Malasakit 2.0: A participatory online platform with feature phone integration and voice recognition for crowdsourcing disaster risk reduction strategies in the Philippines

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***Abstract*— We present Malasakit 2.0 (meaning "sincere care" in Filipino), an inclusive, multilingual participatory online platform with feature phone integration for collecting and analyzing quantitative and qualitative textual and audio data on disaster risk reduction (DRR) strategies. Malasakit 2.0 introduces interactive voice response (IVR) to support collection of audio data via feature phone. Malasakit utilizes peer-to-peer collaborative evaluation to identify and prioritize local DRR strategies. We present results from four field tests where 261 participants provided 1,582 evaluations of current DRR strategies, and over 950 peer-to-peer evaluations on 280 textual and audio suggestions for how local government (i.e., barangays) could better support vulnerable groups (e.g., elderly, women, children, and people with disabilities) during typhoons and floods. Results suggest that individuals who engage in disaster drills are also likely to participate in their barangay's clean-up drives to reduce flooding risk by clearing drainage pathways and that those who participate in disaster drills are also likely to have enough emergency supplies for a disaster. High-rated suggestions for DRR strategies for vulnerable groups emphasize the need for communities to establish response teams that prioritize reaching out to vulnerable groups for coordination during a disaster. Malasakit can be accessed at tiny.cc/Malasakit2.**

Keywords*— *collaborative filtering, development assessment, participatory assessment, disaster risk reduction, canonical correlation analysis

I. Introduction

Natural disasters are on the rise globally [1], affecting more than 160 million people each year [2]. The impact of these events is often most catastrophic in developing countries due to lack of effective disaster risk reduction (DRR) strategies [3]. Government-initiated DRR strategies tend to emphasize a top-down approach that minimizes the engagement of local communities in data collection, interpretation, planning, and response. To increase bottom-up engagement, we extended the Malasakit 1.0 (meaning "sincere care" in Filipino) platform, a customizable, multilingual participatory assessment platform that streamlines collection of quantitative and qualitative data and utilizes peer-to-peer collaborative evaluation to identify and prioritize local DRR strategies [4].

Fig. 1. The Malasakit v2.0 platform was deployed in the Philippines to crowdsource disaster risk reduction strategies. 261

As smartphones are not widely available in rural areas, Malasakit 2.0 introduces interactive voice response (IVR) and speech recognition to create a feature phone interface (see https://github.com/BerkeleyAutomation/malasakit). Incorporation of multilingual text and audio enhances participation from individuals who speak different languages and those who may have auditory or visual impairments (see http://opinion.berkeley.edu/pcari/v21/).

Malasakit 2.0 was evaluated in four field tests in the Philippines, the second most at-risk country for disasters worldwide [4], to gain insights into current and potential flood and typhoon DRR strategies employed by barangays (i.e., local government units): (1) Barangays 412 and 432 in Sampaloc, Manila; (2) Simon of Cyrene, a non-government organization for persons with disabilities (PWD) in Albay, Bicol; (3) Barangay 402 in Sampaloc, Manila; and (4) Barangay 401 in Sampaloc, Manila.

We present results from **261** participants who provided **1,582** evaluations of DRR strategies and over **950** peer-to-peer ratings on **280** submitted ideas for how their community could help vulnerable groups such as the elderly, women, children, and PWDs during typhoons and floods.

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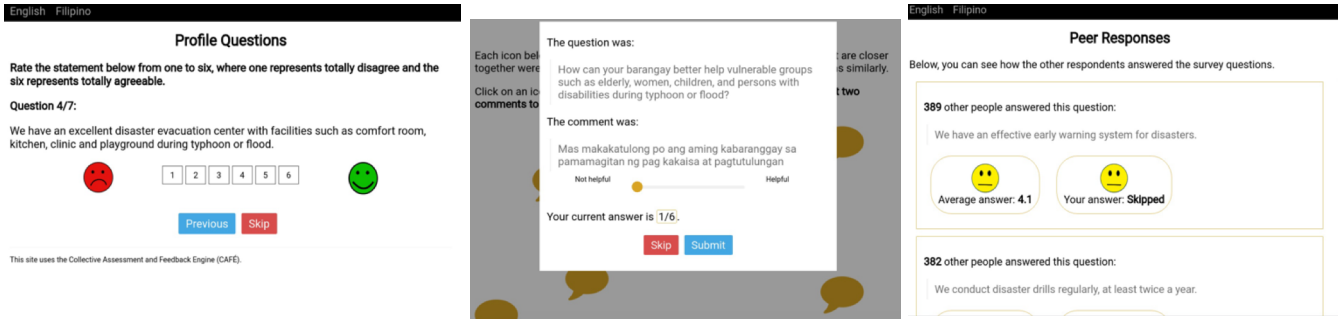

Fig 2. Screenshots of the Malasakit 2.0 platform. Participants first provide quantitative responses on key issues on a scale of 0 "Totally Disagree" to 6 "Totally Agreeable." Participants next enter an open-ended discussion where they can evaluate other participants' suggestions and provide their own. Participants then see how their quantitative responses relate to their peers' responses.

II. Related Work

Studies have shown the value of digital data collection tools for humanitarian evaluation and disaster risk reduction [5, 6, 7]. Open Data Kit (ODK), an Android-based platform, collects text, voice, image, and sensor data and features a variety of data export formats. Built on the ODK platform, the Harvard Humanitarian Initiative's KoBo Toolbox collects quantitative and qualitative data and features real-time processing of quantitative data [8]. Alternatives to online data collection tools include ODK Voice, Dimagi's CommCare, FrontlineSMS, and RapidSMS, enabling collection of audio, text, image, video, and other data over smartphones and feature phones.

While many of the features of ODK, CommCare, and Malasakit 2.0 overlap, we emphasize the value of peer-to-peer collaborative evaluation of qualitative data to enable participant-driven problem exploration and issue discovery. Through Malasakit 2.0, participants not only provide assessments of the status quo of DRR strategies, but also collaboratively evaluate the potential effectiveness of new DRR strategies proposed by their peers.

Malasakit 2.0 builds on our previous work on Opinion Space, DevCAFE, and Malasakit 1.0. Results from Opinion Space affirmed that presenting participants textual data in a 2D visualization increased engagement [9] and our field tests of DevCAFE in Uganda illustrated its ability to rapidly scale quantitative and qualitative analysis of the effectiveness of development interventions [10]. Malasakit 1.0 enabled rapid collection and analysis of quantitative data on effectiveness of DRR strategies and revealed novel qualitative ideas for DRR strategies through peer-to-peer evaluation [4].

III. Malasakit 2.0 Platform

A. Overview

Malasakit 2.0 is a customizable, multilingual, audio- and visual-based digital data collection platform that collects quantitative assessments, qualitative feedback, and peer-to-peer collaborative evaluation of qualitative textual and audio data (see tiny.cc/Malasakitv2, Malasakit 2.0 codebase available at github.com/BerkeleyAutomation/malasakit). Malasakit 2.0 was developed as a cross-platform web application using Django web framework and SQLite database backend and integrated an audio-based interactive voice response (IVR) version through Twilio. Textual and audio quantitative and qualitative data can be collected simultaneously through Malasakit 2.0 on a tablet, computer, smartphone or via Twilio on a feature phone. Due to intermittent internet connectivity in the field, Malasakit 2.0 features offline caching of application pages and responses with the JavaScript Service Workers and HTML5 LocalStorage APIs. All data are integrated into a single read-only database.

Malasakit 2.0 features three stages (see Figure 2.) In the first stage, participants provide their quantitative assessments of DRR strategies and assess their own disaster preparedness. In stage two, participants provide textual or audio responses to an open-ended qualitative question and collaboratively evaluate the helpfulness of others' responses. In the final stage, data from all participants are analyzed and presented back to participants, enabling each participant to see their responses in relation to others' responses.

The Malasakit 2.0 admin panel allows researchers to easily change the topical focus of the survey, modify question structures and presentation (e.g., change questions from Likert scale to short answer response), change landing page images and icons used to represent each participant's qualitative suggestion, moderate suggestions, create detailed data visualizations and reports, export data in CSV format, and add new users as administrators with view or edit permissions.

B. Integration of voice-based feature phone

Malasakit 2.0 includes a feature phone integration that accommodates participants without access to a "smart" device with internet browsing capabilities by calling a number to listen to an IVR version of the Malasakit 2.0 questions. This feature makes the toolkit more inclusive by enabling participation by those with visual impairment or low literacy. We use Twilio's programmable call service to provide a toll-free number for incoming calls. Then, Twilio will request instructions over HTTP from a server running Malasakit; these instructions are written in TwiML (i.e., Twilio's custom markup language) and

the Twilio client acts like a browser (e.g., accepts cookies). Twilio then executes these instructions for the caller by playing messages or waiting for input. This instruction fetch and execute loop continues until either the caller or Malasakit terminates the connection.

C. Demographic Questions & Issue Assessment

Participants first answer a set of demographic questions, including age, gender, barangay membership, and whether they identify as an individual with a disability. Next, participants answer quantitative assessment questions measuring barangay disaster preparedness, their participation in preventative measures to mitigate negative impacts of typhoons/floods, and whether their barangay has implemented additional support for vulnerable groups (e.g., elderly, women, children, and PWDs) during disasters.

D. Collaborative Evaluation

Malasakit 2.0 features a visual, interactive interface to enable peer-to-peer evaluation of qualitative DRR strategies for vulnerable groups. Malasakit 2.0 presents a 2D visualization presenting a subset of DRR strategies to aid vulnerable groups. Each participant is invited to evaluate the helpfulness of at least two of their peers' responses before submitting their own suggestion for ways their barangay can better assist vulnerable groups during a typhoon/flood. Rather than relying on the frequency of a particular DRR strategy for vulnerable groups to signify helpfulness, peer-to-peer collaborative filtering can identify novel strategies. For example, if DRR strategy "A" is submitted by a majority of participants but receives a low average helpfulness score, it may be a commonly thought of strategy but most agree will not be effective. Alternatively, DRR strategy "B" may be submitted by a minority of participants but receives a high average helpfulness score, indicating that it may be a novel strategy the community believes could be more effective.

E. Statistical Analysis Tools

Malasakit 2.0 offers the ability to export quantitative, qualitative, user activity data in portable file formats (e.g., CSV) for rapid analysis. In addition, the Malasakit 2.0 admin panel allows researchers to search and filter the database, allowing them to analyze data and draw insights without requiring direct access.

1) Demographics & Quantitative Data: Malasakit 2.0 applies principal component analysis (PCA) to the quantitative issue assessment questions in order to identify "factors" that most differentiate participants. PCA identifies a set of orthogonal linear combinations of principle components, also interpreted as latent, or unobserved "factors," providing a computationally efficient method for identifying correlations in the quantitative issue assessment questions. Results from the PCA can then be correlated with demographic or qualitative textual data.

2) Qualitative Data: Malasakit 2.0 supports peer-to-peer evaluation of qualitative suggestions, providing researchers with insight into top-rated suggestions by the community. Malasakit 2.0 employs "collaborative filtering" to allow participants to collectively rank each other's textual suggestions. Participants are provided a random sample of eight suggestions and are asked to rate the helpfulness of at least two of their peers' suggestions on a scale from 1 "Not Helpful" to 6 "Helpful."

Textual suggestions are selected for presentation to participants based off of the standard error of the mean rating for each suggestion. We construct a normalized cumulative probability distribution from which we sample 8 times without replacement. New suggestions are assigned the max standard error of the mean of [1,6], 3.5. Suggestions are then projected onto the 2D plane through random placement. Because suggestions with a larger standard error will be sampled more frequently, controversial suggestions with varied ratings and suggestions with fewer ratings will be sampled more often, encouraging more ratings to validate their salience. Suggestions that are consistently rated very highly or very lowly are not prioritized to be presented to participants. For the feature phone integration, two suggestions with large standard errors are selected and presented to each participant for evaluation.

IV. Case Studies & Results

Malasakit 2.0 was evaluated in four field tests in the Philippines, the second most at-risk country for disasters worldwide [4], to gain insights into current and potential flood and typhoon DRR strategies: (1) Barangays 412 and 432 in Sampaloc, Manila; (2) Simon of Cyrene, a non-government organization for persons with disabilities (PWD) in Albay, Bicol; (3) Barangay 402 in Sampaloc, Manila; and (4) Barangay 401 in Sampaloc, Manila (see Table 1). We used Malasakit 2.0 web version for the field tests in barangays 412, 432 and Simon of Cyrene and deployed the feature phone integration in barangays 402 and 401.

TABLE 1. MALASAKIT 2.0 FIELD TEST LOCATION

Method	Location	Description	Date (2018)	Partner Type	#
1. Tablet	Sampaloc - Barangays 412, 432	Urban	Feb. 3	Local Government	162
2. Tablet	Simon of Cyrene	Rural and urban	Feb. 6-7	NGO serving PWDs	30
3. Feature Phone	Sampaloc Barangay 402	Urban	March 14	Local Government	29
4. Feature Phone	SampalocBarangay 401	Urban	March 23	Local Government	40
Total Users					**261**

Malasakit 2.0 includes demographic questions (e.g., age, gender), seven quantitative assessment statements, and one open-ended qualitative question. The seven quantitative evaluation statements were drafted in coordination with local DRR experts and barangay leadership through focus group discussions and preliminary surveys. Malasakit 2.0 asked participants to evaluate seven quantitative statements on a scale from 1-6, representing "Strongly Disagree" to "Strongly Agree":

1. We have an effective early warning system for disasters (***Early Warning System)***
2. We conduct disaster drills regularly, at least twice a year. (***Disaster Drill)***
3. I regularly participate in our barangay's clean-up drives to fix drainages to reduce the risk of flooding (***Clean-up Drives***)
4. We have an excellent disaster evacuation center with facilities such as comfort room, kitchen, clinic and playground during typhoon or flood (***Disaster Evacuation Center***)
5. Our barangay doesn't have an early-warning system for disasters (***No Early Warning***)
6. To my knowledge, the barangay administration does not extend special care or help to senior citizen/elderly, pregnant women and person with disability (PWD) during disasters (***Special Care***)
7. My family has plenty of food and water supplies ready to survive in times of disaster (***Supplies***)

Malasakit 2.0 also asked participants to provide a qualitative suggestion to the question: "How can your barangay better help vulnerable groups such as elderly, women, children, and persons with disabilities during typhoon or flood?"

1) Quantitative Data: 261 participants responded to the four field tests (see Table 1). Nearly 35% of the participants were between the ages of 34 - 53.

We conducted two field tests using Malasakit 2.0 web version. The first field test included participants from barangays 412 and 432 in Sampaloc, Manila. There were 38 male and 116 female participants. Most of the participants were between ages 34-53 and 18-23 years (see Fig. 3).

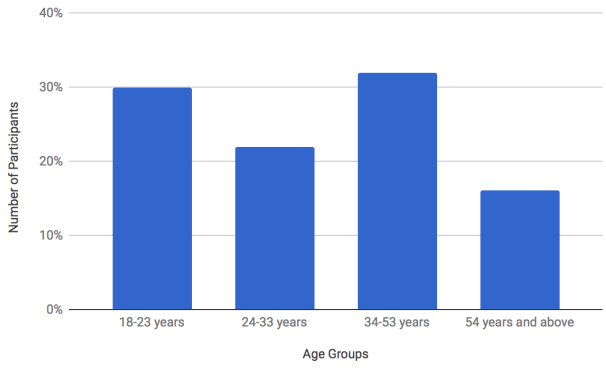

Fig. 3. Age distribution for field test at Barangay 412 and 432

Overall participants positively rated their barangay's DRR strategies. However, barangays were rated lower on their attention to special care and services needed among PWDs and facilities available within disaster evacuation centers (see Table 2).

TABLE 2. MEAN RESPONSE SCORE FOR QUANTITATIVE EVALUATION QUESTIONS ON DRR STRATEGIES

Quantitative Questions	*Barangays 412, 432*	*Simon of Cyrene*	*Barangay 402*	*Barangay 401*
Early Warning System	4.52	3.9	4.17	4.07
Disaster Drills	4.4	4.03	4.52	3.72
Clean-up Drives	4.4	3.38	4.27	4.13
Evacuation Center	4.4	3.7	4.70	3.89
Special Care for PWDs	2.9	3.76	3.03	2.46
Supplies	3.30	4.21	4.52	4.33

We observed strong positive correlations among the following quantitative responses:

- *Early Warning System* and *Disaster Drills* (corr=0.526, $p<0.001$). Barangays with an effective early warning system also conduct disaster drills regularly.
- *Disaster Drill* and *Clean-up Drives* (corr=0.536, $p<0.001$). Participants who regularly participate in disaster drills also likely to participate in their barangay's clean-up drives to reduce flooding risk by clearing drainage pathways.
- *Disaster Drill* and *Supplies* (corr=0.255, $p<0.05$). Participants who regularly participate in disaster drills are also likely to have enough food and water supplies to survive a disaster.
- *Clean-up Drives* and *Supplies* (corr=0.239, $p<0.05$). Participants who participate in clean-up drives are also likely to have enough food and water supplies to survive a disaster.

Question 5 served as a sanity check question to ensure participants were accurately recording their responses. A negative correlation was found between "We have an effective early warning system for disasters" and the sanity check question "Our barangay doesn't have an early-warning system for disasters" and (corr=-0.17, $p<0.05$). The negative correlation affirms that responses for question 1 are accurate.

Results from the second field test included participants affiliated with Simon of Cyrene, a non-government organization that assists PWDs in Albay, Bicol. There were 5 male and 20 female participants. Majority of the participants were from the age group 34-53 years (see Fig. 4).

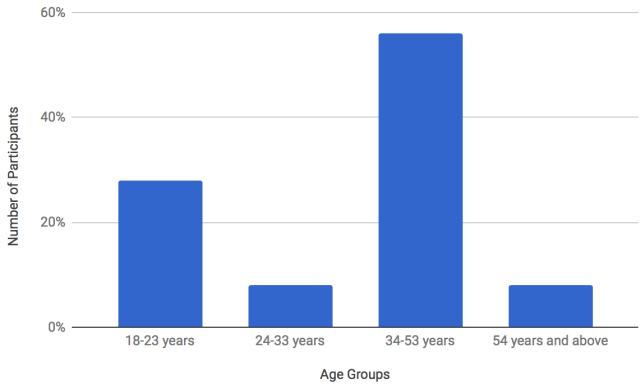

Fig. 4. Age distribution for field test at Simon of Cyrene, a non-governmental organization that assists people with disabilities in Albay, Bicol

We observed statistically significant correlations among the following quantitative responses:

- *Early Warning System* and *Disaster Drills* (corr=0.603, $p<0.001$). Barangays with an effective early warning system also conduct disaster drills regularly.
- *Clean-up Drives* and *Supplies* (corr=0.404, $p<0.05$). Participants who participate in clean-up drives are also likely to have enough food and water supplies to survive a disaster.

We also present results from the feature phone integration in barangays 402 and 401, which included 69 participants mostly between ages 18-23 and 34-53 years (see Fig. 5).

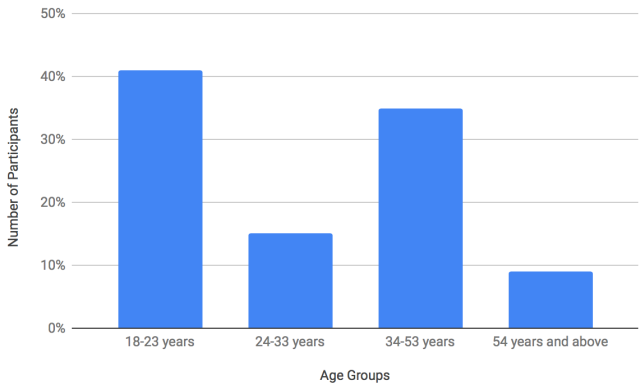

Fig. 5. Age distribution for Malasakit feature phone integration field tests in Sampaloc, Barangays 401 and 402

Following are statistically significant correlations observed for quantitative responses:

- *Early Warning System* and *Disaster Drills* (corr=0.527, $p<0.001$). Barangays with an effective early warning system also conduct disaster drills regularly.
- *Disaster Drill* and *Clean-up Drives* (corr=0.589, $p<0.001$). Participants who regularly participate in disaster drills also likely to participate in their barangay's clean-up drives to reduce flooding risk.
- *Clean-up Drives* and *Supplies* (corr=0.269, $p<0.05$). Participants who participate in clean-up drives are also likely to have enough food and water supplies to survive a disaster.

2) Qualitative Data: We collected over 950 peer-to-peer ratings on 280 submitted textual and audio suggestions for ways barangays could help vulnerable groups (e.g., elderly, women, children, and PWDs) during typhoon or flood.

Participants rate their peers' suggestions on a scale of 1 - 6 (1 corresponding to not at all helpful and 6 corresponding to extremely helpful). We identify top-rated suggestions by calculating the lower bound of the 95% confidence interval of the sample mean for the ratings on each suggestion, taking into account uncertainty in estimating the population mean rating. We selected the suggestions with the highest lower bounds and present the top four suggestions along with their average helpfulness score:

1. *"We must prioritize bringing people with disabilities in our community to the evacuation center."* (5.58)
2. *"Each barangay must have a 'Rescue Team' to help the senior citizens, pregnant women, people with disabilities and others more easily."* (5.21)
3. *"The barangays should have a profile of their constituents so that they can prioritize evacuation and rescue of vulnerable groups and should make their evacuation*

center friendly to these vulnerable sectors. In DRR Plan there must be a team assigned to them." (4.89)

4. *"In times of disaster, the barangay should move around their jurisdiction to find out who among their constituents needs special assistance. And after the disaster, they need to know what the citizen needs."* (4.44)

Highly rated qualitative suggestions focused on disability-inclusive disaster risk reduction and management, including efficient profiling and mapping of vulnerable groups in the community and identifying tactics to prioritize assisting the elderly, pregnant women, and PWDs during evacuation. Malasakit 2.0 also surfaced unique suggestions among participants, including building recreational facilities for children in evacuation centers—an important consideration to support children's mental and physical well-being during disasters.

V. Conclusion

Malasakit 2.0 is a participatory online platform with feature phone integration for collecting and analyzing quantitative and qualitative textual and audio data on DRR strategies. We evaluated Malasakit 2.0 across four field tests to identify bottom-up DRR strategies for typhoons and floods and to crowdsource DRR strategies to assist vulnerable groups.

We observed positive correlations among the following quantitative responses across all field tests:

- *Early Warning System* and *Disaster Drills*
- *Disaster Drill* and *Clean-up Drives*
- *Clean-up Drives* and *Supplies*

These correlations suggest that a barangay's commitment to following sound disaster risk mitigation practices such as facilitating disaster drills and having an effective early warning system are related to citizens' implementation of DRR practices such as taking part in clean-up drives and having adequate supplies of goods in times of disasters.

Participants provided helpful suggestions for DRR strategies for assisting vulnerable groups, including establishing response teams that will prioritize reaching out to vulnerable groups during disasters and the need for barangays to ensure their evacuation centers are disability friendly. Results were shared with local barangay leadership to help inform their DRR strategies and follow-up interviews with partner non-governmental organizations were conducted and confirmed that a number of evacuation centers and early warning devices were not designed for vulnerable persons, especially those with disabilities. This affirms that incorporating disability friendly facilities and services is a necessary and beneficial next step.

In future work, we will integrate a voice-based feature to the Malasakit 2.0 online version to enable audio recording of responses and presentation of audio recordings collected via feature phone. Audio recordings from the online version will also be distributed via the feature phone to enable simultaneous participation across all formats. Due to problems encountered with feature phone mobile connectivity (i.e., dropped calls or unclear connections), some data loss occurred. We are exploring strategies to mitigate poor online and mobile connections through Malasakit 2.0. We also propose a follow-up study to better understand user experience with the voice recognition feature offered in Malasakit 2.0 in comparison to participation via the screen-based version.

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