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NEW ZEALAND SOCIETY FOR EARTHQUAKE ENGINEERING

Outlook for earthquake early warning for Aotearoa New Zealand: Insights from initiating a community-of-practice

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ABSTRACT

A community-of-practice (CoP) is a community that comprises of members that build relationships with each other to create technical advancements motivated by shared goals. Establishing communities-of-practice has been demonstrated to enhance exchange and mobilisation of knowledge and facilitate the adoption and use of technological systems. At the beginning of 2020, a project had initiated a CoP for earthquake early warning (EEW) research and practice in Aotearoa New Zealand. In 2020, the project conducted three workshops and four webinar engagements with the CoP. One of the workshops focused on the shared values of the EEW research and practice community. This paper presents the findings from the shared values workshop. The paper shows views of the members of the CoP, including their technical and social opportunities and challenges for EEW in Aotearoa New Zealand. The CoP is an ongoing initiative and will be responsive to the various socio-technical issues of conceptualising an EEW system.

1 BACKGROUND

A nationwide earthquake early warning (EEW) system is not currently available in Aotearoa New Zealand, but conversations about it are starting to happen. Majority of the surveyed public (97%) supported an EEW system in New Zealand, viewing it potentially useful to some extent for the country (Becker, Potter, Vinnell, et al., 2020). Various sectors (i.e. utilities, emergency management, health, and education) also perceive benefits for their respective organisations (Becker, Potter, Prasanna, et al., 2020). An EEW system will motivate sectors to plan for organisational or site-specific actions to reduce impacts or aid in situational assessments (Becker, Potter, Prasanna, et al., 2020). However, despite the potential benefits, establishing an EEW system in New Zealand also comes with reservations and limitations as there are many technical and societal challenges to overcome. The challenges include determining whether it is technically feasible to send out alerts, how, to whom, what medium, and whether users will heed warnings to take appropriate action (Wald, 2020).

Understanding the viability of EEW for New Zealand requires a multi-faceted transdisciplinary approach that engages with various stakeholders to address the complex technical and social issues. Establishing a community-of-practice will support the needed conversations with various stakeholders from research and industry on EEW for New Zealand. A community-of-practice (CoP) comprises members who share a common concern or passion, and they regularly interact learning how to do things better. The CoP build relationships to create technical advancements motivated by shared goals (Wenger, 1998). In the disaster resilience space, establishing CoP can enhance a community's resilience as CoP promotes exchange among stakeholders, improves knowledge mobilisation, and facilitates the adoption and use of technological systems (Amaratunga, 2014).

1.1 Starting a community-of-practice for earthquake early warning in New Zealand

In 2020, the Earthquake Commission (EQC) and Massey University funded a project to investigate the feasibility of using community-based low-cost sensors to issue out earthquake early warning. The project is using a social engagement approach by starting a CoP to support technological research and development. The project started to facilitate conversations with the broader community of researchers and practitioners engaging in EEW. From January to March 2020, the project team identified and corresponded with different stakeholders from universities, research institutions, sensor manufacturers, emergency management authorities, and other interest groups to be part of the CoP. The CoP's philosophy is to maintain engagement with various parties with different project objectives but collectively want to advance EEW for New Zealand. The project had planned for three main activity types for the first year: (1) meet and greet events, (2) information sharing seminars with experts locally and internationally, and (3) requirements gathering activities for EEW systems.

However, because of the COVID-19 pandemic, the activities had to be adapted. The project team had to re-strategise for 2020 to ensure ongoing and continuous engagements with the CoP on EEW despite the unfolding situation. Despite the limitations brought about by the pandemic, the project team was able to hold the planned CoP activities with seven online events (see summary on Table 1). The online events had an average of 25 attendees each. Members of the CoP joined these activities voluntarily, and not all participated in each of the events. But with each event, new people joined in and are included in the distribution list for invitations to future CoP activities.

The CoP was launched with the first online workshop with 29 attendees. The launch workshop aimed to discuss previous EEW research and initiate a collaborative discussion on advancing EEW. It included short presentations from different stakeholders (sectors from academia, business, emergency management, etc.) discussing current research and experiences on EEW. The workshop gave the members of the CoP to meet each other share their knowledge about the current projects and opportunities for EEW in New Zealand.

Table 1: Summary of the CoP activities for 2020

Date	Activities
3 Apr 2020	Launch workshop for the CoP
5 May 2020	Webinar on citizen science with Prof Muki Haklay
11 Jun 2020	Webinar on Taiwan's EEW system with Prof Yih-Min Wu
23 Jul 2020	Shared values workshop
30 Jul 2020	Workshop on the potential for EEW in New Zealand
29 Sep 2020	Webinar on Social Science and ShakeAlert system with Dr Sara McBride
10 Nov 2020	Webinar on Sensors in schools with Raspberry Shake's Gabriel Low

After the launch workshop, the project team arranged succeeding webinars and workshops to ensure continued conversations on the various topics involving EEW. For the webinars, international subject matter experts shared their knowledge with the CoP. Workshops were also held with the participation of CoP member to discuss the issues, concerns and expectations of EEW in New Zealand.

2 SHARED VALUES WORKSHOP

From the initial activities, it became evident that the members of the CoP come from different backgrounds but have shared interest in advancing EEW for New Zealand. The project team realised that it is important to understand the shared values and the different perspectives of the CoP members. A community with shared values and common interests opens an environment for its members to share knowledge and information (Lave & Wenger, 1991). A shared values workshop was designed and conducted in July 2020 to scope the perceptions of EEW and shared values among researchers and practitioners. The online workshop was conducted after obtaining appropriate approval under the Massey University code of ethical conduct for research, teaching, and evaluations involving human participants. This paper presents the insights gained from the shared values workshop.

2.1 Participants

The 22 workshop participants came from different sectors, including universities, crown research institutes, emergency management authorities, private companies, and outreach programmes. The groups had a diversity of expertise on different topics including structural engineering, information systems, seismology, computer science, warning systems and public alerting structures, risk assessment and management, emergency management, science communication, social sciences, and community engagement,

2.2 Workshop structure and guide questions

The online workshop involved semi-structured discussion with the attendees. The project team presented three guide questions for the workshop that helped prompt discussions. The questions were piloted and refined before its use in the workshop. (1) What are your aspirations for EEW in New Zealand? (2) What strengths do you wish to share with the community-of-practice? (3) Where do you think is a good place to start EEW research with communities?

The three questions provide a way for the participants to share their insights on their shared values for EEW looking at a future perspective, their own strengths, and an outlook towards EEW conversations beyond the CoP. The workshop structure was designed to ask a future-oriented question first to help the participants orient towards aspirations and not get caught up too much about the current technical limitations. The second question's role is to prompt the participants to share and learn about each other's capabilities. The third question provided an opportunity for the participants to think beyond the CoP, on where the EEW conversations can start with communities.

The workshop used ZOOM as the teleconferencing platform as it had a feature for virtual breakout rooms. The workshop had three breakout groups of 7 to 8 participants, where more in-depth discussion occurred. The three questions guided a 45-minute conversation for each group. After the breakout session, all 22 participants and facilitators returned to the main virtual room for 10-minute wrap-up, where everyone had a chance to provide their additional thoughts and comments.

2.3 Analysis of the workshop

The breakout groups sessions and the final wrap-up session were recorded and subsequently transcribed. The facilitators of the breakout groups also took notes during the sessions. The transcriptions, along with the facilitator's notes, were subjected to qualitative analysis. The qualitative analysis involved four steps: (1) listing of keywords, (2) clustering keywords into themes, (3) plotting the participants' responses and quotes onto matrices based on the keywords, and (4) using patterns and commonalities to form insights to the CoP's views towards EEW research and practice.

3 FINDINGS

The members of the CoP that participated in the workshop had different expertise. They shared their experience and knowledge of EEW from the perspectives of seismology, engineering, computer science, information systems, social sciences, risk communication, community engagement, etc. Given the diversity of backgrounds, the participants highlighted different perspectives to their expectations and concerns for an EEW system in New Zealand. The analysis of the transcriptions indicated that the topics discussed by the participants fall into four broad themes: (1) technology, (2) people, (3) knowledge, and (4) broader perspectives (i.e. broader framework of the early warning system and hazard risk management).

The workshop brought about the participants' thoughts on technological considerations, challenges, and benefits for an EEW. The workshop also emphasised that an EEW system also involves the people; the public must understand, trust, and use the system. Furthermore, the effectiveness of an EEW system requires knowledge exchange between the technological and social sides. Finally, the CoP also needs to have an overarching outlook to considers the risks, benefits, and broader considerations of an EEW system. Below we highlight some key points the participants have raised along with these themes.

3.1 Technology

Participants indicated that when considering an EEW system for New Zealand, it is essential to know what technologies already exist and recognise technology's fast-changing pace. An EEW system must utilise current technologies and the different data streams available and have the capacity to integrate with new sensors, methods, and data streams as they become available. A comment from a participant highlighted the need for a system to have thoughtful integration with current and new technologies:

> *I can well imagine, and I've seen it actually happen that through the course of technological advances, new methods and new data streams come into play. And I think it's absolutely crucial for us when we go forward we don't go forward just purely on some sort of technological platform*

rather we do so on an ideological platform that's capable of ingesting different datasets, […] capable of using everything we have available to us […]

An EEW system also needs to leverage a large amount of data from different data sets from various sensors and systems. The group discussed the assortment of instruments data sources, and quick and real-time processing challenges to issue warnings. Other participants encouraged further research for a platform that can ingest different datasets while rapidly delivering accurate information. There is also a need to test the warning system's efficacy when integrating all data sources.

The participants also discussed the potential for having multiple technological benefits and other uses to come with an EEW system. For engineers, an EEW system can pave the way for instrumentation. Instrumentation of infrastructures can help monitor structural health and provide bettering understanding of downstream effects. A participant commented:

There may be some benefits for having an early warning system, but I would like to maybe broaden the discussion and include also instrumentation that is not just for detection of waves that are coming but also instrumentation that can help us figure out what happened even after the fact. We can identify areas that need more attention in a city or maybe buildings at may need more attention on the basis of what we record.

The group also acknowledged the benefits of learning from other countries' technological EEW applications but recognised the need to tailor EEW to the New Zealand context. However, the groups also raised issues regarding the feasibility and affordability of widespread instrumentation in New Zealand. A participant reiterated that low-cost sensors already exist in the market, and asked the group on how and what we can do with existing low-cost technology to provide solutions to community

3.2 People

The participants agreed that an effective EEW system is not solely based on sound technology but also well-informed users. Designing an EEW system must consider whether people will adapt and use the system. The participants have highlighted that an EEW system is successful when people trust the information given and take appropriate actions.

The participants agreed that a CoP for EEW should work to understand the users and the social aspects of implementing early warning systems. There should be a match between people's expectations and the system's capability. A participant who had experience with working with communities reiterated: doing the groundwork is fundamentally important right at the outset, getting the people's trust and their buy-in, and consequently addressing their resistance, are important matters.

The workshop findings highlight that a people-centred technology solution is paramount for EEW in New Zealand. Members of the CoP also have an interest in ensuring that people's perspectives are included in developing an EEW system. A participant shared why they have the interest to be part of the EEW CoP:

My interest in the early warning space [is on] how we get those community voices and the design and processes involved in setting up early warning system.

When asked which communities these EEW engagements should start, the participants' suggestions focused on geographic communities with higher seismic risks. It was also suggested that the engagements could start with communities that the members of CoP have linkages with, where previous or similar conversations have already started. A participant said: *It is important to consider mana.* The linkages and communities identified by the participants will be helpful as the project considers its future engagements.

The participants also highlighted the need to ensure representation from various demographics. When having conversations with different groups, consider what the community's desired involvement level is.

[How] are we engaging with them? Are we [just] informing them? Are we involving them as co-design partners and then setting out […] the steps that we go forward with those people? […] Ask how they want to be involved […] might be a good starting point.

A participant also suggested that the conversations with the people start with pilot engagements by rolling-out small scale technology with target communities. Pilot case studies can provide evidence and support for a broad implementation of EEW. A case study approach can bring a better understanding of how to communicate early warnings to different communities and help authorities frame adaptable but consistent messaging.

3.3 Knowledge

Conversations on EEW systems may often be dichotomised between technology and people. However, the workshop's discussion had a more holistic view on EEW and recognised that there should also be knowledge exchange between the technological and social sides.

On the one hand, those working on technological developments should understand the people. A participant noted that science communities such as this CoP have the risk of being insular; that there should be an effort for CoP to understand and learn from the end-users. The people's contexts and expectations should also be communicated to those who make decisions on warnings systems. A participant with computer science background mentioned that successful technological solutions are those that understand their users:

Before developing […] technological solutions, we need to understand the requirements from users [and] the social aspects [of EEW systems].

Reciprocally, the technological aspects and capabilities of an EEW should be understood by the users. For an EEW system to work, the public should comprehend the information the system gives out. Public education efforts should translate science better, helping communities to conceptualise risks better. A participant with an emergency management background encouraged the CoP to include and involve the Civil Defence and Emergency Management (CDEM) groups as they already have a role in educating communities on emergencies and disasters. There should be ongoing liaison within regions. The conversations with the public may not be just limited to EEW but also include earthquake preparedness and response.

A participant with community outreach background mentioned that with EEW, expectations with the people should be clear on the outset:

Being aware of what is realistic. [Set] clear expectations and what it can and can't do. [Say] you can't give people a 10-minute heads up or we can give you possibly couple of seconds. I think making that clear is a big thing. People have expectations and if you don't meet those expectations, people can get […] very upset.

Building a bridge between the technical and social sides is critical for an EEW system. The CoP should look into ways of communicating impacts the fit with the EEW and make sure that the language is not focussed on the technicalities but also consider how people will perceive and use the information. A participant working on the technical side of EEW acknowledges the importance of the mutual exchange. The participant highlighted that, as scientists, they would work their best on getting the technical aspect right. They also acknowledge that the key to successful early warning system is to have well-informed users, and this will only be built by having mutual trust between scientists and end-users:

The really important part of the successful early warning is to have informed end-users. We [need to] engage end-users that […] they understand what the early warning is providing to them. The [people's] trust [is more] than just with the product, because it's really about mutual trust.

[Reliable] information […] and transparency will help build the trust between end-users and the scientists.

3.4 Broader perspectives

Finally, the participants talked about EEW more broadly. There is a need to have a holistic perspective or framework that looks at the risks, benefits, and wider contexts of implementing an EEW system in New Zealand. There are other considerations in the EEW conversations that will be raised as the CoP becomes larger, and as the EEW conversations start with the public. For example, earthquake risk may not be the forefront concern for communities. Other natural hazards, such as flooding recur more often with impacts, and there may be other more prominent issues for some communities.

Also, there are broader frameworks that must be considered. For example, there are already national warning structures in place. How does an EEW align with existing frameworks on tsunami and earthquake warnings? How does an EEW system integrate and consider the various public alerting options already available in New Zealand? Furthermore, the participants anticipate that an EEW system will reap more benefits, and subsequently more support if it has an integrated design that is not limited only for the earthquake early warning purposes.

The participants' general expectations for an EEW system can be summarised in four categories:

- a system that generates useful information that can be used for decision making by end-users,
- an EEW system that prioritises people-centred technology solutions,
- a nationally implemented system that uses affordable technology, and
- an integrated design that uses current and new technologies, can incorporate different data sources and be utilised for other purposes.

4 DISCUSSION AND CONCLUSION

It must also be recognised that Aotearoa New Zealand has a complex and diverse tectonic setting, as such there will challenges in implementing EEW in the local and national context. EEW is a worthwhile endeavour that has potential benefits, but there are technical and social hurdles to overcome to ensure an effective and trusted system. The workshop findings show that, although the CoP members are diverse, there are common aspirations for establishing EEW in New Zealand. The priorities of the participants to EEW differ depending on their various backgrounds. However, the participants generally agreed that a holistic approach supporting constant knowledge exchange is desirable. Neither technology requirements nor the people's needs can be addressed in isolation.

Findings from the workshop also substantiated the need to start engaging EEW conversations with the public. Suggestions on partner programmes and communities from the participants of this workshop will be useful as the project develops approaches to community engagement. Initiating this CoP is a crucial first step towards a people-centred approach to addressing the challenges a viable warning system for New Zealand.

The workshop highlighted the importance of having a collaborative framework for EEW research and practice. The productive discussion stemming from the workshop demonstrated that engaging with the CoP enhances exchange and mobilisation of knowledge. The valuable insights and diversity of perspectives that stemmed from the workshop provide support to continue engaging with the CoP through different activities. These conversations must continue to happen as research in EEW progresses. More focussed discussion can be held with the CoP as different projects address the socio-technical concerns of EEW systems. The EEW CoP, as an ongoing initiative, will be responsive to the various socio-technical issues of conceptualising an EEW system.

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