A Comparative Usability Analysis of Instant Messaging and Online Forms for Crowdsourcing Disaster Image Collection

Shih Hsien Yang[1], Zih-Jing Yang[1], Hao-Yung Chan[2], and Meng-Han Tsai[1]

[1]Department of Civil and Construction Engineering, National Taiwan University of Science and Technology (Taiwan Tech), Taiwan
[2]Policy and Socio-Economics System Division, National Science and Technology Center for Disaster Reduction (NCDR), Taiwan
yangshixianqaz@gmail.com, neilyoung0107@gmail.com, hychan@ncdr.nat.gov.tw, menghan@mail.ntust.edu.tw

Abstract –

This study aims to explore how crowdsourcing mechanisms can address the limitations of traditional disaster monitoring systems regarding coverage and timeliness. Targeting the general public, this research leverages the features of instant messaging software and online forms to design disaster data collection interfaces. Furthermore, various platforms—including LINE, Google Forms, and Ragic—were implemented and evaluated for their applicability in reporting disaster imagery. Based on the System Usability Scale (SUS) and field tests, the results indicate that both Google Forms and LINE reached acceptable usability thresholds, significantly outperforming the more structured Ragic platform. This study confirms that interface designs aligned with existing digital habits effectively reduce users' cognitive load, serving as a critical factor in enhancing the resilience of crowdsourced disaster response systems.

Keywords –

Crowdsourcing; Disaster Image Collection; Disaster Resilience; Usability Analysis

1 Introduction

1.1 Background

Located in a subtropical monsoon climate zone, Taiwan is characterized by high mountains, steep slopes, and short, rapid rivers, resulting in inherently unstable hydrological conditions. According to disaster statistics from the National Fire Agency [1], typhoons and floods account for more than 88% of all recorded disaster events in Taiwan, often leading to widespread and severe socio-economic losses. Consequently, river management and disaster reduction have long been primary national policy priorities.

Modern river governance strategies have shifted from traditional engineering-centric approaches toward holistic planning that integrates physical hydrology, socio-economic activities, and natural ecological landscapes [2]. Furthermore, according to the disaster technology classification framework proposed by the Water Resources Agency (WRA) of Taiwan, providing precise real-time data contributes significantly to disaster preparedness [3]. Therefore, constructing a resilient disaster reduction system—one that effectively integrates structural and non-structural measures to achieve the goals of mitigation, prevention, and avoidance—is currently a critical challenge in the fields of hydraulic engineering and disaster management.

1.2 Motivation

1.2.1 Spatial Constraints of Current Monitoring Systems

Disaster response relies heavily on real-time data. Although Taiwan has established an extensive riverside surveillance network, information asymmetry remains a critical issue in remote areas and monitoring blind spots due to limited equipment coverage. Since fixed hardware sensors cannot achieve comprehensive monitoring, there is an urgent need for a complementary mechanism characterized by high mobility and wide coverage to eliminate blind spots and reduce decision-making latency.

1.2.2 Technical Barriers for Public Participation

In emergency scenarios, users have extremely low tolerance for complex operations. While traditional applications offer robust features, the typical need of download, installation, and registration creates significant entry barriers, discouraging participation from the general public. The core challenge of this study is to design a low-learning-cost interface that allows users to intuitively initiate reporting via existing digital tools without prior preparation.

1.2.3 Potential and Challenges of Crowdsourcing

Implementing crowdsourcing is a key solution to filling information gaps. By leveraging internet technology to redistribute tasks, the public can act as ubiquitous sensors, expanding isolated data points into collective intelligence and enhancing the resilience of information systems [4]. However, existing reporting tools often prioritize data rigor over user experience, resulting in high operational barriers. This study aims to overcome this conflict by exploring how interface optimization can maximize the benefits of crowdsourcing while maintaining data value.

1.3 Objectives

To effectively monitor the precursors of environmental disasters and the evolving trends of disaster conditions, it is essential to obtain extensive information through diverse methods and channels. Therefore, this study proposes that by extending the scope of information collection to the general public and encouraging collective participation in gathering disaster imagery, a more detailed and comprehensive record of disaster status can be established.

Consequently, the primary objective of this research is to design a user interface suitable for public operation to facilitate the effective collection and reporting of disaster images, thereby enhancing the completeness and integrity of information.

2 Related Works and Challenges

2.1 Case Analysis

To explore the design trade-offs of disaster information collection systems in depth, this study conducts a comparative analysis of two representative official systems in Taiwan. The selected cases include the "Agricultural Natural Disaster Photography App," a professional tool characterized by high entry barriers and high data reliability, and the "WRA Flood Protection Helper," a popularized tool known for its low entry barriers and high coverage. By analyzing the design logic of these two contrasting cases, this research aims to clarify the gap between professionalism and usability in current technologies, thereby establishing design benchmarks for public participation interfaces.

2.1.1 Agricultural Natural Disaster Photography App

Although this study focuses on public participation in hydro-meteorological disasters, a universal challenge across all disaster domains is balancing data reliability with user effort. The "Agricultural Natural Disaster Photography App", released by the Agriculture and Food Agency, Ministry of Agriculture, represents a rigorous model for verifying image authenticity to support government subsidy claims with two essential features:

- Reliability and Evidentiary Value: To ensure photos serve as valid administrative evidence, the system employs mandatory metadata embedding (GPS locations, timestamps, and cadastral data) and anti-tampering mechanisms. Its guided interface requires both wide-angle and close-up shots to ensure the visual data is interpretable and verifiable.
- System Resilience: As a native application, it offers superior offline functionality. Users can capture data in areas with poor connectivity and upload it later, utilizing pre-downloaded offline maps. This offline-first architecture is a critical advantage over web-based or messaging platforms during infrastructure failures.

However, there are barriers to public participation; despite its technical strengths, the high entry barriers—including mandatory installation and registration—deter spontaneous participation. While incentivized users (e.g., farmers) may tolerate these costs, the general public requires a more intuitive, easy-accessible interface. To maximize data collection during emergencies, the design must prioritize accessibility over complex technical requirements.

2.1.2 WRA Flood Protection Helper

In contrast to the high barriers of native applications, the Water Resources Agency (WRA), Ministry of Economic Affairs utilizes a LINE Official Account—the "WRA Flood Protection Helper"—to disseminate disaster information. This strategy bypasses the need for download, installation, and registration. By leveraging a platform already integrated into daily life, the system significantly reduces entry barriers and training costs. This case demonstrates the superiority of instant messaging platforms over traditional apps in terms of public reach and user adoption.

Despite its accessibility, the system remains primarily a unidirectional information channel. While users can receive alerts and query water levels, it lacks the interactive mechanisms for active reporting found in the Agricultural App. Specifically, the absence of a feature for uploading precise GPS-tagged disaster locations impedes the potential of the system to fully leverage its large user base as an effective monitoring system. Consequently, while the platform excels at information dissemination, it struggles to collect spatially-accurate, real-time field data during emergencies.

2.2 Challenges

Based on the analysis of current disaster reporting tools, this study identifies a conflict between participation breadth and data depth. The core issue is the lack of an interface truly optimized for the general public, which can be dissected into two aspects:

- Technical Barriers Hindering Information Capture: Professional tools prioritize evidentiary rigor through complex registration and download processes. This results in a technical exclusion that prevents the public from reporting during critical moments. Consequently, a lack of sufficient data points makes it difficult to detect subtle disaster precursors or establish representative trends.
- Low-Structure Interfaces Resulting in Critical Data Gaps: Conversely, while popular platforms lower entry barriers, their simplified interfaces lack the guidance necessary to collect critical metadata (e.g., precise GPS data). This results in fragmented data that lacks spatial and temporal context, making it difficult to perform trend comparisons or systematic analysis for disaster decision-making.

A gap exists for an interface that combines the usability of instant messaging with the data quality of professional applications. Designing an intuitive, low-load interface is the key to harnessing public participation and achieving a comprehensive overview of disaster evolution.

3 Methods

First, this study performs a functional and cost-benefit analysis of current mainstream image data collection methods to select interface platforms with low-barrier characteristics. Second, based on the critical requirements of disaster reporting, three sets of prototype systems with different architectures are constructed. Finally, through field testing in simulated disaster scenarios, a quantitative evaluation is conducted using the System Usability Scale (SUS) [5] to verify the suitability of each interface for public participation.

3.1 Analysis of Interface Platforms

To identify the most suitable reporting medium for the general public, this research analyzed three technical solutions: online forms, instant messaging software, and native applications (Apps). The evaluation criteria focused on functional accessibility, dependence on external services, user installation barriers, development costs, and cross-platform support.

Analysis results (Table 1) indicate that while native apps are powerful and independent, their requirement for “additional download and installation” and lack of cross-platform compatibility create significant entry barriers, alongside high costs for development and user training. In contrast, online forms and instant messaging software offer zero-installation access and cross-platform support, which significantly lowers the operational threshold for users. Furthermore, both are efficient, lightweight options with lower costs for development and user training.

Table 1 Functional Comparison of Technical Solutions

Technical Solution	Online Forms	Instant Messaging Software	Native Apps
Functional Accessibility	Limit	Limit	Extensive Access to Device Features
Dependence on External Services	Dependent	Dependent	Independent
Additional Installation	No installation required	No installation required	Additional installation required
Customization	Supported	Supported	Supported
Development Cost	Low	Low	High
Cross-platform Interoperability	Supported	Supported	No cross-platform support
User Training Cost	Low	Low	High
Information Sharing	Requires additional steps	Higher in-app efficiency	Requires additional steps

Based on this analysis, this study posits that zero-installation should be prioritized to encourage spontaneous public participation. Consequently, instant messaging software and online forms were selected as the primary experimental groups, while common online form tools were designated as the control group for subsequent system construction and comparison.

3.2 System Functionality and Implementation

Based on the aforementioned selection results, this research implemented three data collection systems for testing: Google Forms (based on universal cloud services), Ragic (a database platform), and LINE (an instant messaging platform).

To ensure that the collected disaster imagery possesses decision-making value, all systems were standardized with core functional requirements. During the reporting process, each system must guide users to provide the following critical field data:

1. Field Photos: To present the actual disaster situation.
2. Capture Time: To verify the timeliness of the data.
3. Capture Location: To confirm the disaster location

via GPS positioning or descriptions.

4. Supplementary Description: To provide textual explanations for details not captured in photographs.
5. Reporter Information: To collect basic names and contact information.

3.2.1 Google Forms

Google Forms has become a standardized tool for data collection due to its low implementation barriers and highly intuitive editing interface. Its core advantage lies in its seamless integration with the Google service ecosystem; collected data can be directly imported into Google Sheets for structured management, significantly reducing data format conversion costs.

Google Forms offers a web-based questionnaire interface that accepts various input formats. For collecting field photos, it utilizes a file upload question type that requires respondents to log in to their accounts. The capture time is manually selected by users through date and time fields. Since the platform cannot automatically retrieve GPS signals, it relies on users to manually input addresses or paste coordinate links. Supplementary descriptions are provided using paragraph text fields, and reporter information is collected through standard text fields for names and contact details.

3.2.2 Ragic

The Ragic platform offers significant customization flexibility, allowing this study to overcome the field and format limitations inherent in Google Forms. By utilizing its layout design capabilities, the form was restructured to visually separate disaster imagery from reporter information. The Images block at the top focuses on collecting spatiotemporal data from the disaster scene—including photos, descriptions, location, and time—while the Provider block at the bottom independently records the reporter's name, contact details, and status. This tiered design aims to reduce the user's visual burden during data entry and enhance the overall integrity of the information collected.

Ragic operates as a structured database. For photo collection, it allows users to activate the camera directly within the application field for real-time capture and upload, or to select files from their device's gallery. The capture time is manually selected via a designated field. For the capture location, a dedicated geolocation field enables one-tap GPS capturing or manual selection on a map. Supplementary descriptions are recorded using text fields. Regarding reporter information, the system automatically logs accounts for internal staff, while external users provide their details through standard input fields.

3.2.3 LINE

As LINE is the most prevalent instant messaging (IM) software in Taiwan [6], its high accessibility significantly lowers the entry barrier for the general public. Consequently, this study selected LINE as the platform to develop a chatbot for collecting disaster data. The interactive Q&A format of the chatbot effectively guides users, ensuring they clearly understand each step of the reporting process.

The LINE interface utilizes intuitive conversational interaction to collect data. Users can complete field photo collection by sending images directly within the chatroom. The capture time is manually selected and confirmed by the user. For the capture location, the system guides users to use LINE's built-in location-sharing feature to transmit map coordinates. Reporter information can be automatically retrieved by the system via the user's LINE account profiles.

3.3 User Testing Design

To evaluate the applicability of the three design models, this study developed a testing framework based on a standard environmental patrol workflow: "Upload Image – Mark Location – Mark Time – Text Description." The evaluation required participants to execute standardized reporting tasks designed to assess the usability of each interface. To ensure a comprehensive assessment, the following protocols were integrated into each task:

- Comprehensive Feature Utilization: Participants were required to complete all mandatory reporting fields to verify the integration of the core workflow components.
- Interface Flexibility Testing: Each task included an intentional error of uploading and then deleting an unrelated photo. This specific requirement was designed to test the system's flexibility in handling user corrections and file management.
- Operational Scenarios: The testing spanned various conditions, including disaster response, pre-disaster inspection, and real-time reporting, to validate the design models across diverse environmental contexts.

To supplement qualitative interviews, this study employs the System Usability Scale (SUS) [5] to quantitatively assess effectiveness, efficiency, and user satisfaction. The SUS is a globally recognized tool for rapid usability testing of interfaces and applications. It consists of 10 alternating positive and negative statements (Table 2). Participants rate their agreement with each statement on a 5-point Likert scale (1 for "Strongly Disagree" to 5 for "Strongly Agree"). These responses are then converted into a final SUS score, providing a standardized metric for quantitative analysis.

Table 2 System Usability Scale (SUS) Items

Item No.	Statement Type	Statement
1	Positive	I think that I would like to use this system frequently.
2	Negative	I found the system unnecessarily complex.
3	Positive	I thought the system was easy to use.
4	Negative	I think that I would need the support of a technical person to be able to use this system.
5	Positive	I found the various functions in this system were well integrated.
6	Negative	I thought there was too much inconsistency in this system.
7	Positive	I would imagine that most people would learn to use this system very quickly.
8	Negative	I found the system very cumbersome to use.
9	Positive	I felt very confident using the system.
10	Negative	I needed to learn a lot of things before I could get going with this system.

4 System Usability Scale (SUS)

This study conducts a comparative analysis of the usability of three platforms: Ragic, Google Forms, and LINE. The research objective is to identify a solution that combines high performance with low learning costs. Through the analysis of the System Usability Scale (SUS), the study seeks to verify a system that satisfies functional requirements while providing the lowest learning threshold for users, thereby enhancing the overall efficiency and accuracy of data collection.

4.1 Results

Following the recommendation of Sauro and Lewis (2012) [7], this study established a score of 68 as the threshold for a passing grade. Regarding the sample size, according to the research of Nielsen (2000) [8] and Virzi (1992) [9], five participants are sufficient to identify approximately 85% of usability issues. Furthermore, subsequent studies have confirmed that small samples of 8 to 12 individuals yield high reliability in SUS assessments [10]; therefore, eight participants were recruited for this study. All eight participants were adults aged 20-30, including both students and working professionals, all of whom are regular smartphone users.

This study utilized the System Usability Scale (SUS) to validate and evaluate the three platforms. The results, shown in Table 3, indicate no significant difference in usability performance between Google Forms (M = 69.06) and LINE (M = 68.75), as both achieved the SUS passing score. Regarding standard deviation, Google Forms recorded 21.3 while LINE recorded 17.9, indicating a lower dispersion of scores for LINE and suggesting more consistent feedback among participants. In contrast, the average score for the Ragic platform (M = 56.56) was below the passing threshold of 68, falling into the “Poor” range, which indicates that participants encountered significant difficulties during the process.

Table 3 Descriptive Statistics of SUS Scores

Platform	Google Forms	Ragic	LINE
Mean	69.06	56.56	68.75
Standard deviation	21.3	15.1	17.9

A one-way repeated measures ANOVA test was performed to verify the statistical significance of the observed differences in usability across the three platforms. Mauchly’s test indicated that the assumption of sphericity was not violated, $\chi^2(2) = 5.625$, $p = 0.060$; hence, no degrees of freedom corrections were applied. The ANOVA test revealed a significant difference in the SUS scores across the three platforms, $F(2, 14) = 4.15$, $p = 0.038$ ($\alpha = 0.05$).

4.2 Testing Observations and Interviews

Through observations during user testing and post-test interviews, this study found that participants, operational performance is highly correlated with their prior experience with the interfaces. Specifically, when encountering unfamiliar interfaces such as Ragic, participants required the reconstruction of operational cognition, leading to a significantly higher frequency of inquiries. In contrast, when using familiar interfaces such as Google Forms, participants were able to complete tasks quickly by leveraging their previous experience.

Notably, even with a platform as familiar as LINE, participants may still initially lack confidence when performing non-routine data collection tasks. However, this psychological barrier can be rapidly overcome through simple guidance, demonstrating that even for familiar tools, appropriate training is crucial for converting daily experience into operational confidence.

Regarding interaction design, interview results revealed that participants prefer intuitive interfaces that offer a seamless and concise flow to help them complete the tasks. Furthermore, there is a strong demand for clear system status feedback (e.g., completion prompts) to effectively minimize uncertainty and cognitive load during the operational process.

5 Discussion

5.1 Crowdsourcing Limitations and Data Bias

Crowdsourcing delegates organizational tasks to a large, unspecified public through voluntary online participation. However, data samples often exhibit spatial and socioeconomic biases, primarily representing tech-equipped demographics while under-representing remote areas and vulnerable populations. As a result, the collected information tends to concentrate in urban areas, leaving severely impacted but poorly connected regions under-reported. This imbalance compromises the fairness and accuracy of disaster assessment and decision-making.

5.2 Quality, Privacy, and Ethics

Data collection faces constraints in quality and completeness. Harsh disaster conditions often produce blurry or poorly lit images. Also, the absence of metadata (e.g., automated timestamps and coordinates) hinders accurate event mapping. In addition, a platform's technical limitations can further exacerbate data degradation. For example, LINE's default image compression significantly reduces resolution, potentially compromising the evidentiary details required for professional assessment. Without standardized formats or verification workflows, the high volume of unverified data increases the risk of misleading conclusions.

Furthermore, privacy risks arise from identifiable information or sensitive content (e.g., casualties or property loss) within images. Without robust de-identification and consent mechanisms, these risks can undermine public trust. Finally, temporal distribution is uneven; data typically surges immediately post-disaster due to media attention but remains insufficient during pre-warning and long-term recovery phases [11]. This study reflects this trend, focusing on short-term aftermath rather than long-term restoration processes.

6 Conclusions and Future Outlook

6.1 Conclusions

Based on the objective of strengthening disaster resilience, this study explores how to overcome the physical limitations of traditional fixed-point monitoring equipment regarding spatial coverage, while addressing the predicament of low public participation willingness caused by the excessively high barriers to downloading, installing, and registering current applications. To construct a public-participatory disaster image collection mechanism with low technical thresholds and high coverage, this study selected the most ubiquitous instant messaging software (LINE), online forms (Google Forms), and a database platform (Ragic) for system implementation and usability evaluation.

Through field testing simulating disaster scenarios and System Usability Scale (SUS) analysis, the research results indicate that the usability scores for Google Forms (SUS = 69.06) and LINE (SUS = 68.75) were both above the passing threshold of 68 points. This confirms that interface designs which align with the public's existing digital habits can significantly reduce users' cognitive load and learning costs. Conversely, the Ragic platform, due to its relatively unfamiliar interface structure, received a score of only 56.56, demonstrating that an overly unfamiliar design hinders intuitive operation by the general public.

This study confirms that when facing data collection scenarios involving non-victims or the general public, removing the barrier of application installation and adopting conversational or form-based interfaces—which provide process continuity and real-time feedback—is key to increasing reporting willingness and data quality while lowering learning thresholds. This ready-to-use pattern not only validates the feasibility of lightweight interfaces in disaster intelligence collection but also provides a specific empirical basis for the system design of future collaborative disaster reduction frameworks between the government and the general public.

6.2 Suggestions and Future Outlook

6.2.1 Evaluation and System Evolution

The current findings are derived from a limited participant demography who might possess high smartphone proficiency, creating a potential bias in both platform preference and usability performance. Since the intended user base encompasses the general public, subsequent iterations must involve older populations and individuals with lower digital literacy. Testing across these demographics is essential to determine if the observed usability advantages remain consistent or if demographic-specific barriers emerge. Expanding the participant pool will ensure that the resulting crowdsourcing systems are resilient and accessible to all citizens regardless of their technical background.

Future systems should be based on the System Usability Scale (SUS) measurement results of this study, using 68 points as the minimum acceptable usability threshold. The impact of different design adjustments on score variations should be continuously examined through multi-version iterations and long-term observations. By incorporating actual feedback from disaster management scenarios into the design cycle, interface stability and operational efficiency can be progressively enhanced, transforming the system into a work platform suitable for long-term adoption by practical units.

Also, future research should expand platform selection criteria to establish a standardized guideline for crowdsourcing disaster image collection. While this study identifies that unfamiliar interfaces require the reconstruction of operational cognition, this observation requires validation through more robust quantitative metrics. Specifically, measuring task completion time or error rates across diverse interface layouts could highlight functional differences that a subjective scale might overlook. Such metrics would provide a more granular understanding of how specific interface elements facilitate or hinder the reporting process.

6.2.2 Data Sources and Regional Bias Adjustment

Given the potential risk of bias in crowdsourcing, the system must establish a diagnostic mechanism for data distribution. For instance, geographic and demographic indicators should be integrated into the database and analysis modules to flag regions with sparse samples or potential bias. Furthermore, technical interfaces should be reserved for integrating diverse data sources—such as official surveys, remote sensing imagery, and field investigations—to compensate for systemic biases arising from a reliance solely on populations capable of uploading images.

6.2.3 Network Accessibility for Operations

Considering that communication disruptions often occur in the most severely affected areas during actual deployment, the system architecture must proactively account for unstable network scenarios. This study recommends developing operational modes featuring offline caching, delayed synchronization, and integration with other communication infrastructures (such as social media or dedicated wireless systems) to mitigate the risk of "the more severe the disaster, the harder it is to report," thereby avoiding blind spots in rescue decision-making caused by technical limitations.

6.2.4 Data Quality and Verification

To address variations in image quality, information completeness, and labeling accuracy in crowdsourced data, future systems should establish quality check and standardization procedures within the data import workflow. This includes verifying time and coordinate fields, identifying blurred or heavily obscured images, and providing semi-automated auxiliary labeling tools. Simultaneously, clear data verification and version tracking should be constituted to allow analysts to determine data sources, processing history, and credibility levels, reducing the risk of misinterpretation.

6.2.5 Privacy Protection and Ethical Governance

At the system level, privacy and ethics must be core design principles rather than afterthoughts. The platform should implement functions such as de-identification, access control, sensitive image masking, and usage log tracking. Additionally, the documentation of informed consent processes should be supported to protect the rights of victims and uploaders while maintaining public trust in the system and research.

6.2.6 Temporal and Long-term Observation

Crowdsourced imagery tends to concentrate during short-term post-disaster peaks, often lacking in the pre-disaster warning and long-term post-disaster recovery phases. Future systems could incorporate temporal distribution monitoring and notification functions to clearly indicate which disaster stage the current data reflects. By further combining long-term monitoring data with local reporting mechanisms, a cross-stage, multi-source disaster dataset can be constructed. This dataset can then be cross-referenced with usability evaluation results to support decision-making needs across the entire life cycle—before, during, and after a disaster.

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