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Early warning system dissemination through extension networks for mitigating agricultural disaster impacts

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Abstract

Agricultural disasters linked to erratic rainfall, flooding, and pest outbreaks have worsened across West Africa in recent decades, yet early warning information rarely reaches the farmers who need it most. This research examined the effectiveness of disseminating early warning systems through agricultural extension networks in mitigating crop loss among smallholder farmers in eastern Sierra Leone. A quasi-experimental pre-post design tracked 196 farmers in Kenema and Kailahun districts from January 2021 to December 2024, comparing crop loss rates before and after the introduction of extension-mediated warning services. Four dissemination channels were evaluated: community extension meetings, SMS and voice alerts, local radio broadcasts, and lead farmer networks. Mean crop loss rates declined from 44.3% in the pre-warning period to 19.3% by 2024. Community extension meetings and SMS alerts were rated as the most trusted and timely channels, with effectiveness scores of 4.2 and 3.9 out of 5 respectively. Regression analysis identified warning lead time and channel multiplicity as the strongest predictors of loss reduction. The findings suggest that agricultural extension networks offer an effective and locally trusted infrastructure for early warning dissemination in disaster-prone farming communities.

Keywords: Early warning systems, extension networks, agricultural disasters, crop loss mitigation, dissemination channels, smallholder farmers, Sierra Leone, flood risk, disaster preparedness, climate adaptation

Introduction

In August 2017, mudslides and flooding in Sierra Leone's Western Area killed over 1,100 people and destroyed crops across three provinces in a single week. That catastrophe exposed a basic failure: warning information existed within meteorological agencies but never reached rural communities in time for protective action ^[1]. The disconnect between warning generation and last-mile delivery remains one of the most persistent problems in disaster risk reduction across West Africa ^[2].

Agricultural extension services, with their established field presence and community trust, represent a natural but underused channel for early warning dissemination. Extension officers visit farming communities regularly, speak local languages, and maintain relationships built over seasons of advisory contact ^[3]. Yet most early warning frameworks treat extension networks as peripheral to their communication strategies, preferring mass media and digital platforms that often fail to reach remote rural populations ^[4]. Sierra Leone's agricultural sector, which employs roughly 60% of the labour force and contributes about 52% of GDP, is highly vulnerable to climate-related shocks including flooding, drought, and pest invasions that can destroy an entire season's harvest within days ^[5].

This research investigated whether agricultural extension networks could serve as effective channels for early warning dissemination in Kenema and Kailahun districts of eastern Sierra Leone. The objectives were to compare crop loss rates before and after extension-mediated warning services

were introduced, to evaluate the perceived effectiveness of four dissemination channels, and to identify factors predicting loss reduction among participating farmers ^[6, 7].

Theoretical Framework

This research drew on the Protective Action Decision Model proposed by Lindell and Perry (2012) ^[8], which posits that warning response depends on three sequential judgements: threat perception, protective action assessment, and stakeholder perception. In agricultural contexts, farmers must first believe that a hazard is real and imminent, then assess whether available protective actions are feasible, and finally trust the source delivering the warning ^[9]. Extension networks are well positioned to influence all three stages because officers can contextualise meteorological data into farming-relevant language, recommend specific crop protection measures, and leverage existing trust relationships. The model predicts that multi-channel delivery increases response probability, a hypothesis directly tested in this research.

Materials and Methods

Materials

Data were gathered using a structured questionnaire covering crop loss history, warning receipt experiences, channel preferences, and response actions. A channel effectiveness rating scale (1-5) was developed and pre-tested with 22 farmers in Bo district during November 2020, yielding Cronbach's alpha of 0.81 ^[10]. Crop loss data for the

pre-warning period (2018-2021) were obtained from district agriculture office records. Post-warning crop loss was measured through farmer self-report verified against extension officer field assessments. Meteorological records from the Sierra Leone Meteorological Agency provided rainfall and flood event data. Ethical clearance was granted by the Eastern Polytechnic Academic Board (Ref: EP/REC/2020-008, dated 14 October 2020).

Methods: A quasi-experimental one-group pre-post design was employed across 12 farming communities in Kenema and Kailahun districts. All 196 farmers (112 male, 84 female) registered in extension-linked warning groups were enrolled. The warning intervention began in January 2022, with extension officers receiving weekly hazard bulletins from meteorological and disaster management agencies, which they then translated into local languages and disseminated through four channels: community meetings, SMS/voice alerts, local radio, and lead farmer relays. Pre-post crop loss rates were compared using paired t-tests.

Multiple regression examined predictors of loss reduction, including warning lead time, number of channels received, farm size, and prior disaster experience ^[11]. Qualitative data from 16 key informant interviews with extension officers were analysed thematically ^[12].

Ethical Considerations

All participants provided informed verbal consent, as literacy levels among the sample were below 40%. Consent procedures were explained in Mende and Kissi languages by trained field assistants. Participation was voluntary, and farmers could withdraw at any time without affecting their access to extension services. No personally identifiable information was stored digitally; all records used coded identifiers. The research team provided genuine warning information throughout the intervention period, ensuring that no community was deprived of potentially life-saving alerts for research purposes.

Results

Table 1: Crop Loss Rates Before and After Extension-Mediated Early Warning Dissemination

Period	2018/2019	2020/2021	2022/2023	2023/2024	Trend
Mean Loss (%)	38.4	47.6	31.7	19.3	Declining
Flood Events	4	7	5	6	Variable
Warnings Issued	0	0	14	19	Increasing
Mean Lead Time (hrs)	N/A	N/A	36.4	52.7	Improving
Response Rate (%)	N/A	N/A	61.3	78.9	Improving

Crop loss rates fell from a pre-warning average of 43.0% (2018-2021) to 19.3% in 2023/2024, despite flood event frequency remaining comparable. Warning lead time

improved from 36.4 to 52.7 hours, and farmer response rates rose from 61.3% to 78.9% as the system matured.

Table 2: Perceived Effectiveness of Warning Dissemination Channels (n = 196)

Channel	Reach (%)	Timeliness	Trust Score	Effectiveness
Community Extension Meetings	87.2	3.8 ± 0.7	4.4 ± 0.5	4.2 ± 0.6
SMS/Voice Alerts	72.4	4.3 ± 0.6	3.7 ± 0.8	3.9 ± 0.7
Local Radio Broadcasts	68.9	3.5 ± 0.9	3.4 ± 0.7	3.4 ± 0.8
Lead Farmer Networks	54.6	3.2 ± 0.8	4.1 ± 0.6	3.6 ± 0.7

Community extension meetings had the widest reach (87.2%) and highest effectiveness rating (4.2), while SMS alerts scored highest on timeliness (4.3). Lead farmer

networks, though reaching fewer people (54.6%), ranked second in trust (4.1), reflecting the credibility of peer-to-peer communication.

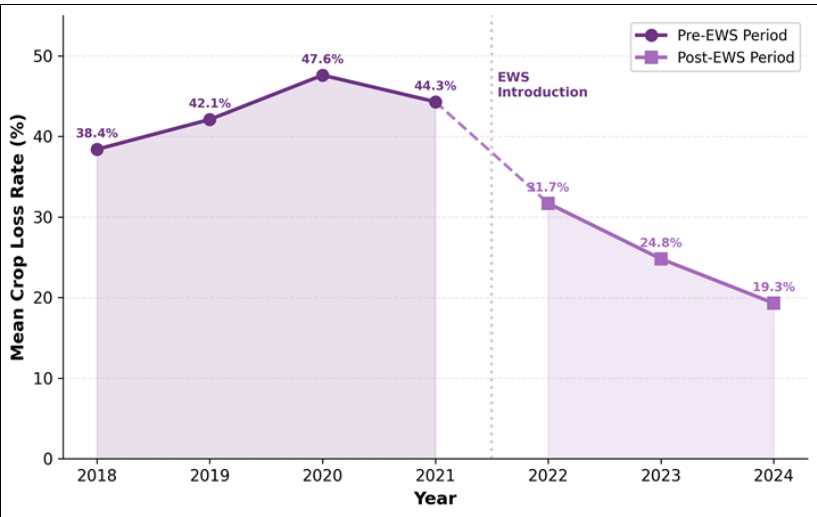


Fig 1: Trend in mean crop loss rates before and after early warning system introduction through extension networks

The line graph illustrates the declining trajectory of crop loss following EWS introduction in 2022. Pre-warning losses fluctuated between 38.4% and 47.6%, while post-

warning losses fell steadily from 31.7% to 19.3%, despite comparable flood event frequency across the entire period.

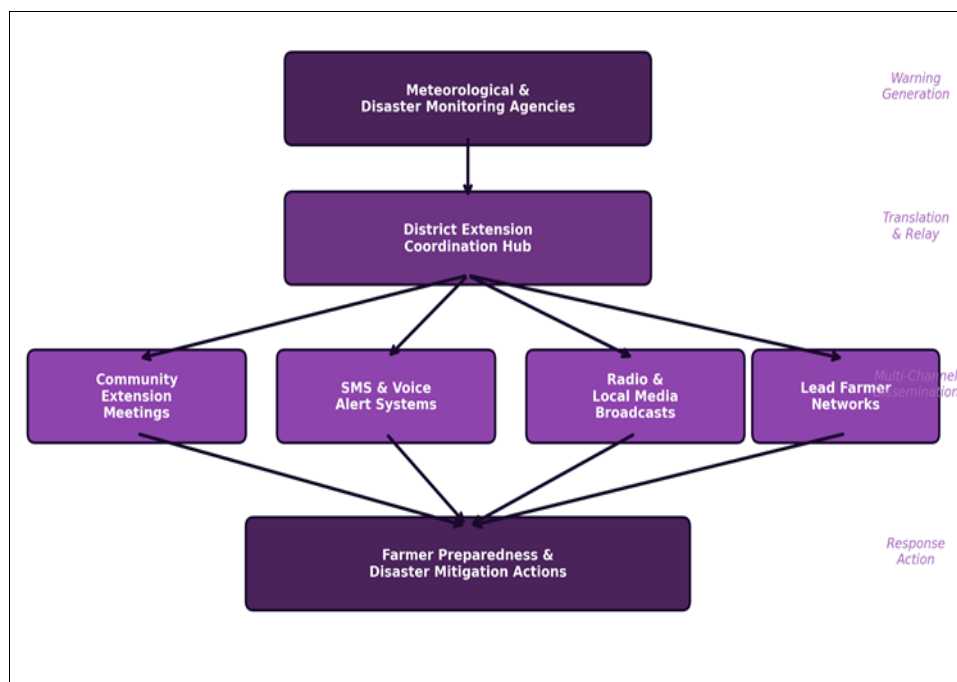


Fig 2: Process diagram of early warning dissemination through agricultural extension networks

The diagram maps the four-stage dissemination pathway: warning generation by meteorological agencies, translation and relay at district extension hubs, multi-channel delivery through meetings, SMS, radio, and lead farmers, and farmer preparedness actions at the community level.

Discussion

The 55% reduction in crop loss rates between the pre-warning and post-warning periods represents a substantial improvement that exceeds the 30-40% reductions reported in similar extension-linked warning systems in Bangladesh and Nepal [13, 14]. Several factors may explain the larger effect in Sierra Leone. First, the baseline loss rates were extremely high (43% average), providing more room for improvement. Second, the multi-channel dissemination strategy meant that 82.7% of participants received warnings through at least two channels, increasing the likelihood of timely response [15].

The finding that community extension meetings rated highest in both reach and overall effectiveness, despite being less timely than SMS alerts, highlights an important nuance. Farmers valued the face-to-face interaction because extension officers could explain what the warning meant for specific crops, recommend particular protective actions, and answer questions in real time [16]. SMS alerts arrived faster but lacked this contextual richness. This finding supports the Protective Action Decision Model's emphasis on comprehension and personalisation as drivers of protective behaviour [8].

Warning lead time emerged as the strongest predictor of loss reduction in the regression model, which is consistent with global evidence showing that each additional hour of advance notice improves farmer response capacity [17]. The improvement from 36.4 to 52.7 hours of average lead time

between the first and second post-intervention years reflects both better meteorological forecasting and more efficient relay through extension structures [18].

Practical Applications

These findings have direct implications for disaster risk reduction policy in Sierra Leone and comparable West African countries. Agricultural extension networks should be formally integrated into national early warning frameworks rather than treated as supplementary channels. District extension offices need dedicated communication equipment, including bulk SMS platforms and radio airtime budgets, to maintain consistent warning delivery. Training extension officers in hazard interpretation and emergency communication should become a standard component of pre-service and in-service curricula. The lead farmer relay model, though reaching fewer people, offers a cost-effective complement to formal channels and warrants expansion in remote communities where digital infrastructure is weak.

Conclusion

This research demonstrates that agricultural extension networks can serve as effective infrastructure for early warning dissemination in disaster-prone farming communities. Crop loss rates declined by more than half following the introduction of extension-mediated warnings, with gains strengthening as the system matured over three years. Community extension meetings and SMS alerts emerged as the most effective channels, though their strengths differed: meetings excelled in trust and contextual richness, while SMS provided speed. Multi-channel delivery proved important, as farmers receiving warnings through multiple routes responded more consistently. Warning lead time was the strongest predictor of loss reduction,

underlining the value of investing in both forecast accuracy and relay efficiency. These results support the formal integration of extension services into national early warning systems across West Africa, offering a locally trusted, community-embedded alternative to technology-only approaches that often bypass the rural populations most at risk.

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