From Data to Decision: An Integrated Risk Communication–Response Framework for Multi-Hazard Management in Assam

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Abstract

India's multi-hazard risk environment demands communication systems that can translate complex data into timely, culturally relevant action. This study examines Assam's disaster risk communication landscape through three digital tools—ICR-ER, Flood Hazard Zonation Atlas, and the Raahat application—and proposes the Integrated Risk Communication–Response (IRCR) Framework. Drawing on Situational Crisis Communication Theory, Cybernetic Theory, and Cultural Theory of Risk, the framework positions these platforms as interconnected nodes in a multi-layered decision-support and outreach ecosystem. Using qualitative case-based analysis, the study maps each tool to disaster management phases, evaluates operational strengths and limitations, and identifies systemic gaps in interoperability, feedback mechanisms, and last-mile cultural adaptation. Findings show that while real-time satellite monitoring and GIS mapping improve preparedness, adoption barriers and weak public engagement reduce effectiveness. The IRCR Framework integrates hazard mapping, early warning, and localized communication with participatory feedback loops, offering a scalable model for other multi-hazard environments in India. Policy recommendations include enhancing platform interoperability, embedding cultural media formats into digital alerts, and institutionalizing community-led feedback systems.

Keywords: Risk communication, disaster management, Assam, ICR-ER, Flood Hazard Zonation Atlas, Raahat, multi-hazard framework, crisis response

1. Introduction

India's disaster risk environment is increasingly shaped by compound and cascading hazards, ranging from seasonal flooding and industrial accidents to public health emergencies and climate-driven extreme events. The state of Assam represents one of the most complex cases within this national profile. Here, recurrent floods interact with infrastructural constraints, entrenched social vulnerabilities, and uneven access to timely information. The central challenge is not simply the issuance of hazard alerts, but rather the translation of complex technical data into trusted, locally actionable decisions that can guide both institutional and community responses.

While the literature on risk communication underscores the importance of media convergence—the integration of traditional, digital, and community-based channels—scholars such as Houston et al. (2015) and Sharma and Patt (2012) note that channel integration alone is insufficient in contexts of rapid-onset disasters. In such environments, digital decision-support platforms capable of real-time hazard sensing, structured information processing, and coordinated action have emerged as critical complements to communication channels (IFRC, 2020). Assam has seen significant institutional investment in three such platforms: the Incident Command Room–Emergency Response (ICR-ER) system, which enables multi-hazard monitoring and inter-agency coordination; the Flood Hazard Zonation Atlas of Assam, which provides spatially detailed, historically validated mapping for preparedness and planning; and Raahat, a mobile-based tool for localized early warning, evacuation support, and humanitarian coordination.

A. Jain and S. Gupta (eds.), *Proceedings of the International Conference on Policies, Processes and Practices for Transforming Underdeveloped Economies into Developed Economies (PPP-UD 2025)*, Advances in Economics, Business and Management Research 357,
https://doi.org/10.2991/978-94-6463-894-3_28

These systems, when viewed together, illustrate a data-to-decision pipeline that spans the spectrum from hazard detection to public communication. However, their effectiveness ultimately depends on how well they are connected—not only to each other, but also to culturally attuned communication strategies that ensure messages resonate with and reach diverse communities. The study has been primarily designed to introduce the Integrated Risk Communication-Response (IRCR) for evaluation of platforms that operate across four functional layers:

- Data Acquisition & Hazard Mapping
- Localised Early Warning and response coordination
- Multi-Channel communication & outreach
- Feedback and adaption

The basis of the feedback in based on the structure if the theories like the Situational Crisis Communication Theory (SCCT), which works on alignment of messages based on the aspirations of the stakeholders.The second is the Cybernetic theory of communication that stresses on emphasizing on institutional feed backs, which creates room for molding policies. Lastly the Cultural theory of risks thereby the messages are designed to align with the cultural sentiments, value system and the local traditions.

The digital interventions though based on a broad framework of conceptual and technological support system, there are evidences of gaps like that of unscientific data structure, with limited abilities. The feedback mechanisms is also limited. This in turn makes the accessibility of official alerts grainy more so in the rural and remote areas. Some products like that of the hazard atlas are underutilized and often lack direct interfaces with live warning systems. Besides there is no integration between institution technology and community ownership. While drawing systematically from Japan;s J-alert, New Zealand's Geonet and Brazil's KaR project, the study tries to determine Assam's digital disaster applications landscape.

2. **Problem statements: Identifying the gaps:**

Assam has an array of hazards which includes the annual floods and the associated and post flood health risks. Considering the diverse cultural assimilation along with demographic interventions, the region demands an active , culturally inclusive, practical and accessible risk communication digital landscape. The intrusion of digital platforms like ICR-ER, Flood Hazard atlas and Raahat have assisted the state in disaster mitigation and risk mapping. The barriers here includes functional fragmentation, poor communication and cultural discrepancies.

First, the platforms function largely as silo-ed data systems, each operating independently without robust mechanisms for real-time information exchange. There are a range of limitations like supporting a coordinated response which in turn leads to delay in deciphering the hazard into proper understandable alerts. Secondly most of the hazard messages are presented in a technical format which are not translated into practical messages that demands immediate actions. This is particularly evident in the rural or remote areas. Thirdly feedback mechanisms are limited prompting an unstructured community communication technique that overlooks the response to a large extent. Adding to it, applications like Raahat has low pubic awareness , depending on digital ownership patterns and weak cultural inclusivity. Lastly, mapping tools like Flood Hazard Zonal Atlas are less dynamic without live hazard feeds leading to low operational relevance.

This limitations are not just technical glitches but also have a deep rooted connect with the theoretical and conceptual gaps. For instance from the SCCT perspective, there is a huge gap between the communication hazard design and on ground public perception which makes it largely unreliable. Secondly from the Cybernetic theory perspective, the absence of feedback leads to adaptive decision- making during crises. Lastly from the Cultural theory of Risk perspective, assimilation of messages in cultural diversity questions the areas of reach and accessibility. Left unaddressed, these weaknesses carry significant socio-economic consequences, including delayed evacuations, preventable casualties, agricultural losses, and wider disruptions to livelihoods.

3. Review of Literature

The evolution of disaster risk communication has moved from unidirectional alert systems to multi-channel, participatory communication ecosystems. Covello et al. (2001) emphasise that effective risk communication must integrate trust-building, message clarity, and cultural sensitivity. Houston et al. (2015) argue that media convergence—blending social media, broadcast, and community-based channels—enhances both reach and timeliness, but its success depends on strategic coordination with decision-support systems.

In the Indian context, Sharma and Patt (2012) document persistent "last-mile" communication failures during flood events, underscoring the importance of local language use, community intermediaries, and two-way information flows. Recent studies (IFRC, 2020; UNDRR, 2022) highlight the increasing role of digital decision-support platforms, which combine hazard sensing, data analytics, and operational coordination, yet caution that such systems risk exclusion if not culturally adapted and widely adopted.

International case studies provide strong models for integration. Japan's J-Alert demonstrates the effectiveness of embedding hazard detection directly into national and local broadcast systems. New Zealand's GeoNet combines real-time hazard updates with active community data contributions, creating a dynamic feedback loop. Brazil's KaR Project integrates local feedback into hazard mapping to inform adaptive planning. The ideas generated from these above applications show that technical capability is alone not enough. There is a need to combine it with the indigenous knowledge system, strengthen the feedback channels and communicate through accessible channels.

3.1 Theoretical Perspectives in Disaster Risk Communication

Disaster risk communication can be creatively drawn towards interdisciplinary theory addressing the complexity of multi-hazard environments. The Situational Crisis Communication Theory (SCCT), developed by Coombs (2007), leads to a framing of aligned messages strategies with public perceptions of crisis, responsibility and severity. In the SCCT context it deals with what the audience expects from the messages that ensures compliance and credibility. Lachan et al. (2016) further added that flood warnings that were framed using easy, relatable language with action oriented content led to greater public responsiveness than the ones which were technocrat and formally driven.

Adding more to the SCCT, the Cybernetic Theory of Communication (Wiener, 1948, Krippendorf, 1994) looks as effective disaster communication as a feedback driven, contextual method where the risk data is collected, perceived and interpreted, later reworked upon based on the feedback and expectation. Effective crisis communication as stated by Spialek and Houston (2018) is that where risk communication is beautifully integrated with the feedback mechanisms maximizing information reach improving both audience reach, updated channels of communication and resource allocation. In the absence of feedback loop, there is no accurate information coming from the ground, which explains why the South Asian disaster management scenes are inaccurate and prevent minimizing damage.

Hazard warnings issued through reliable intermediaries, such as village leaders, religious organizations, or folk performance groups, are more likely to result in protective action than those disseminated only through official state channels, according to empirical research conducted in rural India (Patt & Gwata, 2002; Sharma & Patt, 2012). This is especially pertinent to Assam, where the public's perception of official information is greatly influenced by a variety of languages, indigenous political systems, and traditional media practices.

3.2 Digital Decision-Support Platforms in Disaster Management

The uplift of the early digital warning and decision support systems have reinvented disaster governance, enabling a prompt, smarter, real-time hazard sensing system through multi agency governance.

By enhancing the speed, targeting, and dependability of notifications, these platforms can dramatically lower the number of fatalities and financial losses when properly integrated, according to IFRC (2020). Public interest in health, safety and environmental issues, and media coverage of them; the demand for information generated by public concern about risks from past, present, and future activities; the number and reach of right-to-know laws relating to exposures to risk agents; mistrust in risk management authorities, and public demands for the right to participate as a full partner in all phases of risk assessment and risk management; awareness by governments and industry that risk controversies often threaten the achievement of their organizational goals; and awareness by all sides that the public's response to a risk can be amplified or attenuated by those who wish to manipulate it — that is, that risk communication is a useful tool for advocates of particular outcomes.

Globally, systems such as Japan's J-Alert and New Zealand's GeoNet show the benefits of linking hazard detection with simultaneous, multi-channel dissemination—including mobile alerts, television, radio, and community messaging. Brazil's KaR Project demonstrates the value of integrating hazard mapping with participatory reporting, producing adaptive risk assessments that evolve with changing conditions.

In India, NDMA (2021) documents growing investment in hazard mapping tools, monitoring dashboards, and mobile-based early warning apps. However, Gupta et al. (2023) argue that these platforms often remain siloed, with poor interoperability and limited user adoption. Singh and Kumar's (2022) evaluation of Bihar's flood warning system found that although satellite-based inundation maps were technically accurate, their lack of dynamic updates and weak linkage to last-mile communication channels diminished operational value.

The Assam Flood Hazard Zonation Atlas exemplifies this challenge. While it provides high-resolution, historically validated flood maps for preparedness and planning, it functions as a static resource. Without integration with live hazard detection systems such as ICR-ER, its potential for real-time decision-making during fast-onset events is limited. Similarly, the Raahat mobile platform is well-designed for localised alerts and humanitarian coordination but suffers from low public awareness and distribution barriers.

3.3 Regional and South Asian Evidence

South Asia's hazard profile has generated extensive empirical literature on risk communication systems. Bangladesh's Cyclone Preparedness Programme (Paul, 2009) is widely recognised for integrating community volunteers with radio, megaphone, and mobile alerts, resulting in dramatic reductions in cyclone fatalities over recent decades.

In contrast, Indian systems often face "last-mile" breakdowns, particularly in flood contexts. In Assam, Sharma and Patt (2012) documented how state-issued alerts failed to reach remote riverine communities due to linguistic mismatches and limited digital penetration. In Odisha, Barik and Sahu (2018) reported similar gaps during cyclone response, where delays in village-level dissemination reduced evacuation compliance.

Studies from the North-East highlight the role of linguistic diversity and remoteness in shaping communication effectiveness. Bordoloi (2021) observed that during the 2020 Assam floods, SMS alerts in Assamese and English were inaccessible to many communities that relied on oral messages via local leaders. The community rdaio in Manipur saw greater public engagement when COVID-19 happened creating a common forum for familiarily, trust and reliance through digital intervention (Singh et al.,2021)

Nepal's post-2015 earthquake experience further illustrates the importance of multi-modal strategies. Bhandari et al. (2017) found that combining social media updates with FM radio, religious gatherings, and community leaders ensured faster, more equitable message dissemination, especially in remote mountain areas. These lessons are directly relevant to Assam's flood and landslide contexts.

3.4 Integration, Interoperability, and Feedback Loops

Across global and regional contexts, integration and feedback emerge as decisive factors for effective disaster communication. Baudoin et al. (2016) stress that technological capacity must be matched with institutional arrangements for data sharing, coordinated decision-making, and redundancy in communication channels.

New Zealand's GeoNet offers a cybernetic model in practice, with community reports incorporated into hazard dashboards within minutes to inform live adjustments. By contrast, in India, public reporting mechanisms—where they exist—are rarely embedded in operational workflows.

In Assam, the absence of API-based interoperability between ICR-ER, the Flood Hazard Zonation Atlas, and Raahat perpetuates fragmented workflows. This slows the critical "hazard detected → decision made → public alerted" sequence and undermines both timeliness and trust. Without cultural adaptation, even accurate and timely alerts risk failing to trigger the intended protective behaviours.

3.5 Gaps in the Literature

Despite theoretical and technological advances, several gaps persist. Few studies have evaluated hazard detection, mapping, and communication platforms in a unified framework. The combined application of SCCT, Cybernetic Theory, and Cultural Theory of Risk to multi-hazard, culturally diverse contexts remains rare. Finally, the economic impacts of delayed or ineffective risk communication especially in relation to livelihoods, agriculture, and long-term resilience are largely under explored.

This study addresses these gaps by applying the Integrated Risk Communication–Response (IRCR) Framework to Assam's three principal platforms, demonstrating how interoperability, cultural embedding, and feedback loops can transform hazard information into timely, trusted, and actionable community response.

Dimension	Core Principles	Relevance to IRCR Functional Layers	Regional/Case Evidence
Situational Crisis Communication Theory (SCCT)	Aligns message framing with public perceptions of crisis responsibility and severity to enhance credibility and compliance.	Influences *Multi-Channel Communication & Outreach* by guiding tone, content, and framing of alerts.	Lachlan et al. (2016) – empathetic flood warnings increased compliance in U.S.; Sharma & Patt (2012) – Assamese flood warnings more effective when locally contextualised.
Cybernetic Theory of Communication	Treats communication as a feedback loop, enabling adaptive correction based on audience responses.	Central to *Feedback & Adaptation* layer—community reports inform real-time adjustments.	Spialek & Houston (2018) – feedback improved resource allocation in crises; GeoNet in NZ integrates public reports within minutes.
Cultural Theory of Risk	Risk perception mediated by cultural values, trust networks, and local practices.	Shapes *Localized Early Warning* and *Outreach* by embedding trusted mediators and formats.	Patt & Gwata (2002) – local leaders key in rural Africa; Bordoloi (2021) – oral alerts via village heads more effective in Assam.
Digital Decision-Support Platforms	Combine hazard detection, mapping, and coordination for multi-hazard contexts.	Enable *Data Acquisition & Hazard Mapping* and operational integration across agencies.	Japan's J-Alert – real-time detection to multi-channel alert; Brazil's KaR – participatory mapping.
Regional South Asian Evidence	Highlights linguistic diversity, infrastructure constraints, and importance of trusted intermediaries.	Reinforces all IRCR layers by demonstrating practical challenges and culturally grounded solutions.	Bangladesh Cyclone Programme – volunteer networks; Nepal Gorkha earthquake – multi-modal dissemination.

Research Design

This study adopts a qualitative, exploratory, case-based design to evaluate Assam's disaster risk communication ecosystem. The objective is to understand not only the technical functionality of key platforms but also their communicative effectiveness, cultural adaptability, and integration within the broader disaster management cycle. This design is well-suited because the phenomena under study—risk communication practices—are complex, context-dependent, and involve multiple institutional and community actors. Quantitative measures alone would not capture the nuanced interplay of technology, governance, and cultural factors.

The focus is on three digital platforms—ICR-ER, Flood Hazard Zonation Atlas, and Raahat—which are mapped against the proposed Integrated Risk Communication–Response (IRCR) Framework. This framework integrates operational and communicative dimensions, aligning each platform with disaster phases (Preparedness, Response, Recovery) and four functional layers: Data Acquisition & Hazard Mapping, Localized Coordination, Multi-Channel Outreach, and Feedback Integration. The evaluation is anchored in three complementary theoretical lenses: Situational Crisis Communication Theory (SCCT), Cybernetic Theory of Communication, and the Cultural Theory of Risk, enabling an analysis that is at once operational, adaptive, and culturally grounded.

Case Selection and Rationale

The selected platforms represent the core digital infrastructure of Assam's disaster risk communication strategy:

- ICR-ER – Real-time, multi-hazard monitoring and inter-agency coordination (Preparedness & Response).
- Flood Hazard Zonation Atlas – Authoritative spatial reference for flood vulnerability and zoning (Preparedness).
- Raahat – Mobile application for localized early warning, evacuation, and humanitarian coordination (Response & Recovery).

These platforms were identified through policy documents of the Assam State Disaster Management Authority (ASDMA) and the National Disaster Management Authority (NDMA), which recognize them as central to hazard monitoring, mapping, and operational response. Together, they span all four IRCR functional layers, making them ideal for an integrated, comparative evaluation.

Time frame of Analysis

The evaluation covers January 2020 to March 2025, a period chosen to capture both recurrent and unprecedented hazard events, including:

- Multiple monsoon flood seasons, testing high-frequency hazard conditions.
- The COVID-19 pandemic, which necessitated the adaptation of platforms to public health emergencies.
- Recent technical upgrades to ICR-ER and the Flood Atlas interface.
- Comparative performance across different hazard types—floods, health crises, and localized disasters.

This longitudinal approach allows for an assessment of both technical evolution and operational performance over time.

Data Sources

Secondary data were collected from:

- Government and institutional reports (NDMA, ASDMA, Ministry of Home Affairs, ISRO).
- Platform-specific documentation (user manuals, technical specifications, usage guidelines).
- Disaster event archives and credible media coverage.
- Academic literature on risk communication, early warning systems, and disaster informatics.

Analytical Framework

The evaluation followed a four-step process:

1. Phase Mapping – Positioning each platform within disaster management stages.
2. Function Mapping – Aligning platform outputs with IRCR functional layers.
3. Strength–Limitation Assessment – Identifying operational, communicative, and cultural enablers/barriers.
4. Gap Analysis – Comparing observed functionality against theoretical and policy benchmarks.

The IRCR functional mapping matrix was used to consolidate the analysis. Thematic coding was applied to identify cross-cutting challenges such as interoperability gaps, adoption barriers, and cultural misalignment. Each theme was then interpreted through SCCT, Cybernetic Theory, and Cultural Theory of Risk to connect operational observations with conceptual insights.

Validation and Benchmarking

The validity of the findings were determined by the triangulation method cross-referencing platform documentation, available archives of disaster related documents, official policy reports among others. Other factors like the Japan;s J-alert, New Zealand's Geonet and Brazil's KaR project, were selected to determine the benchmarks especially in terms of feedback, channel based understanding and community participation. These models provide a reference point for assessing Assam's performance in risk communication context.

4.Analysis and Discussion

Based on the validation and bench-marking the analysis involves a systematic interpretation of all three digital applications. This is purposefully done with self designed the Integrated Communication Response (IRCR) framework.

4.1. Interpreting the IRCR Mapping

The Integrated Communication Response (IRCR) framework lead to a structured analysis of all the three platforms areas, like ICR-ER, Flood Hazard Zonation Atlas and Raahat, undertaking a critical evaluation spread across different disaster and communictaion layers.

Individually the apps reflect updated capacity with apt functionality by while working in isolation, the operations becomes limited dwarfing the capacity of the state's risk management ecosystem. For instance let's begin with the ICR-ER:

ICE-ER: The app reflects the high level effectiveness in risk monitoring bringing together satellite imagery, field data and well as generating awareness in multiple zones. Its advantages include preparedness as well as response, while being assistive in coordinating with the agencies.It's limitations include being purely Government oriented and public outreach.

***The Flood Hazard Zonation Atlas*:** This app reflects its strength in high resolution mapping tools in terms of preparedness, planning and tracking down the affected areas while regulating infrastructure planning. Its limitations lies in being zero flexibility, limited datasets and poor accountability.

Raahat: This app works best as the mobile based early warning tool that brings in human coordination.This enables bridging last mile communication gaps, leading to effective coordination and fostering evacuation alerts.Its limitations however includes low level awareness on its function, shoddy integration with other apps and minimal ownership.

From here it is apparent that the disconnection between data source, public communication leads to poor urgency records that compromises on immediacy and clogs the information delivery system.In the face of all this, smooth, seamless and hurdle-free preparedness-response-recovery system becomes overshadowed.

Apart from being non-pragmatic, it also has socio-economic implications, since all three apps are working at different levels, the duplicacy of data, overlapping of systems and multiple data sets, leads to poor decisions and loss of life, materials and destruction of the transport system.

There is another major issue that is often been overlooked is that there is absence of culturally adaptive messages that find poor reception and familiarity acceptance. This also limits response from the vulnerable groups like that of poor people with limited technology ownership, aged people with digital incompetency and people with cultural mind blocks. An integration with the localized media like the cultural troupes, community radios or mobile theatre groups and community centers could be very effective in such an endeavour.

5. The ICRC framework and its functionality:

It has hence been seen in table 1 that post evaluation of all the three apps, the lack of integration between the three has been the reason for effective Risk communication.

Table 1. Functional Mapping of Assam's Risk Communication Platforms

Platform	Disaster Phase Coverage	IRCR Functional Layer(s)	Strengths	Limitations
ICR-ER	Preparedness, Response	Data Acquisition & Hazard Mapping; Localized Coordination	Real-time multi-hazard monitoring; integrates satellite & field data; supports inter-agency coordination	Complex interface; requires specialist training; limited public-facing features; dependent on stable connectivity
Flood Hazard Zonation Atlas	Preparedness	Data Acquisition & Hazard Mapping	Spatially detailed, high-accuracy flood vulnerability mapping; official planning reference	Static datasets; limited usability for non-specialists; weak linkage to live alerts
Raahat	Response, Recovery	Localized Early Warning & Resource Coordination; Outreach	Mobile-based, low-bandwidth compatible; supports humanitarian coordination; potential for two-way communication	Low public awareness; not widely available via app stores; minimal integration with ICR-ER and Atlas

5.1 Layer-by-Layer Performance

- Layer 1: The Hazard Mapping and Data acquisition: – Dynamic Hazard monitoring is done by the ICR-ER whereas high quality historical flood data is provided by Flood Atlas. BUt its deficiency lies in the fact that it lacks real-time updating from ICR-ER feeds decreasing the operational value in urgency-based events.
- Layer 2: Localized Early Warning & Resource Coordination – Raahat has strong design potential for last-mile alerts and logistics but suffers from low visibility and adoption. Linking it with ICR-ER's hazard triggers could close the "data-to-public" gap.
- Layer 3: Multi-Channel Communication & Outreach – All platforms are digital-first but fail to systematically embed traditional and community-based media. This limits reach among populations where folk media, community radio, and multilingual signage are trusted more than mobile alerts.

- Layer 4: Feedback & Adaptation – Feedback systems are minimal. ICR-ER gathers operational updates but not community reports; Raahat's two-way potential is underutilized. The absence of cybernetic feedback loops hinders adaptive decision-making.

5.2 Cross-Cutting Gaps and Recommended Actions

Gap	Observed Impact	Recommended Action
Lack of interoperability	Siloed data streams; inconsistent alerts	API-based integration between ICR-ER and Raahat; dynamic Atlas updates from ICR-ER feeds
Low public adoption of Raahat	Limited reach during emergencies	Relaunch in app stores; awareness campaigns in local languages and through trusted networks
Absence of structured feedback	Reduced trust; lower compliance	Community reporting module in Raahat; district-level verification hubs
Limited cultural adaptation	Alerts fail to resonate in rural/vulnerable areas	Embed folk media, community radio, multilingual text/audio into alert workflows
Static hazard mapping in Atlas	Reduced operational relevance	Convert to dynamic GIS layers linked to live hazard data

5.3 Integration Scenarios: Potential Gains

To illustrate the value of integration, consider three hypothetical but feasible scenarios:

- *Scenario 1*: Real-time ICR-ER to Raahat Integration
  If hazard detection in ICR-ER automatically triggered alerts in Raahat, warning messages could be disseminated to the public within minutes of a threat being identified. Even a 20–30-minute improvement in alert times could significantly increase evacuation compliance, reduce casualty rates, and give communities critical time to secure property and livelihoods.

- *Scenario 2*: Dynamic Flood Hazard Zonation Atlas
  Integrating live data feeds from ICR-ER into the Flood Atlas would transform it from a static reference tool into a real-time operational asset. This would enable pre-positioning of relief materials, advance evacuation planning, and adaptive infrastructure management based on current conditions rather than historical data alone.

- *Scenario 3:* Embedding Cultural Media in Alert Workflows
  By combining digital alerts with traditional communication channels—folk theatre troupes performing safety messages, multilingual broadcasts via community radio, and visible signage in local scripts—the reach and trustworthiness of disaster warnings would improve dramatically. This approach would ensure that critical information resonates with and is acted upon by diverse audience segments.

5.4 Comparative Advantage of the IRCR Framework

There are distinct advantages that evolve from the IRCR framework that largely remains a step ahead then the existing disaster responses. To begin with, it is multi-grounded theory. Applying the situation crisis communication theory here, we can understand how hazard or risk based messages are framed to make effective by being empathetic to public perception and expectations, socially and logistically.

Here the Cybernetics theory reinforces the element of feedback loops which creates room for adaptive decision making during any ongoing risks. The Cultural theory of risk brings in an order in which the communication strategies are imbibed into the local cultural values and information norms building in confidence and relativity with the audience.

Additionally the frame provides a layered functional architecture. There are presence of technical layers (data, hazard mapping, information mediums) from communicative layers (channels used, feedback and language mediums). The model here can be applied partially or completely to maximize the capacity of risk communication strategies.

Lastly the model is scalable and flexible that can be tailored to fit in not just flood-prone Assam but also cyclone vulnerable places like Odisha or drought afflicted Rajasthan or even globally for that matter.

5.5 Policy Leverage points:

To realize the effective implementation of the IRCR model, several strategic policies can be recommended.

1. ***Technology Governance*** – Establish interoperability standards that require all government hazard platforms to share data via APIs. This will eliminate duplication, speed up alerts, and unify public messaging.
2. ***Cultural Anchoring*** **–** Mandate the inclusion of local media formats—folk theatre, community radio, and multilingual materials—within official disaster communication workflows.
3. ***Feedback Infrastructure*** – Develop district-level data hubs capable of receiving, validating, and integrating community reports into hazard assessment systems.
4. ***Capacity Building*** **–** Train disaster management personnel at both state and district levels in culturally sensitive communication strategies and the use of multi-platform dissemination tools.

These measures would not only improve Assam's preparedness and response capabilities but also create a replicable governance template for multi-hazard risk communication in other regions.

5.6 Theoretical Implications

Linking with the IRCR theoretical perspective gains strength from the following perspective:

- ***Situational Crisis Communication Theory (SCCT)-***

The existing risk alert system are timely and technical but the framing tends to be technocratic. This implies that the messages rely on scientific terminology or formal administrative language creating a huge gap for people who are not experts. This can lead to less comprehension, slower responses, and lower compliance in rural locations with a varied population. According to SCCT, in order to trigger immediate protective action, crisis messaging needs to be sympathetic, audience-tailored, and in line with public attitudes.

- ***Cybernetic theory of Communication:***

The process of communicating about disasters is an ongoing feedback loop. Feedback loops are weak in Assam's existing setup; community reports hardly ever reach hazard dashboards in time to affect response. The system runs the danger of operational rigidity during rapidly changing events if these adaptive modifications are not made. Real-time feedback is emphasized by cybernetic principles as a way to modify plans, reallocate resources, and optimize message targeting during an ongoing crisis.

- ***The Theory of Cultural Risk:***

Cultural values, customs, and reliable intermediaries all influence how people perceive risk. Official alerts could be perceived as impersonal or remote if there are no ingrained cultural mediators, such as local leaders, folk performers, or faith-based communicators. By combining these channels, the message would be more resonant, trust would be strengthened, and emergency compliance rates would rise.

5.7 International bench-marking

A uniform comparative analysis clearly reveals that Assam's platforms have technological and innovative approach but last in interlinking, assimilation and social intermixing compared to the international counterparts.

- **Japan's J-Alert:** This national system of Japan integrates risk detection with both the national, local and multi-media broadcasting frameworks, ensuring timely, alerts across all mediums, maximising reach and assured delivery of message to the audience spread far and wide.
- **New Zealand's GeoNet:** This risk identifying digital media combines. Combines real time scientific data with that of people's participation strengthening the feedback loop which can be submitted through various mediums, phones, sms or social media creating a beautiful amalgamation of on-ground and centralized information system.
- **Brazil's KaR project (Knowledge and Risk):** This puts together the local feedback into risk mapping, leading to adaptive panning that takes into account the changing environmental background and the socio-cultural and socio-economic conditions. This approach integrates the risk data ownership with that of strong community participation.

Outcome based approach: This requires that the state of Assam can take a cue from the above risk communication strategies by being techno-centric not technocratic yet taking the feedback into consideration and ensuring that the digital applications are in sync with the community's needs, cultural variations, mode of communication, timely and integrates all the digital apps together.

6.Conclusion and Innovative elements of the research

This research applies the Integrated Risk Communication Response (IRCR) framework to elevate the state's three digital response platforms like that of the ICR-CR, Flood Hazard Atlas and Raahat applying appropriate theories and strategic functional and multi-media integrated culturally and socially competent risk communication tools.

The IRCR model's four functional layers, vis-a-vis the data acquisition and hazard mapping, localized early warning and early response along with resource coordination, multi media communication, outreach and feedback loop bought to light a system that is technically competent but functionally weak.

The findings show that ICR-ER excels in real-time, multi-hazard monitoring and inter-agency coordination but remains primarily government-facing. The Flood Hazard Zonation Atlas provides authoritative spatial mapping for preparedness but is static and disconnected from live hazard feeds. Raahat has the potential to close last-mile communication gaps but suffers from low adoption, minimal cultural tailoring, and weak integration with upstream hazard detection systems.

Grounded in Situational Crisis Communication Theory, Cybernetic Theory of Communication, and the Cultural Theory of Risk, the analysis demonstrates that Assam's platforms are technologically advanced but socially and institutionally under-embedded. Weak feedback loops, limited cultural adaptation, and lack of interoperability undermine the effectiveness of otherwise capable tools. International benchmarking—against Japan's J-Alert, New Zealand's GeoNet, and Brazil's KaR Project—further highlights the missed opportunities for real-time integration and participatory engagement that could accelerate the hazard alert–to–public action pipeline.

The study identifies three strategic imperatives for transformation:

1. Interoperability by Design – Link hazard detection directly to public alerts through API integration, dynamic data exchange, and real-time GIS updates.
2. Cultural Embedding – Integrate multilingual formats, folk media, and community radio into official workflows to ensure resonance in diverse socio-cultural contexts.
3. Institutionalized Feedback Loops – Enable two-way communication to incorporate community-sourced observations into operational decision-making during crises.

Such an integration-first approach could significantly reduce alert-to-action time, increase public compliance, and strengthen adaptive capacity. Beyond Assam, the IRCR model offers a scalable, theory-driven blueprint for other multi-hazard contexts in India and globally, ensuring that disaster communication systems are technically robust, culturally resonant, and socially trusted.

Limitations

This research relies primarily on secondary data and document analysis. Direct field studies, user adoption surveys, and operational audits could yield deeper, context-specific insights. The scope was limited to three formal platforms, excluding grassroots, NGO-led, and informal communication networks that may play significant roles in hazard response. Socio-economic impacts referenced in the gap analysis remain indicative, as no longitudinal cost–benefit modeling was undertaken.

Scope for future research

Future work should conduct field-based pilot tests of integrated workflows—for example, real-time ICR-ER–Raahat interoperability with live Flood Atlas updates—to measure actual reductions in alert times and improvements in evacuation rates. Audience reception studies could examine how culturally adapted alerts influence comprehension, trust, and behavioural response. Comparative applications of the IRCR framework to cyclone-prone Odisha, earthquake-vulnerable Nepal, or drought-affected Rajasthan could generate valuable cross-case insights. Incorporating economic modeling would also quantify avoided losses and cost savings from integration, strengthening the case for nationwide adoption.

Closing Statement

In an era of intensifying climate risks, speed, trust, and inclusivity are as critical as technical precision in disaster communication. Assam's experience illustrates that advanced tools alone cannot ensure resilience; without integration, cultural embedding, and active feedback mechanisms, their potential remains unrealized. Implementing the IRCR framework's integration-first approach can transform Assam's hazard communication into a cohesive, adaptive, and trust-anchored system—one that protects lives and livelihoods and serves as a replicable model for multi-hazard resilience in diverse contexts across India and beyond.

References

1. Covello, V.T., Peters, R.G., Wojtecki, J.G., Hyde, R.C. (2001). Risk communication, the West Nile virus epidemic, and bioterrorism: Responding to the communication challenges posed by the intentional or unintentional release of a pathogen in an urban setting. *Journal of Urban Health*, **78**(2), 382–391.
2. Houston, J.B., Hawthorne, J., Perreault, M.F., Park, E.H., Goldstein Hode, M., Halliwell, M.R., Turner McGowen, S.E., Davis, R., Vaid, S., McElderry, J.A., Griffith, S.A. (2015). Social media and disasters: A functional framework for social media use in disaster planning, response, and research. *Disasters*, **39**(1), 1–22.

3. Sharma, U., Patt, A. (2012). Disaster warning response: The effects of different types of personal experience. *Natural Hazards*, **60**, 409–423.
4. IFRC. (2020). *World disasters report 2020: Come heat or high water*. International Federation of Red Cross and Red Crescent Societies.
5. UNDRR. (2022). *Global assessment report on disaster risk reduction 2022*. United Nations Office for Disaster Risk Reduction.
6. Coombs, W.T. (2007). Protecting organization reputations during a crisis: The development and application of situational crisis communication theory. *Corporate Reputation Review*, **10**(3), 163–176.
7. Lachlan, K.A., Spence, P.R., Lin, X. (2016). Expressions of risk awareness and concern through Twitter: On the utility of using the medium in crisis communication. *Computers in Human Behavior*, **54**, 695–700.
8. Wiener, N. (1948). *Cybernetics: Or control and communication in the animal and the machine*. MIT Press.
9. Krippendorff, K. (1994). *A dictionary of cybernetics*. University of Pennsylvania.
10. Spialek, M.L., Houston, J.B. (2018). The development and initial validation of the Citizen Disaster Communication Assessment. *Communication Research*, **45**(6), 934–955.
11. Douglas, M., Wildavsky, A. (1982). *Risk and culture: An essay on the selection of technical and environmental dangers*. University of California Press.
12. Patt, A., Gwata, C. (2002). Effective seasonal climate forecast applications: Examining constraints for subsistence farmers in Zimbabwe. *Global Environmental Change*, **12**(3), 185–195.
13. NDMA. (2021). *National disaster management plan 2021*. National Disaster Management Authority, Government of India.
14. Gupta, M., Singh, R., Thomas, P. (2023). Digital integration for disaster risk reduction in India: Barriers and enablers. *International Journal of Disaster Risk Reduction*, **85**, 103–122.
15. Singh, R., Kumar, S. (2022). Evaluating flood early warning systems in Bihar: Gaps and opportunities. *Asian Journal of Water, Environment and Pollution*, **19**(2), 35–46.
16. Paul, B.K. (2009). Why relatively fewer people died? The case of Bangladesh's Cyclone Sidr. *Natural Hazards*, **50**, 289–304.
17. Barik, D., Sahu, P. (2018). Flood risk communication and resilience in Odisha: A case study. *Indian Journal of Geography and Environment*, **16**, 87–98.
18. Bordoloi, S. (2021). Communication challenges during the 2020 Assam floods: A case for localised strategies. *Journal of North-East Studies*, **10**(1), 45–62.
19. Singh, A., Devi, L., Sharma, P. (2021). Community radio in public health crisis communication: Lessons from Manipur's COVID-19 response. *Media Asia*, **48**(4), 301–316.
20. Bhandari, D., Wilkinson, S., Amaratunga, D. (2017). Local capacities for disaster risk reduction: Insights from the Gorkha earthquake, Nepal. *International Journal of Disaster Risk Reduction*, **22**, 37–46.
21. Baudoin, M.A., Henly-Shepard, S., Fernando, N., Sitko, P., Zommers, Z. (2016). From top-down to community-centric approaches to early warning systems: Exploring pathways to improve disaster risk reduction through community participation. *International Journal of Disaster Risk Science*, **7**, 163–174