analytical approach as a way to ensure data analysis is rooted in the participants' perspective (Flick, 2018) through an In Vivo coding approach (Adu, 2019; Saldaña, 2016), which is grounded in the raw data, capturing meaning portrayed by empirical indicators (Adu, 2019).

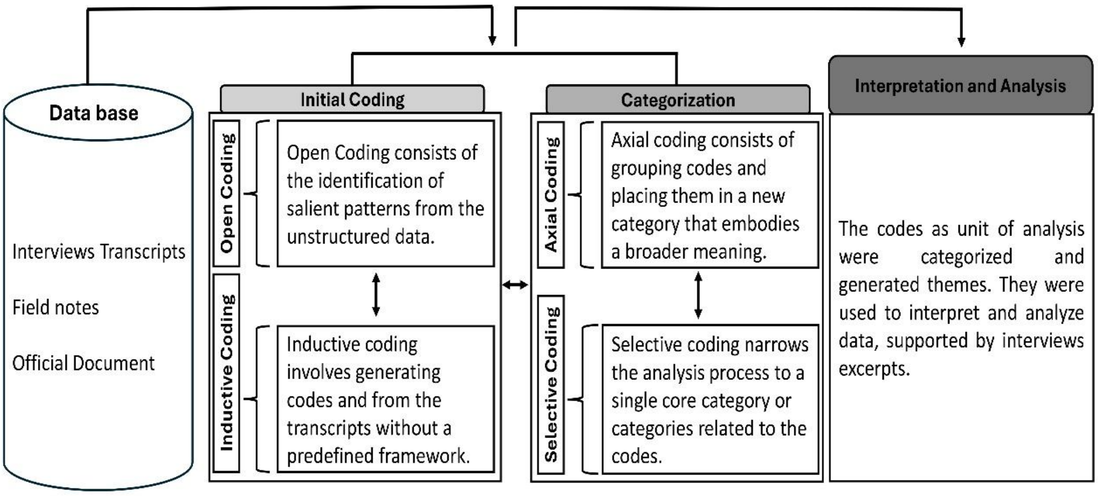

Figure 4. 2: *ATLAS.ti Data Coding Processing*

4.4. Results and Discussions

4.4.1. Implementation of Climate Services: An External Agenda-Setting

In Niger, the implementation of CS to address the risk of climate-induced disaster has evolved into a dynamic arena of development intervention with an interplay of various state and non-state actors (NSA). When attempting to understand the gaps hindering the implementation of CS from a policy perspective, it becomes apparent that they are determined by an external agenda-setting process. Indeed, the analysis revealed that these areas appeared to be left in the hands of external development interventions, primarily in terms of funding. In this regard, CS implementation is dominated by a project-driven approach. A non-exhaustive stocktaking of interventions from 2008 to 2023 has revealed 22 implemented and 9 ongoing. This status quo depicts an acute reliance on external funding for CS implementation for DRM. Most of the financial flow is ensured by the NSA, including Non-Governmental Organizations (NGOs), Banks, and development cooperation agencies. Upon reviewing the state-led funding initiatives, it was evident that the financial flow provided was quite insufficient.

"Niger relies on international cooperation to mobilize sufficient financial resources to achieve the objectives of the NDC. The resources that can be mobilized at the national level are limited and insufficient, hence Niger's keen interest in accessing Climate Funds". (NDC 2)

Reliance and dependency on external funding are evidenced in the updated Nationally Determined Contribution (NDC), which represents the national climate policy instrument per the Paris Agreement's recommendations. Indeed, as quoted above, the NDC 2 boldly stated the reliance on external funding sources to meet national objectives, highlighting at the same time the weak capacity of the state to mobilize domestic financial resources. Indeed, in terms of funding, the NDC 2 devoted two main scenarios (mechanisms), including Conditional Funding (CF), which represents the financial resources intended by donors, and Unconditional Funding (UF), which represents the public's investments, to finance the country`s climate actions for mitigation and adaptation.

The adaptation funding encompasses investments related to CS and DRM, specifically, in the agriculture, forestry, and other land use (AFOLU) sectors, in which policy priorities include climate-smart agriculture (CSA), CS, and DRR, the funding scenarios to meet national objectives account for 6.743 billion USD. Thus, throughout 2021-2030, the funding requirement represents $ 2.40 billion (35.6%) for the UF and $ 4.343 billion (64.4%) for the CF (**Table 4.1**). The same trends were found in the first Intended Nationally Determined Contribution (INDC) from 2015 to 2020, in which the CF represents the most significant funding flow and needs to implement national climate policies.

Table 4. 1: *NDC 2 Funding Scenario, Amount, and Period of Implementation for (AFOLU)*

Funding Scenario (USD Billion)	**Period of Implementation** 2021-2025	2026-2030	**Percentage**	**Total**
Unconditional Funding (UF)	0.85	1.55	35.6%	2.4
Conditional Funding (CF)	1.87	2.473	64.4%	4.343
Total	2.72	4.023	100%	6.743

Note. (NDC 2, 2021)

As highlighted in (**Table 4.1**), there is an acute reliance on external intervention in the implementation of CS for DRM, translating the relegation of the state's role to execution and coordination, while implementation is ensured by the network of the state`s bureaucracy, which encompasses various institutions.

Consequently, the funding gap represents the primary impediment to the implementation of CS for DRM in Niger. Indeed, notwithstanding the fact that external funding is, in some cases, framed by various united nations (UN) mechanisms towards Least Developed Countries (LDCs) like the Green Climate Fund (GCF), this reliance implies serious challenges for the policy process in this sector, because this gap has further ramifications that induce far-reaching impediments to the implementation of CS for DRM.

Indeed, securing funding from donors, either in the format of a loan or aid, may require quite a long time, from the design to the acquisition. This represents another state of the funding. As it is pictured in an interview with a senior official of the MHA/DRR

> "While we rely heavily on international aid, it is important to remember that access to funding can be a major challenge. As in other development sectors, it usually takes a long time to get funding, whereas natural disasters are not going to wait for us. We have to predict them, and to do that, we have to mobilize the players and the technical capabilities, particularly regarding weather forecasting. For example, we may start the process this year, and to obtain funding, we have to wait one or two years later." (Interview, Senior official, MHA/DRR, 05.04.2023, Niamey).

At this level, the delay in the acquisition of funding and political instability constitutes other considerable issues. Indeed, while most of the external donors require a certain level of political stability to fund projects, the recurrence of instability affects this process. For instance, the recent coup d`Etat has a likelihood of impacting the ongoing initiatives or those in the pipeline by affecting the financial flow, which might be stopped or delayed, and at the subregional level, those that involve a partnership with subregional organizations like ECOWAS and affiliated institutions are likely to stop because of the Niger withdrawal from this institution, as it is expressed in these terms:

> "Because we share many common problems regarding climate risks, at the sub-regional level, the states have developed many projects together. This is the case, for example, of certain funds granted by the AfDB or the European Union, which are generated under the aegis of ECOWAS. […] For the moment, we do not really know how the situation will be managed, but there could be problems receiving these funds once our country is no longer a member of ECOWAS. However, as it takes a year to become effective, let us wait and see[...]. And then there are the

other technical structures working on risk and climate change issues that are sharing data, but we hope that it will not be like at the political level and that the collaboration will continue […]. We all know that it will definitely affect the country" (interview, Agent of MHA/DRR, 09.03.2024, Niamey)

As highlighted in the excerpt below, political instability may even affect the technical institutions, which means those involved in the production of CS for DRM and other related interventions. Another emerging critical aspect related to the political instability regarding the development and integration of CS for DRM is the frequent cancelation of existing policies, often without a viable backup or alternative plan.

4.4.2. Funding Gap for CS Implementation and Project Takeover

In their mandate of producing CS, the main providers face several issues, starting with the lack of sufficient funding, which represents a recurrent pattern echoed by interviewed actors that have a role in the CS and DRM. Specifically, the lack of sufficient funding limits their capability to perform their mandate of producing relevant CS for decision-making, as stated during an interview with a technical agent from ACMAD.

> "The science of climate services requires massive data caption and that is another problem within the African continent. It requires a lot of investment. Because each domain has its pressing needs, money allocated to meteorological services may not be enough to meet their needs. That means they have to rush on, and while rushing on, so many things may be left undone. […]." (Interview, ACMAD Senior Agent, 12.06.2023, Niamey).

Other states' policies and priorities tend to cloud the funding need for this sector, and when it comes to CS projects, without a permanent funding flow, implemented or undergoing interventions may likely stop, thereby affecting their sustainability over time. As a matter of fact, the case displayed in (**Appendix 7**), the implementation of the METAGRI project from 2008 to 2011, illustrates this situation. Indeed, the WMO funded the project in partnership with the Agencia Estatal de Meteorología (AEMET) to enhance the integration of CS into farmers' climate risks management through Roving Seminars (RS). As the implementation has been proven efficient for the beneficiaries, at the end of the funding period of the project, concerns arose about the sustainability of the intervention, as pointed out by a technical agent who participated in the project implementation,

> "Funding for the METAGRI project was provided by WMO and other partners such as USAID. As far as I know, we have not received any money from the national treasury to run these seminars. It is always done based on project support or a partner (NGOs and humanitarian

> organizations) […]. I wonder how we will handle these seminars at the end of the project." (Interview, Project Technical Agent, 15.08.2023, Niamey)

In this case, despite the continuation of the same approach through another project (ANADIA) to implement CS, concerns remain since the state does not take charge of the funding in the national budget to ensure a stable financial flow at the policy-making level for more sustainability in the implemented intervention. This constitutes a serious shortcoming even in the more recent policy initiatives to implement CS. Indeed, the funding gap, especially its irregularity and external nature, undermines the implementation of the national framework for climate services (NFCS), which represents the more recent national systematic policy instrument to effectively develop CS for all the climate-sensitive sectors. This issue is pointed out in the interview with a technical agent of the NMD.

> "[…] funding is not forthcoming on an ongoing basis. Our hope was that once we had tested this pilot phase with the support of USAID, and once the users and the various stakeholders had seen the value of the project, there would be advocacy and lobbying of the national budget so that funding for the framework would be included in the budget programming of each ministry. But until then, we are relying on projects and funding from partners to get the national framework for climate services up and running." (Interview, NMD Agent, 31.01.2024, Niamey)
> "Frankly, when it comes to funding, we would have liked it to be ongoing, to be part of the operating budget of the various structures, but that is not the case. At the moment, I think it is a WFP project that takes care of the running of the national climate services framework. But, once the WFP project comes to an end, what will be the fate of the national framework for climate services, because I think the project has a duration of about six years. So, once this funding comes to an end, what will be the fate of the national framework for climate services in Niger? This reflects the irregularity of funding, which is a serious problem for the production of climate services." (Interview, NMD Agent, 31.01.2024, Niamey)

Although the lingering project-driven approach to the implementation of CS has produced some significant results, as in the case of the RS and many other projects, it is still subject to shortcomings. Furthermore, as project funding is limited in time and space, this approach can only reach a limited geographical area within the country. Thus, this reflects the lack of more effective dissemination mechanisms and affects the sustainability of implemented projects.

The systematic lack of state-led financial mechanisms remains a critical gap in that it considerably limits the takeover of CS projects implemented. CS interventions are often limited to a specific timeframe during which donors ensure the funding. In the spirit of interventions, these are meant to instill a new dynamic and, subsequently, a takeover from the state institutions. However, the situation seemed to be else since there was a lack of takeover to ensure the sustainability of the interventions.

4.4.3. Cancellation of Existing Policy: The case of 3N

While the 2021-2025 action plan of the 3N is being implemented (HC3N, 2021), the cancellation of existing policies implies the likelihood of creating a critical need for the development and implementation of CS for DRM. In the following analysis, the findings focus on the 3N initiatives, which were established by the then government in 2011. Indeed, over the past years, this policy represented one of the backbones of government policies in agriculture, food security, and poverty reduction (HC3N, 2012). Thus, due to the critical importance of this policy, it was anchored at the state presidency and led by the High Commission for 3N Initiative (HC3N). Many projects linked to CSA have been implemented through the policy, as in the cases of the BOAD Adaptation fund (RAAF, 2022) and that of (World Bank, 2016), which have components related to strengthening CS for climate risk management in the sector. While the implementation interventions were underway, as a consequence of the Coup d'état that occurred in July 2023, the military government recently canceled this policy through a decree. This cancellation involved the dismissal of the HC3N governing commission (Nigerdiaspora, 2024; NigerInfos, 2024).

The cancellation 3N Initiative which is a pivot of Niger's agricultural and food security strategy, has significant implications for the development and integration of CS for DRM, given that many of Niger's policies, especially in agriculture and food security, are aligned with its goals and framework. The 3N initiative serves as an overarching framework that integrates climate-smart agriculture, food security, and resilience-building strategies. Its cancellation leads to a fragmentation of agriculture, food security, and climate risk management sectors. This would potentially hinder the implementation of CS for DRM, particularly in agriculture. In addition, the cancellation disrupts the implementation of CSA interventions, thereby negatively affecting climate risks management in the sector. As a matter of fact, despite its institutional anchoring at the presidency, which is supposed to be effective (Moussa, 2020), it shares some aspects regarding risks management with the NMPMCF, particularly in the aftermath of a disaster, for instance, with the FCU and SNU.

As a consequence, it leads to a disruption in the decision-making process. Furthermore, given that the 3N initiative aligns with broader national policies like the NAP and the NDC and international frameworks like the SFDRR, this cancellation leads to a loss of policy alignment with these national and international frameworks. Moreover, this cancellation induces a likelihood of challenges in terms of funding and institutional support. Indeed, through the 3N initiative, much funding has been implemented, as the cases cited earlier, to support climate-smart agriculture and food security initiatives. Canceling the policy is likely to result in loss of financial and technical support, which could, in turn, affect the development and implementation of CS for DRM as part of the overall agriculture and food security policies.

4.4.4. Infrastructural and Human Resource Capacity Gaps

Another critical impeding gap in CS implementation, particularly in CS development, represents the infrastructural deficiency, a corollary of the funding gap and project-driven CS implementation detailed previously. In this regard, the first recurrent element is the insufficiency of the weather observation network (WON). Indeed, as a pillar of weather observation and CS production, the WON remains critically insufficient in various ways, namely, the national coverage, the deterioration of available equipment, the collection and monitoring of data in insecure zones, and the lack of incentive for field agents responsible of collecting and transferring data from non-automatic stations.

Regarding the national coverage, according to recent data from the Système d`Information Environnementales sur les Ressources en Eaux et leur Modélisation (SIEREM), the available WON (**Figure 4.3**) is spared, showing a geographical disparity across the country. This figure concurs with the saying of the senior ACMAD agent complemented by that of the agent of NMD, which highlighted that,

> "[…] The production of relevant CS requires generating massive data, which is always a problem because you have to start from the rudiments, creation, and installation of meteorological stations to collect the necessary data that you really want, and where the stations are not existing, that means there will be gaps. […]" (Interview, ACMAD Senior Agent, 12.06.2023, Niamey)

This reflects the same issue pointed out by a technical agent of the Niger weather services. According to their standpoint, the current revealed the insufficiency of the infrastructure:

> "The observation network also is far from satisfactory. […]. In addition to the obsolescence of the equipment. […]. (Interview, NMD Agent, 31.01.2024, Niamey)

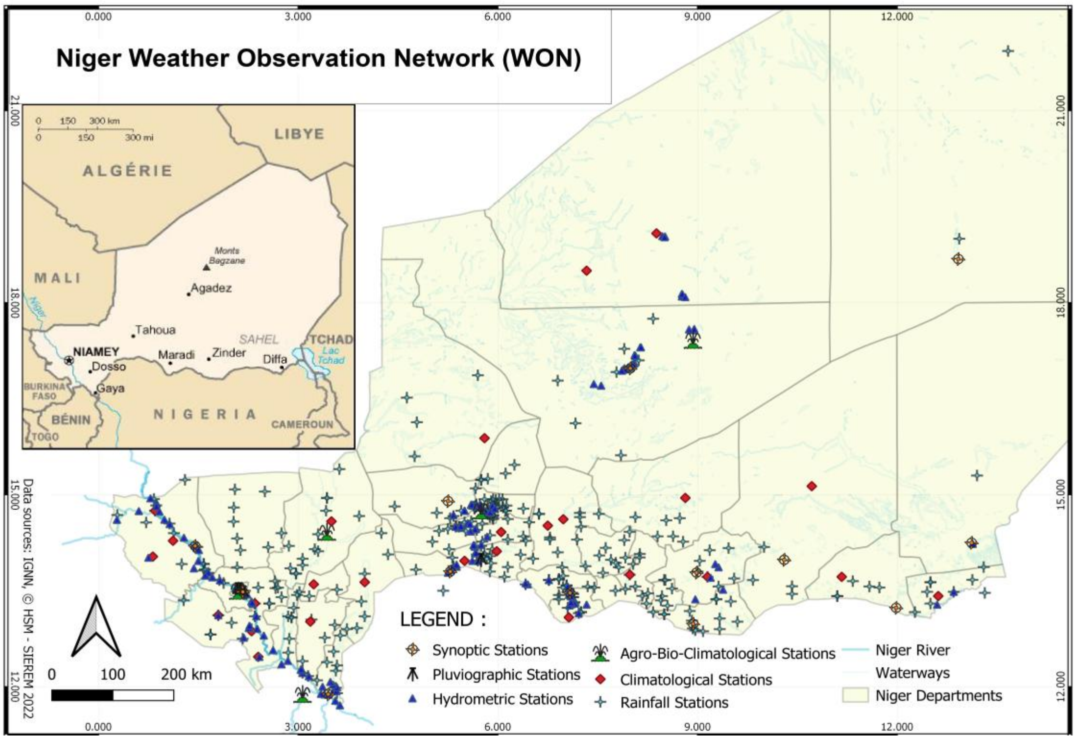

__Figure 4. 3__: Niger Weather Observation Network

Another flaw identified in the WON is closely related to the project-driven CS implementation. Indeed, it appeared in the analysis of the evaluation report from GDCP that many recently installed weather stations have been funded through project interventions, like the case of 73 in the frame of PDIPC and 30 in the frame of PASEC. A technical agent of the NMD echoed this evidence:

> "[…] We have begun to shift towards automation of the network, installing over 100 automatic stations as part of the PASEC project (a World Bank project), which was managed by the Ministry of Agriculture." (Interview, NMD Agent, 31.01.2024, Niamey).

The maintenance of the WON requires care and investment. While these equipment are installed in the frame of project interventions, their maintenance may be difficult when the project ends. Furthermore, the data collection from installed stations is often limited due to the deteriorating security conditions in certain zones, including the eastern and western parts of the country.

> "[…] And where those stations exist, they may not be functioning at their maximum capacity, probably for one reason or another. Maybe due to armed conflict, it is not expected for scientists to stay where there is armed conflict. Maybe due to lack of proper funding, […]. So that will be a gap in that area."

In general, concerning the manual meteorological stations, the data collection is ensured by volunteer assistants in the zone, which means without constant remuneration, a situation that undermines capturing the data in these areas and leads to not capturing the real weather parameters in the zones. Thus, the lack of financial incentives for field agents onsite impacts their motivation to stay engaged. The data collection becomes more critical when looking at the qualification of the volunteer-based field agent. In this regard, according to a technical NMD agent,

> "For the other existing stations, data collection, transmission, and feedback is often problematic, either because the agent has retired or because sometimes it is even a senior member of staff who goes out to make observations while waiting to find a qualified agent. I think that at least two agents are normally needed at each station, so even if the agent is on leave, he will not need to take on a volunteer to collect the data. "(Interview, NMD, 31.01.2024, Niamey)

Regarding human resources capacity, another flaw arises, particularly at the end of CS experts. Due to advancements in science and technology, climate science has transcended the confines of meteorology. This necessitates CS experts to possess expertise and competencies in multiple related disciplines to effectively analyze complex datasets and generate efficient CS, thereby enhancing the speed, reliability, and accuracy of the output. However, it appeared that these skills are not widespread among CS experts, as echoed by a senior agent at ACMAD.

> "You see, to be a climate scientist is not a day journey. Climate scientists are not picked on the shelves of the supermarket. Apart from academic qualification, they also need some long-term experience and these experiences are so diverse they are not limited to dynamical meteorology of synoptic meteorological aspect. They are so diverse in the sense that they have to spread their tentacles into all those disciplines, like take, for example, computer programming, because gone are the days where climate scientists rely on computer programmers to do their stuffs for them […]."

It is reported that the occurrence of discrepancies between CS experts and other agents, especially when there is a need to perform a task that complements that of CS by programmers, for instance, because they understand the task differently than the way CS experts excepted. The interviewee expressed the dire need for a *"holistic knowledge package"* for CS experts in their mission.

4.4.5. The gap between official and practical norms in the bureaucracy

a. Institutional Fragmentation

One of the patent particularities of the domain of CS for DRM in Niger is undoubtedly the diversity of institutions and actors, both when it comes to the development of CS and their implementation for decision-making, as it has been highlighted in the previous chapter. Indeed, although the institutions mandated to produce CS are structurally few, those mandated for DRM are relatively many. As it appeared in the national DRR policy, institutions are characterized by the fragmentation of the institutional framework. Thus, each type of disaster has its specific response mechanism, compounded by the pre-eminence of the central level, because some institutions are directly anchored at the presidency of the Republic, others at the Prime Minister's Cabinet, and the rest at various ministries. As a matter of fact, the recently established MHA/DRR has a unit flagged the Disaster Prevention and Alert Department (DPAC), dealing with particularly flooding, while the EWS/CU, anchored at the Prime Minister Cabinet, addresses food crisis and drought. As stated in the same national DRR policy,

> Order n°0030/PM of 09 February 2012 establishing the NPDRR set the mandate of "defining a national reference framework containing: policy, guidelines, objectives, strategies and action programs for risk prevention". This acknowledges the NPDRR mandate to define national policy on disaster risk reduction. However, the same competence is vested in the MHA/DRR by Decree n°2016-623/PRN of 14 November 2016, by virtue of which "the Minister, in relation with the Ministers concerned, for the design, development, implementation, monitoring, and evaluation of national policies on humanitarian action and disaster management, following the guidelines defined by the Government."

This institutional fragmentation depicts a patent overlapping mandate, a status quo expressed by a participant during an interview:

> "[…] With the establishment of the MHA/DRR in 2016, some of the NMPMFC's competencies have been transferred to the Ministry. But this is a political decision, and it is one of the problems we have in Niger. The climate is a whole, there is no border between drought and excess water, and if you compartmentalize it into different entities, it becomes a problem." (Interview, CNEDD, 07.007.2023, Niamey)

b. Institutional Overlap and Institutional Rivalry

The MHA/DRR holds the official mandate for managing the humanitarian response to disasters; however, its presence and implementation across the country are hampered by limited financial and human resources. As a result, in certain regions, the MHA/DRR often depends on the National Multi-Purpose Management and Coordination Framework (NMPMCF) for operationalizing its mandates. This reliance leads to an overlap of roles and responsibilities between the two institutions.

4.4.6. The Gaps Between Science and Policy-making

Findings revealed an underutilization of CS for flood management due to an implicit disconnection between science and policy. Indeed, as highlighted in the excerpt above, this is the case with the 2020 flooding in Niamey. In addition to the leading national CS providers and others, experts often produce CS within the framework of their scientific activities or as part of a specific project funded by donors. Climate information is generally disseminated through project reports, newspapers, policy briefs, public conferences, and workshops. However, the information has not effectively reached the last mile despite the experts' forecasting.

> "In 2015, we mapped Niamey's flood zones and simulated a river flood with breaching of the dykes [...] We thought at the time that this was an unlikely scenario after the reinforcement of the dykes in response to the 2012 flood. In the simulation, the first dike to be breached was the one between the first and second bridges, followed by the Lamordé dike. Unfortunately, this scenario has now become a reality. Although published and presented in workshops, the information developed has not been used to its full potential due to the disconnect between scientists and decision-makers. This disconnect is present everywhere but is particularly severe in French-speaking Africa. It is important for the next steps that these two groups talk to each other because science without action, and action (or inaction) not guided by science, are both ineffective in solving our problems." (Facebook Post, CS Expert, 09.09.2020)

4.4.8. Last-Mile Communication of Climate Services

The effectiveness of CS depends on good communication between the service provider and the recipient, as well as a reliable access system that enables quick and effective action (WMO, 2024). The simplified flow of CS (**Figure 4.4**) is structured around a multi-level institutional framework that connects upstream production to downstream last-mile communication systems. The process is embedded within the National Framework for Climate Services (NFCS) and informed by Regional Climate Outlook Forums (RCOFs). In the case study, various channels were utilized to reach the last mile. The national television, the NDM, broadcasts information on the current weather situation and that of the following day. The GDCP officially issues the SMS Alerts for flood risks through the national alert code. The NDM, ACMAD, and AGHRYMET post information on their social media pages. The NBA monitors the SATH-NBA EWS (**Figure 4.4**), which is available online. The DH/WR hosts and monitors the SLAPIS while the MHA/DRR hosts and monitors the SAICU-GTN.

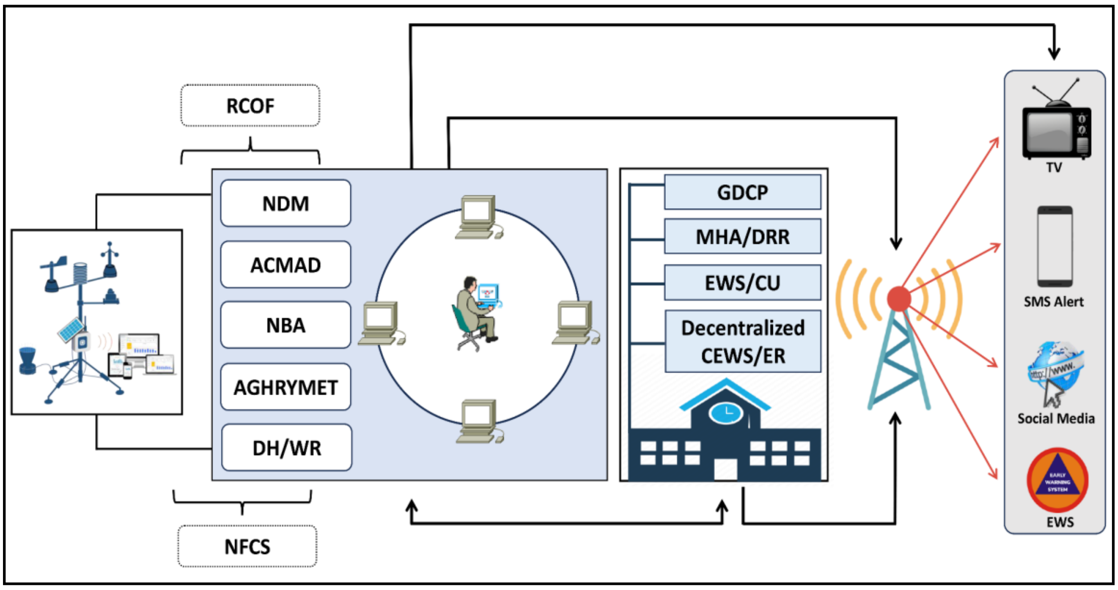

Figure 4. 4: Simplified Climate Services Last-Mile Communication Flow

4.4.9. Limited Accessibility to Climate Services

The accessibility of CS among 75 participants (**Figure 4.5**) revealed significant disparities in reach across different last-mile communication channels. Indeed, SMS Alerts and NDM's television broadcasting (NDM RTN) emerge as the most accessible, with 60 and 55 respondents affirming access.

In contrast, the EWS, such as FANFAR, GDCAS, SATH-NBA, and SLAPIS exhibit extremely low accessibility, with almost no participants reporting usage. Social media pages show mixed results: NDM's Facebook page has moderate engagement (about 15 users), while ACMAD's Facebook and Twitter pages, along with NDM's Twitter page, have minimal reach among participants.

Concerning the available EWS, most of the interviewee are not aware of their existence. One interviewee noted, *« I have never heard of these tools. If the platforms that you mentioned earlier really exist, I think that the authorities need to ensure that people are aware of their existence. So that people can really take an interest and get information. »*

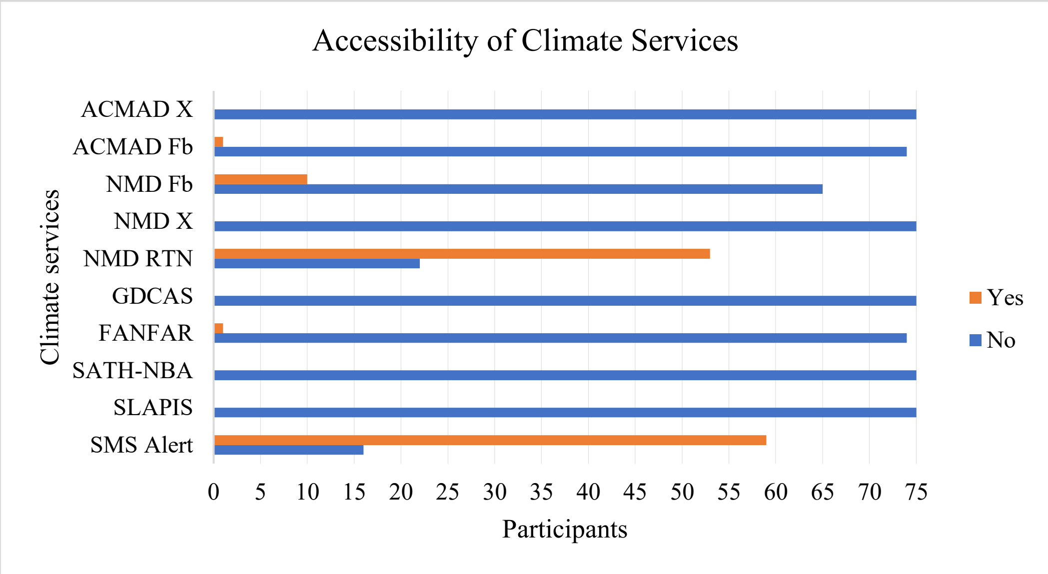

Figure 4. 5: *Accessibility to CS Last Mile Communication Channels*

4.4.10. The Inadequate Format of Climate Services

Results have shown that most participants received the Flood SMS Alert. However, the reception does not guarantee the integration of the alert for participant decision-making in the event of a flood. Indeed, the alert was flagged as inadequate by participants due to its format, language, and geographical scope. A participant stated: «*The telephone companies used to spam us with many notifications using the same approach. Therefore, one can receive the flood SMS alert and ignore it, considering it is an advert from the company* » (Interview with a participant, Niamey, Lamordé, January 17, 2024).

Significant flaws in the alert remain its timeliness and the lack of precision in its geographical scope. As illustrated in (**Figure 4.6**), the content of the alert is somewhat generic and not tied to precise, actionable timing (e.g., "Heavy rains expected within the next 48 hours") or (timeframes or forecasts indicating when flood risks are highest). For the television broadcasts, the content of the information focuses mainly on (temperature, dust, wind, and rainfall probability forecast) without any specific indication of flood risk, its impacts, and geographical scope. Regarding the impacts, for the 2020 case, no specific information was available about the state of the dike that collapsed due to heavy rainfall. It is evident that the information disseminated did not include details regarding the potential impact of the rainfall on the infrastructure, namely the dike. In this case, the information solely conveys information about what will happen, which highlights a significant flaw in the CS format, particularly being not impact-based.

Another significant aspect is the language used to issue or display information. CS, including alerts, television broadcasts, social media, and EWS, are primarily disseminated in French (in a technical language), which many people do not easily understand. Even those who understand French find it difficult to digest without literacy on the platform. The lack of communication in local languages such as Zarma and Hausa limits the accessibility and integration of these CS.

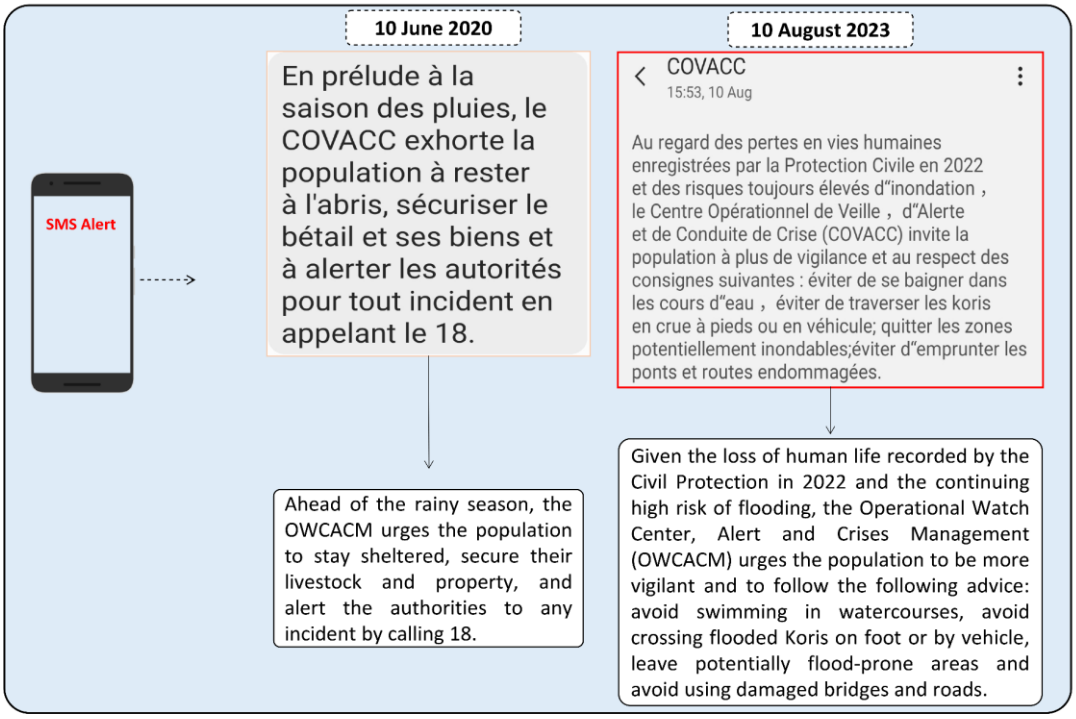

Figure 4. 6: *Flood SMS Alert Issued by the GDCP*

4.4.11. Perceptions and Trust in Climate Services

A recurring theme of religion and culture fuels skepticism and mistrust in CS. Some participants either do not believe the forecasts or are influenced by cultural and religious beliefs, which leads them to think that disasters are acts of God beyond human control. As attested by an inhabitant of Kombo: *« People are convinced that only God knows what can happen tomorrow. Anything that has not happened yet remains in the realm of the divine »* (Interview with a participant, Niamey, Kombo, 18 January 2024). This undermines the reliability of CS, such as the Flood SMS alert and information broadcast on television.

Additionally, the perceived reliability of alert is often shaped by experience where the information proved not effective, as noted by one interviewee, « *After receiving the warning, we did nothing at all because it was not the first time we had been told about the risk of flooding, but it never reached our level. So, we thought it was just like every other year »* (Interview with a participant, Niamey, Nogaré, January 17, 2024).

The "information-action gap" also remains critical. It indicates that even when climate information reaches individuals effectively, socioeconomic and practical constraints may prevent appropriate protective responses. This situation is reflected in a statement made by a participant, who said: *« Of course, we had the information, but we did not leave our home because we had nowhere else to go. At the moment, it is also difficult to find a rental house. We decided to stay and hope the water would not reach us »* (Interview with a participant, Niamey, Kirkissoye, February 3, 2024).

The public response to the flood primarily emphasizes relocating affected individuals to schools, as these events typically coincide with the holiday season. However, given the high number of people impacted, available shelters are often insufficient. Hence, some individuals may hesitate to relocate due to the challenging living conditions in these temporary accommodations.

4.4.12. Policy Implementation, Actors, Practices of Power, and Agency Influence on CS Implementation

Table 4. 2: *Policy Implementation, Actors, Practices of Power, and Agency Influence on CS Integration*

CS-DRM Policy Implementation	Actors at Interfaces (CS-DRM)	Observed Practices of Power and Agency	Influence on CS-DRM Integration
Implementation of Flood Alert for community to manage flood risks	General Direction of Civil Protection (DGPC)	Dominance (Provision) on Alert Dissemination	Impede/Improve the development and integration of Climate Services in DRM decision-making
	Local Community	Contestation (Reluctance) to adopt CS introduced via certain channels. Contestation (Preference) of other Channels of Dissemination Contestation, resistance to follow instructions imbedded in disseminated Alert and supply-driven Alert	
	Municipality Authority	Negotiations (Inform and	Improve development and integration of Climate Services in DRM decision-making

CS-DRM Policy Implementation	Actors at Interfaces (CS-DRM)	Observed Practices of Power and Agency	Influence on CS-DRM Integration
		interact with the community)	
	Local Traditional Authority	Negotiations (Interact with the community)	Improve development and integration of Climate Services in DRM decision-making.
	Ministry of Humanitarian Action and Disaster Management (MHA/DRM) and others	(Negotiations) Provision of Humanitarian Response and Relief support	Improve development and integration of Climate Services in DRM decision-making
Dissemination of Warnings and Forecasts on rainfall and flood	National Direction of Meteorology (DMN)	Dominance (Provision) of warnings and forecasts	Impede/Improve the development and integration of Climate Services in DRM decision-making.
	African Centre of Meteorological Application for Development (ACMAD)	Dominance (Provision) of warnings and forecasts	Impede/Improve the development and integration of Climate Services in DRM decision-making.
Implementation of Flood EWS for the community to manage flood risks	Ministry of Humanitarian Action and Disaster Management (MHA/DRM)	Provide Flood Warnings and Forecasts	Impede/Improve the development and integration of Climate Services in DRM decision-making
	Niger Basin Authority (NBA)	Provide Flood Warnings and Forecasts	
	AGHRYMET	Provide Flood Warnings and Forecasts	
	General Direction of Civil Protection (DGPC)	Dominance (Provision) on Alert Dissemination	

Note. Developed by author based on field data analysis

4.4.13. Discussions about the Challenges Limiting Implementation of Climate Services

The decision-making process of CS implementation for DRM involves multiple actors and institutional settings, subject to various factors that either enhance or impede the processes.

Mahon *et al.* (2019) have identified the absence of relevant policies and strategies as a critical barrier to providing CS. From a broader perspective, Grossi and Dinku (2022) have found that "social, political, institutional, and cultural systems surrounding climate information can be just as important as the data themselves in setting up lasting yet adaptive CS." Thus, in the same perspective, according to Rebecca *et al.* (2022), the usability of the existing Weather Information Services (WIS) for farming can be enhanced or obstructed by factors including the origin of the information, information providers' level of interaction with farmers, continuity in the delivery of information, respect for local values, accessible level, and mode of payment, among others. Some of the information design and delivery criteria and factors affecting WIS usability had trade-offs or complementarities, which is inevitable.

Furthermore, with more attention on DRM, in a systematic attempt to unpack the roles of CS, Street *et al.* (2019) have identified four critical challenges to the policy implementation of CS, including (i) disconnection between CS and DRR, (ii) accessibility of relevant and quality-controlled information, (iii) understanding of information needs, and (vi) understanding the role of CS and its link to the DRR planning cycle. The scholarly debate is also dominated by studies on the approaches adopted to design and disseminate CS. As a critical step in the process of CS production, in the design and dissemination, NMHs mostly operate through a top-down pyramidal approach in providing CS, particularly in disseminating EWS, increasing the likelihood of underutilization (Baudoin *et al.*, 2016). Similarly, Lugen *et al.* (2019) have found that farmers who did not actively participate in the implementation process showed low access. While CS are disseminated through media, and to facilitate their use and uptake, national extension services provide technical advice in most countries (FAO, 2019), WMO (2019) has highlighted besides limited access to extension services, the inadequate interaction with the farming community as a major difficulty faced by NMHs. These are mostly attributed to the limited technical facilities and a lack of trained human resources, which are major problems undermining the capacity of most countries (Mahon *et al.*, 2019).

Furthermore, much is at stake in the knowledge systems regarding CS for DRM. For instance, translating technical information into more digestible information has appeared crucial to implementing CS. A Chinese case is the Rich Notifications Architecture (RNA), designed to break down complex data for governmental disaster response, enhancing the implementation of CS. The RNA has enhanced the availability and accessibility of information by breaking down complex procedures to develop alert notifications, which have been proven reliable (Chan & Tsai, 2023). Practically, this approach is similar to the Participatory Integrated Climate

Service for Agriculture (PICSA) (Dayamba *et al.*, 2018). Applied in agriculture, the authors have touted this technique as a catalyst for early action in farming decision-making and innovation among farmers. Various key elements enhanced this condition as identified by Dayamba *et al.* (2018) namely, the essential steps of the PICSA are completed before the beginning of the rainy season, and most importantly, the final step takes place at the end of the season to document successes, challenges, lessons, and discussions of the way forward with farmers and implementers. This allows a feedback loop for decision-makers, implementers, and users, which is assumed to facilitate future interventions. The importance of CS being recognized to tackle climate risks has appeared crucial to advancing the science of CS and its efficiency in solving societal needs (Street *et al.*, 2019).

Furthermore, Dumas *et al.* (2021) have demonstrated the implementation of CS through Action Research. Based on the co-construction mechanism, the approach considered managing the involvement and participation of all stakeholders in the CS implies organizing them through a governing body, even if they belong to the same organization or structure (Dumas *et al.*, 2021). Designed for implementing CS projects, this approach, which involves a co-construction mechanism, has been proven reproducible in other contexts, according to the authors. In similar cases, through a co-production of a story map on CS, Vollstedt *et al.* (2021) confirmed the potential of raising users' awareness and addressing their needs in the implementation process. Likewise, it has shown positive outcomes by improving uptake Chiputwa *et al.* (2020) and increasing the value of crops produced by between 10 and 25 % for farmers with access to a Multidisciplinary Working Group, which represents a coordinated platform of stakeholders to co-produce and disseminate CS. Conversely, some studies have evidenced that co-production is not a silver bullet for CS implementation for decision-making. Sánchez-García *et al.* (2022), in the case of Mediterranean Climate Outlook Forum (MedCOF) projects, argued that common issues remained the communication of forecast uncertainty and skill for efficiently informing decision-making in practice, despite designing the projects through a co-production process and approach.

Another challenge remains to demonstrate the predictions' economic, social, and environmental value. In the same perspective, Hermans *et al.* (2022), exploring the integration of local and scientific knowledge in EWS for DRR, have discovered a dichotomy in framing local and scientific knowledge in EWS for DRR with a focus on people or technology. According to the authors, current implementation processes often overlook the importance of social interaction and power relations. This standpoint concurs with that of Soares and Buontempo (2019), who argued about the challenges of the misemphasis on the co-production of CS, which focuses on its normative facets, but in practical implementation, there are disparities between what it means and the methodology to apply it. Beyond this debate, Grossi and Dinku (2022) presented a concrete framework for co-production in four steps: Generation, Translation, Transfer, and Use, which involves a two-way, iterative, and collaborative process of knowledge construction between those who generate climate information and its users. According to the authors, once these steps are effectively met, the implementation of CS is meant to meet the desired usefulness. A practical implementation of this approach was demonstrated by Daniels *et al.* (2019), dubbed the Tandem Framework, designed to enhance the implementation of CS projects through a holistic approach engaging users of CS as full design partners, collaborating with providers and intermediaries.

These studies reflect the emergence of co-production as a turning point in CS implementation and its increasing use in designing CS projects. Thus, for effective last-mile dissemination of CS, particularly in the context of West Africa, Tarchiani *et al.* (2018) have discussed the need to enhance information and communication technologies to bridge the gap of CS for smallholder farmers. The Intergovernmental Panel on Climate Change (IPCC) has highlighted last-mile communication as essential for delivering usable, demand-driven CS, especially to smallholder farmers and rural communities (IPCC, 2022). According to WMO (2018b), effective CS require clear communication strategies to ensure information reaches the "last mile," emphasizing accessibility and usability at the community level. This analogy aptly describes the last steps between presenting scientific evidence of climate change to decision-makers for use in local adaptation and planning (Celliers *et al.*, 2021). In this regard, CS should effectively reach vulnerable groups in a timely and understandable way (UNDRR, 2021b). However, Obstacles often include mismatched formats or complexities in data presentation, which limits the practical use of climate information (Meadow *et al.*, 2015). The absence of effective communication can lead to the conveyance of misinformation or a lack of information, resulting in the underutilization of investments in CS (Cegnar *et al.*, 2023). As a consequence, this situation reduces the salience, legitimacy, credibility, and accessibility to provided CS.

In contrast, successful practices exist, particularly in Africa, utilizing Information and Communications Technology (ICTs) such as radio, television, voicemail, and mobile phone SMS (Davis *et al.*, 2014). This success is largely attributed to the level of interaction and collaboration between CS producers and end-users. In a recent study, Tarchiani *et al.* (2020) investigated the role of co-production in disseminating EWS for flood management. The authors demonstrated the possibility of connecting the available technical capabilities with local skills through a participatory approach to produce and disseminate flood early warnings. This approach operates capacity and calibrates them locally through risk thresholds, field observations, and potential impacts using flood scenarios. This involved a co-development strategy between experts and users and has been proven efficient in dealing with extreme flood events (De Filippis *et al.*, 2022).

4.5. Policy Recommendations

The absence of public funding is critically acute in the implementation of CS and the uptake of projects implemented by donors. At the upstream of the decision-making process, there should be an institutionalized budget line for the implementation of CS, ensuring that at the sectoral level, funding reaches ministries and decentralized institutions within their mandate.

The current National WON is flagged as insufficient, sometimes containing deficient equipment. Policy-makers must densify and renovate the WONs that do not exist and install new stations, particularly the latest model of automatic weather stations, across the country.

EWS: Develop Software-based (e.g., android application) EWS for Flood alerts. This approach would be more effective as communities are accustomed to such interfaces. For instance, design the web platform EWS and uploaded it on Google Play for free. Leverage Artificial Intelligence (AI) to ensure the software is interactive and includes local languages such as Hausa and Zarma. Most importantly, it would be much more effective to develop mobile-based applications for warnings and alerts, given the widespread use of smartphones among the population.

Decision-makers should ensure the content is disseminated in local languages concerning Flood SMS Alerts. When using French, the alert should use understandable, non-technical words to enable the community to understand the information. Overall, the SMS Alert should be more precise and geographically targeted to specifically inform the community at risk. This would enhance the credibility and trust in the information dissemination.

Regarding alerts and warnings disseminated through social media (Facebook and X), CS providers need to certify their institutional Profile, which will ensure their page is boosted to reach the maximum audience online. In fact, the institutional profiles of national CS providers are not currently certified on these social media platforms.

There is a need to shift from the current way of CS production to impact-based EWS, which should include all relevant information on exposure and vulnerability to enable actionable and effective public and community responses to climate risks.

The literature has highlighted the effectiveness of the co-production approach. In this regard, this approach should be at the heart of the production, dissemination, and evaluation of CS. Furthermore, there is a critical need to develop robust metrics, including qualitative and quantitative approaches, which will enable the assessment of the actual impacts of CS implementation, particularly at sectoral levels.

4.6. Conclusion

This chapter analyzed the prevailing gaps impeding the development of CS and their implementation for DRM decision-making.

Findings revealed several critical gaps that undermine the effective implementation of CS for DRM decision-making. Indeed, Niger relies heavily on external funding for CS implementation. The analysis also revealed an acute reliance on international donors, as the state-led funding mechanisms are minimal. This external funding model creates delays and limits sustainability, and geographic coverage of CS projects and programs. Political instability, including the recent coup d'état, further exacerbates these challenges, potentially affecting financial flow and regional cooperation on CS funding.

The weather observation network (WON), critical for CS production, is flagged as limited. The network is sparse, access to data is often challenging, particularly in areas affected by insecurity, and some infrastructures are outdated. Furthermore, the maintenance and operational capacity of newly installed equipment, which is mainly funded through short-term projects, is uncertain. This is compounded by a human resource capacity gap in some areas crucial for CS production.

Furthermore, the institutional framework for CS and DRM appeared fragmented, with overlapping mandates across various ministries and agencies. This fragmentation leads to institutional rivalries and limited CS implementation and effective coordination.

There is a gap between science and policy in the CS implementation. While CS providers and experts often produce valuable climate information, there are situations in which decision-makers do not act upon. For example, forecasts and simulations related to the 2020 floods in Niamey were available but not acted upon by decision-makers.

Another critical issue remains the project-driven approach to CS implementation. Indeed, in most cases, once external funding ends, there is a lack of state-led mechanisms to ensure the continuity of CS projects, which leads to their discontinuation, undermining long-term effectiveness.

GENERAL CONCLUSION

General Conclusion

5.1. Introduction

Niger is among the most vulnerable countries highly impacted by extreme climate events such as drought, flood, and food insecurity. Thus, over the years, as part of the national adaptation policies, CS has gained an increasing interest. While these events are projected to amplify in the coming years, the management is still subject to various challenges. At the same time, the constant occurrence and rising impacts of climate-induced disasters question the existing institutions and CS capacity implemented to enhance preparedness and management. As the literature on CS is growing in Niger, there is an increasing scholarly interest to improve the understanding of various aspects related to this domain.

This present dissertation is a valuable contribution to empirically improve the understanding of the institutional lens of CS for DRM in Niger. The study attempted to address important issues related to the decision-making processes of CS for DRM, particularly the implementation of CS. The research objectives were to (i) review policy-oriented priority areas of CS for DRM; (ii) to map institutions and Climate Services capacity for Disaster Risks Management Decision-making; (iii) to examine gaps impeding the development and implementation of Climate services for Disaster Risks Management Decision-making. To achieve the three research objectives, three research questions were formulated:

Specific Research Question 1: What are the main policy-oriented priority areas in climate services for disaster risks management?

Specific Research Question 2: How is the status quo of institutions and climate services capacity for disaster risks management?

Specific Research Question 3: What gaps impede the development of climate services and their implementation for disaster risk management decision-making?

To address the research questions, firstly, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach was adopted. Through comprehensive research across five online databases including Google Scholar, ScienceDirect, JSTOR, Research4life, Taylor

& Francis, and snowball research through ResearchRabbit was conducted. A total of 242 studies were included in the review after the screening process based on which the analysis was drawn.

Secondly, a qualitative research approach was adopted, which allowed to collect 47 policy documents, 19 key informants' interviews at the surveyed institutions located in Niamey, and 1 participant observation during the Regional Seasonal Outlook in 2023. The data were analyzed based on institutional mapping and analysis, as well as qualitative document analysis. Thirdly, in the same vein, 47 policy documents were collected, combined with 19 in-depth key informant interviews, and 1 participant observation complemented with the case study of the 2020 flooding in Niamey by conducting 75 semi-structured interviews at the community's levels. (Kirkissoye, Lamordé, Nogaré, Kombo, and Zarmagandey). The qualitative thematic/content approach was adopted to analyze the data.

This section concludes the dissertation by summarizing the key research findings reflecting the research questions and objectives, as well as discussing the theoretical and empirical contributions of the study. It also states the limitations of the study and proposes avenues for future research. The dissertation is structured around three Essays corresponding to the three research objectives.

5.2. Summary of Research Findings

Specific Research Question 1: What are the main policy-oriented priority areas in climate services for disaster risks management?

Essay one corresponding to chapter one aimed to review policy-oriented priorities areas of CS for DRM. To achieve this research objective, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach was adopted.

Based on the 242 studies included in the review, findings revealed flood, drought, and food insecurity as major climate-related disasters addressed. Major CS addressed included early warning systems, (sub)seasonal forecasts, and impact-based warnings. Grounded in the policy processes theoretical perspective, the main focus identified and discussed three prevailing policy-oriented priority areas including (i) development of climate services, (ii) use-adoption-uptake, and (iii) evaluation of climate services. In response to the limitations of the prevalent supply-driven and top-down approach to climate services promotion, co-production emerged as a cross-cutting critical aspect of the identified priority areas.

Despite the extensive research in the field, more attention is needed, particularly pronounced in the science-policy interface perspective, which in practice bridges scientific knowledge and policy decisions for effective policy processes. This perspective offers a valuable analytical lens as an entry point for further investigation, particularly on institutional issues of CS implementation. Hence, future research agendas would generate insightful evidence by scrutinizing this critical aspect given its importance to institutions and climate services capacity, to understand better intricate facets of the development and the implementation of CS for DRM.

Specific Research Question 2: How is the status quo of institutions and climate services capacity for disaster risks management?

Chapter Two examined institutions and CS capacity for DRM decision-making. A qualitative research approach was adopted, combining a review of 47 policy documents, 19 key informant interviews with stakeholders, and participant observation analyzed through institutional mapping, institutional analysis, and qualitative document analysis.

Findings revealed a multi-layered institutional framework composed of several institutions at the upstream and downstream decision-making processes. The National Framework for Climate Services (NFCS) and the Regional Climate Outlook Forum (RCOF) emerged as main science-policy interfaces, bridging CS producers and decision-makers. The institutional layering encompasses NDM, ACMAD, AGHRYMET, and NBA, mainly providing CS in several formats and levels ranging from daily forecast, seasonal forecast, alerts to EWS such as FANFAR, SLAPIS, SAICU-GTN, SATH-NBA, GDACS. Concerning the implementation of CS for DRM, the GDCP and MHA/DRR coordinate the dissemination process for floods as a sudden-onset disaster, while the NMPMFC, through the EWS/CU, coordinates the implementation for droughts as a slow-onset disaster, including food insecurity.

Although there is a notable process in the establishment of institutions and CS capacity, the overall trend of floods and droughts occurrence and their impacts remains upward, which may suggest challenges in the processes.

Based on these insights, the chapter recommends enhancing institutional coordination, expanding EWS coverage, and enhancing mechanisms to integrate CS into DRM decision-making processes.

Specific Research Question 3: What gaps impede the development of climate services and their implementation for disaster risk management decision-making?

Chapter three examined the gaps impeding the development and implementation of CS for DRM decision-making in Niger. Grounded in the policy process, science-policy, and actor-oriented interface perspectives, the study adopted a qualitative methodology that included 19 in-depth interviews, 75 semi-structured interviews, and a review of 47 policy documents.

From the policy process perspective, the implementation of CS appeared to be primarily driven by an external agenda-setting approach focused on projects, resulting in several ramifications. The primary issue is the funding gap, marked by acute dependence on external funding and the lack of state-led funding mechanisms. These gaps affect the sustainability of CS interventions, the limited geographical scope, and the lack of takeover. The infrastructural gap depicted a deficiency in equipment capacity, particularly regarding the weather observation network, which affects the production of CS due to its sparsity and difficult access in areas affected by armed conflicts. From the actor-oriented perspective, results highlighted gaps between CS providers and beneficiaries, which are shaped and influenced by several interface encounters. These gaps included inadequate last-mile communication, CS format, and limited accessibility.

Limited public funding is critical for the implementation of CS and the uptake of projects implemented by donors. This study recommends establishing a sustainable public funding mechanism for CS implementation. Leverage Technological advancement to implement impact-based EWS for effective risks management.

5.3. Theoretical and Empirical Contributions

As an essential component of qualitative research design, the theoretical framework aims to connect the topic under investigation to the relevant existing theories (Adom et al., 2018). Grant and Osanloo (2014) defined the theoretical framework as a blueprint for the entire inquiry, which serves as the guide upon which researchers build and support their study, outlining their approach to the research. Hence, the choice of a theory provides an explanatory framework that underlies the analysis of the problem being investigated and the analysis of findings (Grant & Osanloo, 2014; Merriam, 2009a).

The theoretical framework adopted in this dissertation is grounded in three interconnected theories: the policy process, the science-policy interface, and the actor-oriented interface perspective.

The theory of policy process provides insights into the mechanisms that underpin the decision-making processes of CS for DRM and the roles of various actors in these processes. The SPIs are considered a critical facet of bridging scientific knowledge and policy-making. It elucidates how CS are developed and integrated into disaster risk policy and decision-making and the challenges associated with this process. As an analytical framework for understanding development interventions, Norman Long's Actor-Oriented interface perspective elucidates the agency of beneficiaries and actors at different interfaces in implementing CS for DRM. The following sections discuss the theoretical underpinnings of the adopted theories and their relevance to the research.

The field of CS has historically been dominated by the supply-driven approach, which is typified by a top-down method of production and dissemination. This method appears to be consistent with the linear model of the policy process, in which policies or services are produced by experts and then transferred down for implementation. However, this approach has drawbacks, notably in terms of climate services. The top-down character of the supply-driven strategy might result in misalignment and a certain level of discrepancies between the services offered and the real needs of end-users. This imbalance presents a high likelihood of leading to underutilization of CS or slowing down the uptake process, which limits their potential to enable managing disaster risks. The co-production approach has evolved in response to these limitations and is gaining momentum in this field. Co-production entails active collaboration between service suppliers and end users throughout the process, from development to assessment.

This strategy remains, therefore, in line with the interactive model of policy implementation, which emphasizes the value of iterative learning and feedback loops. Thus, by customizing CS to end users' unique needs and settings, co-production ensures these services are more relevant and widely adopted. However, co-production is not without challenges. Indeed, it requires a significant commitment of time and resources and a change in the balance of power so that end users are more actively involved in the process.

Thus, at first glance, this emerging approach provides a theoretical pathway to understanding the interplay of different actors involved in the process and institutional layering, which have significant implications for the development of CS and their integration into DRM. From a practical perspective, co-production provides a concrete enabling environment for actors in the process to better engage and overcome barriers and discrepancies.

Chapter one of this dissertation, grounded in a policy-process theoretical perspective, has identified three main policy-oriented priority areas in the CS for DRM as summarized in the previous section. By doing so, the chapter has identified a need for further investigation in the domain, particularly from a science-policy interface perspective. To shed more light from a theoretical perspective, we adopted the science-policy interface and actor-oriented perspectives in complement to the first theory. This has allowed an insightful discussion of research findings connected to these theories.

From the policy process perspective, three major critical policy-oriented areas were identified, including the development of CS, use-uptake-adoption of CS, and evaluation of CS (Gaoh et al., 2024). These are also marked by the emergence of the co-production approach, which characterized a paradigm shift from a supply-driven approach to a more interactive model of CS promotion.

From a theoretical and practical perspective, much attention is needed to the science-policy interface perspective. The realm considered a critical cog of the wheel in implementing climate services was overlooked throughout the dedicated literature.

Climate services have become an area of interest among experts and scholars in Niger, as it is evidenced by abounding literature on various facets of this field. The analysis of the dedicated literature confirmed a focus on two significant aspects, including the assessment of the needs and the effectiveness of CS, particularly on use-uptake-adoption among users. This focus is much more pronounced in agriculture, which is the most exposed and vulnerable to climate-induced disasters. The focus is on seasonal climate forecasts and short-term forecasts and advisories for farming decision-making, with an increasing interest in EWS.

The current study attempted to fill these gaps by investigating climate services for disaster risk management in Niger from a science-policy interface perspective. Furthermore, an actor-oriented interface perspective complements a science-policy interface perspective, which is all part of the policy process. By doing so, the research focused on various facets of the subject, including the institutional and climate services capacity and significant gaps impeding the effective development of CS and their integration into disaster risk management decision-making in Niger. This investigation supports the view that from the gaps in the literature, understanding the facets of climate services for DRM would greatly benefit from a combination of the policy process, science-policy interface, and actor-oriented perspective. This is also demonstrated in the conceptual framework operationalizing the variables and concepts.

Practically, this dissertation has contributed to the understanding of the emerging realm of CS in Niger. Indeed, chapter two explored the current institutional landscape and CS capacity for DRM. It highlighted policies that frame the decision-making process of CS implementation, institutional mechanisms for CS production and dissemination, particularly in the context of flood and drought, and the current status quo of CS capacity for DRM. The analysis grounded in the policies and stakeholders' consultations depicted relative progress in the establishment of institutions and CS. However, the status quo is clouded by the constant occurrence of climate-induced disasters and various challenges in their management as in the case of the 2020 flooding. As demonstrated in the chapter, there are trends of occurrence of climate-induced disasters as well as their impacts on the rise, a situation that questions the effectiveness of the effort implemented to face extreme events.

This dissertation has also contributed to the understanding of the gaps that significantly undermine the effective development of CS and those at the implementation level in DRM decision-making.

Disaster risk governance remains a cross-cutting issue across the main climate-sensitive areas, namely water, energy, food, and health, amid the current climatic conditions in Niger. For decades, Niger has suffered from climate-associated disasters, which continue to pose serious challenges for both government and population. As they become inevitable, prediction, prevention, and preparedness become critical to ensure a cost-effective approach to climate risk governance. In this vein, developing sound, timely, and tailored climate services at all scales and effectively integrating them into disaster risk management strategy should be at the heart of the country's climate risk governance. However, many issues still underpin the effectiveness of the implementation of climate services for disaster risk management concerning institutions, actors, and capacity, as well as the development of climate services and their integration to support disaster risk governance.

In this context of disaster risk reduction, climate services have become a central element and critical for decision-makers and the population in their continuous effort to address the challenges posed by climate-related disasters. In Niger, one of the most significant current discussions in this field concerns the strengthening of institutions' capacity, infrastructures, and human resources to provide relevant and timely information. In addition, in recent years there has been increasing interest in discussions regarding the capacity of beneficiaries for the widespread utilization of CS. The contribution of the current study lies in its potential to improve understanding of institutions and climate services capacity, as well as prevailing gaps impeding the effective development of climate for disaster risk management decision-making in Niger. This interest stems from the conclusion that climate-induced disasters continue to claim victims despite increasing efforts deployed, and various problems persist when it comes to management. This endeavor aims at an institutional assessment of climate services for disaster risk management decision-making in Niger. The findings generated from this study would be a great asset to policy and decision-makers in ensuring sound disaster risk governance, for founders to be aware of the climate services priorities areas for future investments and interventions, for both to be UpToDate on the prevailing gaps to fill to ensure effective development and integration of climate services into disaster risk management decision-making in Niger.

5.4. Limitations of the Study

A typical shared idea among scholars, especially social scientists, is that in scientific inquiry, the field (natural study setting) commands. The researcher plays a central role in the process.

Despite planning the process, many external factors have impacted the course of the events. Indeed, the primary factor is the availability of participants at the institutional level. The administrative procedure has made access quite challenging, though a letter of authorization is submitted for each request for an interview. When a request is submitted, one to two weeks of waiting should be observed to receive feedback, in some cases, one month. There was an instance where the request letter was misplaced, necessitating a resubmission to the administration.

Another major factor that affected the course of the fieldwork was undoubtedly the political instability in Niger. Indeed, the aftermath of the coup d'état has made the situation very tense in the country. Most of the public administration and institutions were affected due to the appointment of the military government. Some participants with whom the interview was already scheduled have been removed from their offices.

To overcome this problem, agreements were made with informants to proceed with the interviews, as their dismissal was not anticipated to impact the data collection. Furthermore, some informants have not allowed to record the interview because they were afraid of being disclosed in the context of the coup d'etat. This issue has compelled to rely solely on field notes.

5.5. Avenue for Future Research

The field of CS is emerging in Niger. Over the past years, many studies have been conducted to shed light on various issues in the field, particularly regarding the socioeconomic impacts of their adoption among smallholder farmers.

While this dissertation has contributed to understanding the field through institutional assessment of CS for DRM in Niger by shedding light on several facets including the institutional mechanisms, CS capacity, and the implementation of CS for DRM decision-making, there remain other aspects that need further investigation.

Another avenue could be a longitudinal study that may investigate the effect of the implementation of CS into DRM at the national scale over a long-term period. Researchers could also endeavor to investigate the implications of political instability on the country's ability to implement its nationally determined contribution through a comprehensive approach.

The roles of the private sector are also another area to further understand their contribution to the field.

Furthermore, while this dissertation improved the understanding of issues under investigation through its research objectives by adopting a qualitative approach, including institutional mapping and analysis and thematic analysis, future studies could improve by crafting a new quantitative methodological approach that would allow for a deeper understanding of the capacity of CS.

It is widely acknowledged that extreme climate events, such as droughts and floods, can be caused by various factors, including natural ones, those linked to climate change, and those driven by human activities. Hence, it is crucial to investigate the attribution of extreme events from perspectives other than the failure of CS implementation.

Scholars can also focus on quantifying the rate of reception in urban and rural areas, including the gender aspect of CS, particularly concerning EWS and SMS alerts.

There is also interest in investigating the factors that contribute to the success or failure of public policies related to CS and DRM.

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APPENDICES

Appendices

Appendix 1: Legal Frameworks

Legal Framework
Loi N°2017-06 du 31 mars 2017, déterminant les principes fondamentaux de l'organisation de la protection civile ;
Loi N°2017-20 du 12 avril 2017 fixant les principes fondamentaux de l'urbanisme et de l'aménagement urbain ;
Loi 2018-74 du 10 décembre 2018 relative à la protection et à l'assistance aux personnes déplacées internes au Niger
Décret 2018-538 du 27 Juillet 2018, définissant le code d'alerte nationale
Arrête N°000970/MISP//AT/SG/COVACC du 8 Novembre 2023, Portant organisation, fonctionnement, mission du Centre Opérationnel de Veille d`Alerte et de Conduite des Crises
Decret N°2017-876/PRN/MISP/ACR/MAH/GC du 10 Novembre 2017, déterminant les conditions d'élaboration des plans d'organisation des secours (ORSEC)
Arrete N°0016/MAH/GC/SG, du 14 Septembre 2017, portant création, attribution, composition et fonctionnement d`une Cellule de Crise pour la Gestion des Inondations
Décret N°96-004/PM du 09 janvier 1996, portant création, composition et attribution du Conseil National de l'Environnement pour un Développement Durable (CNEDD)
Arrêté N°003/PM du 10 janvier 1996, portant modalités de fonctionnement du Secrétariat Exécutif du CNEDD
Arrêté N°037/SE/CNEDD/PM du 5 août 1996, déterminant les attributions et l'organisation du SE/CNEDD.
Arrêté N°054 /PM /CNEDD du 21 juillet 97 portant création de la commission technique sur les changements et variabilités climatiques (CNCVC)

Arrêté N°0016/MAH/GG/SG du 14 septembre 2017 portant création, attribution, composition et fonctionnement d'une Cellule de Crise pour la gestion des inondations

Arrêté N°607/MISP/D/ACR/SG/DGPC du 01 septembre 2017 portant missions organisation et fonctionnement du Centre Opérationnel de Veille d'Alerte et de Conduite des Crises COVACC.

Decret N°2016-384/PRN/MAH/GC du 22 juillet 2016, portant organisation du Ministere de l'Action Humanitaire et de la Gestion des Catastrophes

Arrêté N°210/PM du 29 décembre 2016 portant réorganisation du Dispositif National de Prévention et de Gestion des Crises Alimentaires (DNPGCA)

Arrêté conjoint N°00619 MISPD/ACR/MC du 24 juin 2019 fixant la liste des services de radiodiffusion sonore et de télévision chargés de diffuser les messages d'alerte et les modalités de diffusion

Arrêté conjoint N°00879 MISPD/ACR/MT/MHA/MAH/GC/MC/MSP/ME/U/DD du 16 septembre 2019, définissant le code couleur caractérisant l'information sur l'état de vigilance

Arrêté N°0012 ter/MAH/GC/SG du 12 Octobre 2019 portant création, attributions, composition et fonctionnement du Comité National de Collecte de données et de Gestion des Informations sur les Personnes Déplacées Internes au Niger

Appendix 2: Policy Documents Collected

Official Documentation	Type
Arrêté Création du Cadre National pour les Services Climatiques (CNSC) 8 Mai 2017	Arrêté
Loi déterminant les principes fondamentaux de l`organisation de la protection civile	Loi
Arrêté n° 70/PM du 3 septembre 2002, portant création attributions, organisation et fonctionnement de la Cellule de Coordination du Système d'Alerte Precoce (CC/SAP)	Arrêté
Projet de Politique Nationale de l'Action Humanitaire et de La Gestion des Catastrophes	Politique
Arrêté Portant Création, Missions, Organisation et Fonctionnement du Cadre National pour les Services Climatiques (CNSC)	Arête
Cohérence des politiques de réduction des risques de catastrophe et d'adaptation au changement climatique	Rapport
Contribution Déterminée au Niveau National (NDC1)	Politique
Contribution Déterminée au Niveau National (NDC 2)	Politique
Document de Programmation Pluriannuelle des Dépenses MAHGC - 2023-2025	Programme
Elaboration de la Stratégie Nationale de Reduction des Risques de Catastrophes au Niger : Proposition d'une stratégie Nationale de Réduction des Risques de catastrophes au Niger (SNRRC)	Stratégie
Elaboration de la Stratégie Nationale de Reduction des Risques de Catastrophes Naturelles 2013	Stratégie
Emerging priorities for climate services in Niger	Rapport
Evaluation des besoins Technologies d'Adaptation aux Changements Climatiques pour les secteurs de l'Agriculture et des Ressources en Eau (2020)	Rapport
Informations Nationales sur La Prevention et La Gestion des Catastrophes au Niger	Rapport
Le Plan d'Action National de Lutte Contre la Désertification/ Gestion des Ressources Naturelles avril 2000 (PAN- LCD/GRN)	
Loi Organisation Protection Civile Niger 2017	Stratégie
Mécanismes Institutionnels Et Cadres de Reduction des Risques de Catastrophes Niger	Politique
Plan d'Action Cadre National des Services Climatiques 2016	Plan

Official Documentation	Type
NIGER-Plan-d-Action-National-RRC- 2015-2018	Plan
Rapport d`Evaluation des Capacités en RRC 2016	Rapport
Plan d'Action National De Renforcement Des Capacités Pour La Reduction Des Risques De Catastrophe, La Préparation et la Réponse aux Urgences	Plan
Plan de Développement Economique et Social PDES I	Plan
Plan de Développement Economique et Social PDES II	Plan
Plan de Développement Economique et Social PDES III	Plan
Niger Plan d'Action Cadre National des Services Climatiques (2016)	Plan de mise en Ouvre
Plan National de Contingence Multi Risque Niger (PNC_MR)	Plan
Plan Triennal de Contingence Inondations 2023-2025	Plan
Plan National d'Adaptation Changement Climatique 2022	Plan
Politique Nationale Gestion des Risques de Catastrophes 2018	Politique
Rapport D'évaluation Des Capacités Nationales Pour La Reduction Des Risques De Catastrophes Au Niger	Rapport
Stratégie et Plan National d'Adaptation face aux changements climatiques dans le secteur Agricole SPN2A 2020-2035	Stratégie
Stratégie nationale d'adaptation face aux changements climatiques dans le secteur agricole (SPN2A-2035)	Plan d`Action 2022-2026
Système d`Alerte Precoce et de Gestion des Catastrophes SAP/GC	Rapport
Système Locale d'Alerte Precoce contre les Inondations de la Sirba SLAPIS : Evaluation Année hydrologique 2020 et améliorations 2021	Rapport Technique
Plan National Contingence 2013	Plan/Stratégie
Programmation Pluriannuelle des Dépenses MAHGC (2023-2025)	Programmation
Situation De Reference Des Systèmes Communautaires D'alerte Precoce et Des Réponses Aux Urgences Au Niveau Des 7 Communes D'intervention Du Projet ABC	Rapport
Niger_1ere Communication Nationale sur le Changement Climatique	Politique
Niger_2e Communication Nationale sur le Changement Climatique	Politique
Niger_3e Communication Nationale sur le Changement Climatique	Politique
Niger_4e Communication Nationale sur le Changement Climatique	Politique
Development of Metrics to Assess National Meteorological Services in Africa	Rapport
Plan_action_2021-2025_initiative Les Nigériens Nourrissent les Nigériens	Politique
Initiative (3N) Les Nigériens Nourrissent les Nigériens : Bilan consolide 2011-2015	Rapport
Emerging priorities for climate services in Niger	Rapport
Cadre Stratégique de l`Initiative (3N) Pour la sécurité alimentaire et nutritionnelle et le développement agricole durable : Les Nigériens Nourrissent les Nigériens	Politique
SLAPIS : Système d'Alerte Précoce contre les Inondations de la Sirba	Rapport
Stratégie de Prevention et de Gestion des Crises Alimentaires 2021-2025 du DNPGCA	Politique

Appendix 3: Individual Interview Protocol

Date:

Time:

Neighborhood: Kombo ☐ Nogaré ☐ Lamordé ☐ Kirkissoye ☐ Zarmagandey ☐

Name of the interviewer:

Name of the interviewee:

Age:

Gender: Male ☐ Female ☐

Marital status: Single ☐ Married ☐ Divorced ☐ Widow/Widower ☐

Occupation: Student ☐ Civil servant ☐ (Specify position): Trader ☐ (Specify type): Other (Specify):

Property lost or destroyed during the 2020 flood:

Level of education: Uneducated ☐ Quranic ☐ Literate ☐ Primary ☐ Secondary ☐ University ☐

General Questions

1. Do you own a mobile phone? Yes ☐ No ☐

- If yes, is it an Android? ☐ or Basic phone? ☐

2. Do you have permanent internet access on your mobile phone? Yes ☐ No ☐

3. Do you have a Facebook account? Yes ☐ No ☐

- If yes, do you follow the Niger Meteorology Facebook page? Yes ☐ No ☐
- If yes, what is your perception of the information shared?
- If no, what is your perception of the information?

4. Do you have a Twitter account? Yes ☐ No ☐

- If yes, do you follow the Niger Meteorology Twitter page? Yes ☐ No ☐
- If yes, what is your perception of the information shared?
- If no, what is your perception of the information?

5. Do you follow the Facebook page of ACMAD (African Center for Meteorological Applications for Development)? Yes ☐ No ☐ - If yes, why? - If no, why?

6. Do you follow ACMAD's Twitter account? Yes ☐ No ☐

- If yes, what is your perception of the information shared?
- If no, what is your perception of the information?

7. Do you rely on a close one to help you understand the climate information shared? Yes ☐ No ☐

8. Do you own a television? Yes ☐ No ☐

9. Do you follow the weather segment broadcasted before the news on ORTN? Yes ☐ No ☐

- If yes, what is your perception of the information shared?
- If no, what is your perception of the information?
- How frequently (e.g., during the rainy season) do you follow the weather segment broadcasted on ORTN?

10. Do you understand the information shared by Niger Meteorology? Yes ☐ No ☐

- Please elaborate:

11. Do you receive flood alerts on your phone? Yes ☐ No ☐

- Did you receive the alert in 2020 before the flood? Yes ☐ No ☐

- Please elaborate (Perception, observation, which telephone company):

12. Do you understand the content of the alerts shared or received? Yes ☐ No ☐ - Please elaborate:

13. Do you rely on a close one to explain the content to you? Yes ☐ No ☐ - Please elaborate:

Situation of the 2020 Flood

1. During the 2020 floods, did you receive alerts on your phone? Yes ☐ No ☐

2. What decision did you make after receiving the alert, knowing that you live in a flood-prone area?

- What were the reasons for this decision?

3. How did you react after the flood occurred? Did you stay at your place of residence, work, or business?

4. What do you think about the weather information broadcasted on ORTN?

5. What do you think about the alerts sent to mobile phones?

6. Do you think this information was broadcasted in time to allow you to make a decision (e.g., to stay or leave your residence or business)?

7. Do you think the format of the information is sufficient to allow timely decision-making?

8. If you received information and alerts about the flood, did they help you mitigate the damage or loss of property?

9. Do you think the climate information and alerts have shortcomings? In what sense?

10. In your opinion, are the communication methods used appropriate for timely decision-making?

11. Do you understand the climate alerts and information broadcasted?

12. Are you aware of or do you have access to the Early Warning System for Floods (SLAPIS)? Yes ☐ No ☐

- If yes, was it helpful during the 2020 floods? - If no, why?

13. Are you aware of or do you have access to the Early Warning System for Floods (SATH-ABN) from the Niger Basin Authority? Yes ☐ No ☐ - If yes, was it helpful during the 2020 floods? - If no, why?

14. Are you aware of or do you have access to the FANFAR Flood Early Warning System? Yes ☐ No ☐

- If yes, was it helpful during the 2020 floods? - If no, why?

15. Are you aware of or do you have access to the Global Disaster Alert and Coordination System (GDACS)? Yes ☐ No ☐ - If yes, was it helpful during the 2020 floods? - If no, why?

16. Were you warned by authorities (e.g., Meteorology or Civil Protection) about the impending flood in 2020?

17. Would you have preferred to be informed by the authorities about the flood situation in 2020?

18. Are you aware of the existence of a flood alert and management mechanism?

19. Were you rescued by the authorities during the 2020 floods?

20. What type of information would you have preferred to make decisions during the flood event?

Appendix 4: Key Informant Interview Protocol

Date:

Time:

Institution:

1. What are the major roles of your institution/department/division? regarding:

- Production of climate and meteorological information,
- Communication of climate and meteorological information
- Application of climate and meteorological information.

Based on the mentioned roles,

- Does your institution /department/division possess the appropriate number of staff with the required expertise/training to fulfill the prescribed roles?
- Please explain your response.
- If NO, how do you address the problem of staffing?
- Are the budgetary resources concomitant to fulfill the roles?
- If NO, explain how do you accomplish the prescribed roles given the limited resources?
- Does your institution receive funding from Niger Government?

2. How do you communicate climate and meteorological information to the users? How effective/reliable are the communication pathways that you use?

3. What gaps/ shortfalls/ challenges have you observed in producing climate services for decision-making?

4. What gaps/ shortfalls/ challenges have you observed in the integration of climate services into decision-making?

5. How your institution/department/division collaborates with other sector/institutions that have a stake in climate change, locally, regionally, nationally and internationally.

6. Who are the partners with complementing, conflicting or overlapping roles? And what are the areas of collaboration?

***CLIMATE SERVICES FOR DISASTER RISKS MANAGEMENT:**

7. What is the current capacity in terms of climate services for disaster risk management?

8. Does the institution participate in the implementation and monitoring of the Sendai Framework?

9. What are the current capacity needs of the institutions regarding climate services for disaster risks management in Niger?

10. Do the mandates of national, regional and local institutions cover all aspects of DRM, in accordance with the Sendai Framework?

11. Do the mandates of national, regional and local institutions cover all aspects of DRM, in accordance with the Global Framework for climate services?

12. Which aspects of DRM does your institution cover at national, regional and local level in Niger?

13. Can you list the projects or programs implemented during the last five years in the domain of climate services for disaster risks management in Niger?

Appendix 5: Participant Observation

Participant Observation			
Institution/Event	**Activity**	**Date**	
Regional Climate Outlook Forum (RCOF) 2023	**Group Work** Climatology	24-25 Apr-2023	**AGHRYMET** Regional Climate

Agro-Meteorology	24-25 Apr-2023	Centre for West Africa and Sahel
Hydrology	24-25 Apr-2023	
Discussions with Experts	26-Apr-23	Mahatma Gandhi Conference Center
Participation in Plenary Sessions		
Outlook Restitution	27-Apr-23	Palais de Congres

Appendix 6: Institutions Surveyed and Participants

Institutions	Respondents
National Directorate of Meteorology (NDM)	2
Directorate General of Civil Protection (DGPC)	2
Ministry of Humanitarian Action and Disaster Risk Management (MAH/GC)	2
Coordination Unite of Early Warning System (CC/SAP/DGNCA)	1
Ministry of Hydraulic and Sanitation (MH/A)	2
Niger Basin Authority (NBA)	1
Network of Niger's Chambers of Agriculture (RECA)	1
Regional Climate Centre for West Africa and Sahel AGHRYMET CC-AOS	2
The African Centre of Meteorological Applications for Development (ACMAD)	1
University (University Abdou Moumouni UAM)	2
National Council of Environment for Sustainable Development (CNEDD)	1
Municipalities (Niamey 5 and 1)	2
Total	**19**

Appendix 7: Implemented and Ongoing CS Projects/Programs

Project/Program	Implementation	Funding Institution
Climate Services for Increased Resilience in the Sahel (CSIRS)	2018	USAID & NRC
Agriculture Meteorology (METAGRI)	2008-2011	WMO & AEMET
National Action Program for Adaptation to Climate Change (PANA Resilience)	2009-2013	UNDP
(NAPA) Resilience Agriculture Sector Project	2009-2019	UNDP
Prevention/Management of Natural Disaster Management Project	2009-2020	World Bank
Community Action Program (PAC) I, II	2010-2014	World Bank, IDA, IFAD, GEF, State
Strategic Program for Resilience to Climate Change (PSCR)	2011-2019	World Bank
The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)	2011-2020	CGIAR
Community Action Project for Climate Resilience (PACRC)	2012-2021	World Bank
Community-Based Disaster Risk Reduction	2012-2016	World Bank, EU, GFDRR
Climate change adaptation, disaster prevention and agricultural development for food security (ANADIA I)	2013-2015	Italian Agency for Development Cooperation

Project/Program	Implementation	Funding Institution
Climate Resilience Pilot Program (PPCR)	2013-2021	African Development Bank Group
Disaster Risk Management and Urban Development Project (PGRD-CU)	2013-2022	World Bank
Climate Information Development and Forecasting Project (PDIPC)	2014-2018	African Development Bank Group (AfDB)
Community-based Adaptation Project	2014-2019	UNDP
Projet de Gestion Intégrée de la Sécheresse en Afrique de l'Ouest (PROGISAO)	2015-2017	WMO & Global Water Partnership
Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED)	2015-2018	UK Department for International Development (DFID)
Project to support climate-sensitive agriculture (PASEC)	2016-2022	World Bank, State & Millennium Challenge Corporation (MCC)
Climate change adaptation, disaster prevention and agricultural development for food security (ANADIA II)	2017-2021	Italian Agency for Development Cooperation
Early Warning Services Modernization (CREWS)	2017-2021	WMO, UNDRR, World Bank
Climate Resilience Support Project for Sustainable Agricultural Development (PARC-DAD)	2018-2020	European Union (EU)
Initiative the Nigeriens Nourish Nigeriens (I3N)	2012-2024	State & Donors (UNDP) &
Planning and Financing Adaptation in Niger Project (FSP)	2019-Ongoing	Global Environment Facility (GEF)
Designing and Implementing Climate Services for Climate Change Adaptation	2020-Ongoing	World Food Program (WFP)
Intra-ACP Climate Services and Related Applications project (ClimSA)	2021-Ongoing	European Union (EU)
Climate-Smart Agriculture (FSP)	2023-Ongoing	World Bank
Integrated Program for Development and Adaptation to Climate Change (PIDACC)	2024-Ongoing	African Development Bank Group (AfDB)

Project/Program	Implementation	Funding Institution
Strengthening the resilience of small farmers through Climate Smart Agriculture (PRP-AIC) techniques in Tahoua Region	2024-Ongoing	Global Environment Facility (GEF)
West Africa Food System Resilience Program (FSRP)	2021-Ongoing	World Bank
The Satellite and Weather Information for Disaster Resilience in Africa (SAWIDRA) project	2020-Ongoing	African Development Bank (AfDB) & African Development Fund
SERVIR West Africa Project	2022-Ongoing	NASA & USAID

Appendix 8: NDM CS Provision, Frequency, and Dissemination Channel

Climate Services Provider	Climate Services Provided	Description	Frequency	Dissemination Channel
National Direction of Meteorology (NDM)	Special Weather Bulletin	Detailed forecasts and warnings of extreme weather conditions, such as dust storms that can disrupt daily life and present public health and safety risks	Monthly	Website, SMS, WhatsApp, Email, TV, Radio, Facebook, Twitter (X)
	Weather briefing bulletin	Weather forecasts valid for the next six hours, providing a detailed analysis of the observed weather situation, monitoring forecasts for the morning until midday, on cloud cover, airborne dust, winds and temperatures.	6 hours	Website, Facebook, Twitter (X)
	Decadal Agrohydrometeorological Bulletin	Information on the rainfall, agro-meteorological and hydrological situation, as well as on crops, livestock and agricultural and livestock markets.	10 days	Website, WhatsApp, Email
	Weekly Weather bulletin	Detailed six-day forecasts of weather trends across the country, including information on monsoon penetration, rainstorm activity, and the position of the Intertropical Front (ITF).	6 days	Website, WhatsApp, Email

Climate Services Provider	Climate Services Provided	Description	Frequency	Dissemination Channel
	Daily Weather Forecast	Weather information on: the general situation and a trend for the next 24 hours. (1) The general situation describes current weather conditions, such as the presence of airborne dust and cloud cover, and forecasts maximum temperatures. (2) The trend for the next 24 hours anticipates future weather changes, such as stronger winds or improved visibility.	Daily	Website, Email, WhatsApp, TV, Radio, Facebook, Twitter(X)
	Monthly Climate Bulletin	Information on climatic indicators such as precipitation, wind, temperature, sunshine, humidity, evaporation and ITD fluctuations	Monthly	Website, WhatsApp, Email
	Seasonal Weather Forecasts	Forecasts on the situation of the agricultural season, on rainfall and water availability for crops, Onset and end dates of the season.	Yearly	
	Special Bulletin for Decision-makers	Information on: (1) the detailed situation regarding the start of the crop year, including information on successful sowings, necessary reseeding and the phytosanitary situation. (2) forecasts of expected crop yields, particularly for millet. These bulletins incorporate rainfall data compared with the 1981-2010 normal and are essential for guiding agricultural and economic strategies, and optimizing decision-making for efficient resource management and food security.	Twice a year	Website, SMS, WhatsApp, Email, TV, Radio, Facebook, Twitter (X)
	Website	Interactive Web Platform of Climate Services	Available	Online

Appendix 9: Policy Instruments, Formulation and Goals

Policy Instrument/Strategy	Formulation/Adoption	Policy Goal
Intended Nationally Determined Contribution (INDC 1)	2015	Determine the national action plan and efforts to reduce Greenhouse Gas emissions and adaptation strategies (Period 2015-2020)
Nationally Determined Contribution (NDC 2) Updated	2021	Determine the national action plan and efforts to reduce Greenhouse Gas emissions and adaptation strategies (Period 2021-2030)
National Communication on Climate Change 1	1990	Establish the National climate change situation (Vulnerability, Adaptation, Gaps, and Needs)
National Communication on Climate Change 2	2000	Establish the National climate change situation (Vulnerability, Adaptation, Gaps, and Needs)
National Communication on Climate Change 3	2008	Establish the National climate change situation (Vulnerability, Adaptation, Gaps, and Needs)
National Communication on Climate Change 4	2014	Establish the National climate change situation (Vulnerability, Adaptation, Gaps, and Needs)
Plan of the Implementation of the National Framework for Climate Services	2016	Enhance the production and Dissemination of reliable climate services for climate-informed decision-making for effective CCA and DRM.
Flood Contingency Plan	2022	Early Anticipatory Actions to contribute to anticipating and protecting affected and exposed populations
Policy for Humanitarian and Disaster Risk Management	2020	Promote a framework for preventing and alleviating the suffering of populations at risk before, during, and after the occurrence of a disaster, and meet the needs of disaster-stricken and risk-exposed populations in the short, medium, and long term by strengthening their resilience.
National Strategy for Disaster Risk Reduction	2021	Determine operational strategies to substantially reduce disaster-related losses and damage to strengthen the resilience of populations and socio-economic infrastructures.
National Climate Change Policy	2012	Defining a global, multi-sectoral framework for strategies and policies to combat climate change and achieve sustainable development. Coordinate public initiatives in this field and contribute to the country’s sustainable development by reducing the negative impacts of climate change.
National Action Program to Combat Desertification and Natural Resources Management	2015	Coordinate public initiatives in this field to reduce the negative impacts of climate change and contribute to the country’s sustainable development.
National Adaptation Plan for the Agricultural Sector	2023	Integrating adaptation to the effects of climate change into the planning and implementation of agricultural sector development in Niger
National Environmental Plan for Sustainable Development (PNEDD)	1998	Define Niger’s environmental and sustainable development policy.

Policy Instrument/Strategy	Formulation/Adoption	Policy Goal
3N Initiative “Nigeriens Nourrissent les Nigériens” for Sustainable Food Security and Agricultural Development	2012	Improving populations’ resilience to climate change, crises, and disasters. Climate-smart agriculture approach
National Strategy and Action Plan on Climate Change and Variability (SNPACVC)	2014	To improve the adaptation responses and resilience of communities and socio-economic sectors vulnerable to climate change, to improve the mitigation of GHG emissions, and to strengthen the capacities of all stakeholders.

Appendix 10: Studies Batch 5 Risk of Bias

Study	D1	D2	D3	D4	Overall
Liu et al. 2021	+	+	+	-	+
Msemo et al. 2021	+	+	+	-	+
Newth et al. 2021	+	+	+	-	+
Paparrizos et al. 2021	+	+	+	+	+
Rahaman et al. 2021	+	+	-	-	+
Simm et al. 2021	+	+	+	X	+
Swart et al. 2021	+	+	-	-	+
Vollstedt et al. 2021	+	+	+	+	+
Zuccaro et al. 2021	+	+	+	-	+
Gure 2021	+	+	+	+	+
Hansen et al. 2021	+	+	+	+	+
List et al. 2021	+	+	+	+	+
Salamanca et al. 2021	+	+	+	+	+
Twigg 2021	+	+	+	+	+
Watkiss et al. 2021a	+	+	-	-	-
Watkiss et al. 2021b	+	+	-	-	-
Dash et al. 2022	+	+	-	X	-
Šakić Trogrlić et al. 2022	+	+	+	+	+
Street 2022	+	-	-	X	-
Awolala et al. 2022	+	+	+	-	+
De Filippis et al. 2022	+	+	-	X	-
Dinku et al. 2022	+	+	-	X	-
Dione et al. 2022	+	+	+	+	+
Gudoshava et al. 2022	+	+	+	+	+
Kim et al. 2022	+	+	+	+	+
Lala et al. 2022	+	+	-	-	-
Maripe et al. 2022	+	+	+	-	+
Mason et al. 2022	+	+	+	+	+
Mwangi et al. 2022	+	+	+	+	+
Nobert et al. 2022	+	+	+	+	+
Nyadzi et al. 2022	+	+	+	+	+
Rigby et al. 2022	+	+	+	+	+
Streefkerk et al. 2022	+	+	+	-	+
Visman et al. 2022	+	+	+	+	+
Yu et al. 2022	+	+	+	+	+
Barlis et al. 2022	+	+	+	+	+
Soksophors et al. 2022	+	+	+	+	+
Awolala et al. 2023	+	+	+	-	+
Guimarães et al. 2023	+	+	-	-	-
Lempert et al. 2023	X	-	-	X	-
Seydou et al. 2023	+	+	+	-	+
Twahirwa et al. 2023	+	+	+	+	+
Vanuytrecht et al. 2023	+	+	+	+	+

Risk of bias

D1: Study eligibility criteria
D2: Identification and selection of studies
D3: Data collection and study appraisal
D4: Synthesis and findings

Judgement
X Some concerns
- Moderate
+ Low