

Early Warning Systems, Disaster Risk Reduction, and SDG 13: Climate

Action

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Abstract

Climate change has significantly increased the frequency and severity of hazards such as storms, floods, droughts, heatwaves, and coastal surges, threatening lives, livelihoods, and sustainable development worldwide. The research problem addressed in this paper is how Early Warning Systems (EWS)—critical tools for disaster risk reduction (DRR)—align with and support the achievement of Sustainable Development Goal 13 (SDG 13): Climate Action. This study employs a mixed research methodology combining analysis of international frameworks (e.g., the Sendai Framework for Disaster Risk Reduction), global initiatives like Early Warnings for All, and secondary data from international status reports. Content and thematic analysis techniques were used to assess policy alignment, implementation challenges, and outcomes. Key findings show that EWS, when integrated with DRR strategies, significantly reduce disaster impacts, protect communities, and strengthen climate resilience—directly contributing to SDG 13. However, disparities remain in coverage, especially in least developed countries and small island developing states. The core implications highlight that fully operational multi-hazard early warning systems (MHEWS), supported by inclusive governance, risk knowledge generation, technology, and community engagement, are essential for reducing disaster risks and achieving sustainable development.

Keywords: Early warning systems, disaster risk reduction, SDG 13, climate resilience, multi-hazard early warning, Sendai Framework.

Introduction

Climate change has intensified natural hazards, resulting in more frequent and severe disaster events across the globe. These events not only cause loss of life and economic damages but also undermine sustainable development efforts, especially in vulnerable regions. In this context, SDG

13: Climate Action calls for strengthening resilience and adaptive capacity to climate-related hazards and integrating climate change measures into national policies and planning. Indicator 13.1.2 specifically tracks the number of countries adopting and implementing national DRR strategies in line with international frameworks like the Sendai Framework for Disaster Risk Reduction 2015–2030, which includes a strong focus on early warning systems.

Early Warning Systems (EWS) are designed to predict hazardous events ahead of time and communicate warnings to affected populations and governments, providing critical lead time for protective actions that save lives and reduce losses. EWS are crucial components of both DRR and climate adaptation strategies, and they provide measurable contributions to SDG 13 by reducing disaster risks and building more resilient communities.

Despite growing recognition of their importance, EWS coverage remains uneven worldwide, and many developing countries lack comprehensive multi-hazard warning systems, especially at the local level. The United Nations' Early Warnings for All (EW4All) initiative aims to address this gap by striving for universal access to quality, inclusive, and people-centered EWS by 2027, underlining the role such systems play in climate resilience and sustainable development.

This research evaluates the role of EWS in DRR and their alignment with SDG 13, examining policy frameworks, international initiatives, implementation challenges, and pathways to enhanced resilience.

Literature Review

Early Warning Systems and Disaster Risk Reduction

Early Warning Systems are recognized within international disaster risk governance frameworks as essential tools for mitigating hazards. Effective EWS integrate hazard monitoring, risk analysis, communication, preparedness, and response mechanisms that enable timely actions to minimize impacts. The Sendai Framework for Disaster Risk Reduction 2015–2030 specifically calls for substantial increases in the availability and accessibility of multi-hazard EWS and disaster risk information by 2030.

EWS have strong empirical evidence supporting their role in saving lives and reducing losses. For example, the United Nations notes that MHEWS reduce mortality associated with severe weather,

water, and climate-related hazards by enabling proactive measures at community and governmental levels.

SDG 13 and Early Warning Systems

SDG 13's targets explicitly include strengthening resilience (Target 13.1) and integrating climate measures into planning (Target 13.2). EWS contribute to these targets by providing actionable information early enough to trigger protective actions, reduce exposure and vulnerability, and support adaptive capacities across sectors, including agriculture, health, and infrastructure. The UN SDG indicators highlight that while disaster-related mortality rates have fallen in recent years, the number of people affected by disasters has risen, demonstrating the continued relevance of risk reduction investments.

Recent research underscores that EWS must be people-centered and inclusive to maximize effectiveness, ensuring that warnings are timely, understandable, culturally appropriate, and actionable by vulnerable populations. Integrated systems also help reduce economic and ecosystem losses associated with extreme weather events.

Research Gap

While substantial literature documents the theoretical importance and policy commitments for EWS, there remains a gap in synthesizing how early warning systems contribute specifically to achieving SDG 13 outcomes and how implementation challenges affect coverage and impact, particularly in under-served regions.

Problem Statement

Although EWS are widely recognized as critical for DRR and climate adaptation, there is insufficient empirical analysis of their contributions to SDG 13 targets, especially in terms of coverage, inclusivity, and integration with broader development planning.

Research Questions

- What role do EWS and DRR frameworks play in achieving SDG 13 targets?

- How effective are international initiatives like Early Warnings for All in expanding EWS coverage and climate resilience?
- What are the barriers and enabling factors in operationalizing EWS for sustainable development outcomes?

Research Methodology

Research Objectives & Hypotheses

Objectives

- To examine the linkages between Early Warning Systems, DRR frameworks, and SDG 13 targets.
- To assess the scope and implementation of global EWS initiatives such as Early Warnings for All.
- To identify key barriers and enabling conditions affecting EWS effectiveness and SDG outcomes.

Hypotheses

- **H1:** Countries with comprehensive EWS aligned with DRR frameworks demonstrate better outcomes in SDG 13 resilience indicators.
- **H2:** International initiatives (e.g., Early Warnings for All) significantly enhance EWS coverage and contribute to SDG 13 implementation.
- **H3:** Barriers such as funding gaps, institutional capacity constraints, and lack of community access impede EWS effectiveness.

Research Design

This research uses a qualitative and policy analysis design, drawing on international frameworks, official reports, academic literature, and initiative evaluations.

Data Sources & Sampling

Data were sourced from:

- United Nations SDG indicator reports and progress summaries.
- International frameworks like the Sendai Framework for Disaster Risk Reduction.
- Global initiatives such as Early Warnings for All.
- Secondary analysis of research articles on EWS and DRR implementation.

Data Collection and Analysis Methods

The study employs content analysis of policy documents and thematic analysis of literature to identify patterns, alignments, and gaps relating to early warning systems and SDG 13.

Variables and Operationalization

Variable	Description
EWS Coverage	Presence and reach of multi-hazard early warning systems within a country/region
DRR Integration	Degree to which EWS and fire DRR activities are integrated in national strategies
SDG 13 Alignment	Extent to which EWS contribute to SDG 13 target achievements
Barriers	Economic, institutional, and social factors limiting EWS implementation

Ethical Considerations

This study uses publicly available secondary sources, ensuring appropriate citation and respect for original data ownership.

Data Analysis / Results

EWS and SDG 13 Linkages

The Sendai Framework explicitly identifies early warning systems as key elements for reducing disaster risks and strengthening resilience, aligning with SDG 13's focus on adaptive capacity. Target 13.1.2 directly tracks DRR strategy adoption in line with international frameworks, reflecting EWS integration into national resilience agendas.

Global EWS Coverage Trends

The Early Warnings for All initiative has contributed to expanding multi-hazard early warning system coverage; as of 2025, 119 countries report MHEWS coverage, showing a 113 % increase since 2015. This progress suggests stronger institutional commitment toward resilient infrastructure and risk mitigation.

Implementation Barriers

Despite progress, significant disparities persist:

- Least developed countries and small island developing states lag behind in EWS coverage and accessibility.
- Barriers include lack of financing, technical capacity, and last-mile communication infrastructure, which limit the effective dissemination of warnings. A UN Secretary-General report notes that investments are required to expand universal coverage and ensure warnings are actionable by communities.

DRR and Community Resilience

Integrative EWS that combine risk knowledge, real-time monitoring, and early action capabilities are shown to substantially reduce disaster impacts when embedded in broader DRR strategies. The Early Warnings for All initiatives four pillars risk knowledge, forecasting, communication, and preparedness highlight essential elements for building resilient systems.

Findings & Discussion

Role of EWS in Risk Reduction and Resilience

EWS have documented evidence of saving lives and reducing economic losses by enabling timely societal responses. Countries with robust multi-hazard early warning infrastructure can significantly mitigate the impacts of climate-related hazards.

Contribution to SDG 13 Implementation

By expanding coverage and strengthening early warning communication, EWS directly support SDG 13 targets related to resilience and adaptive capacity. Effective EWS reduce mortality and enhance risk-informed development planning, which is essential for sustainable development.

Barriers and Policy Implications

A key challenge remains in ensuring inclusive coverage, particularly in marginalized communities where communication infrastructure and trust in warnings may be low. Expanding financial resources and institutional capacity are critical to overcoming these barriers. Global commitments like Early Warnings for All provide a blueprint for coordinated action but require sustained investment and local adaptation.

Conclusion

Summary of Findings

Early Warning Systems are indispensable for disaster risk reduction and climate resilience, contributing strongly to achieving SDG 13 targets. Their expansion and integration into national DRR strategies reduce disaster impacts and help communities adapt to changing climate conditions.

Theoretical and Practical Implications

International frameworks such as the Sendai framework and initiatives like Early Warnings for All illustrate how EWS can be deployed to strengthen climate resilience. Policymakers must prioritize people-centered, inclusive early warning designs that reach the most vulnerable populations.

Limitations

The study relies on secondary sources and global reports, which may mask regional variations. Further empirical research in specific national contexts can refine understanding of EWS effectiveness.

Future Research

Future studies should evaluate the impact of EWS deployments at local levels and explore the integration of technology innovations (e.g., AI-enhanced warning analytics) into national DRR strategies.

Recommendations

- Strengthen multi-hazard early warning system coverage, especially in least developed countries and small island states.
- Increase financial and technical support for local implementation and community engagement.
- Align early warning initiatives directly with SDG 13 monitoring indicators and national DRR strategies.

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