



A Localized Community-Centered Early Warning System Framework for Climate Risk Management in Jordan

Doa'a Lutfi Mahmud Hassnin Al Derabani¹, Abdallah Munther Abdallah Abu omar²,
Hamza Odeh Ahmad Abusuailik³

Abstract

Climate change is increasing the frequency and intensity of climate-related hazards worldwide, placing growing pressure on governments, municipalities, and communities to strengthen preparedness and resilience. Early Warning Systems (EWS) have emerged as a critical component of disaster risk reduction and climate adaptation efforts, particularly in vulnerable regions facing increasing exposure to floods, heatwaves, and other extreme weather events. In Jordan, while significant progress has been achieved in strengthening national early warning capacities, challenges remain in translating warning information into effective local preparedness and response actions.

This study assesses the current status of climate-related Early Warning Systems in Irbid and Ramtha, Jordan, and examines opportunities for strengthening localized and community-centered approaches to climate-risk management. The research adopted a qualitative case-study design combining desk review, institutional analysis, stakeholder consultations, and focus group discussions. The assessment was guided by the four pillars of people-centered Early Warning Systems promoted under the Sendai Framework for Disaster Risk Reduction and the United Nations Early Warnings for All initiative: risk knowledge, monitoring and forecasting, warning dissemination and communication, and preparedness and response capacity.

The findings indicate that Jordan has established a progressively evolving institutional framework for climate-related Early Warning Systems. However, significant gaps persist at municipal and community levels, including limited integration of Geographic Information Systems (GIS), fragmented data management systems, weak interoperability between national and local information platforms, insufficient impact-based warning mechanisms, and challenges related to last-mile communication and community engagement. The study further demonstrates that warning effectiveness depends not only on forecasting capabilities and technological infrastructure, but also on community awareness, preparedness, trust in institutions, and the ability of vulnerable populations to access and act upon warning information.

Based on these findings, the study proposes a Localized Community-Centered Early Warning System Framework that strengthens linkages between national forecasting institutions, municipalities, and local communities through integrated risk analysis, GIS-supported decision-making, multi-channel communication mechanisms, anticipatory action planning, and community participation. The study also highlights the role of the Al-Munther Climate Initiative, a community-based climate awareness and preparedness initiative, as a complementary mechanism for strengthening climate literacy, risk awareness, and public engagement within localized Early Warning Systems.

The proposed framework provides practical insights for advancing impact-based and people-centered Early Warning Systems in climate-vulnerable and resource-constrained settings. Although developed in the context of Irbid and Ramtha, its principles may be adapted and replicated in other municipalities across Jordan and the wider Middle East region to support climate resilience, disaster preparedness, and sustainable risk governance.

¹Chief Executive Officer CEO of Climate Action Association in Jordan CAN Jordan – Researcher, Climate Action Association in Jordan CAN Jordan- Amman, Jordan, pdm@climateaction-now.org

²Researcher, Climate Action Association in Jordan CAN Jordan- Amman, Jordan, a.abuomar@climateaction-now.org

³Researcher, Climate Action Association in Jordan CAN Jordan- Amman, Jordan, env@climateaction-now.org

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1. Introduction

This report presents a comprehensive desk review of climate risks, disaster risk reduction (DRR), and early warning systems (EWS) in northern Jordan, with a particular focus on Irbid and Ramtha municipalities under the framework of Al-Munther Al-Monakhi Initiative - implemented by Climate Action Association CAN Jordan. The review consolidates information from national policies and strategies, institutional reports, scientific literature, climate risk assessments, municipal consultations, and stakeholder engagement activities conducted within Al Munther Al Monakhi Initiative framework. Its purpose is to establish a baseline understanding of Jordan's multi-hazard climate profile, institutional preparedness, municipal capacities, and community vulnerabilities, while identifying existing gaps and opportunities for strengthening localized and impact-based early warning systems.

Jordan is among the countries most vulnerable to the impacts of climate change due to its arid to semi-arid climatic conditions, limited natural resources, and increasing exposure to climate-induced hazards. More than 90% of the country receives less than 200 mm of annual rainfall, while northern governorates such as Irbid experience seasonal rainfall variability that contributes simultaneously to drought conditions and flash flood risks. Climate change projections indicate increasing temperatures, declining precipitation rates, and growing frequency and intensity of extreme weather events, including droughts, heatwaves, and flash floods. These climate pressures are compounded by rapid urbanization, infrastructure stress, environmental degradation, and demographic pressures associated with large refugee populations.

Jordan also faces significant socio-economic and environmental challenges resulting from regional instability and forced displacement. The country hosts one of the highest refugee-to-population ratios globally, placing substantial pressure on water resources, infrastructure, municipal services, and local governance systems. At the same time, Jordan remains one of the most water-scarce countries in the world, with renewable freshwater availability significantly below international water poverty thresholds. These overlapping pressures increase vulnerability to climate-related hazards, particularly in northern municipalities such as Irbid and Ramtha, where rapid population growth and urban expansion have intensified risks associated with flooding, water scarcity, infrastructure stress, and inadequate disaster preparedness.

Jordan's hazard profile is multi-dimensional and includes flash floods, droughts, earthquakes, heatwaves, snowstorms, landslides, and emerging climate-related risks such as wildfires. Among these, flash floods represent one of the highest-priority hazards due to their sudden onset, recurrent impacts, and potential for significant human and infrastructural losses. Historical events, including the Dead Sea floods in 2018 and recurring flood incidents in northern wadis, demonstrate the growing importance of strengthening early warning systems and anticipatory action capacities at both national and local levels.

Early Warning Systems (EWSs) play a critical role in disaster risk reduction by enabling timely preparedness and response actions before hazards escalate into disasters. Effective early warning systems help reduce human casualties, economic losses, and damage to infrastructure by ensuring that warnings reach vulnerable communities in a timely and understandable manner. However, the effectiveness of EWSs depends not only on forecasting technologies and institutional coordination, but also on community awareness, preparedness, and participation. Communities need to understand existing risks and be actively engaged in preparedness activities before disasters occur. Limited awareness and inadequate preparedness can undermine emergency response efforts and reduce the effectiveness of warning dissemination and evacuation measures.

International experiences demonstrate the importance and effectiveness of well-functioning early warning systems. One notable example is Bangladesh, where the implementation of cyclone early warning systems and evacuation mechanisms significantly reduced disaster mortality. The system provides communities with up to 48 hours of advance warning before cyclone landfall, enabling large-scale evacuation and preparedness measures. As a result, cyclone-related deaths declined dramatically from approximately 300,000 fatalities during Cyclone Bhola in 1970 to around 3,500 deaths during Cyclone Sidr in 2007. This example highlights the critical value of community-centered early warning systems and the importance of linking forecasting, communication, preparedness, and local response capacities.

In response to growing climate and disaster risks, Jordan has made progress in strengthening its institutional framework for disaster risk reduction and climate adaptation. The National Center for Security and Crisis Management (NCSCM), the Jordan Meteorological Department (JMD), the Ministry of Local Administration (MoLA), and sectoral ministries play central roles in monitoring hazards, issuing warnings, and coordinating emergency response efforts. Furthermore, the National Disaster Risk Reduction Strategy 2023–2030 indicates that Jordan's early warning system still requires greater institutional and technical integration, particularly in relation to data sharing, local preparedness, and the coordination of roles among sectors and municipalities.

Within this context, this study proposes a localized and community-centered early warning system framework under the Al-Munther Al Monakhi Initiative for application in Irbid and Ramtha, Jordan. The proposed framework aims to strengthen coordination among national institutions, local authorities, and communities through integrated risk

communication, GIS-based hazard mapping, community participation, anticipatory action planning, and localized warning dissemination mechanisms. Special consideration is given to vulnerable groups, including refugees, women, informal settlements, and communities located in flood-prone areas. The framework is designed to enhance preparedness, support timely response, and strengthen local resilience to climate-related hazards.

This desk review therefore provides the analytical foundation for understanding the current status of climate risk management and early warning systems in the project areas. It also supports the identification of institutional, technical, and operational gaps that need to be addressed in order to develop more inclusive, integrated, and impact-based early warning systems capable of improving resilience and reducing climate-related risks at the municipal and community levels.

1.1 Statement of the Problem

The climate change crisis highlights the need to put a higher emphasis on climate diplomacy as a means of cooperating in reducing its impact on countries. Although the world community has been negotiating for decades, it has not reached equitable and enforceable agreements because the global system contains structural issues, including conflicting national interests and geopolitical divisions between developed and developing nations (Council of the EU, 2020; United Nations, 2020). This poses a challenge: climate change is a borderless problem that needs to be addressed by a unified effort, yet despite all international efforts being fraught with competing priorities and effective implementation strategies (Bulkeley, 2015).

The gap in the research is the lack of discussion of the possibility of redefining climate diplomacy not as negotiations, but as its practical way to implement and organize mitigation policies among various actors. More recent national reports, such as the Fourth National Communication (2023) of Jordan and its National Adaptation Plan (2023), explain new vulnerability figures, namely an estimated water shortage of more than 480 million cubic meters over 2030 and an extent of energy dependence of more than 90%, therefore, elucidating the urgency of integrating climate diplomacy into national adaptation and mitigation strategies.

In addition, the First Transparency Report (2024) enhances monitoring, reporting, and verification (MRV), which enhances the accountability and transparency of Jordan in the implementation of its international climate commitments.

The majority of the scholarship focuses on agreements like the Paris Accord, but little has focused on the process of operationalization of climate diplomacy in inequality as a form of addressing North-South relations, resilience building, and balancing between development and mitigation (Kamali & Jönsson, 2019; Krampe & Mitrotta, 2018). The answer lies in enhancing climate diplomacy by involving all countries in cooperating internationally by incorporating science, development, and security views. It includes the identification of differentiated roles, mobilization of financial and technical resources, as well as the creation of governance structures that would guarantee accountability in addition to empowering the vulnerable states (Oberthür & Groen, 2017; Moran et al., 2019). In such a way, climate diplomacy will change the image of symbolic negotiations into practical strategies of global mitigation. In light of the above, the following research questions are targeted in this study:

1. How does climate diplomacy facilitate international cooperation in developing and implementing effective mitigation strategies against climate change?
2. What are the challenges and opportunities for international cooperation in advancing climate diplomacy as a tool for mitigating climate change, particularly between developed and developing countries?

2. Literature Review

Over recent years, Jordan has witnessed gradual progress in the development and use of digital systems and platforms related to disaster risk management and early warning, particularly in light of the growing impacts of climate change, including flash floods, heatwaves, droughts, and severe weather events. National institutions have increasingly moved toward developing Multi-Hazard Early Warning Systems (MHEWS) that integrate climate monitoring, digital analysis, data management, and rapid communication with governmental entities and local communities. These systems include centralized national platforms, local flood early warning systems, digital emergency applications, and municipal communication platforms that support emergency response and crisis management.

1. National Center for Security and Crisis Management (NCSCM)

The National Center for Security and Crisis Management is the primary national institution responsible for coordinating disaster and crisis management in Jordan. The Center leads national efforts aimed at developing an integrated multi-hazard early warning system and strengthening institutional coordination among governmental, technical, and security entities within a unified national emergency response framework.

The Center operates in coordination with national institutions, including:

- Jordan Meteorological Department.
- Civil Defense Directorate.
- Ministry of Water and Irrigation.
- Jordan Valley Authority.
- Ministry of local administration.
- security agencies and national operation rooms.

This coordination framework aims to:

- support decision-making during emergencies.

- accelerate response procedures.
- improve data sharing mechanisms.
- issue early warnings related to climate and natural hazards.

In recent years, Jordan has increasingly focused on developing multi-hazard warning systems and linking them with national crisis management platforms, in line with the Sendai Framework for Disaster Risk Reduction and the United Nations' "Early Warnings for All" Initiative.

2. Pilot Launch of the Mobile Early Warning System

In 2026, the Ministry of Digital Economy and Entrepreneurship, in cooperation with the National Center for Security and Crisis Management, announced the pilot launch of a Mobile Early Warning System aimed at delivering instant alerts to citizens during severe weather conditions and natural disasters.

The system is designed to:

- send direct warning messages to mobile phones.
- issue automated audio alerts.
- rapidly reach populations within affected areas.
- support communication during emergencies and climate-related disasters.

This initiative represents an important step toward establishing a modern national early warning infrastructure based on digital communication technologies and mobile networks, particularly given the need to deliver timely and effective alerts to residents, tourists, and vulnerable groups.

The Petra region was selected as the first pilot area to evaluate the system's efficiency and operational effectiveness, especially during unstable weather conditions and flash flood events.

Local Flood Early Warning Systems: The Petra Experience

The experience of the Petra Development and Tourism Region Authority is considered one of the most advanced local examples of flood early warning systems in Jordan. The Authority developed a specialized system for monitoring flash floods in order to protect residents, tourists, and archaeological sites in Petra and Wadi Musa.

The system was developed in response to repeated flood incidents over previous decades, which caused significant human and material losses and negatively affected tourism and heritage sites. Studies indicate that the rugged topography of Petra, combined with increasing climate change impacts, significantly raises the likelihood of recurrent flash floods.

The Petra Flash Flood Early Warning System represents one of the most advanced localized EWS experiences in Jordan. Since its establishment in 2018, the system has undergone several phases of institutional and technical development, providing a practical example of how localized warning systems can enhance preparedness and reduce disaster impacts (Figure 1).

Phase One: System Establishment (2018)¹

In 2018, the United Nations Development Programme, in cooperation with the Petra Development and Tourism Region Authority and with support from the Swiss Agency for Development and Cooperation (SDC), launched the first integrated flash flood early warning system in Petra.

The project aimed to:

- improve early prediction of flood risks.
- reduce human and material losses.
- support evacuation and rapid response plans.
- protect residents, tourists, and heritage sites.

The project included:

- installation of flood monitoring equipment.
- development of hazard and risk maps.
- training of local and technical staff.
- enhancement of monitoring and climate analysis capacities.

Phase Two: Expansion and Institutional Development (2019–2023)²

Beginning in 2019, Jordan initiated broader efforts to develop a more integrated national flood early warning approach through cooperation between the National Center for Security and Crisis Management and the United Nations Development Programme, with the objective of unifying national flood risk management efforts.

In 2023, the Petra Authority launched an upgraded version of the system in cooperation with the USAID-funded Municipal Support Program and Arabia Weather.

The upgraded system included:

- real-time monitoring maps.
- hazard level maps.

¹ <https://www.undp.org/jordan/stories/undp-and-pdtra-establish-early-warning-system-flash-floods?utm>

² https://jordantimes.com/news/local/pdtra-launches-second-early-warning-system?utm_

- hourly weather forecasts for up to five days.
- monitoring of valleys and flood channels.
- proactive warning issuance.
- support for emergency operation rooms.

The system also contributed to:

- increasing emergency preparedness.
- accelerating disaster response.
- reducing damages and operational costs.
- improving protection of tourists and heritage sites.

Recent Developments (2025–2026)

Between 2025 and 2026, the system underwent additional upgrades, including:

- modernization of monitoring stations.
- rehabilitation of warning sirens.
- expansion of geographical coverage.
- enhancement of communication and monitoring systems.
- improved integration with the national mobile early warning system.

The Petra experience is widely considered a national model that could be replicated in other municipalities, particularly in northern governorates such as Irbid and Ramtha, where municipalities face increasing challenges related to flash floods and inadequate stormwater infrastructure.

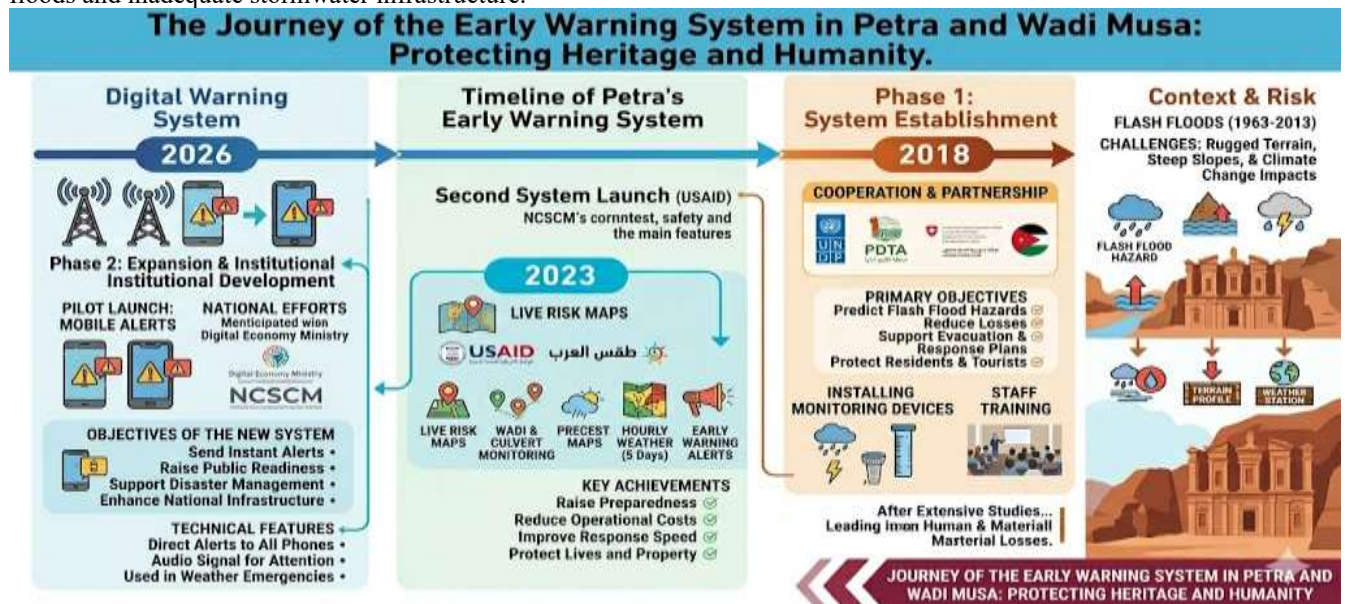


Figure 1. Evolution of the Petra Flash Flood Early Warning System in Jordan (2018–2026)

3. Digital Applications for Emergency Response

The Public Security Directorate developed the Aman 911 application as a digital emergency and public safety platform. The application enables users to:

- report accidents and emergencies.
- communicate rapidly with emergency services.
- monitor road and weather conditions.
- receive official alerts and emergency instructions.

The application is considered one of the key digital tools supporting emergency response and early warning communication in Jordan, especially during weather-related emergencies and disasters.

4. Municipal Digital Platforms and Community Communication

Jordan has also witnessed increasing use of digital municipal and community engagement platforms. The Ministry of Local Administration launched digital initiatives aimed at improving interaction between municipalities and citizens and facilitating access to municipal information and services.

In addition, the Greater Amman Municipality, in partnership with the United Nations Development Programme, developed the “Amman is Listening” platform, which supports urban resilience and improves communication during emergencies and crises.³

Despite the importance of these initiatives, many municipalities in Jordan, including those in northern governorates, still face significant challenges related to:

³ https://sdglocalaction.org/amman-platform-launch/?utm_source

- limited digital integration.
- insufficient localized climate data.
- lack of municipal-level warning systems.
- weak connectivity with national platforms.

5. National Flood Mapping Program (2026)⁴

As part of Jordan's efforts to strengthen preparedness and flood risk management, the National Center for Security and Crisis Management, in cooperation with the Ministry of Water and Irrigation and the Jordan Valley Authority, launched the National Flood Mapping Program in 2026.

The program aims to:

- develop accurate flood hazard maps.
- support early warning systems.
- strengthen climate risk management.
- protect lives and infrastructure.
- improve urban planning and emergency response.

The first phase covered:

- Aqaba.
- Wadi Zarqa Ma'in.

with future plans to expand the program to other regions across the Kingdom.

The program also focused on:

- improving institutional governance and coordination.
- developing national databases.
- strengthening data collection and analysis.
- enhancing integration among technical and governmental entities.

This initiative represents an important strategic step toward establishing a unified national database related to flood hazards and climate risks in Jordan.

Current Challenges in Digital Systems and Early Warning

Despite the gradual development of digital systems and early warning initiatives in Jordan, national reports and literature indicate the persistence of several key challenges, including:

- weak interoperability among institutions and systems.
- limited data sharing between national agencies and municipalities.
- insufficient local monitoring systems in some governorates.
- limited use of real-time data.
- absence of impact-based early warning systems.
- varying levels of technical and institutional readiness among municipalities.

Studies further emphasize the need to develop a unified national platform linking:

- meteorological data.
- flood maps.
- municipal infrastructure information.
- emergency operation rooms.
- community communication systems.

in order to ensure faster, more coordinated, and more effective responses to climate-related hazards and disasters.

Agricultural and Climate Early Warning Systems

The Ministry of Agriculture, in cooperation with a number of international projects and programs, utilizes a range of agricultural and climate early warning tools and services aimed at supporting the agricultural sector and strengthening farmers' capacity to adapt to climate change. These include:

- Forecasting drought conditions and monitoring rainfall deficits and soil moisture indicators.
- Issuing warnings related to heatwaves, frost, and extreme cold events and their potential impacts on agricultural crops.
- Providing agro-climatic services to farmers, including seasonal guidance and recommendations related to planting schedules, irrigation practices, and climate risk management.

⁴https://www.mwi.gov.jo/Ar/NewsDetails/%D8%A5%D8%B7%D9%84%D8%A7%D9%82_%D8%A7%D9%84%D8%A8%D8%B1%D9%86%D8%A7%D9%85%D8%AC_%D8%A7%D9%84%D9%88%D8%B7%D9%86%D9%8A_%D9%84%D8%A5%D9%86%D8%AA%D8%A7%D8%AC_%D8%AE%D8%B1%D8%A7%D8%A6%D8%B7_%D8%A7%D9%84%D9%81%D9%8A%D8%B6%D8%A7%D9%86%D8%A7%D8%AA_%D9%84%D8%AA%D8%B9%D8%B2%D9%8A%D8%B2_%D8%A7%D9%84%D8%AC%D8%A7%D9%87%D8%B2%D9%8A%D8%A9_%D9%88%D8%A5%D8%AF%D8%A7%D8%B1%D8%A9_%D8%A7%D9%84%D9%85%D8%AE%D8%A7%D8%B7%D8%B1_%D9%81%D9%8A_%D8%A7%D9%84%D8%A3%D8%B1%D8%AF%D9%86?utm_

- Supporting the use of climate and digital data to improve agricultural productivity and facilitate early decision-making related to food security and water resource management.

The Institutional Flow of Climate Early Warning Information to Municipalities in Jordan

The process through which climate information reaches municipalities in Jordan involves several interconnected stages that begin with meteorological monitoring and end with local field-level response. This process starts with the Jordan Meteorological Department (JMD), which monitors and analyzes climate and weather data through observation stations, satellite imagery, and numerical weather forecasting models. Following data analysis, the Department issues weather forecasts and climate-related warnings concerning extreme weather events such as heavy rainfall, flash floods, storms, and heatwaves.

In the next stage, this information is transmitted to the national authorities responsible for emergency and crisis management, primarily the National Center for Security and Crisis Management (NCSCM), in addition to the Ministry of Interior, the Ministry of Local Administration, the Civil Defense Directorate, and administrative governors. These entities assess the level of risk and coordinate response measures according to the nature of the weather event and the areas expected to be affected.

Subsequently, warnings and climate information are communicated to municipalities through multiple channels, including official correspondence, operation rooms, telephone communication, and practical digital tools such as WhatsApp groups and social media platforms, which are frequently used as supportive and rapid coordination mechanisms alongside formal communication channels. In some cases, direct coordination takes place between national operation rooms and municipalities in order to raise preparedness levels and implement the necessary precautionary measures.

In the final stage, municipalities translate this information into practical field actions, such as increasing the readiness of emergency teams, cleaning stormwater drainage systems, preparing machinery and equipment, closing hazardous roads when necessary, and warning residents in high-risk areas.

Despite the existence of this institutional process, several challenges remain, particularly regarding the speed of information flow, the standardization of communication channels, and the level of digital integration among institutions. Local early warning systems in Jordan are still under development toward a more integrated framework that enables direct and real-time connectivity between national authorities and municipalities. This information flow reflects the current governance structure of climate-related Early Warning Systems in Jordan (Figure 2).

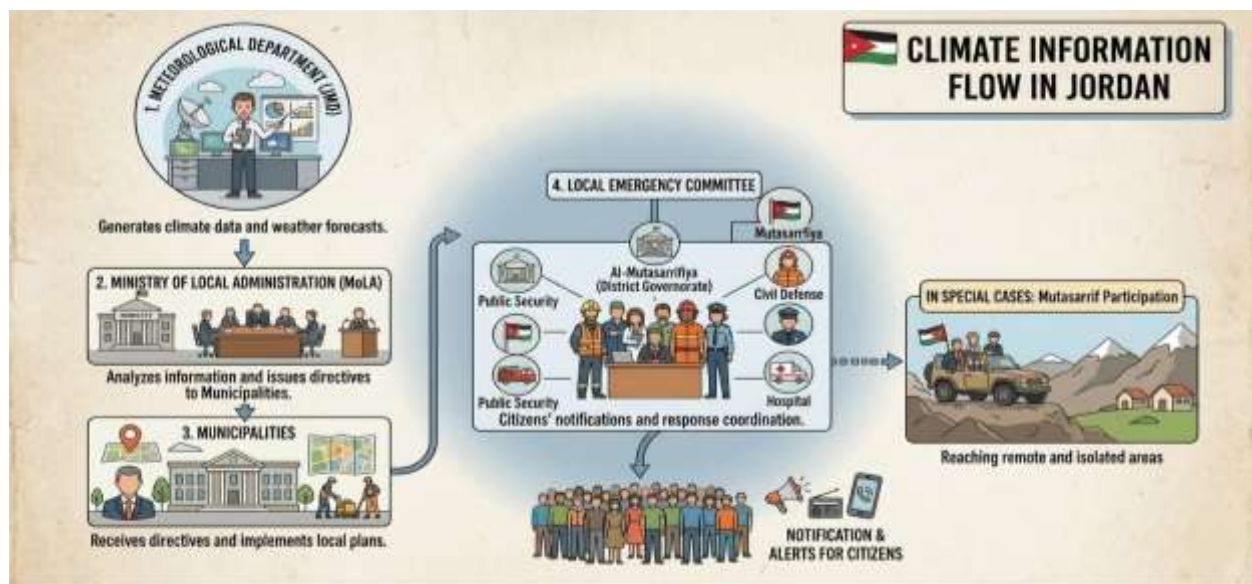


Figure 2. Institutional Flow of Climate Information and Warning Dissemination in Jordan

3. Methodology

3.1 Research Design

This study adopted a qualitative case-study design supported by a mixed-methods approach to examine climate-related risks, institutional preparedness, and the effectiveness of existing Early Warning Systems (EWS) in Irbid and Ramtha, Jordan. The methodology combined desk-based analysis, institutional assessment, and stakeholder engagement to develop a comprehensive understanding of current capacities, operational gaps, and opportunities for strengthening localized and community-centered early warning systems.

3.2 Data Collection

3.2.1 Desk Review and Literature Analysis

A comprehensive review of national policies, strategic frameworks, technical reports, academic literature, and international guidance documents related to climate change adaptation, disaster risk reduction, and Early Warning

Systems was conducted. Sources included documents issued by the National Center for Security and Crisis Management (NCSCM), Jordan Meteorological Department (JMD), Ministry of Local Administration (MoLA), Ministry of Environment, and relevant international organizations. The review focused on institutional arrangements, climate-risk governance, impact-based forecasting, municipal preparedness, and localized EWS practices.

3.2.2 Institutional and Systems Analysis

An institutional assessment was undertaken to examine Jordan's existing EWS architecture, including coordination mechanisms, warning dissemination pathways, digital platforms, crisis management structures, and the integration of Geographic Information Systems (GIS). Particular attention was given to the relationship between national-level institutions and municipal response structures in climate-risk management.

3.2.3 Focus Group Discussions and Stakeholder Consultations

A series of focus group discussions and stakeholder consultations were conducted with municipal emergency committees, technical staff, local authorities, civil society representatives, and community stakeholders in Irbid and Ramtha. The discussions explored:

- Existing warning dissemination mechanisms.
- Climate-risk response procedures.
- Institutional coordination practices.
- Community communication channels.
- GIS and digital system capacities.
- Preparedness gaps and operational needs.
- Perceptions of climate-related risks and vulnerabilities.
- Opportunities for strengthening localized and impact-based early warning systems.

The **consultations** also facilitated collective reflection on institutional challenges, community preparedness capacities, vulnerable population needs, and practical options for improving local warning dissemination and anticipatory action mechanisms.

3.3 Data Analysis

Qualitative data collected through focus group discussions and stakeholder consultations were analyzed using thematic analysis. Emerging themes were coded and organized around key dimensions including risk knowledge, institutional coordination, warning dissemination, preparedness capacities, GIS integration, community engagement, vulnerability considerations, and anticipatory action planning. Findings from different data sources were triangulated to improve consistency, validity, and analytical rigor.

A gap analysis was subsequently conducted to identify institutional, technical, and operational constraints affecting the effectiveness of climate-related Early Warning Systems at both national and municipal levels.

3.4 Analytical Framework

The analytical framework was guided by the principles of people-centered and multi-hazard Early Warning Systems promoted under the Sendai Framework for Disaster Risk Reduction (2015–2030) and the United Nations Early Warnings for All (EW4All) initiative. The analysis was structured around the four core pillars of effective Early Warning Systems:

1. Risk Knowledge.
2. Monitoring and Forecasting.
3. Warning Dissemination and Communication.
4. Preparedness and Response Capacity.

This framework enabled a systematic assessment of institutional readiness, operational capacities, and community engagement mechanisms while identifying opportunities for strengthening localized and community-centered EWS approaches in northern Jordan.

3.5 Quality Assurance and Data Validation

The study employed methodological triangulation by integrating evidence from literature review, institutional analysis, focus group discussions, and stakeholder consultations. Findings were cross-validated across different stakeholder groups and information sources to ensure consistency and credibility. The analytical process followed a systematic thematic coding approach, and emerging findings were reviewed against established Early Warning System frameworks, including the Sendai Framework for Disaster Risk Reduction and the Early Warnings for All initiative, to enhance analytical rigor and reliability.

4. Findings

4.1 Institutional Characteristics of Existing Early Warning Systems

The findings indicate that the existing Early Warning System (EWS) landscape in Irbid and Ramtha is characterized by a predominantly centralized flow of climate and weather information. Municipalities receive warnings and forecasts through official governmental channels, which provide a structured mechanism for information dissemination and emergency coordination. Participants generally reported that warning information is received within a timeframe that allows for initial preparedness measures to be undertaken.

However, the findings also reveal that existing warning products remain largely hazard-oriented and are not consistently translated into localized impact information that supports operational decision-making at the municipal level. Consequently, municipal response mechanisms continue to rely heavily on institutional experience, field observations, and historical knowledge of hazard-prone locations. While these practices contribute to operational continuity, they limit the ability of municipalities to implement more advanced and evidence-based approaches to climate-risk management.

4.2 Gaps in Risk Knowledge and Spatial Analysis

A key finding emerging from the stakeholder consultations was the gap between the availability of climate information and the capacity to translate this information into detailed local risk assessments. Although municipal emergency teams demonstrated strong familiarity with recurrent flood-prone areas and climate-related vulnerabilities, risk identification remains largely dependent on accumulated field experience rather than systematic spatial analysis.

The findings revealed limited use of Geographic Information Systems (GIS), predictive modelling tools, and integrated risk-mapping platforms capable of identifying high-risk neighborhoods, critical infrastructure, and vulnerable population groups. Furthermore, municipalities lack comprehensive spatial and socio-economic databases that could support targeted warning dissemination and vulnerability-informed preparedness planning.

This limitation constrains the transition from generalized hazard warnings toward impact-based early warning approaches capable of providing location-specific information and supporting anticipatory action at the community level.

4.3 Challenges in Warning Dissemination and Community Communication

The study found that municipalities employ multiple communication channels to disseminate warning information, including social media platforms, municipal websites, local media outlets, emergency hotlines, and community communication networks. While these channels provide broad outreach opportunities, important challenges remain regarding the effectiveness of last-mile warning dissemination.

Participants consistently highlighted the absence of systematic mechanisms for verifying whether warning messages reach intended recipients, are correctly understood, or lead to appropriate protective actions. Communication processes remain primarily one-directional, focusing on information broadcasting rather than interactive engagement and feedback collection.

In addition, misinformation and the rapid spread of unverified information through social media platforms were identified as emerging challenges that may undermine public trust in official warnings and complicate emergency response efforts. Stakeholders emphasized the need for more inclusive and diversified communication approaches that combine digital technologies with community-based dissemination mechanisms.

4.4 Preparedness and Response Capacities

The findings demonstrate that both municipalities possess established emergency management structures and considerable operational experience in responding to climate-related hazards. Emergency committees, coordination mechanisms with national institutions, and field-based response procedures provide an important foundation for managing floods, heatwaves, and other climate-related emergencies.

Despite these strengths, preparedness and response activities remain predominantly reactive in nature. Decisions regarding resource deployment, equipment allocation, and emergency interventions are often based on incoming reports, field observations, and historical experience rather than predictive analytics or predefined anticipatory action protocols.

The findings further indicate that post-event assessment processes are largely conducted through field inspections and administrative reporting procedures. Integrated systems for documenting, analyzing, and learning from previous climate-related events remain limited, reducing opportunities for evidence-based planning and continuous institutional improvement.

4.5 Digital Infrastructure and System Integration

Limited digital integration emerged as one of the most significant constraints affecting the effectiveness of local early warning systems. Although basic digital tools and mapping resources are available, municipalities currently lack integrated platforms capable of linking meteorological information, spatial risk data, infrastructure records, resource management systems, and emergency operations.

The findings also revealed the absence of unified digital databases for documenting historical climate events, monitoring damages, tracking interventions, and supporting predictive risk analysis. Furthermore, interoperability between national and local information systems remains limited, restricting the real-time exchange of information required for effective early warning and rapid response.

Stakeholders consistently identified digital transformation, GIS integration, and data interoperability as priority areas for strengthening local EWS capacities.

4.6 Opportunities for Strengthening Localized Early Warning Systems

Despite the challenges identified, the findings reveal significant opportunities for strengthening localized and people-centered early warning systems in Irbid and Ramtha. Participants emphasized the potential value of integrating GIS-

based risk mapping, developing unified climate-risk databases, and strengthening information exchange between national institutions and municipalities.

The consultations also highlighted the importance of establishing multi-channel warning dissemination mechanisms, including mobile alerts, community focal points, local volunteer networks, and targeted communication strategies for vulnerable populations. Strengthening community participation in preparedness planning and response activities was widely viewed as a critical component of an effective and sustainable early warning system.

Overall, the findings suggest that municipalities possess a strong foundation of institutional experience and local knowledge that can support future EWS development. However, achieving a fully localized, impact-based, and people-centered system will require enhanced digital infrastructure, stronger institutional integration, improved risk communication mechanisms, and greater community engagement in all stages of the warning cycle.

5. Discussion

5.1 Bridging the Gap Between National and Local Early Warning Systems

The findings indicate that Jordan has established a relatively advanced national framework for climate-related Early Warning Systems through institutions such as the National Center for Security and Crisis Management (NCSCM), the Jordan Meteorological Department (JMD), and sectoral ministries. However, the study reveals a persistent gap between warning generation at the national level and operational implementation at the municipal level.

Although municipalities receive climate and weather information through formal governmental channels, warning products remain largely centralized and generalized. This limits municipalities' ability to translate national forecasts into localized preparedness measures tailored to specific neighborhoods, vulnerable populations, and infrastructure systems.

These findings are consistent with international studies highlighting that effective Early Warning Systems depend not only on forecasting accuracy but also on the ability to localize warning information and support decision-making at sub-national levels (UNDRR, 2015; WMO, 2024). Strengthening vertical coordination between national institutions and municipalities therefore represents a critical prerequisite for improving climate-risk governance and enhancing local resilience.

5.2 Advancing Toward Impact-Based Early Warning Systems

A major finding of this study is the limited availability of impact-based warning information at the municipal level. Existing warning messages primarily communicate meteorological hazards while providing limited information regarding expected impacts, exposed populations, vulnerable infrastructure, or recommended preparedness actions.

This challenge reflects a broader global transition from traditional hazard-based forecasting toward Impact-Based Early Warning Systems (IB-EWS), which focus on communicating the consequences of hazards rather than the hazards themselves. According to the World Meteorological Organization and the Early Warnings for All initiative, effective warning systems should clearly communicate what is expected to happen, who will be affected, and what actions should be taken (WMO, 2024).

The findings suggest that integrating localized risk assessments, vulnerability mapping, and impact forecasting into municipal planning processes would significantly enhance anticipatory action and improve preparedness capacities.

5.3 Digital Transformation and GIS as Enablers of Localized Early Warning Systems

The study identified significant limitations in the use of Geographic Information Systems (GIS), digital databases, and integrated decision-support tools. While municipalities possess extensive operational knowledge of recurrent hazard locations, risk identification remains largely dependent on institutional memory and field experience.

This finding aligns with international evidence emphasizing the importance of geospatial technologies in strengthening risk analysis, hazard mapping, resource allocation, and emergency response planning. The absence of integrated GIS platforms, interoperable databases, and real-time information systems limits municipalities' ability to conduct dynamic risk assessments and support data-driven decision-making.

The findings therefore indicate that digital transformation should be considered a foundational component of future localized Early Warning System development in Jordan.

5.4 Strengthening Last-Mile Communication and Community Engagement

The study demonstrates that communication remains one of the most critical challenges affecting warning effectiveness. Although multiple communication channels are available, including social media, municipal websites, local media outlets, and emergency hotlines, mechanisms for verifying message reception, comprehension, and behavioral response remain limited.

These findings support the people-centered Early Warning System approach promoted by the Sendai Framework and the Early Warnings for All initiative, both of which emphasize that warning effectiveness ultimately depends on whether communities receive, understand, and act upon warning information.

Participants also highlighted concerns regarding misinformation, declining public responsiveness to repeated warnings, and limited engagement of vulnerable populations in preparedness activities. Strengthening community-based communication networks, local volunteer mechanisms, and feedback systems may therefore improve warning effectiveness and enhance public trust in official warning processes.

5.5 Proposed Framework for a Localized Community-Centered Early Warning System

Building upon the findings of this study, a localized community-centered Early Warning System framework is proposed for application in northern Jordan (Figure 3). The framework seeks to strengthen the connection between national forecasting institutions, municipal authorities, and local communities by integrating climate information, risk analysis, communication mechanisms, and preparedness actions within a single operational structure.

The proposed framework combines national forecasting and warning generation capacities with municipal-level risk analysis and community-level dissemination mechanisms. It incorporates Geographic Information Systems (GIS), vulnerability mapping, anticipatory action protocols, multi-channel communication systems, and community feedback loops to ensure that warning information is translated into timely and actionable preparedness measures.

Particular emphasis is placed on vulnerable populations, including refugees, women, low-income households, outdoor workers, elderly persons, and residents of flood-prone areas. By strengthening both institutional coordination and community participation, the framework supports the transition from hazard-based warning approaches toward more inclusive, impact-based, and people-centered Early Warning Systems.

The proposed framework is designed to be scalable and adaptable, allowing replication in other municipalities facing similar climate-related risks across Jordan and the wider Middle East region.

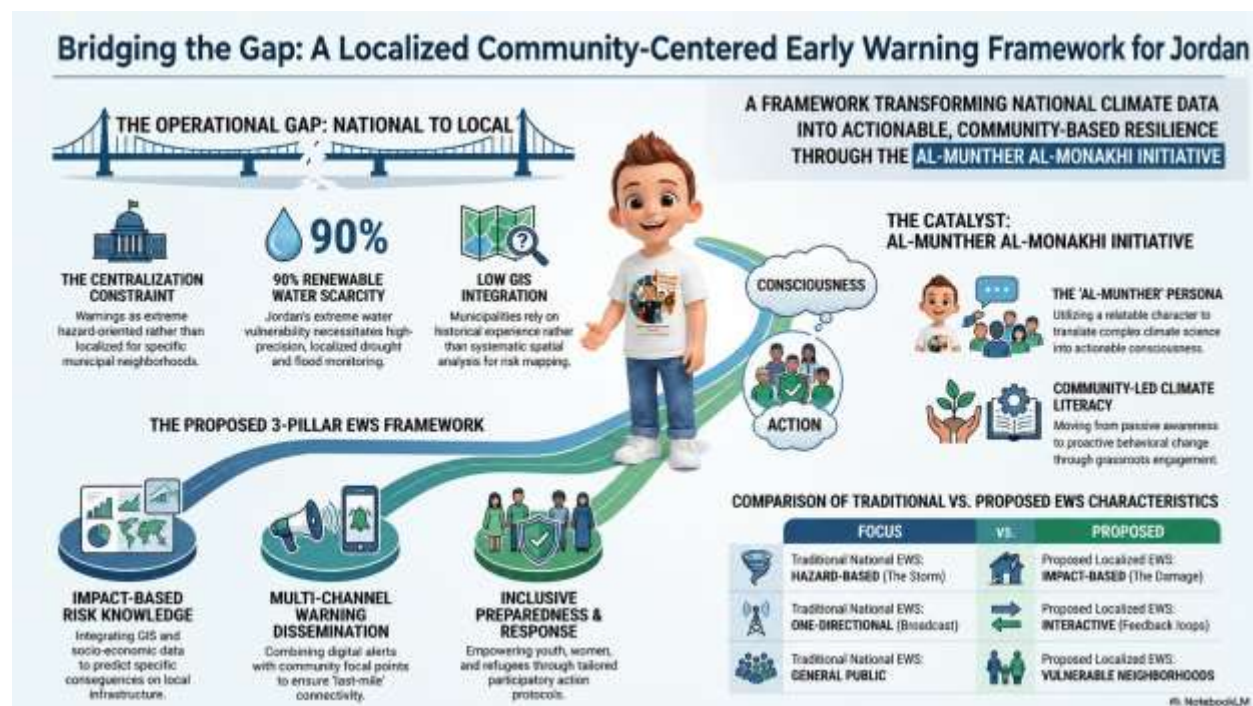


Figure 3. Proposed Localized Community-Centered Early Warning System Framework for Northern Jordan

5.6 The Al-Munther Al-Monakhi Initiative as a Community-Based Model for Climate Risk Awareness and Early Warning Preparedness

The findings of this study highlight that the effectiveness of Early Warning Systems depends not only on forecasting capabilities and technological infrastructure, but also on the capacity of communities to understand climate risks, interpret warning information, and translate alerts into appropriate preparedness actions. In this context, awareness, risk communication, and community engagement emerge as essential components of people-centered Early Warning Systems.

The Al-Munther Climate Initiative was developed as a community-based climate awareness and preparedness model that seeks to strengthen public understanding of climate-related risks and promote proactive engagement in climate adaptation and disaster risk reduction efforts. The initiative was launched during the twenty-ninth session of the Conference of the Parties (COP29) as a voluntary and locally driven platform designed to bridge the gap between climate science and community action.

The initiative was established in response to the growing impacts of climate change across the Arab region and recognizes that women, youth, and children are among both the most vulnerable groups and the most influential actors in driving long-term behavioral and societal change. Building upon principles of climate literacy, risk awareness, and community participation, the initiative aims to translate complex climate information into accessible and actionable knowledge that can support preparedness and resilience-building efforts at the household and community levels.

A distinctive feature of the initiative is the use of the fictional character "Al-Munther" as a communication tool to illustrate future climate scenarios and encourage intergenerational dialogue on climate risks. Through educational materials, awareness campaigns, training resources, and community engagement activities, the initiative seeks to

connect projected climate impacts with everyday experiences and decision-making processes. By emphasizing practical actions and locally relevant solutions, the initiative promotes a transition from awareness to behavioral change and from knowledge acquisition to community resilience.

The initiative places particular emphasis on empowering women and youth as local agents of change. This approach reflects growing international recognition that inclusive participation enhances the effectiveness of climate adaptation, disaster preparedness, and risk communication strategies. By strengthening local capacities and encouraging community ownership of climate action, the initiative contributes to creating enabling conditions for more effective warning dissemination, preparedness planning, and anticipatory action.

Within the context of the proposed localized Early Warning System framework, the Al-Munther Climate Initiative represents a complementary mechanism for strengthening the social and behavioral dimensions of resilience. While formal Early Warning Systems provide risk information and technical forecasts, community-based initiatives such as Al-Munther contribute to improving public understanding, trust, preparedness, and responsiveness. The integration of these dimensions is increasingly recognized within the Early Warnings for All agenda as a prerequisite for achieving effective people-centered and impact-based Early Warning Systems.

6. Conclusion

This study examined the current status of climate-related Early Warning Systems (EWS) in Irbid and Ramtha, Jordan, through a combination of institutional analysis, stakeholder consultations, and participatory assessment approaches. The findings indicate that Jordan has established a progressively evolving institutional framework for disaster risk reduction and climate-related Early Warning Systems, led by key national institutions such as the National Center for Security and Crisis Management (NCSCM), the Jordan Meteorological Department (JMD), and the Ministry of Local Administration (MoLA). National initiatives, including flood-risk mapping programs, digital warning systems, and localized warning experiences such as the Petra Flash Flood Early Warning System, demonstrate a growing commitment to strengthening climate resilience and disaster preparedness.

Despite these advances, the study identified several institutional, technical, and operational challenges that continue to constrain the effectiveness of Early Warning Systems at municipal and community levels. While municipalities possess substantial operational experience in managing floods and extreme weather events, current practices remain largely dependent on conventional procedures, accumulated field knowledge, and predominantly reactive emergency management approaches. The limited integration of Geographic Information Systems (GIS), real-time climate information, predictive analytics, interoperable databases, and decision-support systems restricts the ability of local authorities to implement more localized, impact-based, and anticipatory approaches to climate-risk management.

The findings further demonstrate that effective Early Warning Systems extend beyond forecasting capabilities and technological infrastructure. Community awareness, preparedness, trust in institutions, and the effectiveness of last-mile communication mechanisms are equally critical determinants of warning effectiveness. Persistent challenges related to warning dissemination, community engagement, misinformation, and the inclusion of vulnerable populations highlight the need for more people-centered and locally responsive approaches to risk communication, preparedness planning, and anticipatory action.

Based on these findings, the study proposes a Localized Community-Centered Early Warning System Framework (Figure 3) that strengthens linkages between national forecasting institutions, municipal authorities, and local communities. The proposed framework integrates the four core pillars of people-centered Early Warning Systems risk knowledge, monitoring and forecasting, warning dissemination and communication, and preparedness and response capacity while incorporating GIS-supported spatial analysis, anticipatory action protocols, multi-channel communication mechanisms, community participation, and feedback systems within a unified operational structure. By linking climate information with localized preparedness and response actions, the framework supports the transition from conventional hazard-based warning approaches toward more effective impact-based and people-centered Early Warning Systems.

The study further underscores the importance of community-based climate awareness initiatives, such as the Al-Munther Al-Monakhi Climate Initiative, as complementary mechanisms that strengthen climate literacy, preparedness, and public engagement within localized Early Warning Systems. By promoting risk awareness, accessible climate communication, and community participation, such initiatives can support the social and behavioral dimensions of resilience while enhancing the effectiveness of preparedness and response measures.

The proposed framework is designed to be scalable and adaptable beyond the study area. Although developed in the context of Irbid and Ramtha, its principles may be applicable to other municipalities facing similar climate-related challenges across Jordan and the wider Middle East region. By combining institutional assessment, stakeholder perspectives, and a locally grounded EWS framework, the study contributes practical insights into the design of localized and community-centered Early Warning Systems within resource-constrained and climate-vulnerable settings. In this regard, the study contributes to the growing body of knowledge on localized Early Warning Systems and supports the objectives of the Sendai Framework for Disaster Risk Reduction and the United Nations Early Warnings for All Initiative, while providing a practical pathway for strengthening climate resilience and disaster preparedness at the local level.

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