ASSESSMENT OF INLAND FLOOD EARLY WARNING IN CAMEROON

WFP Cameroon, July 2024

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INTRODUCTION

In June 2023, the World Food Programme (WFP) undertook a critical initiative in Cameroon, executing a comprehensive assessment to identify the technical and institutional needs and gaps within the disaster risk reduction and management frameworks. This effort, inspired by the United Nations International Strategy for Disaster Reduction (UNISDR), now rebranded as the United Nations Office for Disaster Risk Reduction (UNDRR), advocates for people-centric early warning systems aimed at elevating the nation's capacity to anticipate, respond to, and mitigate the devastating impacts of climate-induced disasters. The assessment was strategically framed around the four foundational elements of a people-centric early warning system, emphasizing the significance of inclusivity and accessibility in disaster preparedness and response mechanisms (Figure 1).

The findings from this in-depth analysis underscored profound challenges in areas critical to effective disaster management, including risk knowledge, monitoring and warning services, as well as the dissemination and communication of crucial information. It became evident that Cameroon faced significant hurdles in ensuring that communities, especially those most vulnerable to climate shocks, have the resources and knowledge necessary to act decisively in the face of impending disasters.

The objectives of this assessment were twofold: to map out the existing capacities and deficiencies within Cameroon's disaster risk management ecosystem and to lay the groundwork for enhanced, people-centered early warning and response frameworks. Through this endeavor, WFP aspires to bolster the resilience of Cameroon against the adverse effects of climate change, guiding the nation towards a future where every citizen is equipped with the knowledge and tools necessary for disaster preparedness and response. This initiative marks a significant step forward in Cameroon's journey towards achieving sustainable development and climate resilience, aligning with global efforts to minimize the human and material costs of natural disasters.

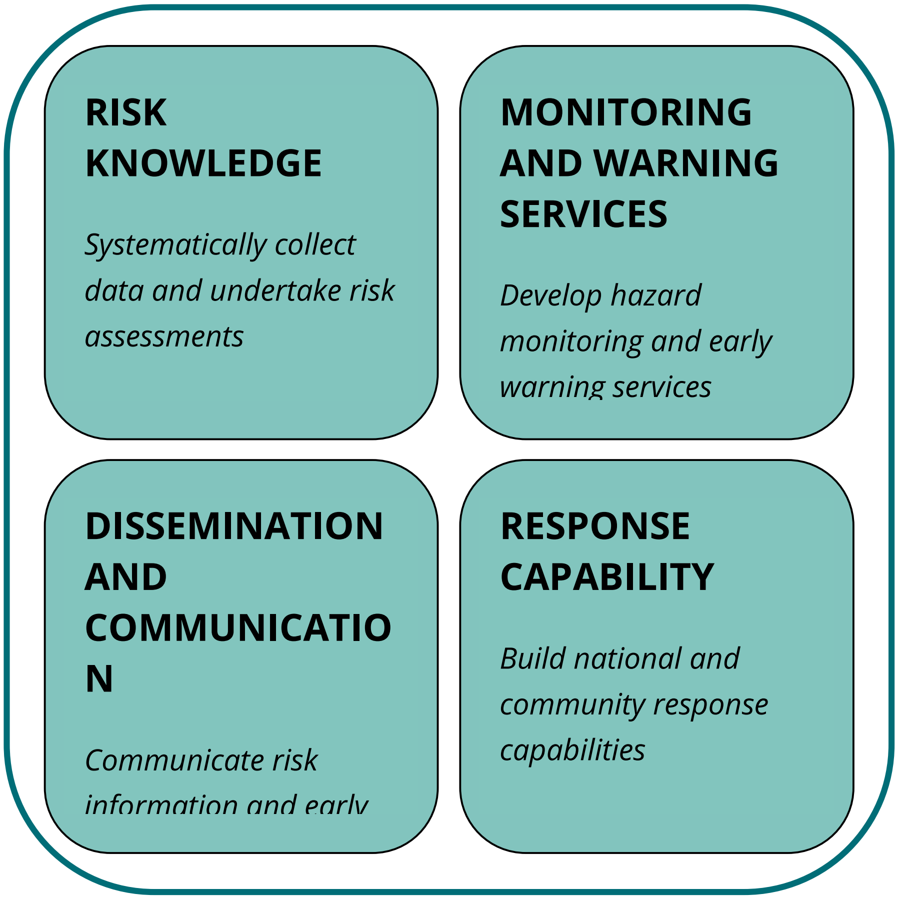
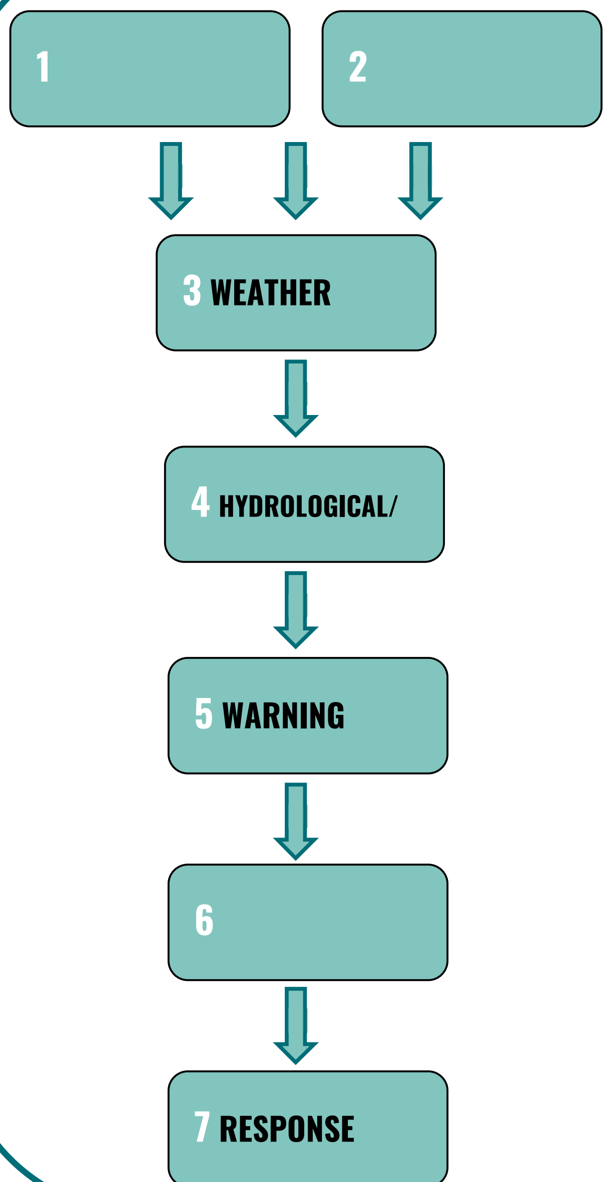


Figure 1: Four elements of people-centered early warning systems.

The analysis of the technical and institutional capacities of Cameroon's flood EWS was analyzed through the framework of a people-centered early warning system, and further divided into seven interconnected components (Figure 2). The assessment consists of two sections:

- **Section 1**: This section aims to provide an understanding of the primary flood disaster risks and the prevailing response mechanisms nationwide, discussions were held with stakeholders at both national and community levels.
- **Section 2**: This segment offers a deeper analysis of the anecdotal data collected through stakeholder interviews and the institutional and policy framework governing key flood EWS institutions. The analysis process was structured around the seven interconnected components of the community-centered EWS, as illustrated (Figure 2). Main sources of information for this evaluation were interviews conducted with essential stakeholders at both national and provincial levels. In addition, the section thoroughly explores a SWOT analysis, which identifies the strengths, weaknesses, opportunities, and threats associated with the key organizations involved in the EWS activities.



The operational flood EWS starts with the collection of meteorological (1) and hydrological (2) observations, which are crucial for making accurate weather (3) and hydrologic/hydraulic forecasts (4).

Based on these forecasts, warning messages (5) are generated following specific operational procedures.

The warnings are then communicated (6) to the relevant target audiences.

Upon receiving the

Figure 2: Key seven elements of a comprehensive people-centered flood EWS.

Section 1: AN OVERVIEW OF EXISTING FLOOD EARLY WARNING SYSTEM IN CAMEROON

1.1 SECTION SUMMARY

Section 1 outlines the insights collected from discussions with key stakeholders, at the central level, in Yaoundé and during the exploratory mission in the Far North region, Diamaré and Mayo-Danay divisions, including villages of Maroua, Yagoua, and Gueme. This section evaluates the knowledge, capacity, and perspectives of national and local entities, including provincial administrations, civil society groups, and community members at the commune levels. It is important to note that some anecdotal inputs from interviewees may be outdated or inaccurate, and there are instances where accounts from different respondents are contradictory. The goal of this section is to compile the insights from these interactions without attempting to verify the facts..

The primary sources of information for this section are interviews conducted with key stakeholders at both national and provincial levels. The interview framework was modeled on the UNDRR checklist for the development of EWS. The semistructured interviews designed to cover a broad range of issues, organized around the four principal themes identified in the UNDRR checklist, namely:

- Risk knowledge,
- Monitoring and forecasting,
- Communication and dissemination,
- Response capacity.

1.2 INTERVIEWS WITH STAKEHOLDERS: THE NATIONAL DISASTER RISKS AND EXISTING RESPONSE CAPACITY IN CAMEROON

This section reports the main issues related to flood EWS based on a series of interviews and discussions with the main stakeholders:

- Ministry of Transport (MINT): Department of National Meteorology (DMN);
- Ministry of Environment, Nature Protection and Sustainable Development (MINEPDED): National Observatory on Climate Change (ONACC) and Sub-Department Environmental Sensitization and Education;
- Ministry of Agriculture and Rural Development (MINADER): Directorate Agricultural Development and Directorate of Agricultural Surveys and Statistics;
- Ministry of Scientific Research and Innovation (MINRESI): Research Center for Water and Climate Change (CRECC) and National Institute of Cartography;

- Ministry of Energy and Water (MINEE): Directorate of Water Resource Mobilization and Directorate of Management of Water Resources. .
- Ministry of Territorial Administration (MINAT): Department of Civil Protection in Yaounde, Maroua, Yagoua, and National Risk Observatory.
- Local leaders in Gueme.

The International Partners, including the development agencies and international financial institutions:

- AFD, USAID, GIZ, World Bank, and AfDB.

The national organizations:

- Red Cross Cameroon in Yaounde (HQ) and Yagoua, Red Cross France, and Premiere Urgence Internationale (PUI).

The UN agencies:

- FAO, UNDP, and OCHA.

1.2.1 Hazard risk knowledge

Natural disasters, such as floods, droughts, landslides, volcanic activity, and epidemics, have always been a part of life for people living in Cameroon (Figure 3). Disasters impact everyone, making it crucial for legislators, planners, strategists, and communities to collaborate on strengthening resilience to enhance community welfare and safety. Floods, in particular, have been the most frequent and impactful natural disaster, consistently affecting large numbers of people over the years.[1] Since 2010, frequent and severe flood events, along with occasional droughts, highlight the significant impact of climate change on the frequency, intensity, and occurrence of disasters. This poses a substantial risk to the most vulnerable populations, emphasizing the necessity for robust disaster management and response systems.

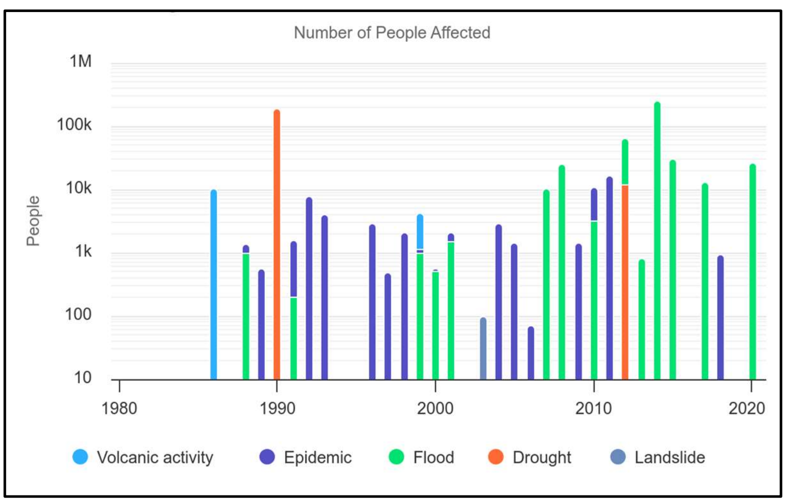


Figure 3: Key Natural Statistics Hazard over Cameroon for 1980 - 2020

[1] World Bank Climate Change Knowledge Portal. "Key Natural Hazard Statistics for 1980-2020." Accessed April 1, 2024. https://climateknowledgeportal.worldbank.org/country/cameroon/vulnerability

This assessment focuses on two distinct types of inland flooding events: pluvial and fluvial floods. Both types of floods pose significant risks to communities, infrastructure, and the environment, but they differ in their origins and have unique characteristics. Pluvial floods occur when extreme rainfall (intense rainstorms, prolonged periods of rain, or sudden downpours) overwhelms the capacity of drainage systems or the ground's ability to absorb water, leading to surface water accumulation and affecting both urban and rural areas. Conversely, fluvial floods, also known as river floods, occur when rivers overflow their banks due to excessive rainfall. These floods primarily affect areas along rivers, streams, and other waterways, resulting from prolonged or intense rainfall that causes rivers and streams to swell beyond their capacities. The extent and impact of fluvial floods can vary depending on the size of the river, the geography of the area, and the existing flood defenses.

1.2.2 Hazard monitoring and forecasting

Hazard monitoring and forecasting in Cameroon involves multiple governmental departments and specialized agencies, each playing a unique role in addressing the country's vulnerability to various environmental and climatic risks. Each main stakeholder operates its own system for monitoring and data management. Comprehensive forecasting capabilities are exclusively held by the Department of National Meteorology (DMN) for meteorological predictions, while no hydrological or flood forecasting capacities are operational. Here is an overview of how these entities contribute to hazard management and forecasting:

The DMN is pivotal in both risk knowledge and meteorological monitoring and forecasting. It maintains a comprehensive archive of historical weather data and hazard patterns, crucial for understanding regional risk profiles and for planning responses to similar future events. DMN oversees a network of 58 synoptic stations across diverse landscapes, from coastal plains to rainforests and mountains, enabling effective dissemination of meteorological information.

The National Observatory on Climate Change (ONACC) focuses on the development and dissemination of climate data to understand the potential risks associated with climate change and to formulate contingency plans for catastrophic events. ONACC plays a critical role in developing climate indicators and analyses for flood risk forecasting based on the mathematical models, but the limited data record hinders the reliability and accuracy of such forecasts.

The Department of Civil Protection (DPC) has no direct role in risk knowledge, while the National Risk Observatory (ONR) acts as the central authority for collecting, analyzing, and disseminating information on natural, health, and anthropogenic risks. ONR's validation of forecasts produced by technical authorities against historical observations plays a crucial role in refining the accuracy and relevance of predictive models to local conditions and leads to issuance of alert for the decision makers if in the comparison with historic conditions the forecasted conditions are deemed anomalous and a threat to the population.

The Water and Climate Change Research Center (CRECC), although not currently active in risk knowledge, oversees an extensive network of 65 hydrological stations and is responsible for monitoring and forecasting hydrological conditions. Like the DMN, CRECC faces technological limitations and is not able to model or produce hydrological forecasts. The need for a robust climate information system that combines satellite, station, and model data for comprehensive and localized forecasting of hydrological conditions is a pressing requirement.

1.2.3 Early warning dissemination and communication

Specific roles in effectively alerting the public and relevant authorities about potential hazards are crucial for preparedness and timely responses to mitigate the impacts of natural disasters.

The Department of National Meteorology (DMN) plays a pivotal role in the dissemination of meteorological warnings. It issues a variety of bulletins and alerts, including daily and seasonal forecasts and specialized bulletins tailored for different sectors and major urban centers. These bulletins are made available in several languages to ensure broad accessibility. DMN's collaboration with urban and local radio stations and partnerships with telecommunications companies such as MTN enhances the direct reach of warnings to end-users. Adherence to the Common Alert Protocol ensures that the information provided is standardized and actionable. Despite these efforts, there are challenges in the current dissemination process, such as multiple friction points that could benefit from automation and optimization through a more sophisticated climate information system.

The National Observatory on Climate Change (ONACC) provides timely and regular bulletins through various dissemination channels (social media, urban and local radios, mobile application - ONACC Alert, etc.) that are used in the decision-making process by the National Risk Observatory (ONR). However, it has been shown that the bulletins produced from mathematical models have biases, while the DMN bulletins are used as a validation reference.

The National Risk Observatory (ONR), in conjunction with the Department of Civil Protection (DPC), manages the issuance of bulletins targeted at decentralized administrative authorities such as division officers, sub-division officers, and governors. The DPC is integral to the communication strategy, ensuring that early warnings reach all stakeholders, including administrative authorities and Disaster Risk Management (DRM) committees. It coordinates the flow of information among DRM actors, engages with the media, and develops communication strategies to maintain consistent messaging during emergencies. Moreover, the DPC oversees the activation of alert systems and the dissemination of crucial information through administrative channels and community surveillance systems.

The Water and Climate Change Research Center (CRECC) currently does not have the capacity to disseminate hydrological bulletins and alerts, paralleling the DMN's role but focusing on hydrological hazards. Unlike the DMN, CRECC is currently noncompliant with Common Alert Protocols to ensure standardization and actionability of the information. The current system primarily validates hazards that have already commenced, which restricts proactive measures. Implementing a climate information system that can simulate changes in water levels, produce bulletins about impending hazards, and effectively disseminate alerts could significantly enhance CRECC's ability to inform and mobilize stakeholders in advance of potential crises.

1.2.4 Response capacity

At the community level

At the community level, as well as at the national level, operational early warning systems do not exist, and the early warning protocol tends to be reactive, activating only as events unfold. The reliance on manual observations and informal local communications for early warnings, rather than automated, scientifically validated methods, limits the ability to make accurate and early predictions. While the DMN forecasts do reach local decision-makers, the reliability of these forecasts is still not high enough to justify utilizing the limited operating budget for preventative measures such as setting up evacuation tents. Additionally, there have been instances of vandalism and theft when locations are not secured, necessitating the payment of security guards.

In flood-prone regions like Yagoua, community-level responses to disasters present a mix of strategies and challenges that underscore the complex nature of disaster risk management. Villagers can only take action when they are aware of impending danger. Traditionally, once the water reaches a certain level, a bell is rung a specific number of times. Past attempts to relocate populations from flooded zones have been unsuccessful primarily for cultural reasons, as the remains of ancestors are located where the affected people have been living, and because the water is considered by many as a ‘stranger that brings benefits and leaves.’

Section 2: AN ANALYSIS OF THE EVIDENCE FROM THE LITERATURE REVIEW AND INTERVIEWS

2.1 SECTION SUMMARY

The examination of established procedures and frameworks for the monitoring, forecasting, and dissemination of warnings for inland flooding, was carried out in a sequential manner. Initially, an assessment was made using a set of criteria based on the resilience-checker approach developed under the FREEMAN – Flood Resilience Enhancement and Management (2011) – project and the UNDRR checklist (UNISDR, 2006), focusing on a comprehensive evaluation of selected indicators.[2,3] This evaluation encompassed a review of relevant stakeholder interviews, legal institutional framework, and the expert judgment. Subsequently, a Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis was performed on the principal institutions involved in the flood EWS in Cameroon. The scoring of EWS indicators, combined with an organizational SWOT analysis, enables the identification of the gaps.

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[2] United Nations International Strategy for Disaster Reduction (UNISDR). (2006). Checklist for the Establishment of Early Warning Systems. Retrieved from https://www.unisdr.org/2006/ppew/info-resources/ewc3/checklist/English.pdf

[3] Uyttendaele, G., van der Craats, I., Schelfaut, K., Krywkow, J., & Mysiak, J. (2011). FREEMAN- Flood Resilience Enhancement and Management: a pilot study in Flanders, Germany, and Italy. CRUE Funding Initiative on Flood Resilience.

2.2 AN ANALYSIS OF EXISTING PROTOCOLS/MECHANISMS FOR MONITORING, FORECASTING AND DISSEMINATION OF WARNINGS FOR INLAND FLOODING

2.2.1 Methodology

In this section, the current status of flood EWS in Cameroon is scrutinized, underscoring their pivotal role in enhancing the resilience of communities to flood hazards. This analysis is anchored in the resilience-checker methodology developed under the FREEMAN project in 2011, which evaluates the resilience of a community against flood-related risks. This approach segments resilience into three distinct dimensions: **(i) tools for managing floods, (ii) institutional frameworks dealing with floods, and (iii) the flood risk perception and communication**. To conduct a thorough assessment across these dimensions, a series of indicators and variables were selected leveraging the UNDRR checklist from 2006. The assessment process utilized a structured, phased approach:

1. The initial step involved an in-depth exploration of the contextual background, as outlined in the previous section of this document.
2. The subsequent step defined the scope of the system under review.
3. The final step established a set of criteria and indicators for evaluation.

In conducting a comprehensive assessment of community flood resilience, several dimensions are defined, such as institutional organization, flood-risk management tools, and the community awareness and perception.

For the purpose of this assessment, analysis was focused on flood EWS, identifying seven critical criteria domains for evaluation. These domains are components of the flood EWS (referenced in Figure 2), include:

- Risk knowledge
- Monitoring: meteorology
- Monitoring: hydrology or streamflow
- Forecasting: meteorology
- Forecasting: floods
- Dissemination and communication
- Response capabilities

A set of indicators for each domain was crafted, drawing inspiration from the UNDRR's checklist for developing EWS (UNISDR 2006b) and further refined through expert judgment based on the field experience.

Indicator scoring involved expert judgment due to stakeholders' limited familiarity with and understanding of flood EWS. Stakeholders' responses were often insufficient for drawing definitive conclusions, leading to a reduction in the number of indicators per domain. Expert assessments, informed by the stakeholder interviews conducted during field visits as encapsulated in Section 1, culminated in the scoring of indicators using a predefined scale outlined in Table 1.

SCORES	VALUE
Not existing	0
Poor	1
Fair	2
Good	3
Excellent	4

Table 1: Scoring of indicators

The following sections list the indicators with a statement on the relevance, the score and a short justification.

2.2.2 Flood risk profile

INDICATOR 1.1: Natural hazards are well documented, historical data is evaluated and mapped, and key characteristics are analyzed.

Sub-indicators relevant to flood EWS: Several types of floods could occur in a catchment, each with its own impact, maximum water level, recurrence and flood extent. Information on all these floods could be obtained from analysis of historical flood events, from modeling, or from expert judgment. This information is important for the design of a flood EWS and can be used to illustrate warnings or messages to the public. Awareness and knowledge of the natural hazards and risks is the first step towards better resilience.

Score: Fair

Comment: Flood risk in the country is not fully mapped. Only three (Far North, North, and Ademawa) out of ten regions have flood risk maps and this information is within DPC. Within emergency planning, the ORSEC plans, there is limited information on historic natural hazards as it only mentions the year when hazard occurred, but not the month of catastrophe or information on the impact, such as damages, loss of life or destroyed crops. Out of 58 divisions, only 21 have ORSEC plans, out which only five are up-to-date while 16 are outdated. Meteorological hazards have been mapped by DMN only for the period 2018-2023. Nevertheless, the information on natural hazards is not systematically recorded to include all the key characteristics. DPC has been developing an application called CRYSIS to systematically collect information on future hazards but the application is not yet operational.

INDICATOR 1.2: Vulnerability and flood risk have been assessed and mapped.
Sub-indicators relevant to flood EWS: In order to develop measures against flood risk, it will be necessary to assess and map the vulnerability. Vulnerability is a function of exposure and resilience.
Score: Poor
Comment: Mapping of vulnerability is mostly conducted after the emergency response during the assessment of the impact. But there is no good understanding on the extent to which people, infrastructure, and other assets are exposed to natural hazards and what is their capacity to cope with, resist and recover from the impact of natural hazards. Out of 21 developed ORSEC plans, many have not been updated for a long time, with the latest update occuring in 2019. The National Cartography Institute can contribute with more precise mapping of the vulnerability.

INDICATOR 1.3: Impact of land-use (changes) or ecosystem degradation are well documented and understood.
Sub-indicators relevant to flood EWS: As part of the flood risk and vulnerability assessment, present and future land-use functions play a central role. Spatial planning and flood risk zoning is considered a major non-structural flood risk measure.
Score: Poor
Comment: The key flood early warning agencies do not have information on the impact of the land-use change and land degradation on the ecosystem. This information is not mapped or collected. However, there is a research program in the academia, at University Yaounde 1, that evaluates the impact of degradation of the mangrove ecosystem to the flood phenomena and involves about fifty students. The Ministry of Agriculture and Rural Development through its network of agronomists collect information on the land use by the small-holder farmers to estimate the yield but this information has not been analyzed to evaluate and understand the impact.

INDICATOR 1.4: Expected impacts of climate change are known.
Sub-indicators relevant to flood EWS: The present situation relating to flood hazards and vulnerability may change in the near future due to the effects of climate change.
Score: Poor
Comment: Based on stakeholder feedback, some climate change modeling has been conducted by ONACC, but not at a significant level to contribute to policy development and planning. The National Adaptation Plan of Cameroon lacks a thorough evaluation of the climate change impact that would quantify potential damage. While the overall climate change trends in temperature and precipitation have been determined by global models, these have not been downscaled to inform decision-making at a decentralized level. There are isolated instances of development agencies conducting such studies, such as the French Development Agency (Agence Française de Développement - AFD), particularly in relation to the impact of climate change on specific value chains. However, hydrological climate change projections have not yet been conducted.

INDICATOR 1.5: People who live in flood-prone areas are aware of the risks.
Sub-indicators relevant to flood EWS: All measures start with improving awareness about flood risks among local communities and stakeholders. To address the problem in a community-based manner, a common perception and understanding is needed.
Score: Good

Comment: The population is aware of flood risks due to various programs, projects, and initiatives, both domestic and international, as almost all regions of Cameroon may face flood disasters. Nevertheless, people living in rural areas perceive flood risk somewhat differently from those living in urban areas. During a field visit to Yagoua, in the Logone et Chari sub-division, cultural, age, and educational attributes were identified as potential factors influencing the inclination of rural communities to refuse relocation from flood-prone areas. For some, it is their bond with ancestry that keeps them at home; for younger people, it may be the risk of not finding income-generating opportunities; while for others, it may be the limited level of education that prevents them from understanding the threat to life posed by flood hazards, as it contrasts with their indigenous knowledge. For example, in one project, the Emergency Flood Control Project (*Projet d'Urgence de Lutte contre les Inondations - PULCI*), populations living in some flood-prone zones were relocated, but nearly half of the inhabitants returned to their old homes, with many vandalizing the new homes and taking parts back to their old homes.

2.2.3 Hazard monitoring and early warning services

2.2.3.1 Monitoring: meteorology (precipitation)

INDICATOR 2.1: Meteorological data availability: time series.

Sub-indicators relevant to flood EWS: Historical time series of meteorological data are essential for risk assessment and for calibration of hydrological models.

Score: Poor

Comment: The quality of the historic record is not clear, but most of the stations currently operational have been installed in the last ten years. DMN collects data from 58 synoptic stations out of which 6 are automated and installed in 2022, and 26 were automated and now manual and installed in 2013/2014. Data is mainly stored in Excel. Records of some stations go back to 1947. Two synoptic stations were installed in the last few years and are accessible by ONACC and provided by a Canadian NGO CUSO International.

INDICATOR 2.2: Meteorological data availability: density of network.

Sub-indicators relevant to flood EWS: The WMO recommends that the spacing between surface land stations should not exceed 250 km and 300 km in sparsely populated regions. In Cameroon, the heterogeneity of the climate demands an even denser network in the interests of a reliable flood EWS.

Score: Poor

Comment: The 58 stations operated by DMN are not sufficient to observe the localized events as well as to perform flood forecasting which requires higher station density throughout the catchment area. As per WMO's calculation and advice, for the surface area of Cameroon of 475,442 km^2, DMN needs to have a minimum of 94 stations. It is an underestimation given the convective character of rainfall in the country with rainfall predominantly highly localized and intense. Satellite- and reanalysis-derived rainfall estimates have been shown to have low skill with correlation coefficients of 0.36 for MSWEP-ng, 0.2 for PERSIANN-CCS, 0.17 for ERA5, 0.14 for CHIRPto name a few.

INDICATOR 2.3: Meteorological data availability: frequency.

Sub-indicators relevant to flood EWS: For early warning of flash floods, rainfall should be reported at least hourly. For other types of inland flooding, daily data is required.

Score: Poor

Comment: DMN collects manual and automatic meteorological data. The data from 52 manual synoptic stations is collected every hour from Monday to Friday between 7h00 and 19h00, while the six (6) automatic observations are collected in real-time on the DMN server. In case of extreme events, observers will be available and responsive throughout the day, night, work day or weekend, but normally DMN does not have night time personal coverage.

INDICATOR 2.4: Quality and maintenance of network.

Sub-indicators relevant to flood EWS: Regular maintenance of observing stations is crucial to ensure adequate reliability and quality.

Score: Poor

Comment: Maintenance is challenging due to limited availability of personnel, spare parts, financial resources for local transport and rehabilitation of stations.

INDICATOR 2.5: Publishing of weather monitoring data.

Sub-indicators relevant to flood EWS: Publication of weather monitoring data encourages third parties, including private companies, to make maximum use of meteorological observations. Publication of data also indicates an effective infrastructure for data management in the national weather services (DMN).

Score: Good

Comment: The DMN does not publicly distribute the synoptic charts from its stations, as selling this information constitutes a significant portion of its budget. Approximately a dozen stations contribute data to the international database.

2.2.3.2 Monitoring: hydrology (streamflow)

INDICATOR 2.6: Stream flow data availability: time series.

Sub-indicators relevant to flood EWS: Stream flow data is needed for model development and calibration.

Score: Poor

Comment: CRECC manitains an old hydrological network that counts 65 stations. Some time series go back to the 1930s. Between the 1990s and 2010s, there were financial challenges to maintain the stations and hence some gaps in the data records. .

INDICATOR 2.7: Stream flow data availability: density of network

Sub-indicators relevant to flood EWS: A denser network will provide more accurate results and will improve the forecasting.

Score: Poor

Comment: The station density varies from basin to basin. Some basins like Sanga have a more dense station network, while other basins have an insufficient number of hydrological stations. The exact number of stations per basin is unclear.

INDICATOR 2.8: Stream flow data availability: frequency

Relevance of indicator: A higher frequency as recording and transmitting of water levels every 10 minutes, will improve the lead time of the forecasting.

Score: Poor

Comment: Data information from the manual station is collected in the field once in three months. It is only the three stations that are close to Yaounde whose data is collected every two weeks). According to CRECC, there are in total about 12 automatic hydrological stations (three in Sangha and four in Nyong basins). The collection time for the automatic stations was unclear.

INDICATOR 2.9: Quality and maintenance of network

Relevance of indicator: Optimal functioning of the network is crucial for accurate forecasting; this is assured by using high-quality equipment and careful maintenance.

Score: Poor

Comment: Financial constraints have severely limited the maintenance capacities of CRECC.

INDICATOR 2.10: Publishing of monitoring data

Relevance of indicator: Data should be available to forecasters and other stakeholders who may benefit from access to monitoring data.

Score: Not existing

Comment: Hydrological data is not publicly available as it generates income for CRECC. Therefore, station data can only be obtained through purchase. Hydrological observations are shared with stakeholders only during impending climate catastrophes.

2.2.3.3 Forecasting: meteorology

INDICATOR 2.11: Forecast can predict events sufficiently accurate in time.

Relevance of indicator: The most relevant variable for flood-forecasting systems is the level of precipitation. The capability of forecasting high-rainfall events accurately is key to operating a functioning flood EWS.

Score: Fair

Comment: DMN forecasting unit is confident in the skill of the forecast that derives from expert judgment. In case of an extreme weather event forecasted, an alert bulletin is issued for a period not exceeding 24 hours. The weather event is then monitored using data from synoptic stations and satellite products.

INDICATOR 2.12: Forecast can predict events sufficiently accurate in place.

Relevance of indicator: The forecasts need to be accurate at the catchment scale for river flooding and at <1km scale for flash flooding.
Score: Poor
Comment: DMN does not have access to a supercomputer and does not have capacity to downscale the forecast to a few kilometer resolution using a regional weather model. It conducts visual analysis of forecasts from public weather forecast websites based on models, such as ECMWF IFS, GFS, and ICON.

INDICATOR 2.13: Lead-time forecast.
Relevance of indicator: The longer the lead time, the more time for preparation, but also the greater the uncertainty in the prediction. The World Meteorological Organization recommends that "a forecast must be made, even if the confidence is low", and that "communicating the uncertainty is vital to users".[4]
Score: Fair
Comment: The DMN issues a daily forecast valid for up to five days, but the hindcast data is not digitized and therefore not available for validation. The forecasts are issued based on expert judgment and the performance of various global models available on the platform windy.com (ICON at 13km, GFS at 22km, ECMWF at 9km). These forecasts take into account the different agro-ecological zones and seasons in Cameroon. The validation of the GFS hindcast is currently being conducted in collaboration with the IFRC; however, no validation of the DMN forecast has been conducted so far.

INDICATOR 2.14: Use of forecasts.
Relevance of indicator: Forecasts of meteorological variables can be used for flood early warning, if the forecasts have sufficient skill.
Score: Fair
Comment: Although DMN does not have a tool to visualize indices of pluvial floods (extreme rainfall), it provides forecasts of rainfall occurrence by forecasting rainfall amounts over a defined period of time. Flood early warning would require integration of rainfall intensity forecast.

2.2.3.4 Forecasting: floods

INDICATOR 2.15: Hydrological forecast
Relevance of indicator: Forecasting floods with a sufficient level of detail is the mandatory prerequisite for the successful operation of a flood EWS.
Score: Not existing
Comment: Cameroon currently does not have a flood forecasting system and lacks the necessary skilled modelers and forecasters. Effective flood forecasting relies on the operationalization of both hydrological and hydrodynamic models. Hydrological models estimate flood volumes, while

[4] WMO Guidelines on Communicating Forecast Uncertainty, WMO TD No 1422

hydrodynamic models determine inundation depths. These models require careful calibration and validation, as well as significant computational resources and expertise, making their implementation a challenging task.

INDICATOR 2.16: The hydrological forecast can predict events with sufficient location accuracy.
Score: Not existing

INDICATOR 2.17: Lead-time hydrological forecast.
Score: Not existing

INDICATOR 2.18: Use of hydrological forecasts.
Score: Not existing

2.2.4 Early warning dissemination and communication methods

INDICATOR 3.1: Warning dissemination chain enforced through government policy or legislation
Relevance of indicator: Warning messages should pass from government to emergency services and communities. Institutional arrangements or responsibilities should be clear, to avoid confusion and to make the warnings trustworthy, messages should be released by a competent authority. Functions, roles, and responsibilities of each actor in the warning and dissemination chain should be specified in legislation or government policy.
Score: Fair
Comment: The dissemination channels fall under the responsibility of administrative authorities, including the Department of Civil Protection (DPC). Alert warnings are issued by the National Risk Observatory (ONR) within the Department of Civil Protection. The National Strategy for Disaster Risk Management (*Stratégie Nationale de Gestion des Risques de Catastrophe*) has been drafted and is awaiting approval. This strategy includes provisions for various mechanisms and the dissemination of warnings. Currently, the DPC's mandate is derived from Decree No. 98/031 of March 9, 1998, which organizes emergency plans and relief efforts in the event of a disaster or major risk. However, the coordination of actors during disaster response remains challenging. The Sub-division officer holds the leadership role in guiding the response actors, but these actors often act independently and fail to adhere to the Standard Operating Procedures, indicating gaps in disaster management responsibilities.

INDICATOR 3.2: Warning services are 24/7 operational.
Relevance of indicator: Time is a critical factor in emergency response. Warning centers therefore should be operational at all times. This means skilled operators need to be present and able to

interpret technical warning information generated by forecasters, and make decisions based on information received and adequate warning protocols.

Score: Fair

Comment: Both DMN and DPC do **not** have around the clock operational centers. DPC used to have a toll free number 241 that has not been working for a couple of years. Within DPC, National Risk Observatory has a platform to receive information 24/7 but issuing the warning would not occur outside of the working hours.

INDICATOR 3.3: Adequate communication technologies are being used.

Relevance of indicator: The communication technologies need to be adapted to the context and needs of the target groups. Ideally a mix of communication technologies or channels is used.

Score: Good

Comment: Depending on the population's purchasing power, not everyone has access to a TV, radio, or phone. Alternative means of communication are used, such as mosque speakers during prayers, noise from roofing sheets, or whistles. It was not possible to verify the operational status of urban and rural radios.

INDICATOR 3.4: Communication technology reaches the entire population.

Relevance of indicator: Dissemination of warning messages depends on communication technologies (which may include traditional communication means).

Score: Poor

Comment: The main challenge remains to be coverage, as internet and mobile services are often unavailable in remote rural areas.

INDICATOR 3.5: Warning messages are clear and tailored to specific needs of target groups.

Relevance of indicator: Warning messages need to be clear and concise. Authorities such as emergency services need to have sufficient information to act appropriately. Warnings need to be geographically specific and need to include information on the nature of the threat and its impacts. Communities need to be informed in a language they can understand, and the message needs to be clear enough for them to know which actions to take. Communities should be updated and a message should be sent when the threat has abated.

Score: Poor

Comment: DMN simplifies the forecast narrative to the public to include information on the impact of the weather conditions. The warning alert from National Risk Observatory within DPC and the forecasts are translated from French to local languages and disseminated through various channels to reach the population. However, the forecast and then alert cover a broader area and it is not possible to give more targeted alert and impact information to the public.

2.2.5 Response capabilities

INDICATOR 4.1: Response options known and available.

Relevance of indicator: Sending a warning without a response option is not useful. When receiving a warning message, one should know how to act.
Score: Fair
Comment: The warning alert does not include the response options. The response is decided by the local leaders and sub-division authorities based on the ORSEC plan which is on division level. In Cameroon, there are 58 divisions and 360 sub-divisions. But only 21 ORSEC plans are developed and only 5 are up-to-date, while 16 are outdated. Further, the forecast should include information about the extent and duration of the flood event so that the stakeholders can prepare themselves in advance and make the right decision about the response option.

INDICATOR 4.2: Community hazard plans available.

Relevance of indicator: The community needs to be aware of the flood risks and the possible response options. Having hazard plans in place can significantly strengthen the response capacity.
Score: Fair
Comment: Within each division, communities define the major risks, and with respect to those risks, the contingency plan, ORSEC, is developed. If a community does not identify floods as a major risk, the contingency plan will not include a plan to respond to floods. Although there have been requests to develop more localized contingency plans on sub-division or commune level, since the 1998 decree that governs MINAT, the ORSEC plans are only at division level. The national contingency plan has not been updated since 2019 and more than two-thirds of divisions do not have a developed ORSEC plan.

INDICATOR 4.3: Community hazard drills and training.

Relevance of indicator: The community needs to become familiar with the possible response actions so that they build routine and can act swiftly to imminent disasters. By organizing flood hazard training sessions, the local community can accumulate experience and trust in possible response actions. Training will also facilitate scrutiny of specific response options and support continuous improvement through updates of hazard plans.
Score: Fair
Comment: The Red Cross trains the population how to respond by simulating the crisis situation and response, including the resettlement process with local authorities, volunteers, and resettlement site. The simulation allows for identification of the gaps and improves the response. These exercises occur in localities most vulnerable to floods, but not all divisions are trained on possible response actions.

INDICATOR 4.4: Evacuation centers, food stocks and emergency services sufficiently equipped.

Relevance of indicator: In times of disaster, it may be necessary to evacuate community members, or to distribute relief aid on a large scale. Readily available emergency stocks will help to drastically improve the response time. Emergency centers need to be sufficiently equipped to reach communities, deliver assistance, or support evacuation.

Score: Poor

Comment: While almost all divisions lack the necessary equipment for disaster response, the Logone-et-Chari division has been equipped with containers of supplies for disaster response during the Emergency Control Project against Flooding (PULCI) project. Nevertheless, the stock is limited in both quantity and diversity. For instance, there is a limited number of transportation means (motorcycles, canoes) to cover all the affected areas better. Effective equipment management has allowed for preservation of reusable equipment, as the Sub-Division Officer (SDO) maintains a log of all equipment that has been issued. However, replenishable supplies, such as first aid kits and empty bags, have not been restocked in the necessary quantities. Additional reusable equipment is also needed, including shovels, gloves, boots, water-resistant suits, and lamps attached to helmets/heads.

INDICATOR 4.5: Individual capacity of communities at risk.

Relevance of indicator: Regardless of the existence of warnings, plans and drills, communities may still take actions to increase their resilience.

Score: Good

Comment: TThe communities living in areas prone to fluvial floods have become accustomed to flooding conditions and are very reluctant to permanently resettle. They understand the warning signs and, during floods, they move to stay with families who are not affected. Afterward, they return to their homes. While the communities have adapted their way of living, it remains challenging to survive until the water recedes.

INDICATOR 4.6: Evaluation/analysis after a disaster has happened; review of plans.

Relevance of indicator: Evaluation of early warning and emergency response provides the information for reviews and updates of disaster risk management plans, protocols and procedures.

Score: Poor

Comment: Securing resources to develop the contingency plans is challenging, and updating these plans is even more difficult.

2.2.6 Cross-cutting issues - institutional context

INDICATOR 5.1: There is sufficient political commitment to a flood EWS.

Relevance of indicator: A political decision and continued support is necessary for the deployment of a functional EWS.

Score: Poor

Comment: From a policy and institutional perspective, as outlined in the National Development Strategy, National Adaptation Plan, and the draft National Disaster Risk Management Strategy, among others, flooding is recognized as one of the most impactful hazards. However, from an infrastructural and operational standpoint, there are significant limitations in hydrological observation capacities and public investments aimed at enhancing the observation network. Moreover, forecasting and modeling capacities are currently nonexistent.

INDICATOR 5.2: The mandates of key government institutions are being harmonized.

Relevance of indicator: If the whole institutional chain of actors in the flood EWS is not properly organized, and mandates, roles and responsibilities are not clearly assigned, the set up and operationalization of the flood EWS will not be possible.

Score: Poor

Comment: The organization, mandates, roles, and responsibilities of the key institutions in flood EWS are not clearly assigned for the effective operationalization of EWS. The actions by the actors overlap.

INDICATOR 5.3: The coordination of relevant institutions at national and provincial level is ensured at the operational level.

Relevance of indicator: If the whole chain in the flood EWS is not properly organized at the operational level, the flood EWS will not be efficient because coordination among relevant actors is inadequate.

Score: Poor

Comment: The operational organization of the flood EWS chain faces challenges, including constraints related to mandates, funding, knowledge, and technological capacities. Initiating and enhancing coordination and communication among key stakeholders, who currently operate in a compartmentalized manner, is essential for improving the system's effectiveness.

INDICATOR 5.4: Sufficient funding is available for EWS.

Relevance of indicator: Without funding, the development, operation and maintenance of any flood EWS will fail. Funding needs to be sustainable over the long term.

Score: Poor

Comment: Insufficient budgetary support hampers the operations and development of the flood EWS chain. The allocated resources are inadequate for essential activities such as data collection, equipment maintenance, staffing, and training at both central and local levels. This financial shortfall makes it nearly impossible to invest in critical infrastructure like new observation stations, data computing capacity, and alert system equipment. Although periodic financial support has come through projects co-funded by international partners, continuous funding is essential for long-term sustainability and effectiveness of EWS.

INDICATOR 5.5: EWS is integrated in natural resource policy (water resource management and land-use planning).

Relevance of indicator: Flood risk management is closely linked to water resource management and land-use planning. Improved water resource management at basin level and better land use planning may reduce flood risk and will improve flood-risk knowledge.

Score: Poor

Comment: There is no legislation regulating integrated water resource management and land-use management. Furthermore, the Ministry of Water and Energy, which is responsible for developing and executing water resource management policies, lacks the knowledge and technological capacities to model and simulate water use.

INDICATOR 5.6: Hydro-meteorological data management at national level is satisfactory.

Relevance of indicator: Good quality hydro-meteorological data are necessary to improve flood risk knowledge and to improve the quality of models and forecasting tools. A national agency for data management will improve both data management capacity and the quality of the tools. Government should invest in data collection and central storage. Moreover, a culture of data sharing, or open data, benefits the economy of the country.

Score: Not existing

Comment: Although flood EWS should be considered a public good with a broad and profound impact on the livelihoods and well-being of the population of Cameroon, limited financial resources have led key national agencies in the flood EWS chain to be very protective of the data they collect, sharing it only on a commercial basis. While there have been instances of one-time data sharing between agencies, no operational data sharing has occurred.

INDICATOR 5.7: Vulnerable groups are taken into account.

Relevance of indicator: In developing EWS, different vulnerabilities among different groups must be recognized. These vary according to culture, gender or other characteristics that may influence their capacity to prepare for, prevent and respond to disasters. In any community, vulnerable people – children, the elderly, sick and disabled – need more assistance in an emergency.

Score: Fair

Comment: During the field visit to Gueme and the meeting with the local and religious leaders, it was evident that the local leadership has a thorough understanding of the community and its vulnerabilities. The particular vulnerability of women and children during floods was especially emphasized. However, the varying levels of vulnerability among different groups (youth, elderly, disabled, etc.) are not integrated into the current EWS, which may affect the adequacy and timeliness of responses during hazards.

INDICATOR 5.8: Gender strategy existing and implemented.

Relevance of indicator: It is important to understand the gender roles associated with warning communication and response capacity at community level. Women may have a greater role to play in ensuring that children and families are informed and can ensure that they are evacuated and prepared for floods.

Score: Not existing

Comment: Disaster prevention, preparedness, intervention or response, and post-disaster recovery are governed at the national level by the National Contingency Plan. However, the gender perspective is not effectively integrated into any phase of disaster risk management and rehabilitation.

2.3 CURRENT GAPS AND OPPORTUNITIES FOR ENHANCING EARLY WARNING SYSTEMS FOR INLAND FLOODING

2.3.1 Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis

In this section, a SWOT analysis is conducted for each principal agency anticipated to play a role in the establishment of a people-centered flood Early Warning System (EWS) in Cameroon. These entities include:

- Department of National Meteorology (DMN);
- National Observatory on Climate Change (ONACC);
- Department of Civil Protection (DPC) and its unit, National Risk Observatory (ONR);
- Water and Climate Change Research Center (CRECC);

Herein, the analysis delves into their strengths, weaknesses, opportunities, and threats, given their existing or envisaged contributions to the formulation and implementation of flood EWS in Cameroon.

2.3.1.1 Department of National Meteorology (DMN)

The National Department of Meteorology (*Direction de la Météorologie National*, DMN) was originally established during the French mandate and has since been a central technical unit within the Ministry of Transport. Since Cameroon's independence, DMN's officials have been appointed by presidential decree. Functioning as an integral part of the Ministry, formerly known as the Ministry of Public Works and Transport and now the Ministry of Transport, it lacks legal autonomy and retains exclusive responsibility for delivering meteorological information critical for the safety of people and property.

Since Cameroon ratified the "Dakar Convention" in October 1974, the Agency for the Safety of Air Navigation in Africa and Madagascar (ASECNA) has provided aeronautical meteorological services at the airports of Douala, Yaoundé-Nsimalen, Garoua, and Ngaoundéré, following amendments to the convention. Additionally, after signing a special contract, Cameroon also entrusted ASECNA with part of its national meteorological observation network, which includes 16 stations, in accordance with Article 10 of the Dakar Convention. The primary activity of ASECNA has been to provide meteorological data to operators, air traffic service organizations, search and rescue organizations, airport managers, and other entities involved in air navigation management and development. Initially, the National Meteorology Department (DMN) was located in Douala, Cameroon's main air and maritime gateway. However, for political and centralization reasons, the DMN was later relocated to Yaoundé and expanded its portfolio to include additional activities.

The Ministry of Transport is organized by a presidential Decree No. 2012/250 of June 1, 2012, concerning the organization of the Ministry of Transport. This decree devotes its Chapter 6 to the organization of the DMN. Under the authority of a Director, the National Meteorology Directorate is responsible for:

1) Developing and implementing government policy on meteorology;
2) Collecting, processing, and disseminating meteorological information;
3) Operating data transmitted by meteorological networks at national and international levels;
4) Establishing climatological information;
5) Developing meteorological forecasts;
6) Disseminating meteorological information;
7) Maintaining relationships with international and regional meteorological and/or hydrometeorological organizations;
8) Monitoring meteorological and climatological vigilance;
9) Monitoring the implementation of conventions and protocols related to meteorology and the atmospheric environment;
10) Overseeing meteorological monitoring centers at airports, in conjunction with the Aeronautical Authority.

The DMN operates a national network for observing and collecting meteorological and climatological data throughout the country as part of its weather monitoring efforts. This network is coordinated by the DMN and is partly managed by two other entities:

- The Agency for Air Navigation Safety in Africa and Madagascar (ASECNA), which manages the stations and centers at state-conceded international airports;
- The Cameroon Civil Aviation Authority (CCAA), which manages the stations and centers at national airports, has not conceded.

The DMN is mandated to centralize, process, and archive all data collected within the national territory, including data collected by other public or private entities**.** Indeed, the decree No. 95/016/CAB/MINT of June 5, 1995, concerning the reorganization of meteorological data collection structures, states that any legal entity, public or private, as well as individuals, may create and operate one or more climatological or pluviometric stations. In this case, they are required to:

- Declare the existence of the station(s) to the Minister in charge of meteorology by any means that leaves a written record, within a maximum of two (2) months from the date of the station's creation;
- Send a copy of each observation record to the same Minister.

The provision of meteorological data in Cameroon is also regulated by the Prime Minister Decree No. 93/700/PM of November 11, 1993, which sets the rates for meteorological information and publications, specifies in Article 2 that: "The National Meteorology Directorate is the sole entity authorized to provide meteorological information collected across its entire observation network."

This decree grants exclusive authority to the DMN for the provision of meteorological data, except in cases of concessions and collections for personal use.

The DMN is structured with various departments dedicated to different aspects of meteorology, including disaster prevention, weather forecasting, and climatology. Key departments include Agrometeorology, Transport Safety Assistance, and Meteorological Data Centralization, among others. The DMN collaborates internationally with meteorological organizations in China and France for development and capacity building, and also with regional centers like African Centre of Meteorological Application for Development (ACMAD) and WMO regional climate center.

The DMN manages an observational network that comprises 58 functional synoptic stations across Cameroon's territory, which spans approximately 475,440 square kilometers and includes diverse topographies such as coastal plains, mountains, rainforests, and savannahs. As per World Meteorological Organization (WMO) Global Basic Observing Network (GBON)[5] initiative, such geographical diversity requires a more dense network of meteorological stations to effectively capture the varying climatic conditions. Currently, the network includes only 6 automated stations installed in 2022 by the Ministry of Posts and Telecommunications and 52 stations that are manually operated, totaling 58 operational synoptic stations. This number is insufficient given the extensive and varied territory of Cameroon. Additionally, of the 26 automated stations installed in 2013 and 2014, none are functional today. The Department of National Meteorology (DMN) also contends with significant challenges such as vandalism. Another major issue is the rehabilitation and maintenance of these stations, which is complicated due to financial constraints and difficulties in finding spare parts.

For treatment of databases, DMN is transitioning out of WMO's open source Climsoft software for treatment of databases to an application that is developed locally with AFREETECH, but intends to continue to use CLIMSOFT for collection and storage of data.

Although most of the data archives are digitized and stored in excel, DMN does not have a climate information system that visualizes and integrates calibrated remote-sensing and station observation of various parameters of the water cycles that can inform on the past, present and future conditions at any locality in Cameroon.

The DMN issues several meteorological products. These include daily numerical weather forecast bulletins; multi-risk meteorological bulletins; coastal marine weather forecast bulletins; 10-day climate bulletins; monthly climate bulletins; monthly rainfall statistics bulletins (monthly average for each of the 10 regions); 10-day agrometeorological bulletins; monthly livestock meteorological assistance bulletins; monthly climate health bulletins; 10-day climate and water bulletins; seasonal

[5] GBON sets minimum requirements for the number and distribution of surface-based meteorological and climatological observing stations. https://community.wmo.int/en/activity-areas/wigos/gbon

forecast bulletins (quarterly); agrometeorological bulletins; extreme weather event risk bulletins; specialized forecasts for the major cities of Yaoundé and Douala; specialized bulletins as assistance to transport in lieu of coastal bulletins for Douala and Kribi autonomous ports; and specialized forecasts available on the WMO portal, focusing on key urban centers with a five-day forecast. It plays a crucial role in early warning for meteorological hazards, mapping and archiving disaster occurrences, and utilizing global and remote sensing models for detailed climatological bulletins. DMN also issues an 'impact-based forecast' based on the satellite data, international weather models, and hazard archive that includes information of past hazards and is used to estimate impact. Cameroon prepared the decree to operationalize WMO's National Framework on Climate Services which intends to develop climate services for priority sectors, but the process is still at the Prime Minister level, and the prepared action plan needs revision.

The operational technical capacity of the forecast unit is limited. The unit has only eight staff members. The work station from the 2015 PUMA project which enhanced capability to receive, process, and visualize satellite data and enable improved accuracy and timeliness in weather forecasting and climate monitoring is not in use anymore. Meanwhile, the climate and weather forecast stations (PUMA 2025) are expected to be installed in the upcoming years in the framework of the CLIMSA project. Further, DMN does not have access to a supercomputer. The current forecasting capacities rely on the interpretation of global forecast models that are visualized in windy.com application.[6] ACMAD trained DMN on downscaling methods, but DMN does not have an operational downscaling method to localize the global forecasts. It was also noted that in development of climatological bulletins that rely on solely remote sensing data ERA5 overestimates rainfall, and that more accurate methodology that combines remote sensing and station data should be used.

The creation of an early warning bulletin map typically takes 30 minutes, followed by an additional 60-90 minutes to complete the early warning form in both English and French. Automating this process with the help of artificial intelligence could significantly expedite the development of alerts, which is crucial in rapidly evolving hazard situations. This enhancement in speed and efficiency could be vital for timely and effective responses to emergencies.

For early warning dissemination, the DMN collaborates with urban and local radio stations, involving regional DMN heads who are responsible for disseminating information in local languages. The DMN is in ongoing discussions with MTN to establish arrangements for reaching end-users directly. The dissemination of alerts adheres to the Common Alert Protocols, with broadcasting coordinated through the National Risk Observatory (ONR) and the Department of Civil Protection, both under MINAT. Local administrators are responsible for implementing measures in response to these alerts. Both ONR and Red Cross indicated that DMN alert is an integral part of the early warning process, because ONACC forecast includes biases and DMN forecast is used as a reference document for

[6] ECMWF at 9kmx9km , ICON at 13kmx13km, and GEFS at 22kmx22km.

validation. However, some regions are not covered with DMN stations and some stations have historic record gaps, which poses a challenge in providing a comprehensive and uniformly reliable early warning system across all areas. This uneven coverage and data inconsistency hinder the ability to deliver timely and accurate forecasts necessary for effective disaster preparedness and response strategies.

At the commune level, anticipatory responses are constrained by limited budgets and the high costs involved in preparing shelters and ensuring their security. Consequently, disaster response tends to be reactive, initiated only after hazards have already occurred. Therefore, DMN roles in people-centered floor early warning system include:

The ***role of DMN in risk knowledge*** is to compile and maintain a comprehensive archive of historical weather data and hazard patterns through its climatological bulletins and specialized forecasts. This collection of data is essential for understanding the risk profiles relevant to different regions and for preparing appropriate responses to similar future events. DMN and National Risk Observatory (ONR) should work together by leveraging their expertise, to optimize the visualization and cataloging of hazard events, since DMN does not have a direct mandate for such activities.

The ***role of DMN in monitoring and forecasting*** is key for meteorological hazards. It involves overseeing an extensive network of 58 synoptic stations strategically placed across the varied landscapes of Cameroon, from coastal plains to rainforests and mountains. This network is complemented by an integrated solution that combines station and satellite data to cover areas without station presence. Although the network's automated capabilities are currently limited, real-time monitoring of atmospheric conditions is crucial for effective dissemination of meteorological information and forecasts. Furthermore, DMN employs global forecasting models at coarse resolutions and uncalibrated remote sensing observations to support weather forecasting. Consequently, there is a pressing need to develop a robust climate information system that optimally combines satellite and station data for comprehensive monitoring and localized forecasting of weather conditions. This system should be adaptable to include various indicators of meteorological extremes and allow for remote sensing validations by drones (for flood mapping) and satellites (for soil moisture), among others.

The ***role of DMN in warning and communication*** is to actively disseminate a range of meteorological bulletins and alerts in various languages, including daily and seasonal forecasts, along with specialized bulletins tailored for various sectors and major urban centers. These publications are critical for informing both the general public and relevant authorities about upcoming weather conditions and potential hazards. Moreover, DMN's efforts to work with urban and local radio stations and its initiatives to form partnerships with telecommunications companies like MTN aim to improve the direct reach of these warnings to end-users. Compliance with Common Alert Protocols ensures that the disseminated information is both standardized and actionable. The current dissemination process involves multiple friction points that could be automatized and optimized through the use of a climate information system.

The ***role of DMN in response capacity*** is to provide 'impact-based forecasts' utilizing historical hazard data to contextualize potential impacts of forecasted weather conditions, significantly aiding local administrators and emergency services in planning and implementing effective response strategies. However, the department's ability to respond promptly to evolving weather situations is hindered by its limited operational and technical capacity, which is exacerbated by outdated technological resources. There is a substantial opportunity to enhance these capacities through the automation of alert systems and the integration of exposure and vulnerability information, which would in turn strengthen the overall trustworthiness of impact-based forecasts and optimize response efforts.

Table 2 reveals DMN’s strengths, weaknesses, opportunities, and threats, highlighting its comprehensive expertise in meteorological data processing and early warning. However, it faces critical challenges such as insufficient observational network coverage and technological limitations in real-time observations. To overcome these challenges, DMN must enhance its technological infrastructure and capabilities in data integration and analysis. Such strategic actions are imperative for DMN to effectively fulfill its role in Disaster Risk Management (DRM), supporting timely and accurate weather-related disaster response and planning.

STRENGTHS	• **Well-established organizational structure.** Clear mandate to centralize, process, and archive all data collected within the national territory, including data collected by other public or private entities, with various specialized departments for targeted and effective meteorological services. • **International and regional collaboration**. Partnerships and knowledge exchange with global and regional meteorological institutions. • **Local presence through extension workers.** • **Crucial role in early warning systems.** DMN forecasts are essential for DRM, effectively supporting the early warning process by mapping and archiving weather-related disasters.
WEAKNESSES	• **Insufficient observational network coverage.** The understanding of weather conditions for distant areas, not covered by weather stations, is limited and hampers development planning, adaptation and mitigation of rural communities. • **Operational technological limitations.** Lack of access to supercomputers, lack of near-real-time or real-time data processing and climate information systems decision-making. • **Maintenance capacity issues.** Rehabilitation of stations is challenging due to lack of spare parts and different manufacturing brands. • **Limited multi-sectoral collaboration.** DMN bulletins are not used by

	most sectors to inform about climate conditions for most sectors. ● **Lack of power backup systems.** Absence of power generators, making operations vulnerable to power outages. ● **Lack of departmental autonomy.** The DMN is not autonomous, limiting its ability to make independent decisions and allocate resources efficiently to address urgent needs and implement strategic initiatives. ● **Insufficient personnel coverage.** There is a lack of personnel available on the ground around the clock, which impedes the department's ability to provide continuous monitoring and immediate responses to emerging weather events and operational issues.
OPPORTUNITIES	● **Improve observational capacities.** Investment in modern meteorological technologies and methods that combine remote sensing and station information to improve the observation of climate conditions across the nation. ● **Development of indicators for meteorological hazards.** Creation and validation of indicators on different types of extreme weather events for improved multi-sectoral decision-making. ● **Capacity building in weather forecasting.** Validation and bias-correction of global forecast models currently in use and downscaling of global forecast models. ● **Development of local numerical weather prediction models.** With the use of the local supercomputer or cloud solutions develop local numerical prediction models. ● **Automation and AI utilization for bulletins and alerts.** Automating the alert development process and enhancing dissemination strategies in multiple local languages. ● **Development of sectoral climate services.** Implementation of National Framework on Climate Services which intends to develop climate services for priority sectors. ● **Develop an interactive hazard library.** For better visualization of the hazard intensity and extent as well as information of future extreme events, a digital platform would enable more effective cataloging of hazards in addition to better disaster risk preparedness and response. ● **Improve national confidence in anticipatory action.** Awareness raising and confidence building in the reliability of the forecasting capacities and the value of preventive over reactive action. ● **Development of the impact-based forecast.** Integration of exposure and vulnerability data into the forecasting process to inform DRM activities and anticipate loss assessments and capacity building in weather forecasting. ● **Equipping and maintaining the broadcasting studio.** Equipping with appropriate materials necessary to broadcast effectively to reach the end users. ● **Accessing a supercomputer.** Leveraging computation power to enhance the accuracy, reliability, and timeliness of weather forecasts and climate predictions.

THREATS	● **Vandalism and operation risks in conflict areas.** ● **Financial and logistical constraints.** ● **Climate variability and increasing weather-related disasters.** Making the extreme events more localized and intense; thus, increasing the need for observational and forecasting solutions that capture extreme events occurring in ungauged areas. ● **Data gaps and historic record inaccuracies.**

Table 2: SWOT analysis on the capacity of the DMN

2.3.1.2 National Observatory on Climate Change (ONACC)

The National Observatory on Climate Change (ONACC) was established on December 10, 2009 by decree number 2009/410 as a national legal implementing body of climate change policies. The Ministry of Environment, Nature Protection and Sustainable Development (MINEPDED) is responsible for the supervision of the ONACC, and overall coordination of climate change activities and policies within the country. It is supervised by the Ministry of Finance for financial matters. It was later reorganized in 2019 by decree number 2019/026 on January 18, 2019.

As per Article 8 of The Board of 2019/026 decree the Board consists of the following 12 members: the President of the Republic and the representatives of the Presidency of the Republic, Prime Minister, and ministries responsible for Environment, Finance, Forests, Technical Cooperation, Scientific Research, Agriculture, Energy, Meteorology; and the elected member. The Board members are appointed by Presidential Decrees. The Board of Directors defines and guides the general policy and evaluates its management. Members and the chair of the Board are appointed for the term of three years, which is renewable once.

As per Article 4 of 2009/410 decree and Article 3 of 2019/026 decree, responsibilities of the ONACC are to:

1) establish relevant climate indicators for monitoring environmental policy;
2) carry out prospective analyses to provide a vision on climate change in short, medium and long-term;
3) Monitor the evolution of the climate, provide meteorological and climatic data to all relevant sectors of human activity, and compile the annual climate assessment for Cameroon;
4) initiate and promote studies on highlighting indicators, impacts and risks linked to climate change;
5) collect, analyze and make available to public and private decision-makers as well as various national and international organizations, reference information on climate change in Cameroon;
6) initiate any action to raise awareness and preventive information on climate change;
7) serve as an operational instrument in the context of other greenhouse gas reduction activities;
8) propose to the government preventive measures to reduce greenhouse gas emissions, as well as mitigation and/or adaptation measures to the harmful effects and risks linked to climate change;
9) serve as an instrument of cooperation with other regional or international observatories operating in the climate sector;
10) facilitate obtaining compensation due to the services provided to the climate by forests through the development, conservation and restoration of ecosystems;

11) strengthen the capacities of institutions and organizations responsible for collecting data relating to climate change, so as to create, on a national scale, a reliable network for the collection and transmission of said data.

On an operational level, ONACC presents a clear, forward-looking vision on its operational strategies, challenges, and ambitions. The Geomatics division showcases its reliance on cloud storage solutions in the wake of physical storage constraints, and utilizes global models and downscaling techniques for forecasting and internal models that support estimates for 48,000 virtual stations. The application of various indicators for environmental and health-related events, underpin ONACC's robust analysis framework that incorporates satellite data, including NASA's global rainfall data and Sentinel's high-resolution imagery. The Climatology division's products, from dekadal and seasonal bulletins that serve the agricultural sector's needs to scientific studies aimed at understanding climate change impacts across socioeconomic sectors, underlines ONACC's ambition to provide actionable insights through climatological services. Partnership efforts at both national and international levels in strengthening ONACC's operational and analytical capabilities underscore ONACC's pivotal role in Cameroon's response to climate change, including FAO, GIZ, AFD, UNECE, USAID, POTSDAM institute.

However, on a technical level, there are three fundamental challenges to ONACC's model that lead to diminishing forecast accuracy. First, ONACC does not own any climate stations, but it has access to few climate stations. ONACC benefited once from accessing the 20 stations managed by DMN, but on a regular basis ONACC benefits from accessing two synoptic stations based in areas of villages Edéa and Awaé that were contributed by the Canadian partner NGO, CUSO International, and also accessing some stations operated by agro-processing companies, such as SODECOTON (La Société de Développement du Coton), SOCAPALM (Société Camerounaise de Palmeraies), and other, such as EDC (Société de Développement de l'Électricité). Further, ONACC does not merge remote sensing and satellite data. ONACC observes global forecasts from the Windy platform[7] and the satellite observations from NASA POWER[8] which has a delay of 2-3 weeks. This delay can affect the timeliness and accuracy of the information ONACC uses to predict weather patterns. Third, the advanced machine learning model, hybrid LSTM - SARIMA does not meet the fundamental data requirement for effective modeling, that is, a large datasets to train the model. While combining LSTM and SARIMA can enhance model performance by capturing both linear and non-linear relationships, the lack of sufficient data limits the extent to which these models can learn and make accurate forecasts. Specifically, Long Short-Term Memory (LSTM) models, being deep learning-based, typically require a substantial amount of data to effectively learn complex patterns, especially non-linear dependencies in time series data. With insufficient historical data, LSTMs may struggle to generalize well, leading to overfitting or poor predictive performance. Without enough data, the LSTM component might overfit to the limited data available, capturing noise as if it were a significant pattern, which diminishes its forecasting accuracy. Seasonal Auto-Regressive Integrated Moving

[7] ECMWF at 9kmx9km , ICON at 13kmx13km, and GEFS at 22kmx22km.

[8] Modern Era Retrospective-Analysis for Research and Applications - MERRA-2.

Average (SARIMA(models, although generally requiring less data than LSTM models to perform well, still need a sufficient historical record to identify and learn the underlying seasonal and non-seasonal patterns in the data. With limited data, accurately estimating the SARIMA model parameters (autoregressive, differencing, and moving average terms, along with their seasonal counterparts) can be challenging, potentially leading to model misspecification. Lastly, the three techniques used for calibration can improve the performance of the model by fine-tuning its parameters, but they cannot inherently compensate for the fundamental limitations posed by the lack of historic data for training of the models.

On the other hand, the development agencies (USAID, GIZ) and IFIs (AfDB) have recognized the challenges posed by inter-ministerial coordination and cooperation and have been supporting ONACC in growing its own meteorological station network and further improving the agro-climatic services.

Although ONACC's primary mandate does not encompass direct involvement in flood EWS, its forecasting capabilities have become increasingly influential in the decision-making processes of various stakeholders, often surpassing those provided by the Department of National Meteorology (DMN). This widespread preference for ONACC's forecasts is attributed to their consistent publication schedule, comprehensive analyses, and inclusion of historical climate trends, which offer valuable context for understanding potential hazards. Notably, entities like the Directorate of Agricultural Development and the Directorate of Agricultural Surveys and Statistics rely exclusively on ONACC for climate forecasts, and do not even receive DMN forecasts. Even the Department of Civil Protection, which necessitates accuracy and reliability in forecasts for disaster risk management, tends to prefer ONACC's outputs, although DPC recognizes the need for validation using DMN forecasts due to inherent machine learning model biases. The reliance on ONACC highlights a broader trend of its growing importance in climate-related decision-making across Cameroon, despite the challenges posed by forecast quality and reliability.

However, on the commune level, with reactive EWS that is triggered during the hazard event, only DMN forecast is used in disaster management planning and response decision-making by local leaders and Government agency representatives within the local Committees. Therefore, within the initiative for developing a centralized people-centered early warning system:

The ***role of ONACC in risk knowledge*** is to support the development of scenarios to help the general public and decision makers to understand the potential risks associated with climate change, and to develop contingencies for catastrophic events.

The ***role of ONACC in monitoring and forecasting*** is to promote and support the development and dissemination of climate data and information by other agencies as needed for specialized purposes under the 'umbrella' of the climate information program. Although, practically, ONACC's forecast is influencing centralized decision-making in many sectors, including flood EWS, it is not part of disaster planning and response on the commune level. DMN has been adamant about supporting statute related operations due to the overlap between its core mandate and the broadly interpreted ONACC mandate. Although it would be beneficial to support ONACC to reduce its external dependencies by improving data collection and infrastructure, it is very unlikely that ONACC will be able to access a long enough historic record of sufficient number of weather stations to fully leverage its advanced machine learning forecast model. DMN owns 58 weather stations. As such, ONACC could play an important role:

a) Development of climate indicators and analyses for short-, medium-, long-term flood risk forecasting. This effort supports environmental policy monitoring and offers a vision on flood risks as part of broader climate change perspectives. (Article 3.1, 3.2 of 2019/026 decree);

b) Monitoring the climate evolution and providing meteorological and climatic data relevant to flood early warning systems. This service aids all sectors involved in or affected by flood risk management, enhancing their ability to respond to flood threats efficiently. It could involve flood mapping using Sentinel-2. (Article 3.3 of 2019/026 decree);

c) Initiating studies to identify flood-related indicators, impacts, and risks, and making this information available to decision-makers, organizations, and the public. This dual approach aids in understanding flood dynamics and enhancing preparedness and response strategies through informed decision-making. (Article 3.4, 3.5 of 2019/026 decree);

d) Raising awareness about flood risks and proposing preventive, mitigation, and adaptation measures. This role involves initiating preventive information campaigns and advising the government and other stakeholders on strategies to manage flood risks effectively. (Article 3.6, 3.8 of 2019/026 decree);

e) Serving as a platform for cooperation with other observatories, government departments, and strengthening the capabilities of institutions in collecting and transmitting flood-related data. This ensures a robust data network for effective flood early warning systems and leverages advanced technologies through collaboration. (Article 3.9, 3.11 of 2019/026 decree).

The ***role of ONACC in warning and communication*** falls within the domain of dissemination of information through various channels (social media, urban and local radios, mobile application - ONACC Alert, etc.)..

The ***role of ONACC in response capacity*** can be to support awareness raising and broadening the understanding of risk through integration of DRM in climate change and adaptation programs, as well as climate change communication.

Table 3 reveals ONACC's strengths, weaknesses, opportunities, and threats, highlighting its comprehensive expertise in climate change and strong partnerships as key assets. However, it faces critical challenges such as data collection constraints and increasing climate variability, which threaten its forecasting accuracy and climate change adaptation efforts. To overcome these challenges, ONACC must enhance its data infrastructure and foster inter-institutional collaboration to secure sustainable climate funding. Such strategic actions are imperative for ONACC to effectively fulfill its role in advancing climate resilience and guiding policy and action.

STRENGTHS	• **Comprehensive mandate for climate change and adaptation.** • **Abundant experience in climate analysis.** • **Innovative forecasting techniques.** • **Strong national and international partnership network.** • **Skilled staff and visionary leadership.**
WEAKNESSES	• **Mainly operational at national level and at the level of regions, but no performance in the division or sub-division level**. • **Data collection limitations.** Dependence on external meteorological stations and access to a limited number of stations. • **Infrastructure and technical gaps.** Challenges in fully integrating and analyzing satellite and in-situ data due to infrastructure limitations. • **Forecast accuracy and historical data scarcity.** Insufficient historical data for effective model training, affecting forecast accuracy. • **Lack of operational downscaling:** Despite training, no operational downscaling to enhance forecast accuracy at local levels. • **Lack of power backup systems.** Absence of power generators, making operations vulnerable to power outages. • **Storage limitations.** Physical storage limitations are hindering data management and operational scalability.
OPPORTUNITIES	• **Reinforced data sharing.** Data sharing platform enables ONACC to leverage its advanced techniques to train its models and improve reliability of the forecasts by accessing stations from other authorities. Or **Expansion of the meteorological station network.** Investment in own meteorological stations to improve forecasts (outside of mandate). • **Strengthened climate analysis.** Enhancing ONACC's ability to predict, assess, and strategize against climate variability and change, and bolster decision-making capacity across sectors through development of climate analysis platform. • **Development of localized seasonal forecast models:** Creation of localized models through operational downscaling for more accurate predictions. • **Agricultural calendar enhancement.** Development of advanced indicators, such as Crop Water Requirement Satisfaction Index (WRSI), using localized blended remote-sensing and in-situ data improves precise planting and harvesting guidance tailored to climate variability. • **Reinforced forecast validation mechanism.** Integrating multi-source data verification merged satellite and in-site as well as station data and cross-referencing with international climate models to increase the accuracy and reliability of climate forecasts. • **Strengthened disaster risk reduction.** Expanding early warning systems and disaster risk reduction strategies in collaboration with national and local authorities based on the climate change impact. • **Climate change mitigation and adaptation programs.** Leading or partnering in projects focused on mitigation strategies and adaptation measures. • **Multi-sectoral policy influence**. Leveraging expertise to influence national and international multi-sectoral climate policies and frameworks by positioning ONACC

	as a central climate data hub. ● **Academic collaborations.** Spurs innovation and strengthens scientific foundations of ONACC services and analysis. ● **Regional and international leadership potential**. Strengthens ONACC's positioning as a climate service hub to strengthen climate resilience in Central Africa and attract climate finance. ● **Access to climate finance.** Development Agencies (AFD, GIZ) tend to prefer and support development of ONACC capacities which is also located under the national focal point for climate finance, the Ministry of Environment.
THREATS	● **Increasing climate variability and extremes.** Raising unpredictability and severity of weather events challenging forecasting and mitigation efforts. ● **Overlaps and overextension in policy framework and mandate.** Broader interpretation of mandate by many agencies, motivated by appeal for climate finance, erodes inter-institutional openness and willingness to collaborate. ● **Challenging multi-sectoral coordination.** Difficulties in achieving effective collaboration and data sharing among government agencies and departments. ● **Forecast and service integrity.** Potential threats to the integrity of forecasts and climate observations amidst over-reliance on machine learning models without sufficient historic record. ● **Competition for funding.**

Table 3: SWOT analysis on the capacity of the ONACC

2.3.1.3 Department of Civil Protection (DPC) and National Risk Observatory (ONR)

Legal and Institutional framework

The **Department of Civil Protection (DPC)** is the key actor within the Ministry of Territorial Administration (MINAT) in coordinating and managing Cameroon's Disaster Risk Management (DRM). The National Contingency Plan (PNC) provides a unified framework to direct the efforts of institutional partners, organizations, and other civil protection entities under the coordination of MINAT. The authority to implement DRM actions is derived from various pieces of legislation and decrees that address DRM through different provisions.

- Law No. 86/016 of December 6, 1986, relating to the general reorganization of Civil Protection.
- Decree No. 96/054 of March 12, 1996, establishing the composition and responsibilities of a National Civil Protection Council.
- Decree No. 98/031 of March 9, 1998, organizing emergency plans and relief in the event of a disaster or major risk. The National Disaster Risk Management Strategy (Stratégie Nationale de Gestion des Risques de Catastrophe) drafted and to be adopted in 2024.
- Decree 2001/184 of 25 July 2001 reorganizing the national military rescue unit.
- Order No. 037/PM of March 9, 2003, relating to the creation, organization, and operation of a National Risk Observatory (ONR).
- Decree 2019/030 of 23 January 2019 organizing the Ministry of Territorial Administration and decentralization (MINATD). As the more recent decree organizing the Ministry than Decree No. 2004/99 of April 26, 2004 and Decree No. 2004/320 of December 8, 2004.
- Decree 2018/190 of 2 March, 2018 providing amendments and completing some provisions of Decree 2011/408 of 9 December, 2011 organizing the government.
- In 2002, Framework Convention for Assistance in Civil Protection.

Civil Protection is tasked with consistently ensuring the protection of people, property, and the environment against the risks of serious accidents, calamities, or catastrophes, as well as mitigating the effects of these disasters. It operates within a sphere of competence and responsibility that primarily falls to the Cameroonian State, but also involves other stakeholders such as decentralized local authorities, the United Nations system, intergovernmental organizations, other development partners, non-governmental organizations, and the population. The main responsibilities of the Department of Civil Protection (DPC) are to initiate and facilitate the implementation of DRM policies and programs and to coordinate all other stakeholders in the DRM implementation. Specifically, within the Ministry of Territorial Administration (MINAT), the Civil Protection Service was first established, which then transitioned to become a Unit of Civil Protection and then a Directorate of Civil Protection (DPC) in 1996 and was responsible for:

- Organizing civil protection initiatives across the national territory, ensuring that systems and protocols are uniformly implemented to safeguard the populace.

- Conducting studies to develop and refine civil protection measures applicable in both wartime and peacetime scenarios, enhancing the country's readiness and resilience.
- Coordinating relations with both national and international civil protection organizations, fostering collaboration and sharing best practices.
- In partnership with the human resources sub-directorate, developing training programs for civil protection personnel to enhance their skills and effectiveness in crisis situations.
- Reviewing and processing requests for compensation and financial assistance from victims of disasters, providing crucial support to those affected.
- Overseeing the use of aid, ensuring that resources are allocated and used transparently and efficiently.
- Coordinating the resources deployed for civil protection, which include relief, rescue, logistics, and the use of supplementary and auxiliary forces, to optimize response efforts.
- Managing body transfers, handling this sensitive duty with the respect and efficiency that such situations require.
- Monitoring and managing aid, continuously assessing the distribution and impact of aid to adapt strategies as needed.

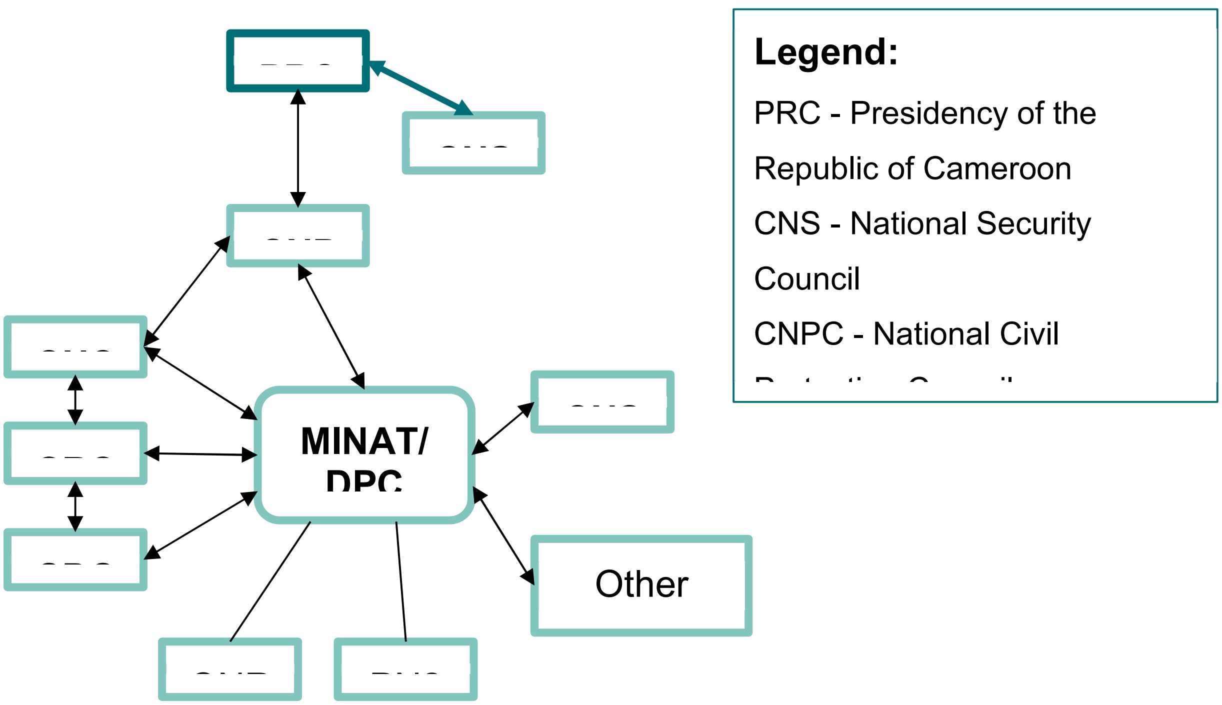

Figure 4: General Framework of Civil Protection; Source: PNC, 2017

Within the DPC, the **National Risk Observatory (ONR)**, established by order No. 037/PM of March 9, 2003, plays a pivotal role in prevention and preparation as the initial phase of national DRM mechanism. This order outlines the creation, organization, and operation of the ONR, which serves as a key governmental structure in charge of managing information on hazards and threats to the population as the National Monitoring System. ONR is responsible for:

- The collection of all information relating to natural, health and anthropogenic risks;
- The analysis, processing, storage, and dissemination of information relating to said risks;
- The exchange of information between the various stakeholders;
- Decentralization through the creation of peripheral sentinel sites for collecting information and monitoring indicators;

Operationally, ONR maintains focal points in each of the ten regions, and also at the level of administrations, tasked with gathering risk-related data and transmitting it to ONR as the centralized authority for analysis and storage. Despite the local development of a mobile app, CRYSIS, for data collection and dissemination of alerts by ONR, its operationalization remains pending, with WhatsApp groups currently serving as the primary means for data collection and diffusion of alerts. For data collection, when incidents occur, focal points complete standardized forms and share them with ONR. To ensure coverage at the sub-divisional level, focal points from other ministries may assist ONR focal points, with some ministries, such as the Ministry of Agriculture (MINADER), having focal points at the village level. In the event of floods, focal points must visit affected villages to gather information on the number of affected individuals, households, crop damage, and measures taken to mitigate impact in the affected area. For alert dissemination, the alerts are issued in the form of bulletins that include information on the risk and suggest actions to reduce the risk. The target audience for the alert bullets are the decentralized administrative authorities, including division officer, sub-division officer, and governor. However, there is currently no feedback mechanism in place to improve the bulletins. The main operational challenges consist of financial constraints, technological hurdles in disseminating alerts to target audiences, the need to harmonize data collection at the regional level for consistent analysis, and the development of regional risk maps to inform the population and authorities about risks. Notably, only three out of ten regions currently have risk maps.

In essence, the ONR serves as the central authority responsible for managing information regarding hazards and threats to populations, encompassing all surveillance, monitoring, and alert actions. Any significant event or fact with the potential to create a crisis situation affecting people, property, the environment, or economic activity, must be reported to MINAT through DPC via ONR as DPC is the only legal entity mandated to implement response activities.

National DRM Mechanism

Before delving into the three axes of the comprehensive national DRM mechanism, it is essential to understand the step-by-step process of how early **warning alerts** are created and lead to intervention decisions, as these are the pivotal aspects that bridge the gap between preparedness and direct intervention during disasters. This process, particularly in the context of Cameroon, involves several critical stages:

Early Warning Alert: Alert Generation (Step 1)

Technical agencies, including the National Observatory on Climate Change (ONACC), the Department of National Meteorology (DMN), the CAPC (Climate Application and Forecasting Center) in Douala, and regional African Centre of Meteorological Application for Development (ACMAD) in Niamey, play pivotal roles in the initial alert generation. These agencies regularly produce forecasting bulletins based on various climate and meteorological data. Alerts are issued based on regular bulletins — dekadal (every 10 days), monthly, and seasonal (quarterly). However, some alerts are issued more regularly and punctually than the others; others, are issued only in response to extreme climatic or meteorological events. The generated alerts are then sent to the DPC for further analysis.

Early Warning Alert: Validation by the ONR (Step 2)

Once the DPC receives these alerts, the National Risk Observatory (ONR) undertakes a critical comparison against a historical database spanning the last 50 years. ONR does not have access to any user-interface where extent, duration, and intensity of the past extreme events can be visualized. Rather, ONR first reviews if the forecast is accurate, and then it evaluates the historic events for the concerned localities to determine the thresholds and then relative to the forecasted weather conditions, issues and sends the alert to decision makers. This step determines whether the forecasted climate conditions signify a usual pattern or an anomaly that could lead to a disaster. Only events that exceed certain thresholds of risk are flagged for action; otherwise, they are noted as normal evolutions and not escalated. This validation can take up to three hours, depending on the complexity of the data and the need to integrate information from various sources. Primary weather variable considered is rainfall, because Cameroon is in the predominantly equatorial zone and temperature amplitudes do not vary as much.

Early Warning Alert: Detailed Analysis and Forecast Validation by DPC (Step 3)

During the analysis and validation process, the ONR conducts a deeper analysis to compare the bulletins with weather forecast (DMN) and future variability of climate change indicators (ONACC) and historical weather data primarily sourced from DMN. However, DMN data records sometimes have gaps or lack observation coverage of the location of interest. Since it is crucial to confirm the accuracy of the data and the appropriateness of the forecasted alert, MINAT would like to have an operational way to use mathematical models to validate forecasts, ensuring that the converging evidence from multiple models supports the justification for the issuance of an alert. In practice, there is no operational model that validates the forecast. The forecast models were never quantitatively validated nor bias-corrected. ONACC forecasts receive substantial acknowledgement for their issuance consistency, punctuality, and the helpful climate change variability insights. Nevertheless, ONR also acknowledges that the ONACC forecast carries biases from the mathematical model and that DMN forecasts are used as reference.

Early Warning Alert: Decision Making Based on ORSEC Plan (Step 4)

Upon ONR's validation of the alert, if the risk is confirmed as significant, the DPC communicates the alert through MINAT down to administrative authorities—governors, divisional officers (DOs), and sub-divisional officers (SDOs), and subsequently to divisions and councils. These authorities then consult with DRM committees, which may involve representatives from various governmental levels. The committee's approval is often required to activate the ORSEC (Organization of the Emergency Response, or Organisation de la Réponse de Sécurité Civile) Plan, a predefined contingency protocol for disaster response. **Nevertheless, not all divisions have ORSEC plans. Note: National Contingency plan (*Plan National de Contingence*) is on national level, while the ORSEC plan is on division level.** Regional and sub-division administrative levels do not have dedicated contingency plans; rather, the division ORSEC plan guides the subdivision and district responses. Heads of the different administrative units are responsible for implementing DRR activities in their respective regions. Government legislation provides guidance on key actions that the heads of administrative units should take, both during and after a disaster. This guidance includes the establishment of crisis committees, management of information, creation of command posts, and development of relief and rescue plans. The divisional crisis committee, consisting of various stakeholders relevant to the specific disaster type, convenes to decide on the specific disaster risk management actions to be implemented. This committee's decisions are guided by the severity and type of the forecasted event, and they coordinate the operational response on the ground. The administrative heads of regions, divisions, and city councils (governors, divisional officers, and government delegates respectively) are appointed by the government, while municipal council heads (mayors) are elected. Under national law, the President has the authority to make policies relating to Disaster Risk Reduction (DRR) at the highest level, which are then implemented under the auspices of MINAT.

One of the major ongoing challenges is ensuring that the alert and subsequent information are comprehensively understood and disseminated across all levels, including to populations in areas with low literacy rates. Effective communication to the public is facilitated through various channels, but sometimes the level of literacy, communication in local language, and complex information can hinder widespread understanding, posing barriers to timely and effective responses. The response time depends on the type of events and the level of emergency.

Another major ongoing challenge is the updating of the contingency plans every three years, which is a participatory process led by the Division officers. Contingency plans include vulnerability analysis and mapping with mandatory actions for most relevant risk. Although the contingency plans are meant to cover all kinds of risks, in practice, only the most important risks are highlighted. Currently, out of 58 divisions in Cameroon, MINAT has 21 division contingency plans, but 37 divisions do not have them. One of the main objectives of MINAT is to develop contingency plans for all other divisions. For 21 divisions that have contingency plans, only five are up-to-date, and 16 are outdated. Furthermore, updating the national contingency plan from 2017 is also of high priority.

As per the National Contingency Plan, the national Disaster Risk Management activities are strategically structured around three axes: before, during, and after.
Axis 1: Preparedness and Prevention of Shocks – 'BEFORE' – focuses on prevention and preparation activities, such as the implementation of emergency and relief plans. This generally

involves strengthening the national surveillance system, raising awareness, educating the population, training stakeholders, developing preparation plans, and testing these plans through simulation exercises. Despite advancements, significant needs remain, particularly in establishing an operational early warning and information system that is crucial for timely and effective disaster response. These systems are essential for ensuring that alerts and critical information reach all stakeholders promptly, thereby enhancing the overall capacity to manage disasters effectively.

- **National Risk Observatory (ONR)** – established in 2003 within the Civil Protection Directorate.
- **Public awareness and education** – is implemented through communication plans and include:
    - Preparation plans and testing of said plans through simulation exercises;
    - Sectoral contingency plans;
    - Updating ORSEC plans at division levels;
    - Specific emergency plans.

Axis 2: Intervention and Response to Crises – 'DURING' – disaster activities are related to the intervention with focus on emergency and relief plans. It involves a process to better manage a crisis. It revolves around 1) information management, 2) implementation of emergency plans, monitoring / evaluation and the closure report.

MINAT is the central entity for coordinating activities for emergency and relief planning. It involves two main bodies:

1) The **National Crisis Committee (CNC)** serves as the principal entity responsible for planning, evaluating, and managing disaster relief operations in Cameroon (Figure 5). The CNC's duties encompass coordinating public relief actions, directing relief operations, preparing rescue resources, delivering aid to disaster sites, determining the needs for aid and assistance for victims, and addressing both immediate and long-term effects of disasters. Furthermore, the CNC oversees all human, material, and financial resources provided by public authorities, international organizations, public or private entities, and general donations and bequests. It integrates all sectors and organizations that play significant roles in disaster response, ensuring a coordinated effort in the event of a disaster or major risk;

2) The **Relief Command Bodies** comprise two types of command posts: the **Operational Command Post (PCO)**, which directs operations **under the authority of the MINAT**, centralizes and utilizes gathered information, and requests and allocates necessary reinforcements; and the **Fixed Command Post (PCF)**, **located at the DPC** of the MINAT, which ensures communication between the operational command post and various services, processes received information and intelligence, and coordinates reinforcements at the disaster site (Figure 6). Together, these command bodies ensure effective management and coordination of relief efforts during emergencies.

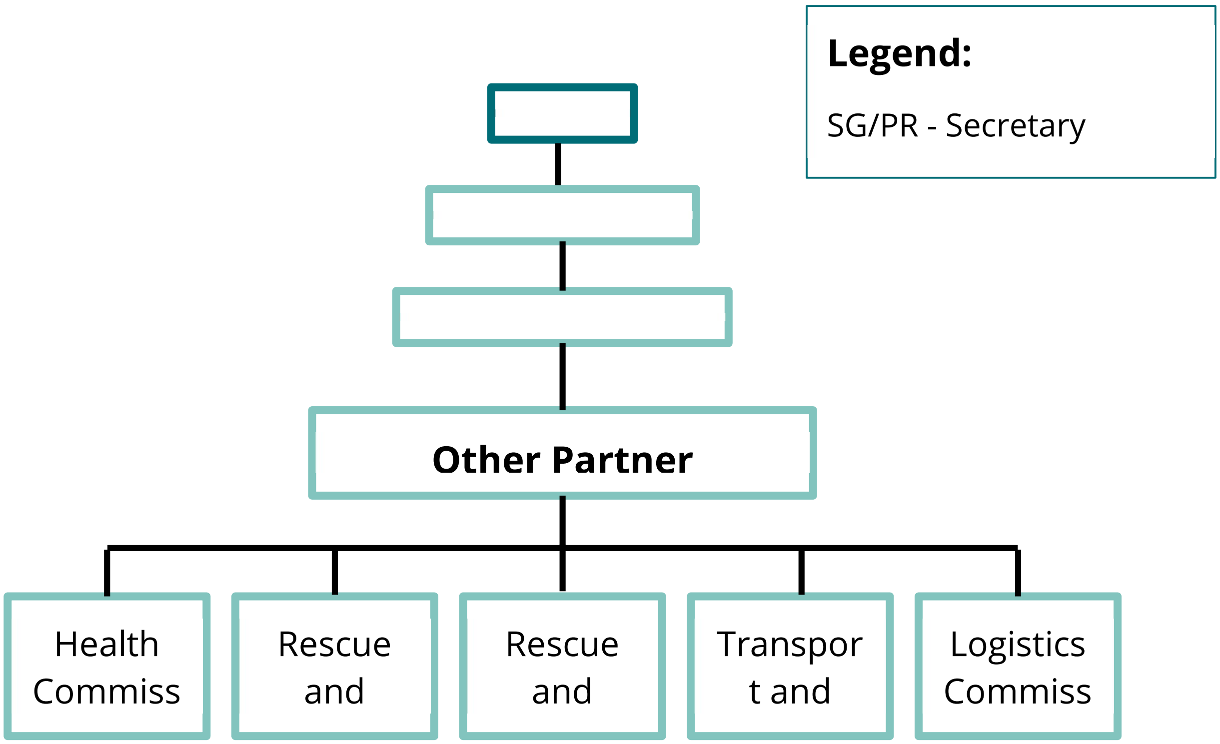

Figure 5: Functional Diagram of National Crisis Committee (CNC); Source: PNC, 2017

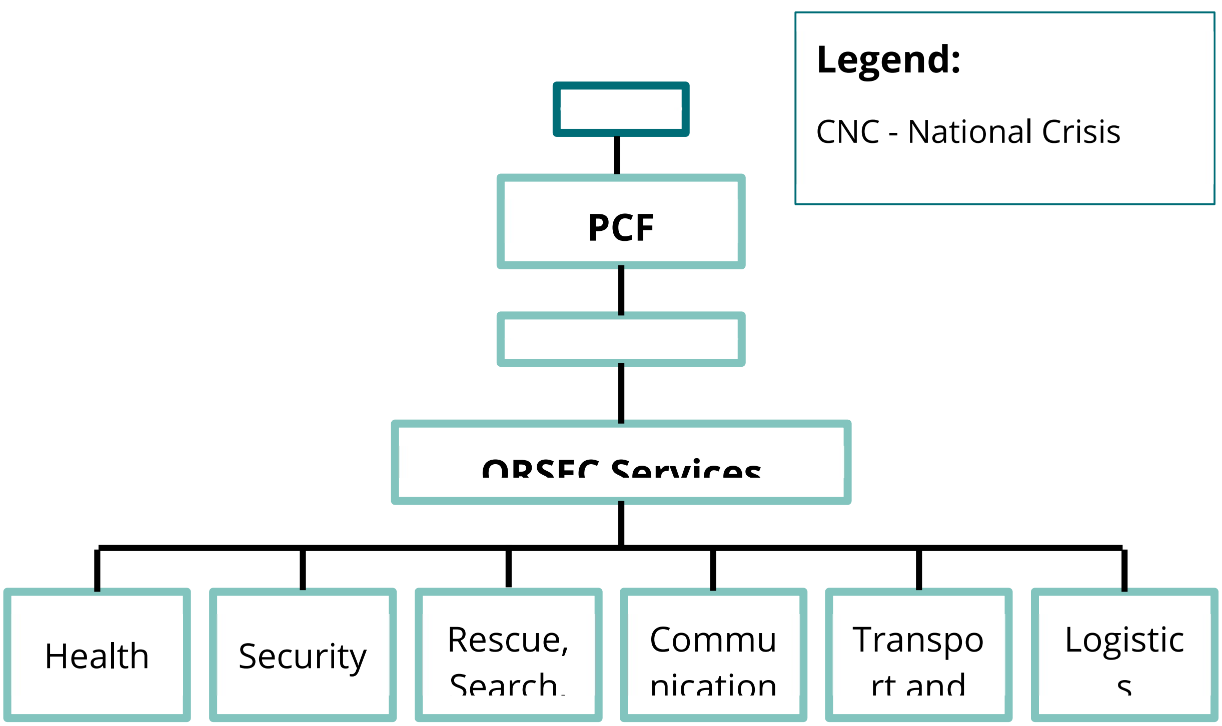

Figure 6: Functional Diagram of National-Level Rescue Organization; Source: PNC, 2017

1) **Information management (communication):**

➢ **The principles:** In the context of Disaster Risk Management (DRM), effective information management is crucial. The principles guiding this process include the sharing of information among DRM actors to ensure coordinated and efficient responses. Additionally, there is a unified advocacy and communication strategy aimed at both local and international media, which is managed and overseen by the Government. This approach not only ensures consistent messaging during crises but also enhances transparency and public engagement. Similarly, advocacy efforts to mobilize resources are conducted commonly across all relevant entities and are also under the government's purview.

➢ **The axes of the information management strategy** encompass several critical components designed to streamline and optimize communication during disaster management operations.

The first major component, **Population Information**, focuses on ensuring that crucial information reaches the general populace efficiently. This involves the dissemination of information to the population through various channels, activation of the alert system to warn the public about imminent threats, and the structured dissemination of these alerts through administrative authorities and the Department of Civil Protection (DPC). This process ensures that all members of the community are informed and can take necessary precautions in a timely manner.

The second component, **Communication with the Media**, is centered on managing and guiding the flow of information to and through the media. This is achieved by developing a comprehensive media plan that outlines how information should be released and updated. Additionally, spokespersons are briefed to ensure that communication is consistent, accurate, and aligned with the latest developments, thus maintaining public trust and clarity during crises.

The third component, **Communication with DRM Actors**, involves a broad network of communication flows among key disaster risk management actors. This includes the dissemination of information up to the highest levels of government, specifically to the President of the Republic (PRC) and the Prime Minister (PM), ensuring that the nation's leaders are fully informed. It also covers the flow of information to the competent administrative authorities and the search for further information by the National Risk Observatory (ONR). There is a systematic referral to specialized structures like the Community Surveillance System, and to crucial operational units such as the Directorate of Coordination and Monitoring (DCS) and Rescue Services (SS). Additionally, information is disseminated to partners, and a robust database is set up to support the collection and accessibility of information. Lastly, there is a focus on the ongoing monitoring and evaluation of the communication efforts to continually refine and improve the effectiveness of the information dissemination strategy.

2) Implementation of the Emergency Plan

➢ Following the structured approach to disaster management, the implementation of the Emergency Plan is a critical phase that involves several coordinated actions. Initially, a multidisciplinary team is established based on the specific requirements of the disaster, and command posts are activated to ensure efficient command and control structures are in place. The political authority, which could include the MINAT, the PM, or the PRC, is responsible for officially declaring a state of disaster.

Once declared, the emergency plan encompasses a wide range of activities aimed at addressing immediate needs and stabilizing the situation. These activities include providing medical care to those affected, offering emergency accommodation, ensuring access to essential resources such as water and food, and managing logistics for separated families and deceased persons. Furthermore, the plan covers the restoration of critical infrastructure, such as water and electricity networks, and the supply of hydrocarbons. It also includes implementing procedures to restore financial and legal frameworks, which are crucial for long-term recovery. Lastly, the plan details the procedures for receiving and disseminating additional aid, ensuring that further resources are distributed efficiently and effectively to support ongoing relief efforts. This comprehensive response strategy is essential for mitigating the impact of the disaster and facilitating a swift recovery.

3) When addressing the needs for effective disaster response during crises, three critical areas were identified: the development of integrated emergency management systems, the provisioning of essential material and logistical resources, and the strategic mobilization of human resources. These components are pivotal in ensuring that all aspects of crisis management are robustly supported, enabling timely and efficient responses during emergencies.

Integrated emergency management systems needs involve a thorough framework designed to boost emergency response capabilities throughout Cameroon. It encompasses the identification and mapping of high-risk areas to better plan and execute response strategies. The communication aspect is enhanced by deploying advanced transmission and mobile equipment, setting up a comprehensive siren system for auditory alerts, and creating free emergency and toll-free contact numbers to ensure wide accessibility in crisis situations. The strategy also includes broadcasting essential safety instructions through media, establishing community monitoring and alert mechanisms, and collaborating with mobile phone operators to guarantee rapid dissemination of information during emergencies. Additional measures include establishing satellite communications and support systems for remote victims, providing training for DRM personnel, building teams of critical human resources ready for emergencies, and initiating public awareness campaigns about risk zones. Plans also include projections for necessary intervention funds on both central and division levels and the setup of localized response centers outfitted with modern firefighting equipment.

Material and logistical resource needs focus on providing the necessary infrastructure and supplies needed for effective disaster management. It includes setting up hangars and warehouses at strategic locations. Civil protection stocks are organized in palletized lots containing essential items like generators, extrication equipment, tents, medical supplies, and water purifiers, which facilitate quick transportation to disaster-affected areas. It also involves maintaining safety stocks of critical resources such as food, water, and hydrocarbons, and acquiring durable transportation means that can operate even when conventional networks are down, including radio stations and satellite phones. The provision of trucks and containers for material transport and mobility solutions for intervention teams and victims is also critical.

Human resource needs indicate necessity for well-trained personnel ready to handle various aspects of crises. This involves continuous training for individuals in diverse fields such as rescue, health care, water management, sanitation, and psycho-social support. A regularly updated roster of emergency specialists is maintained to ensure readiness in at-risk regions and at the national level, ensuring that expertise is available where and when it is most needed.

Axis 3: Post-crisis Rehabilitation – 'AFTER' – focuses on post-crisis rehabilitation. This phase involves comprehensive measures aimed at restoring the dignity of victims and rehabilitating infrastructure. It is crucial to employ technical means to assess and manage the aftermath of a disaster in terms of its manifestations, severity, and duration.

- At the health and social level, the response involves identifying the health and social repercussions of the crisis and implementing procedures to monitor these effects continuously. An essential part of this process is ensuring psychological support for those impacted, addressing the mental health challenges that often follow such traumatic events. Economically, the focus shifts to addressing the consequences of job losses and the destruction of the local economic fabric. This involves rehabilitating damaged homes, sites, and infrastructure to restore normalcy and economic stability to the affected areas.
  In terms of feedback, each Disaster Risk Management (DRM) actor is tasked with evaluating their actions. This review includes detailing the missions carried out, the resources utilized, the challenges faced, and suggestions for future improvements. Such feedback is vital for refining disaster response strategies and enhancing overall effectiveness.

The determination of needs in human, material, logistical, and financial resources is tailored according to the specific rehabilitation efforts required. This targeted approach ensures that resources are allocated efficiently and effectively to support recovery and rebuilding efforts, ultimately helping communities bounce back from the crisis more resiliently.

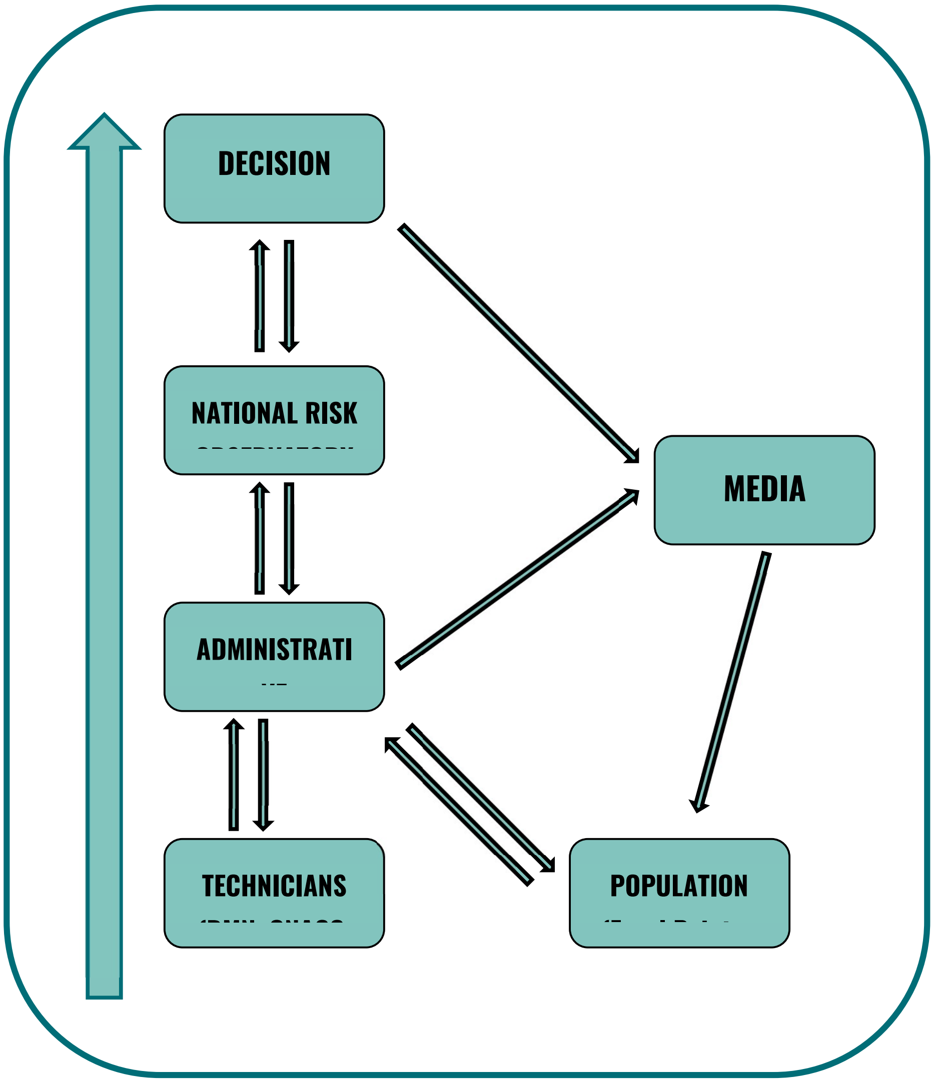

Figure 6: Diagram of interrelationship between DRM actors. Source: PNC, 2017

The key ***role of DPC in risk knowledge*** is to serve as the central government authority responsible for collecting, analyzing, and disseminating information related to natural, health, and anthropogenic risks. Under DPC, ONR collects data on hazards and threats to the population, analyzes this information, and then DPC shares it with various stakeholders. By decentralizing its operations through the creation of peripheral sentinel sites, DPC ensures the collection of data at the regional level, thereby enhancing overall risk knowledge across the country.

The key ***role of DPC in monitoring and forecasting*** is to validate the forecasts produced by the technical authorities of ONR against the historic weather observations and compare the forecasted conditions relative to the localities of the hazards that took place in the past.

The ***role of DPC in warning and communication*** is to ensure effective dissemination and communication of alert bulletins issued by ONR as a form of early warning alerts to all stakeholders, including administrative authorities, DRM committees, and the general public. DPC manages information flows among DRM actors, coordinates communication with the media, and develops advocacy and communication strategies to ensure consistent messaging during crises. The DPC also oversees the implementation of communication plans, activation of alert systems, and dissemination of critical information through administrative channels and community surveillance systems.

The ***role of DPC in response capacity*** is crucial in enhancing response capability by coordinating emergency and relief plans, managing resources, and mobilizing human resources. It implements the Emergency Plan, establishes multidisciplinary teams, and activates command posts to ensure efficient command and control structures during emergencies. The DPC also focuses on providing essential material and logistical resources, including medical supplies, food, water, and transportation means, to support disaster management operations. Additionally, it prioritizes training for DRM personnel and maintains a roster of emergency specialists to ensure readiness at both regional and national levels.

Table 5 reveals DPC/ONR strengths, weaknesses, opportunities, and threats, highlighting its current operational landscape and potential areas for improvement and growth.

STRENGTHS	● **Multi-level Engagement.** DPC coordinates activities from national to local scale, including decentralized operations through regional sentinel sites. ● **Coordination mechanism.** DPC coordinates and unifies the efforts of institutional partners, organizations, and other civil protection entities. ● **Strong national and international partnership network.** Continuous collaboration with various international stakeholders, including the United Nations system, intergovernmental organizations, NGOs, and development agencies. ● **Pivotal role in hazard early warning.** Within DPC, ONR plays a key role in hazard information management, including collection, analysis and dissemination of risk-related data.
WEAKNESSES	● **Very limited number of available and current ORSEC plans.** A significant proportion of divisions (53 out of 58) do not have up-to-date contingency plans, with 37 having no plans at all. ● **Communication barriers.** DPC has challenges in disseminating alerts to populations with low literacy rates. ● **Limited data feedback.** Lack of a structured feedback mechanism hinders ONR's ability to improve data collection and enhance quality and relevance of risk. ● **Incomplete risk mapping.** Three out of 10 divisions have risk maps.

	• **Delayed alert dissemination.** Use technology to lower the ONR risk bulletin development from 3h. • **Field response coordination challenges.** Despite Decree No. 98/031 of March 9, 1998, that organizes emergency plans and relief in the event of a disaster or major risk, the coordination of actors on the ground is challenging.
OPPORTUNITIES	• **Advocacy for DRM legislation.** Strengthen legal frameworks, enhance accountability, and institutionalize DRM activities, providing clear guidelines for disaster management. • **Technological advancement of DPC.** Calculation of access and evacuation routes by the models. • **Technological integration of ONR**. Levaring advancements in technology to visualize the extent, duration, intensity of historic hazards and to simulate and compare their development and parameters. • **Public awareness campaigns.** • **Simulation training of local DRM decision-makers.** • **Improved DRM inventory tracking.** • **Updating contingency plans.** Both local and national. • **Independent and autonomous Civil Protection.** As a directorate, structural limitations impede DPC's efficiency and effectiveness in mitigating and responding to disasters. Being autonomous would allow for greater flexibility in expanding its workforce, managing its budget, and implementing strategies more effectively.
THREATS	• **Limited funding.** • **Confusion in the communication chain of different disseminated warnings.** • **Fragile communication infrastructure and dependance on single channels.** • **Inter-institutional barriers in data sharing.**

Table 4: SWOT analysis on the capacity of the DPC/ONR.

2.3.1.4 Water and Climate Change Research Center (CRECC)

The Geological and Mining Research Institute (IRGM) was established by Decree No. 79/495 on December 4, 1979, concerning the organization of the General Delegation for Scientific Research (DGRST), which, after several transformations, became the Ministry of Scientific Research and Innovation (MINRESI). Under this legal framework, the IRGM carried out its mission until 2018, the year its reorganization occurred, as facilitated by **Decree No. 2018/632 of October 30, 2018**.

This reorganization aims to align the statutes of the IRGM with the new legal environment, including the general statute of public institutions, the code of transparency and good governance in public financial management, and the financial regime of the state and other public entities. The reorganization assigns the IRGM a dual mission:

1. To advise and support the design, implementation, and monitoring-evaluation of public policies in the fields of energy, water resource management, mining, and environmental research.
2. To engage in research and technological innovation in the areas of geological, hydrological, energy, mining, and environmental resources.

According to the **Resolution No. 003/IRGM of 15 December 2020**, the Institute of Geological and Mining Research IRGM continues to be governed by Decree No. 2018/632 of October 30, 2018 with reorganized structure that includes overseeing the operations of the work of seven specialized research centers that align with its objectives. These specialized research centers, along with their main actions and activities, are as follows:

1. Geological and Mining Research Centre (*Centre de Recherches Géologiques et Minières - CRGM*) - Focuses on strengthening environmental monitoring.
2. Center for Spatial Imaging Research (*Centre de Recherches en Imagerie Spatiale - CRIS*) - Concentrates on enhancing geological information.
3. Nuclear Science and Technology Research Center (*Centre de Recherches en Sciences et Techniques Nucléaires - CRSTN*) - Dedicated to nuclear energy development.
4. Renewable Energy Research Center (*Centre de Recherches sur les Énergies Renouvelables - CRER*) - Engages in renewable energy development.
5. Geophysical and Volcanological Research Center (*Centre de Recherches Géophysiques et Volcanologiques - CRGV*) - Manages the prevention and management of natural risks and disasters, primarily involving the degassing of Lakes Nyos and Monoun, volcanic monitoring at Mount Cameroon, seismic surveillance, and nuclear safety enhancements.
6. Environmental and Natural Hazards Research Centre (*Centre de Recherches sur l'Environnement et les Risques Naturels - CRERN*) - Focuses on environmental conservation and the sustainable management of natural resources, as well as the prevention and study of natural hazards.
7. **Water and Climate Change Research Centre (*Centre de Recherches sur l'Eau et les Changements Climatiques - CRECC*)** - Specializes in water sciences research, climate change

impact studies, data collection and management, hydrological risk identification, and providing continuous training and advisory services. The mandate includes:

i. Designing, executing, and coordinating research operations in the fields of Water Sciences;
ii. Collecting the necessary data for the realization of various development projects related to the understanding and management of water resources;
iii. Collecting and processing data on water resources;
iv. Studying Cameroonian hydrological regimes in relation to the realization and execution of major development projects linked to the understanding of the resource;
v. Studying climate change and its impacts on key processes of the hydrological cycle, in collaboration with the concerned administrations;
vi. Studying the quality of territorial waters;
vii. Establishing a national hydrological data bank and disseminating the finished products;
viii. Identifying natural hydrological risks and land use planning, in collaboration with the concerned administrations;
ix. Providing continuous training and supervision in the Centre's areas of expertise;
x. Providing assistance, advice, and other services in the Centre's areas of expertise.

The CRECC is comprised of several specialized laboratories and services:

- the Surface Hydrology Laboratory - responsible for designing and implementing hydrometric networks, collecting and managing hydrological data, studying hydrological regimes, archiving and modeling data, managing a national hydrological data bank, supporting socio-economic development projects, managing transboundary water resources, and disseminating hydrological forecasts and publications.
- the Hydrogeology Laboratory - Responsible for designing and implementing the national piezometric network, developing methodologies and models for groundwater evaluation and monitoring, prospecting techniques, quantifying and qualifying national reserves, protecting and managing aquifers, and creating the hydrogeological map of Cameroon.
- the Climate Change Laboratory - Responsible for assessing the impact of climate change on water resources, the water cycle, and extreme hydrometeorological events; using empirical tools for monitoring impacts over time; and mapping the effects of climate change on seawater intrusion into surface and groundwater along the Cameroonian coast.
- the Hydrobiology Laboratory - Responsible for collecting, storing, analyzing, and disseminating hydrobiological data; monitoring data quality; mapping hydrobiological health of major basins; developing analytical methods and tools;

producing expert data for ecological assessments; and creating reference yearbooks, brochures, and atlases on water quality.

- the Geochemical Water Analysis Laboratory - Responsible for collecting, analyzing, storing, and disseminating geochemical data of natural waters; providing hydrochemical information for socio-economic development projects; and producing reference data yearbooks, brochures, and atlases on water quality in collaboration with the Hydrobiology Laboratory.
- the Scientific Equipment Maintenance Service - Responsible for the preventive and corrective maintenance of scientific equipment for all the Centre's laboratories, manufacturing tools for experiments and data collection, and developing troubleshooting protocols for pilot systems and field equipment.
- the Resources and Logistics Service - Responsible for managing human resources, preparing and monitoring the budget, preparing financial statements, conserving and filing accounting documents, preparing administrative and financial reports, and managing and maintaining movable, immovable, and infrastructure assets.

Examples of CRECC's collaborative agreements and projects:

a. the evaluation of water resources in Cameroon
    - For example, the signed **agreement between Ministry of Water and Energy (MINEE) and IRGM**, as part of the implementation of the "Access to Drinking Water and Sanitation" program of the MINEE, IRGM/CRECC is responsible for realization of the "Studies" component of the Project to guide the realization of investments to improve the low rate of access to drinking water and sanitation services as well as **establishment of a National Water Information System**.
    - Another example is the **agreement between Yaoundé City and IRGM** for the implementation of the second phase of the Yaoundé City Sanitation Project (PADY2), which involved development of a flood prevention and management plan for the city of Yaoundé in collaboration with CRECC. One of the major recommendations of the plan is the installation of a network of hydrometeorological measurement equipment in Yaoundé, to ensure the control of flooding phenomena for more suitable solutions in the implementation of an Early Warning Systems (EWS).

b. and participation in the Global Monitoring for Environment and Security in Africa (GMES and Africa) Program 2022-2025.

    CRECC is one of six International Commission for the Congo-Oubangui-Sangha Basin (SICOS - Commission Internationale du Bassin Congo-Oubangui-Sangha) consortium partners in the project entitled "Management of Water and Natural Resources in Central Africa" (GERNAC), which promotes the sustainable management of natural resources by improving the decision-making process. This improvement is facilitated by providing additional relevant information using Earth Observation data. The project's four axes of intervention include: Service 1: Monitoring water levels for river navigation; Service 2: Monitoring the dynamics of flooded areas in the forests of the central basin; Service 3: Monitoring the hydrological balance of the sub-basins in the Central Africa region; Service 4: Strengthening human capacities in Earth Observation.

CRECC maintains the network of 65 hydrological stations through its network of hydrological observers who make two daily recordings at 6h and 18h. CRECC also manages ten rain gauges. The observations are collected every three months, and entered into the database that is stored in CRECC in Comma-Separated Values (CSV) format. For the stations in the flood prone areas, the observations are communicated via phone daily or subdaily depending on the level of risk, directly to the Director who then transmits the observation to the database technicians. The Director of CRECC is the point person for dissemination of flood Early Warning Alert on behalf of CRECC. However, the issues of maintenance leads to data gaps as observations may not be recorded timely or properly. Further, the Ministry of Water and Energy does not have access to the network of hydrological stations. As indicated earlier, CRECC is in the process of developing the National Water Information System for the MINEE that will display the hydrographs of the stations, but will not provide metadata. CRECC does not operate a hydrological model and does not have a hydrological forecast.

The ***role of CRECC in risk knowledge*** is to compile and maintain a comprehensive archive of the extent of fluvial (river) floods and hazard patterns. Although CRECC does not presently play a role in risk knowledge realm, the collection of this kind of data is essential for understanding the risk profiles relevant to different regions and for preparing appropriate responses to similar future events. CRECC and National Risk Observatory (ONR) should work together by leveraging their expertise, to optimize the visualization and cataloging of hazard events related to hydrological extremes, in a similar way that DMN is to support in relation to meteorological extremes.

The ***role of CRECC in monitoring and forecasting*** is key for hydrological hazards. It involves overseeing an extensive network of 65 hydrological stations and should enhance its technological capacities to leverage calibrated model estimates for regions without hydrological stations. Although the network's automated capabilities are not present at the moment, real-time monitoring of hydrological conditions is crucial for effective dissemination of meteorological information and forecasts. Furthermore, CRECC needs to leverage forecasting and hydrological models to support hydrological forecasting. Consequently, there is a pressing need to develop a robust climate information system that optimally combines satellite, station, and model data for comprehensive monitoring and localized forecasting of hydrological conditions. This system should be adaptable to include various indicators of hydrological extremes (streamflow percentile, etc.) and allow for remote sensing validations by drones (for flood mapping) and satellites (for soil moisture), among others.

The ***role of CRECC in warning and communication*** is to actively disseminate a range of hydrological bulletins and alerts in various languages, including daily and seasonal forecasts, along with specialized bulletins tailored for various sectors and major urban areas. These publications are critical for informing both the general public and relevant authorities about upcoming hydrological conditions and potential hazards. Moreover, CRECC needs to be compliant with Common Alert Protocols to ensure that the disseminated information is both standardized and actionable. Present person-to-person alert is structured to validate the already occurring hazard and does not allow for anticipatory action. A climate information system that simulates changes in water level, produces a bulletin to inform on the impending hazard, and disseminates the alert effectively to all stakeholders would enable more proactive measures, thereby enhancing the capacity to mitigate risks before they escalate into full-blown crises.

The ***role of CRECC in response capacity*** is to provide 'impact-based forecasts' utilizing historical hazard data, present exposure and vulnerability data, and modeling to contextualize potential future impacts, significantly aiding local administrators and emergency services in planning and implementing effective response strategies. Namely, there is a substantial opportunity to enhance these capacities through the automation of alert systems and the integration of exposure and vulnerability information, and operationalization of two- or three-dimensional hydrological models which would in turn provide additional insight of flood extent, depth, optimize the response efforts and improve the overall trustworthiness of impact-based forecasts.

Table 5 reveals CRECC's strengths, weaknesses, opportunities, and threats, highlighting its comprehensive expertise in hydrological and hydrogeological research and operations. However, it faces critical challenges such as data collection issues due to manual and volunteer-based mechanisms, limited technological infrastructure, and inadequate legal and institutional frameworks. To overcome these challenges, CRECC must enhance its modeling and data processing capabilities, streamline its data collection processes, and develop a robust legal framework to support its operations. These strategic actions are imperative for CRECC to effectively fulfill its role in Disaster Risk Management (DRM), ensuring timely and efficient responses to hydrological hazards and contributing to sustainable water resource management.

STRENGTHS	● **Scientifically sound assessments and evaluations.** The forty permanent staff members of CRECC have strong scientific background in hydrology, hydrogeology, hydrochemistry, hydrobiology, hydroecology, with regular scientific publications providing a good foundation for reliance on national capacities for studies. ● **International partnerships.** National collaboration with MINAT/DPC, MINEE and International collaboration with IRD, JICA, AfDB, World Bank, EU, WMO, UNESCO on multiple projects. ● **Strategic position in national projects.** Contribute in water resource evaluation for sustainable development, portable water supply, mining activities, etc. ● **Monitoring and management of hydrological and hydrogeological networks.**

WEAKNESSES	• **Data collection issues.** Data quality issues arise due to manual and observation mechanisms with no automated observation points due to maintenance issues. • **Data dissemination issues.** Observed data is collected every three months, which makes water resource management and early warning communication very difficult, especially, in terms of any timely decision making (delayed response to events, impaired forecasting and planning, etc.). • **Limited technological and operational infrastructure.** Due to constrained financial resources. • **Non-configuration of hydrological network for flood EWS**
OPPORTUNITIES	• **Development of the centralized National Water Information System with multi-level administration.** Optimizes maintenance resources and provides a necessary and acceptable level of data sharing and visualization to other organizations. • **Improved alert dissemination.** Present person-to-person procedures for dissemination of alerts can be streamlined with the use of a climate information system that would offer several significant advantages that can enhance the efficiency, reliability, and reach of the dissemination process. • **Expansion of monitoring capabilities.** Improve the network of hydrological stations to cover priority river catchments. • **Evidence-based policy advocacy.** Improvement of data collection and analysis capabilities, CRECC can play a pivotal role in shaping national water and climate policies, thereby contributing significantly to broader environmental governance. • **Technological advancements.** The interim solutions like calibrated river routing model, such as Routing Application for Parallel computatIon of Discharge model, could provide model estimates of water levels in rivers that are presently not covered by the hydrological network. • **Expansion of automatic hydrological stations and densification of hydrological stations.** • **Development of hydrological and hydrogeological forecast models.**
THREATS	• **Financial and logistical constraints.** • **Technological obsolescence.** • **Inter-institutional challenges.** Lack of collaboration with institutions that produce hydro-climatic data.

Table 5: SWOT analysis on the capacity of the CRECC

2.3.2 Institutional and technical gaps limiting the implementation of a functional flood early warning system in Cameroon.

The legislative and institutional framework for flood early warning systems (EWS) in Cameroon exhibits several critical deficiencies and inefficiencies. While the National Contingency Plan outlines the broad responsibilities, involved entities, and existing as well as missing capacities, a major concern is the unclear mandates assigned to each actor at different phases of disaster risk management. Numerous interconnected infrastructural and capacity challenges further diminish the effectiveness of the flood EWS (Figure 7). The inadequate hydrological network and infrequent data collection from monitoring stations, combined with the absence of operational hydrological or hydraulic modeling, significantly impede accurate and timely flood predictions. Additionally, without clearly defined alert levels and a comprehensive understanding of flood risks and associated vulnerabilities, the issuance of actionable warnings is not possible and it does not inform the affected grassroots communities and also impedes their ability to respond appropriately to flood threats. Figure 7 visually represents these discrepancies. This section further analyzes these gaps, addressing the identified areas of concern.

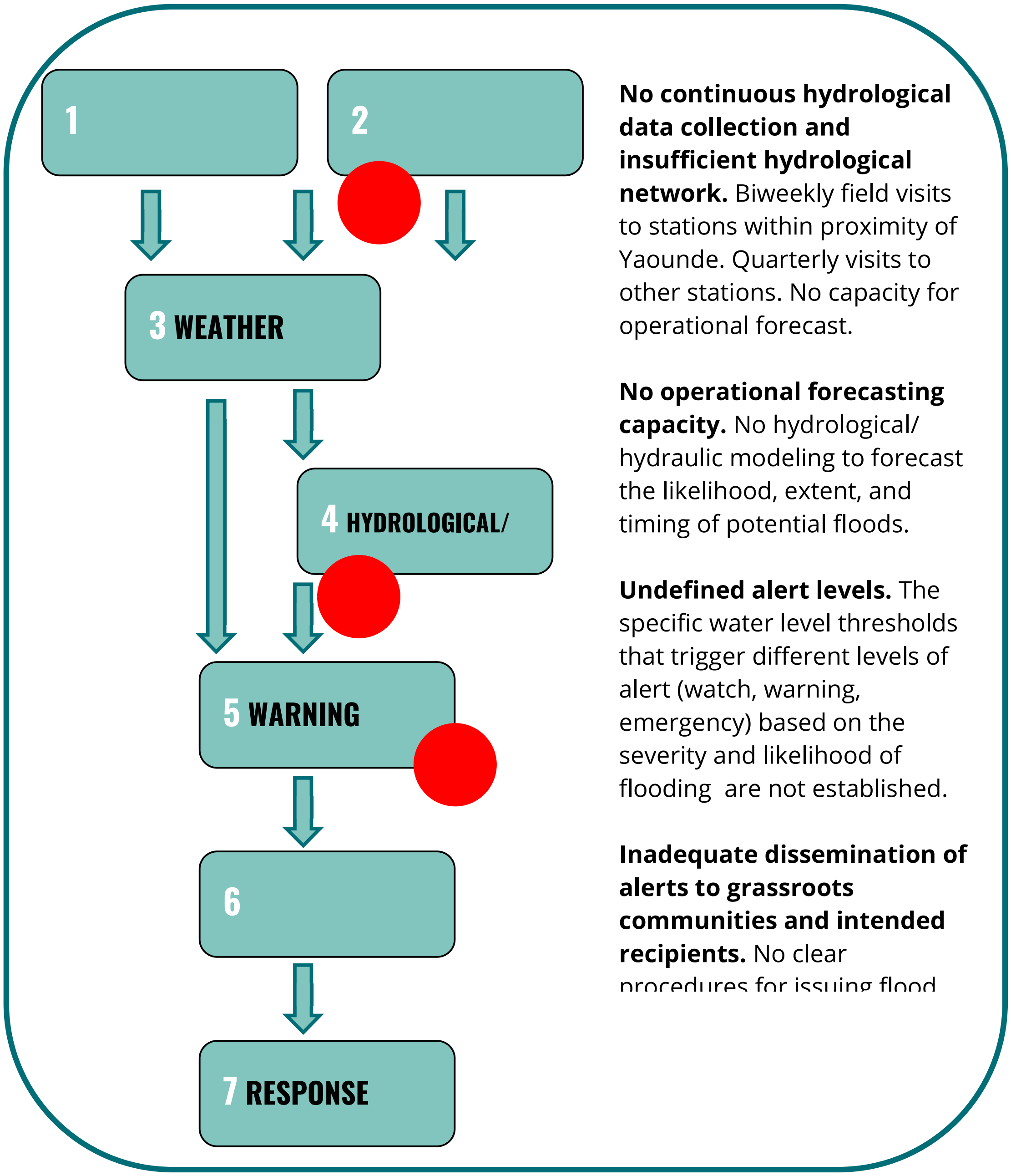

Figure 7: Identification of gaps in the operational framework for early warning systems in Cameroon.

2.3.2.1 Flood risk profile

The flood risk profile in Cameroon has several areas requiring improvement. While some historical flood data is available within the National Risk Observatory (ONR) in the Department of Civil Protection (DPC), it is neither comprehensive nor systematically recorded, indicating a need for more robust data collection and risk assessment processes. Although the DPC has been developing an application called CRYSIS to systematically collect post-disaster data, it is not yet operational. Flood risk mapping exists only for a few regions, and vulnerability mapping is poorly developed and outdated, suggesting that hazards and vulnerabilities are not well known across the country.

There is limited documentation on the impact of land-use changes and ecosystem degradation on flood risks, which hinders the ability to identify patterns and trends in these factors. Additionally, climate change modeling is insufficient to inform policy and planning, further complicating the assessment of future flood risks.

However, there is relatively good awareness of flood risks among the population. Despite this, perceptions and responses vary significantly between urban and rural areas, which impacts the overall effectiveness of flood risk management and community preparedness. The lack of widely available risk maps and comprehensive data on vulnerabilities underscores the need for systematic data collection and improved risk assessments to enhance the country's flood early warning system.

TECHNICAL GAPS	INSTITUTIONAL GAPS
• Comprehensive flood risk maps for all regions are needed. • Vulnerability assessment approaches need to provide clearer understanding of exposure and resilience. • Documentation and understanding of how land-use changes and ecosystem degradation affect flood risks are required. • Detailed hydrological climate change projections are necessary to anticipate and plan for future flood risks. • Data collection and analysis efforts by DPC and other institutions need to be fully operational and integrated.	• Better coordination and integration of efforts between institutions such as DPC, DMN, and academic researchers are needed. • Regular updating and maintenance of ORSEC plans are required to keep them relevant and effective. • Capacity building in institutions is necessary for detailed and continuous flood risk assessments, including impacts of climate change, land-use changes, and ecosystem degradation. • More targeted and culturally sensitive approaches are needed to ensure all communities understand and respond appropriately to flood risks. • Robust policy development and planning processes are required to incorporate detailed scientific data and projections, particularly for climate change impact evaluations.

2.3.2.2 Hazard observation and monitoring

The monitoring of meteorological and hydrological data in Cameroon faces significant challenges due to insufficient station density, limited historical data quality, inadequate frequency of data collection, and poor maintenance, all exacerbated by budgetary constraints. Although some data is shared with international databases, dissemination and accessibility are restricted, limiting broader use and analysis by third parties. Meteorological data is crucial for hydrological modeling, providing essential input parameters like precipitation, temperature, humidity, and wind speed, which are vital for the development of reliable models for predicting water flow and flood events. However, a significant issue in Cameroon is the lack of data sharing among all key flood early warning institutions, which hinders the development of integrated models and the effective use of available data, limiting the ability to create comprehensive and accurate hydrological models and analyses necessary for flood risk assessment and early warning systems.

TECHNICAL GAPS	INSTITUTIONAL GAPS
• The current number of meteorological and hydrological stations is inadequate for comprehensive flood monitoring and forecasting, falling short of WMO recommendations. • The manual collection of data is infrequent, and there is limited real-time data collection, which is crucial for timely flood warnings. • Poor maintenance and lack of high-quality equipment reduce the reliability of the data collected. • There are significant gaps in the historical data due to periods of financial instability and inadequate record-keeping practices. • Data is not widely published or shared, reducing opportunities for external validation, research, and enhanced forecasting capabilities.	• Both the DMN and CRECC face financial constraints that hinder their ability to maintain and expand their monitoring networks and ensure the quality of the data collected. • There is a need for capacity building within the institutions to ensure that they have the necessary expertise and means to manage and maintain the monitoring networks effectively. • Enhanced policy and regulatory frameworks are needed to support the systematic collection, maintenance, and publication of meteorological and hydrological data. • Increasing the transparency and availability of data to the public and other stakeholders could foster greater collaboration and improve the overall effectiveness of the flood early warning system.

2.3.2.3 Hazard forecasting and warning

Cameroon's capabilities in meteorological forecasting for flood early warning are limited but demonstrate areas of potential improvement. According to DMN, meteorological forecasts can predict events with high-rainfall amounts with reasonable skill, but they lack the precision required for accurate spatial predictions. The absence of a supercomputer and higher internet speed hinders the processing of larger amounts of data and the production of higher spatial resolution forecasts.[9] The lead time for forecasts provides some preparation time, but the degree of uncertainty is such that few preparedness actions are taken before the hazard unfolds. Furthermore, there are no hydrological forecasts available, meaning there is no capacity for hydrological / hydraulic modeling to predict the extent of a flood event, its location, or lead times.

TECHNICAL GAPS	INSTITUTIONAL GAPS
• There is a need for capacity building of modelers and forecasters to develop and operate hydrological forecasting models. • The absence of hydrological forecasts means there is no	• There is a need for development of specific water level thresholds and the associated alert levels based on the severity and likelihood of flooding. • Increased investment in technological infrastructure,

[9] The internet speed observed during the visit was measured at 14 Mbps, which is sufficient for basic online activities such as email, web browsing, and some data transfer. However, it is inadequate for handling large datasets, high-resolution satellite imagery, real-time data transfer, and other bandwidth-intensive tasks required by a meteorological department.

capacity to predict flood events, making it impossible to provide accurate and timely warnings. • Currently, there is no tool to visualize indices of pluvial floods, which is necessary for integrating rainfall intensity forecasts into the flood early warning system. • The lack of validation for DMN forecasts and the absence of digitized hindcast data limit the ability to assess and improve forecast accuracy. • The absence of a supercomputer and advanced modeling tools restricts the development of detailed and precise forecasts, which is crucial for effective flood forecasting.	such as supercomputers, advanced forecasting and modeling tools, and internet bandwidth is necessary to enhance the accuracy and utility of forecasts. • Establishing processes for the digitization of forecasts and validation of hindcast, as well as improving data sharing and transparency, would strengthen the overall forecasting framework. • Strengthening policies and regulations to support the development and integration of advanced forecasting systems into the national flood early warning system is crucial.

2.3.2.4 Early warning communication and dissemination

The early warning communication and dissemination system shows mixed effectiveness. While there are established channels for disseminating warnings through administrative authorities and some use of alternative communication methods, significant gaps remain. The dissemination chain is enforced through government policy, but coordination and specific responsibilities among actors are inconsistent. Warning services are not operational 24/7, and communication technology does not reach the entire population, especially in remote rural areas. The clarity and specificity of warning messages are also limited, affecting the ability of communities to respond appropriately.

TECHNICAL GAPS	INSTITUTIONAL GAPS
• Both DMN and DPC lack round-the-clock operational centers, which limits the timely dissemination of warnings outside of working hours. • Internet and mobile service coverage are insufficient in remote rural areas, making it challenging to reach the entire population. • Warning messages lack geographic specificity and detailed impact information, which reduces their effectiveness in guiding community response. • The operational status of urban and rural radios, which are crucial for disseminating warnings, needs to be verified and ensured.	• There are challenges in coordinating actors during disaster response, with many acting independently and not adhering to Standard Operating Procedures (SOPs). • The National Strategy for Disaster Risk Management is still awaiting approval, and its implementation is crucial for a systematic approach to warning dissemination. • Both DMN and DPC need to develop the capacity to operate 24/7, which includes training skilled operators and establishing robust operational protocols. • Increased investment in communication infrastructure is needed to ensure comprehensive coverage and effective dissemination of warnings across all regions. • Efforts should be made to improve community understanding and response to warnings, including translating messages into local languages and ensuring they are clear and actionable.

2.3.2.5 Response capacity

Within the UNDRR people-centered EWS framework, the focus of the capacity response element is on preparedness, community engagement, coordination, regular drills, resource availability, and post-event learning rather than a detailed capacity assessment. To ensure that communities are well-prepared, informed, and capable of responding effectively to warnings, the response capacity for flood events in Cameroon requires significant improvement. While local leaders and sub-division authorities decide on response actions based on the contingency plans, these plans are not comprehensive or up-to-date across all regions. Community hazard plans and drills are in place in some areas but not uniformly implemented. Evacuation centers are established post-factum, only after the floods occur, and emergency supplies are generally insufficient, with significant gaps in equipment and resources. Individual communities have developed adaptive strategies, but overall resilience is limited. Post-disaster evaluations and plan reviews are lacking, which impedes continuous improvement in disaster response.

TECHNICAL GAPS	INSTITUTIONAL GAPS
• 53 out of 58 divisions lack up-to-date ORSEC plans, while 37 divisions do not have a developed ORSEC plan; this, limiting the ability to coordinate effective responses. • Not all divisions are trained in possible response actions, reducing overall preparedness and response effectiveness. • There is a lack of adequately equipped evacuation centers, emergency stocks, and necessary equipment for disaster response. • There is a lack of systematic evaluation and updating of disaster response plans after events, which prevents learning and improvement.	• Coordinating the response efforts of different state actors is challenging, and many do not adhere to the established Standard Operating Procedures. • Clear roles in the legislation for NGOs and private companies are needed. • The National Strategy for Disaster Risk Management has not yet been approved, which hinders the formalization and enforcement of response protocols. • There is a need for increased capacity and resources within institutions to manage and update contingency plans, conduct regular drills, and maintain necessary supplies and equipment. • Securing sufficient quantities and managing resources for disaster response is challenging, leading to insufficient replenishable emergency supplies and a lack of necessary reusable equipment, despite effective management in some areas. • Increased efforts are needed to ensure communities are well-informed and regularly trained in disaster response actions. • The lack of a needs assessment for specific demands on flood-risk knowledge per target group results in a poor understanding at the national level of the needs and demands of local communities.

Section 3: CONCLUSION

The assessment identifies critical technical and institutional gaps that should guide the creation of a roadmap to address these issues. The roadmap should consider the primary institutional and technical gaps, enabling factors, and potential risks. Focused on the UNDRR people-centered early warning system framework, the assessment can be further improved by: (i) conducting a comprehensive review of the current Standard Operation Procedures of the DPC, including communication systems and networks such as mobile coverage, HF radio, FM radio, internet access, and satellite internet; (ii) collecting lessons learned from past and ongoing flood early warning initiatives; (iii) analyzing the legal framework, including policies, acts, and regulations of stakeholders involved in centralized and decentralized decision-making and operational levels; and (iv) performing a thorough capacity assessment of stakeholders, covering staff knowledge levels, staff quantity, training programs, and available resources.

The main institutional gaps are:

- There are significant challenges in coordinating the response efforts of different state actors, with many not adhering to established Standard Operating Procedures (SOPs), leading to fragmented and ineffective disaster response.
- There is a need for increased capacity and resources within institutions to manage and update contingency plans, conduct regular drills, and maintain necessary supplies and equipment.
- Coordination of effective response is severely limited with a large proportion of divisions lacking up-to-date ORSEC plans (53 out of 58).
- There is a lack of systematic evaluation and updating of disaster response plans after events, preventing continuous improvement and learning.
- Financial constraints hinder the ability of key stakeholders in flood Early Warning (EW) to maintain and expand their monitoring networks, ensure the quality of the data collected, and most importantly, share data among themselves.
- Although floods are recognized as one of most impactful hazards in the national strategic documents, the political support in lieu of public investment in strengthening infrastructural and knowledge capacities throughout the flood EWS chain is lacking, resulting in non-existent flood forecasting and modeling.
- Not all divisions are trained in possible response actions, reducing overall preparedness and response effectiveness.
- More targeted and culturally sensitive approaches are needed to ensure all communities understand and respond appropriately to flood risks.

The main technical gaps are:

- The current number of meteorological and hydrological stations is inadequate for comprehensive flood monitoring and forecasting, falling short of World Meteorological Organization (WMO) recommendations, which is an underestimation given the convective character of rainfall in the country with rainfall predominantly highly localized and intense.
- The manual collection of data is infrequent, and there is limited real-time data collection, which is crucial for timely flood warnings.
- Poor maintenance and lack of high-quality equipment reduce the reliability of the data collected.

- The absence of a supercomputer and advanced modeling tools restricts the development of detailed and precise forecasts, which is crucial for effective flood forecasting.
- Data is not widely published or shared, reducing opportunities for external validation, research, and enhanced forecasting capabilities.
- The absence of hydrological forecasts means there is no capacity to predict flood events accurately and provide timely warnings.
- Warning messages lack levels related to likelihood of occurrence and intensity as well as geographic specificity and detailed impact information, which reduces their effectiveness in guiding community response.
- Internet and mobile service coverage are insufficient in remote rural areas, making it challenging to reach the entire population with warnings.

Enabling factors:

- The National Strategy for Disaster Risk Management (*Stratégie Nationale de Gestion des Risques de Catastrophe*) is drafted and aims to provide a comprehensive DRM policy framework, updating the current DPC mandate that dates back to 1998.
- High-level political support within the domain of national DRM policy has potential to be expanded into financial support.
- The key institutions of the flood early warning chain have robust national and international partnership networks, offering opportunities for collaboration, knowledge sharing, resource sharing, and advocacy.
- International partners are willing to contribute resources to strengthen the DRM capacities, as evidenced by the recent $US 183.4 million Resilience and Sustainability Facility from the International Monetary Fund, designed to encourage reforms and strengthen the national DRM and climate change institutional and policy frameworks.
- There is relatively high awareness of flood risks among the population, which can be leveraged for community engagement and preparedness.
- Key institutions for flood early warning possess significant expertise for developing evidence to support data-driven policy formulation, such as ONACC with its mandate and experience in climate analysis, and CRECC with its scientific assessments.

Potential risks:

- Increasing climate variability and extremes raise the unpredictability and severity of weather events, challenging forecasting and mitigation efforts.
- Limited financial resources pose significant threats to (i) achieving necessary staffing levels; (ii) the maintenance and expansion of monitoring networks, particularly the hydrological network, and (iii) the implementation of advanced flood forecasting tools that produce detailed and precise forecasts to capture the predominantly localized and intense rainfall in the country.
- Significant gaps in historical data and inadequate record-keeping practices hinder the development of reliable models for predicting water flow and flood events.
- The integrity of forecasts, warning messages, and decision-making processes is potentially compromised by an over-reliance on machine learning models that lack sufficient historical records and validation.
- Difficulties in achieving effective collaboration and data sharing among government agencies and departments can hinder disaster response efforts and prevent agencies from fully

utilizing their capacities.

- Vandalism and operational risks in conflict areas pose significant challenges to the effectiveness of the early warning system.
- Delays in the approval and implementation of crucial policies and strategies hinder the formalization and enforcement of comprehensive disaster risk management protocols, including clear mandates for flood forecasting and responsibilities related to its management and post-disaster relief.