Abstract

Marae are traditional meeting grounds and a vital component of cultural infrastructure for Māori, the Indigenous peoples of Aotearoa New Zealand. The precarious exposure of marae to natural hazards and climate change poses a significant threat to the cultural identity and wellbeing of Māori communities. In recent hazard events, marae have repeatedly played a central role in providing safety and shelter for the community at short notice. This research explores the resilience of marae to natural hazards and examines the role of marae in emergency preparedness and community response. Adhering to the tenets of kaupapa Māori theory, the research employs a mixed-methods approach with GIS-based hazard maps and semi-structured interviews to assess marae hazard exposure and inform marae-based decision-making. Key outcomes include the development of marae-specific hazard maps contributing to emergency preparedness plans for 26 marae in the study region in collaboration with Te Arawa Lakes Trust, a local tribal post-settlement governance entity. A significant finding is the crucial role of Māori engineers whose understanding of Māori values and protocols bridges the gap between technical solutions and cultural needs. This research presents a novel approach for engineers and practitioners to work collaboratively with Māori. This work highlights the importance of flexibility and patience, recognising the voluntary nature of marae roles.

From past failures to effective engagement: bridging the gap between engineering and cultural infrastructure

Peer reviewed

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Introduction

Aotearoa New Zealand (hereafter, Aotearoa) has many geophysical, hydrological, meteorological and climatological natural hazards. The hazards that have had significant effects in recent events include seismic (Fraser et al. 2014; Hinga 2015; Okaya et al. 2007; Partridge et al. 2011; Soons and Selby 1992; Wibowo et al. 2021; Zhang et al. 2018) and co-seismic (Rosser et al. 2017), fluvial flooding (Kingston et al. 2016; Mason et al. 2021; Reid et al. 2021), coastal flooding (Lane et al. 2017) and high-impact weather events (Anderson et al. 2008; Basher 2013; Melia et al. 2022). Climate change projections in Australasia demonstrate long-term trends toward warming, rising oceans, increased frequency of extreme heat events, fewer events of extreme cold and changes in rainfall patterns (Reisinger et al. 2014). In anticipation of increasing natural hazard frequency and intensity, it is of interest to investigate the effects on Māori communities.

Māori are the Indigenous population of Aotearoa. Many Indigenous communities are already experiencing and adapting to changing climate (Ford et al. 2020; Maldonado et al. 2014), including Māori. Bailey-Winiata et al. (2024) showed that because Indigenous peoples have histories with marginalisation, lower socio-economic opportunities, lack of resources, poorer health outcomes and the ongoing intergenerational effects of colonisation, data suggest that Māori may be vulnerable to natural hazards and climatic variability. Notwithstanding, Māori have long practised the art of resilience for centuries as many cultural practices require rapid response, collaboration and leadership. Further, Māori have coordinated time, people and resources through cultural imperatives due to the artificial hazard of colonisation (Fa`aui and Hoete 2022; Kenney and Phibbs 2014).

This paper explores a novel approach to conducting research with Māori communities in engineering and disaster management contexts. The objectives are threefold:

- To describe the culturally resonant research approach that ensures positive engagement and mutually beneficial outcomes.
- To present the key factors of success when dealing with marae and Māori communities.
- To address the apparent divide between engineers and the community, as well as technical capability for informed decision-making.

The case study relates to the iwi [tribe] of Te Arawa located in the central North Island of Aotearoa. Kaupapa Māori research that is designed by, for and with Māori may be more relevant for disaster research and analysis than mainstream approaches (Phibbs et al. 2015). To this end, the University of Auckland conducted research in partnership with Te Arawa Lakes Trust to document Māori responses, co-develop marae emergency preparedness plans and capture the voices of Māori communities within the study region. This research contributes to the growing body of literature on marae resilience and disaster risk reduction by Indigenous peoples more broadly.

This paper begins by setting the research within its historical and cultural context through an exploration of post-1840 history and the connection between Māori and land. The importance of Māori values and the role of marae in natural hazard contexts is elucidated. The materials and methods section outlines the methodological approach, including kaupapa Māori principles and geospatial analysis, which together underpin the research. The discussion and conclusion sections synthesise the findings and summarise key outcomes, respectively.

Past and present context

This section examines the historical context of Aotearoa, with a focus on the period following the signing of Te Tiriti o Waitangi and the repercussions for Māori. The connection between Māori and land is explored to introduce the concept of marae or pā and their function in contemporary natural hazard contexts.

Post-1840 history

In 1840, some Māori tribal leaders signed Te Tiriti o Waitangi (the Māori language version of the Treaty of Waitangi) with the British Crown (Ruru and Kohu-Morris 2020). The treaty is the founding document of Aotearoa, a covenant between the Māori people and the British Crown, agreed upon to recognise Māori ownership of their lands, properties and to grant the same rights as lawless British subjects (Fa`aui 2017). Because 2 versions of the treaty were created, one in English and one in Te Reo Māori (the Māori language), the contents differed considerably, leading to confusion, ambiguity and contrasting interpretations (Burns et al. 2024). The Crown assumed the treaty granted the British sovereignty over Aotearoa, while Māori believed Te Tiriti allowed the British the right to govern in exchange for protection and the rights of British subjects under the Crown, while still maintaining the authority to manage their tribal affairs (Cant 1995). This discrepancy fuelled a series of injustices against Māori and has since been viewed as a strategic manoeuvre to introduce colonisation and assimilation in Aotearoa (Came 2013).

Aotearoa has a complicated history with engineering projects and working with engineers has often had negative consequences for Māori communities, resulting in irreversible effects across the economic, social, cultural and environmental domains of wellbeing (Fa`aui 2017; Morgan 2008). Numerous examples of this tension can be found since the turn of last century. For example, the Auckland sewage disposal scheme in 1914 depleted the main food source of local tribe, Ngāti Whātua (Morgan 2008); the Ohaaki power station, constructed in 1980s, gave rise to significant land subsidence (Allis and Zhan 2000; Bromley et al. 2015) and displaced local tribe members of Ngāti Tahu (Stokes 2004) and, in the same decade, an effluent discharge into the Kaituna River as a mechanical solution from the mind of an engineer was highly objectionable on medical, social, spiritual and cultural grounds and elicited profound discontent among the local tribe of Ngāti Pikiao (Temm 1990; Waitangi Tribunal 1984).

Engineering New Zealand (2022) (the professional body that represents engineers in Aotearoa) acknowledges that the establishment of institutions grounded in imperial models are examples of chequered histories and failures toward Māori over the years. Central to these cases are the adverse effects that result from a lack of consideration, consultation and understanding of the specific cultural contexts of Māori communities. Despite the validity and practicality of the technical engineering solution, the failure to comprehend the worldview, knowledge and belief systems of Māori resulted in missed opportunities to incorporate and build on the existing body of traditional knowledge present (Poli et al. 2022). By extension, this lack of understanding and consultation gave rise to the oversight of the specific needs of Māori as an end-user community (Engineering New Zealand 2022). To be effective, any solution developed should be fit-for-purpose and aligned with the specific context in which they are applied. It would be fair to say that these instances are undeniably a direct result of the treaty's signing, and the ensuing series of legislative structures instituted to further suppress, marginalise and culturally fragment Māori. The introduction of several key pieces of legislation—chiefly the *New Zealand Settlements Act* (1863), the Native Lands Acts

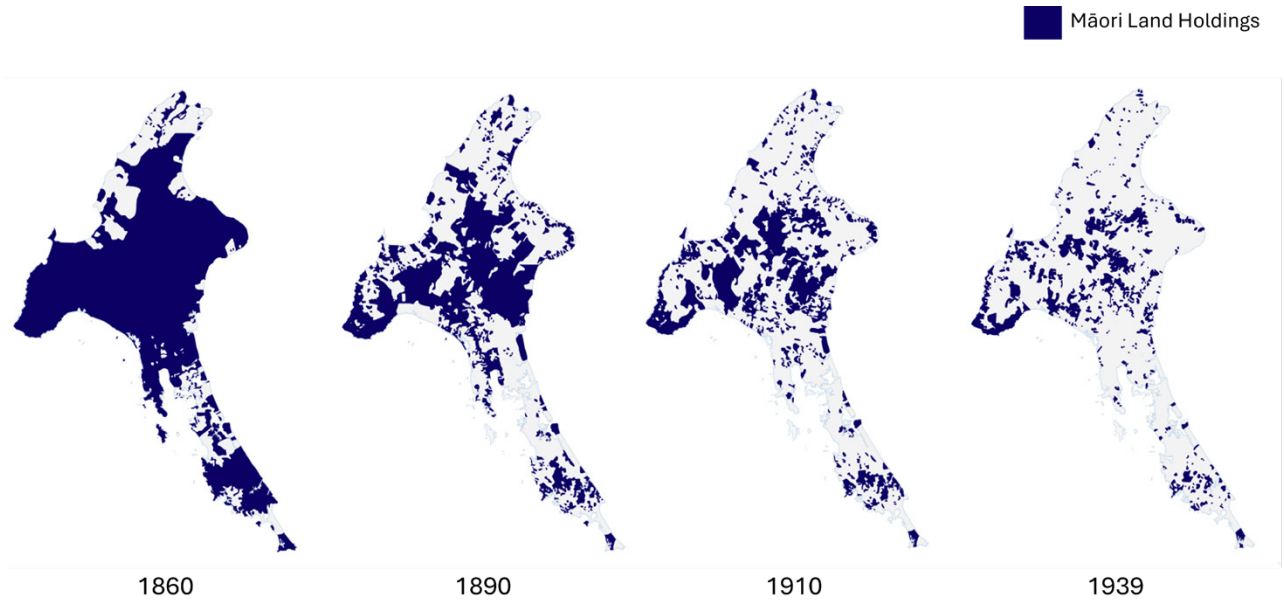

Figure 1: Māori land holdings declined due to confiscations in the North Island of Aotearoa New Zealand in 1860, 1890, 1910 and 1939.
Source: Adapted from Appendix 4, Orange (2004).

(1862 and 1865) and the *Public Works Act 1864* (and later amendments)—resulted in significant land loss for Māori (Thom and Grimes 2022), as illustrated in Figure 1.

Māori connection to land

Like many nations, the relationship between Māori and the land differs significantly from that of their non-Indigenous counterparts (Durie 1999; Gilliam-Knight et al. 1992; Morgan 2008). It has more to do with the notion implied by the English term ‘belonging’ and less about ownership in the sense of possession (Barlow 1994; Davis 1993). Hence, it is not a matter of land ‘belonging’ to the individual, but rather the individual ‘belonging’ to the land. In Māoridom, the nexus between people and land transcends beyond the physical realm where perceptions of land extend into and derive from spiritual associations (Keenan 2012; Lockhart et al. 2019). The English term 'home' most closely aligns with the Māori concept of belonging as when Māori refer to home it typically denotes a place to which they belong rather than somewhere that is owned. In the Māori language, this concept is expressed with the term ‘tūrangawaewae’, a place to stand (Shaw 2021). A pā, or commonly referred to as a marae today, (illustrated in Figure 2) is a living village that serves as the tūrangawaewae for affiliated whānau [family], hapū [sub-tribe] and iwi (Gilliam-Knight et al. 1992; Tapsell 2002). Extended whānau amalgamate to form larger kinship groups: hapū and iwi (Houkamau 2019; Moeke-Pickering 1996). While whānau represent the primary economic

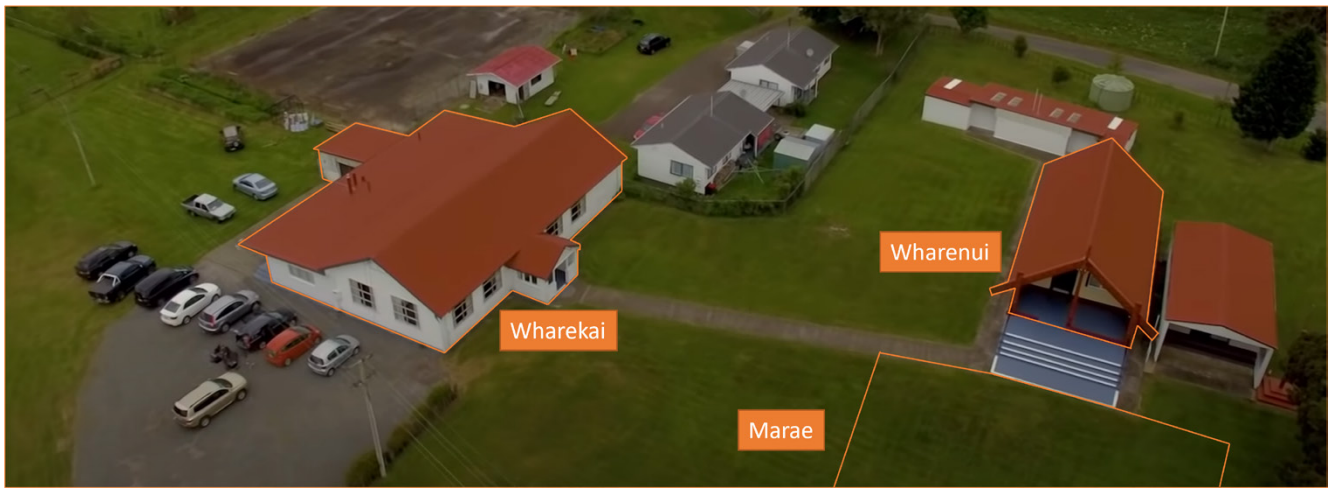

Figure 2: Typical marae layout comprising the wharenui [meeting house] and wharekai [dining hall].

unit and hapū the primary political unit within traditional Māori society (Pihama and Gardiner 2005), iwi serve as the broader socio-political structure that connects several hapū across large geographic areas.

Marae are traditional meeting grounds for Māori (Austin 1975), a bastion of self-determination (Joseph 2002) and a vital component of cultural infrastructure within Māori society (Durie 1999; Te Puni Kōkiri 1999). By definition, a marae is the enclosed space in front of a house, courtyard or village common (Tapsell 2002; Williams 1957). However, the contemporary understanding of a marae often broadly includes the complex of buildings around the marae into this modernised interpretation (Metge 1967). Marae are generally situated on ancestral lands and typically characterised by a wharenui [ancestrally named meeting house] and wharekai [dining hall], as shown in Figure 2. The marae is considered inalienable because it is intrinsically connected to the living soil of Papatūānuku [Earth Mother] (Tapsell 2002). However, the more correct term that should be normalised is 'pā', signifying a fortified village, place or stockade (Williams 1957). This term accurately captures the function and significance of these culturally demarcated sites to Māori and their pivotal role in providing support to communities during times of need. For centuries, physical tribal infrastructure such as marae have spontaneously become support centres for Māori in the face of adversity (Kenney and Phibbs 2014). Typically, urban marae are connected to municipal infrastructure services, whereas rural marae often relies on decentralised infrastructure. These distinctions are crucial in the context of marae resilience, emergency management and preparedness, as they significantly influence each community's capacity to respond to and recover from natural hazards. In the face of colonisation and land loss, Māori continue to uphold their cultural imperatives, language and connection to land, while ensuring that marae remain a vital component of community infrastructure.

Importance of Māori values in natural hazard response

Core values in Māoridom include a concern for past, present and future generations, functioning as an interweaved lattice of guiding principles and value processes (Ritchie 1992). Kenney and Phibbs (2014) described whakapapa [genealogy], whānau [family], whanaungatanga [relationship-building and interdependence], kotahitanga [collective wellbeing and unity], manaakitanga [altruism and hospitality] and kaitiakitanga [stewardship, responsibility and commitment to land and natural resources] as principles that shaped the response of Ngāi Tahu responders' support behaviours in the 2016 Kaikōura earthquakes (Broughton 1993; Harmsworth 2005; Harmsworth and Awatere 2013; Marsden 1992).

At the heart of Māori identity is whakapapa, the genealogical table (Williams 1957) that links individuals to ancestors (Roberts 2013), land (Te Rito 2007) and future generations along a boundless continuum. From whakapapa, the concept of whānau brings this connection into the present, extending beyond the confines of the nuclear family to include extended family and blood relations (Dai and Bentley-Gray 2023; Metge 1990). Whakapapa is synonymous with the concept of whānau as a multi-layered, flexible and dynamic system (Carlson et al. 2023; Hancock and Newton 2022). Whanaungatanga, the broader concept of kinship, intersects with the concept of collectivism (O'Carroll 2013). The intimacy and depth of relationships within whānau underpin the notion of whanaungatanga, often described as the 'glue' that socially connects people (McNatty and Roa 2021). Therefore, while whānau defines who is included, whanaungatanga makes reference to the process and practice of how these relationships are cultivated and maintained.

Putnam (2000) explains bonding social capital as 'the ties that bind groups together on the basis of shared structural positions within a particular social hierarchy; examples include class, age or ethnicity'. Kāwharu (1992) points out that Māori view kotahitanga as their source of bonding social capital within their respective communities. Kotahitanga forms the base of collaborative Māori responses to unfavourable circumstances and is a natural characteristic within Māoridom (Kenney and Phibbs 2015). Manaakitanga is the display of respect or kindness (Williams 1957) by which the collective action is guided (O'Steen 2021). As a form of habitus, particularly in disaster management contexts, Māori altruism is demonstrated through generosity, hospitality and entertainment (Carter and Kenney 2018). Finally, all these values embody kaitiakitanga, which supports the notion of sustainability, guardianship and protection of the environment and people in perpetuity (Hopkins et al. 2015). Long-term orientation is also reflected in the notion of kaitiakitanga (Haar et al. 2019) as the strong ties Māori retain to past generations is a constant reminder to conserve for the collective future (Hook 2007; King 2004). Ritchie (1992) argues that these terms are not mutually exclusive and may coexist, such that the use of any one draws upon a host of meanings linked to the others. Thus, for example, invoking 'whanaungatanga' inherently makes indirect reference to related concepts such as kotahitanga or manaakitanga. Therefore, it becomes evident that every core value plays a distinct role in shaping the Māori worldview. Durie (2005) clarifies that these values, conventions, rules and behaviours are all important indicators of Māori endurance (resilience), uniting people to support and share in times of abundance and adversity. These values are actively enacted through collective efforts that prioritise relational connections, shared responsibilities and community-focused actions in times of crisis.

The role of marae in hazard contexts

The role of the marae and how it might function becomes most apparent during life crises such as tangihanga [funerals] (Tapsell 2002). The tangihanga process lasts several days and can be an extravagant and emotional occasion (Metge 1967). The process typically involves a dedicated workforce of whānau who come together to welcome, feed and accommodate visitors as they bid farewell to the departed. Marae may cater for hundreds to thousands of visitors over the 3-day ceremony. Māori have long practised the art of cooking (Wihongi 2013), organisation (Barnett 2001), coordination and speechmaking (Mahuta 1974). These are desirable skill sets in a natural hazard event. In ancient times, visitors may unexpectedly cause hostility or disrespect the hau kāinga [home people] in speechmaking, often resulting in combat (Vayda 1970). Therefore, it appears that Māori have historically relied on the unknown as a measure of preparedness. Despite the complex nature of tangihanga and the diverse skill sets required, Māori have established quick-thinking, teamwork and leadership abilities that are regarded as key driving factors for community resilience.

Aotearoa's most recent natural hazard events have recurrently seen Māori and pā at the forefront, providing safety and shelter for the community at short notice. Ngāi Tahu's response to the 2011 Christchurch and 2016 Kaikōura earthquakes and subsequent recovery processes embody a standard of excellence (Kenney and Phibbs 2014). The improvised volunteer army by Ngāti Awa in the 2017 Edgecumbe floods exemplified an excellent recovery and relief response (Gillespie 2017; Kenney 2022). Under great stress and significant natural hazards, marae are often the focal point for the community to congregate in times of need (Hudson and Hughes 2007). During times of crisis, Māori enact cultural values such as kotahitanga, whanaungatanga, manaakitanga, kaitiakitanga and most of all, aroha nui ki te tangata [love to all people] (Kenney and Phibbs 2014). The practical realities of pre-colonial Māori economic life and culture gave rise to core values (Harmsworth 2005; Harmsworth and Awatere 2013) upheld by a complex system of tikanga [Māori traditional rules, lore and customs] (Broughton 1993; Marsden 1992). While the external world is governed by law, within the marae, Māori lore prevails (Black et al. 2017).

Despite the complexity of hosting the multitudes with limited resources, marae and Māori communities have continued to demonstrate effective emergency management, response, recovery and relief (Hoskins 2019; Kenney and Phibbs 2015). While some marae may be seen to be flourishing, the institution of marae is considered by many to be under-resourced and in a vulnerable state (Kāwharu and Pfeiffer 2014) with infrastructure and buildings requiring significant repairs or upgrades (Lee-Morgan et al. 2021). As flooding is the most prevalent natural hazard in Aotearoa and earthquakes pose the greatest potential for damaging and disruption (Department of the Prime Minister and Cabinet 2007), gaining a deeper understanding of national marae exposure to natural hazards becomes a critical challenge. People affected by the 2011 Christchurch earthquake agreed that tribal infrastructure such as marae helped the community to adapt after the event. Thornley et al. (2015) argue that the role of marae, as key tribal infrastructure, embodies altruism as a culturally constructed principle. Whakapapa provides a sound emergency management infrastructure for Māori and the wider community, integrating the ties that bind iwi through identity and kinship ties. Whakapapa also mold marae as tribal infrastructure in the sense that specific whānau are already tasked with managerial responsibilities and duties associated with marae operation (Kenney and Phibbs 2014).

Materials and methods

Cahill (1996) argued that neither qualitative nor quantitative techniques have universal application, though qualitative methods can bring quantitative information to life. Wertz (2014) similarly noted that the historical study of qualitative methods offers a treasure trove for understanding and integrating such methods with quantitative inquiry. McKibbon and Gadd (2004) suggested that qualitative studies often incorporate both qualitative and quantitative methods. A mixed-methods approach has the potential to yield unexpected findings and new insights through detailed exploratory data analysis (Jefferson et al. 2014). Further, Fossey and Harvey (2001) pointed out that combining data collection with existing quantitative methods amplifies the voice of the consumer and provides rich contextual data with which to make sense of quantitative data.

The methodological flow chart presented in Figure 3 outlines the 4 stages of the research process. Throughout all stages Māori values such as whakaaetanga [consent], ohaoha [reciprocity] and most importantly, whakaute [respect] were enacted and upheld in line with tikanga, in addition to the cultural values outlined earlier in this paper. Given the nature of the research and process are not linearly sequential, it became clear that following a kaupapa Māori research methodology would be best suited to achieve the aims and objectives of this research.

The fabric of kaupapa Māori research is woven together by the principles of tino rangatiratanga [self-determination], social justice, Māori worldview, Te Reo Māori and whānau (Bishop 1998; Walker et al. 2006). Thus, a kaupapa Māori approach operationalises autonomy and recognises the unique cultural context, aspirations and experiences of Māori to ensure their voices and knowledge systems are

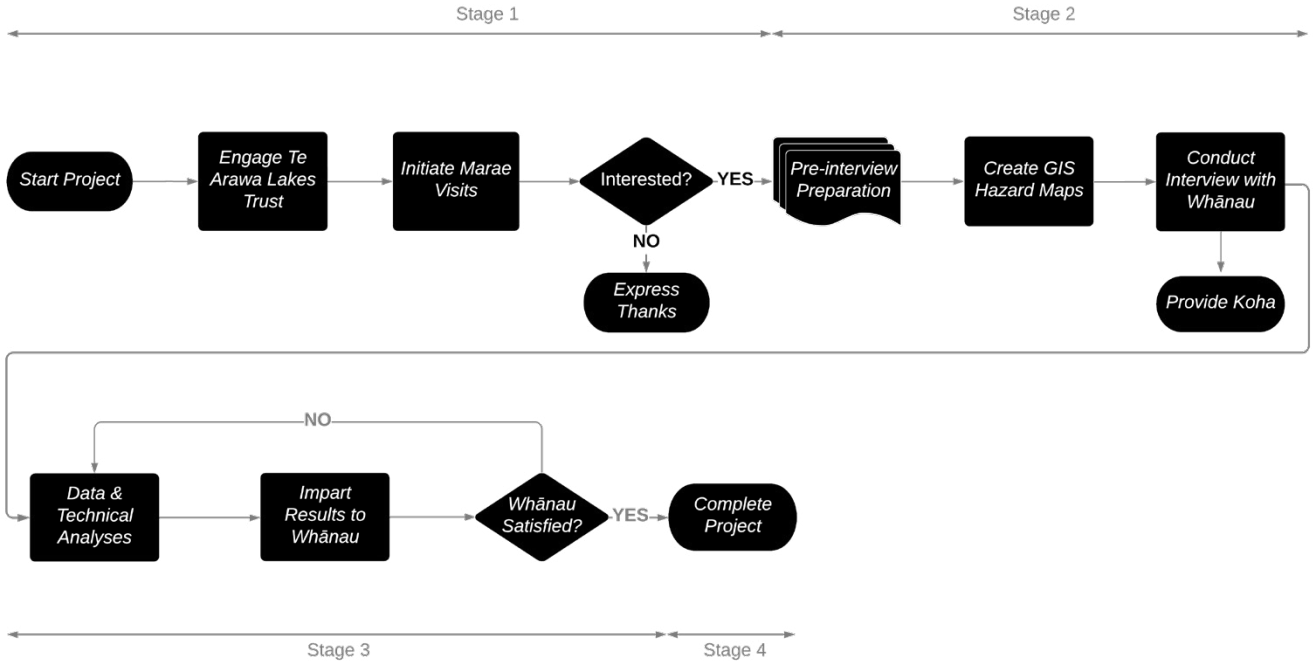

Figure 3: Methodological flow chart used in this research.

central to the research. As kaupapa Māori approaches strive to create positive outcomes (Durie 2013; McIntosh and Mulholland 2011; Smith 1997 1999; Workman 2016), this research assists in reimagining collective and contemporary research practice at the confluence of engineering and Māori in disaster management contexts.

Project initiation and interest

The need to assess marae and infrastructure resilience to natural hazards was identified at the outset, where initial aims, objectives, research design and the scope of the project were outlined. Whakapapa primarily gave impetus to this research as several members of the research team held strong genealogical ties to the Te Arawa region. Secondly, the complex hazardscape of the central North Island enabled the assessment of various hazards and environmental phenomena unique to the region, such as geothermal activity. Early engagement was sought and established with Te Arawa Lakes Trust (TALT), a post-settlement governance entity responsible for the oversight and management of Te Arawa's settlement assets, including the region's 14 lakes located in the central North Island of Aotearoa (shown in Figure 4). TALT was involved in developing marae emergency preparedness plans for 26 marae in the Rotorua region, which presented an ideal opportunity to have a complementary relationship and create mutually beneficial outcomes. Once the partnership had been established, face-to-face meetings or hui were organised at each marae to gauge interest in and address any concerns with the research.

The initial hui allowed for mihimihi [introduction] and the opportunity to present the project's purpose, goals and benefits to the marae and wider hapū. Within this stage, it is important to recognise that arranging hui with marae can be challenging, as whānau volunteer their time and energy out of dedication to their marae. Consequently, these hui often took place on weekends when whānau were not engaged in regular work commitments. Additionally, the rate at which these hui were secured can be attributed to the personal and genealogical connections between TALT staff and marae members. Whanaungatanga is the most critical element in this step as it sets the precedence for future research interactions and remains throughout all marae engagements from inception to completion.

For marae who expressed interest, the research team set a date for the interview and marae emergency preparedness planning session. If a marae declined, we would express thanks for their time and consideration. The research team received a positive response from all marae willing to participate in the research.

Interview preparations and GIS hazard mapping

Prior to the interview, the project brief, interview questions and necessary forms were prepared and sent ahead of time. This step ensured that whānau were well-informed and adequately prepared. Marae-specific GIS hazard maps were produced in advance to visually represent the potential natural hazards as well as to inform and prompt discussion with whānau throughout the discussion. A marae hazard example map is provided

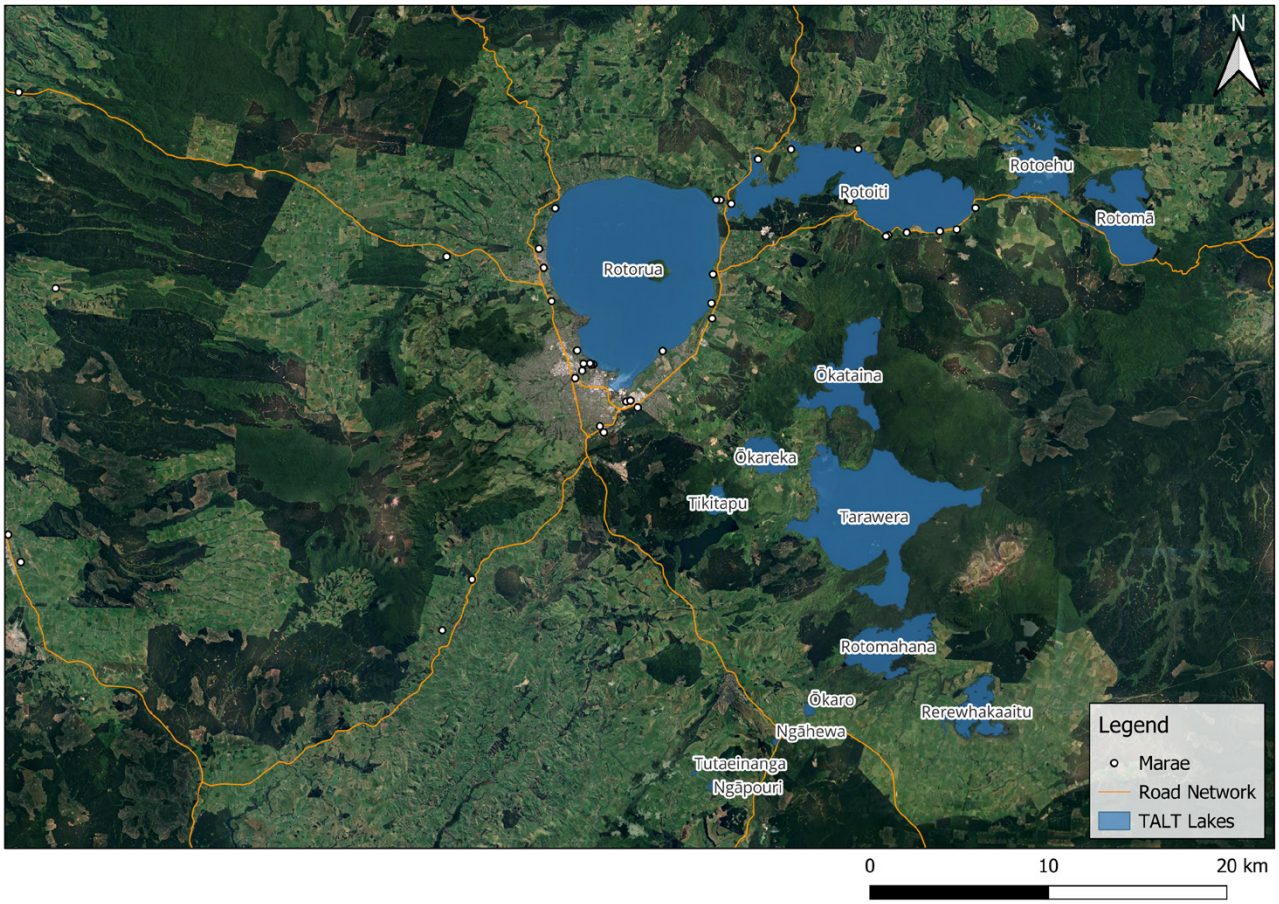

Figure 4: Geographic distribution of lakes managed by Te Arawa Lakes Trust and marae in the Rotorua region.

in Figure 5. It shows 3 marae in close proximity along with site boundaries, building outlines, infrastructure networks and a specific hazard. While the infrastructure data shown in Figure 5 was provided by the local council, the national-scale flood hazard model is an amalgamation of outputs from various local councils in Aotearoa and represents a broad spectrum of underlying assumptions. The indicative flood model is described in Paulik et al. (2029, 2023) and generally represents events with a 100-year return period or a 1% annual exceedance probability. For marae located in urban city centres where local council infrastructure data was accessible, a higher level of detail could be provided. In contrast, marae situated in rural areas had lower levels of infrastructure detail and resolution available for analysis.

The concept of place is central to geography and is seminal to the thinking of Indigenous peoples, including Māori (Murton 2012). Given the process by which Māori knowledge systems were transformed from predominantly visual and oral forms into a written structure (Lilley 2019), it would be reasonable to suppose that Māori may resonate deeply with visual and oral literacy modalities. The longstanding history of traditional Māori artforms such as whakairo [carving] and raranga [weaving] would support that Māori have a natural affinity for visual artforms (Thornton 1989). Traditionally, hazard assessment and mapping were time- and labour-intensive tasks with manual handling and processing of data (Dhakal et al. 1999). GIS have increasingly become integral to the field of geospatial studies and give researchers robust tools for spatial analysis and cartographic representations (Unwin 1996). QGIS (Quantum Geographic Information System) is a free, open source software that allowed the research team to create, edit, visualise, analyse and publish geospatial information. Hence, this research employed a mixed-methods approach.

A geospatial hazard assessment was conducted to quantitatively analyse the exposure of marae to natural hazards, while dialogical and narrative interviewing methods were applied to capture qualitative insights. Ten semi-structured focus groups contained pre-set, open-ended questions with further questions emerging from the discussion (Denny and Weckesser 2022). The flexible nature of the interviews facilitated and improved the richness of discussion, which often led to tangents that provided more in-depth responses while also capturing necessary data. In this way, tikanga of the hau kāinga was adhered to while feeling empowered to tell the story

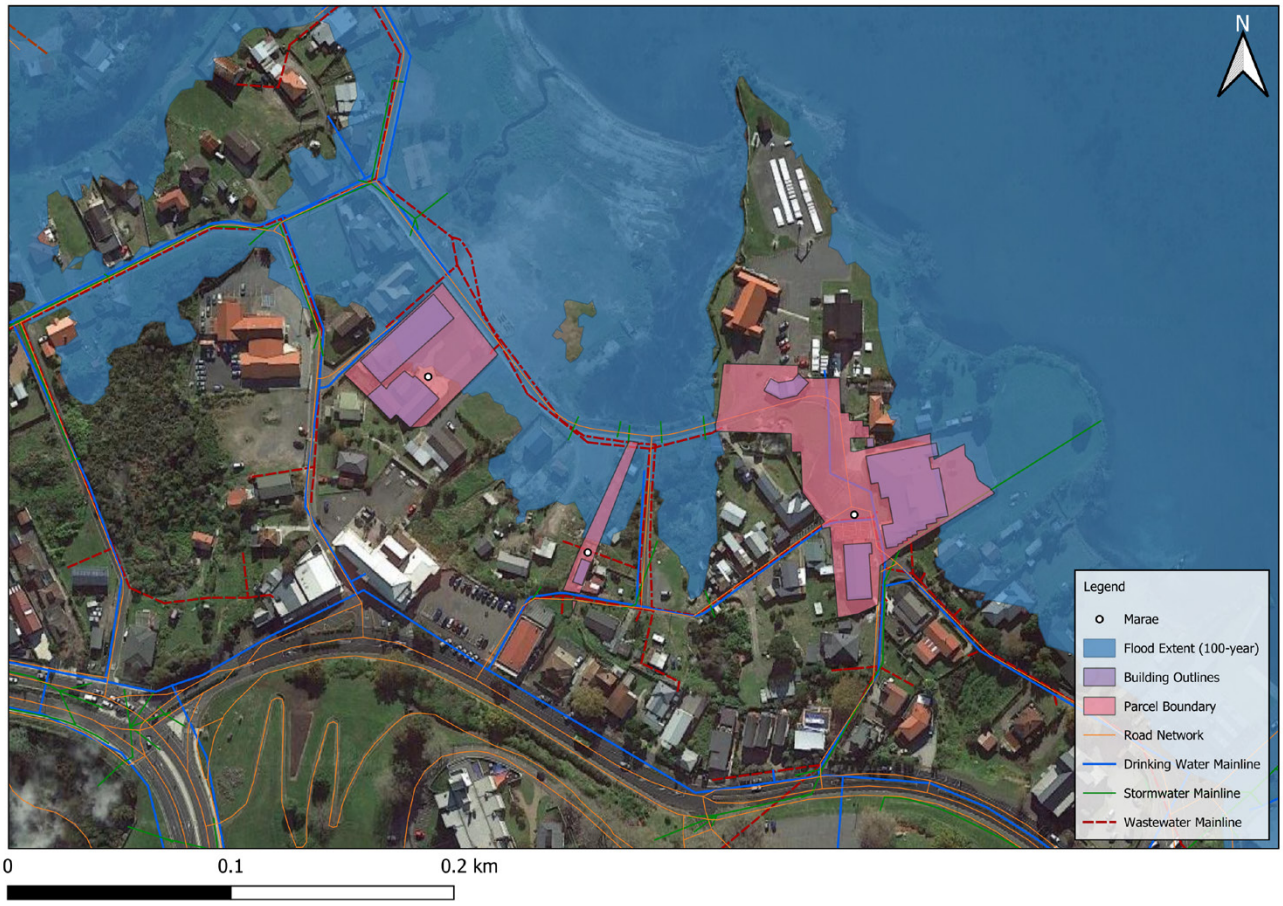

Figure 5: Marae flood map showing 3 marae in close proximity along with site boundaries, building outlines, infrastructure networks and a specific hazard.

through their eyes. The use of GIS-based data and mapping techniques proved highly effective in disseminating data that resonates with hapū.

The interview phase typically took place inside the wharenui or wharekai and involved sitting down with the whānau to discuss their experiences and perspectives on natural hazards, emergency management, preparedness, adaptation, marae resilience and the state of marae infrastructure. The marae could have as many or as few representatives they wished in attendance. This resulted in interviews that included a mix of single or multiple whānau participants. Having already been welcomed onto the marae, the transition to conduct the interview became a fluid process as the relationships and trust had already been established. The flexible structure of the interview often enhanced the depth of the discussion and allowed conversations to veer off on tangents that improved richness while still capturing the necessary data. All interviews were audio recorded (and subsequently transcribed) with notetaking occurring throughout.

Marae participation in the study was of utmost importance given the raw, untouched knowledge and experience on the underlying processes required for a marae to operate under business-as-usual and emergency scenarios. Participants provided in-depth, thorough and specific information on marae operations that could not be retrieved elsewhere. At the conclusion of the hui and in accordance with tikanga, food was shared and the marae was provided koha, a gift to maintain social relationships and has connotations of reciprocity (Durie 1999).

Data analysis and feedback

The interviews were transcribed and thematically analysed to identify commonalities among marae communities such as urban, rural and coastal settings. For transparency, marae were provided shared access to data they provided and deliverables that used their data (questionnaire responses, recordings, transcripts and marae hazard and infrastructure maps). Data sovereignty is important when dealing with Indigenous communities, including Māori (Kukutai and Taylor 2016). In contrast to traditional, individualistic research that primarily benefits the researcher and their personal agenda, kaupapa Māori research adopts a collectivistic approach focused on advancing collectively determined agendas of both the researcher and the researched (Bishop 1998). The recorded data, including computer files, are jointly owned by the researchers and respective marae and are accessible by

researchers, supervisors and respective marae participants only. If the whānau were satisfied with the findings, the overall project moved towards completion. However, if further refinement was required, the process would loop back to the data and technical analysis stage for adjustments after which the findings would be presented again. The transparency of this process helped to strengthen relationships and trust between the research team and whānau. This stage ensured that the whānau fully understood the findings and had the opportunity to provide feedback.

Beyond its emphasis on cultural and data transparency, this process provided marae communities with critical information for informed engineering decision-making. The marae-specific hazard and infrastructure maps shared practical insights into potential hazard and infrastructure exposure. These resources helped whānau understand key technical aspects and equipped marae with the requisite knowledge to interact effectively with engineers. The feedback loop created space for whānau to ask questions, provide input, seek clarity and voice concerns about engineering decisions, resulting in a greater level of inclusion and active participation.

Ethics statement

Ethics approval was granted by The University of Auckland Human Participants Ethics Committee on 21 April 2023 for a period of 3 years, approval number UAHPEC25317.

Discussion

The collaborative nature of this research led to several significant outcomes, particularly within the context of Māori-led engagement in an engineering framework. A key achievement was the successful engagement with all 26 marae within the Te Arawa region, drawing attention to the effectiveness of the approach. In addition to building meaningful relationships, the approach also empowered whānau through the provision of tools and resources to support data-driven decision-making. The tailored hazard maps offered valuable insights into the specific hazards each marae is exposed to and may need to consider for future events, including fluvial flooding and coastal inundation, seismic and co-seismic events, tsunami, erosion and accretion (gradual accumulation of additional layers or matter). The maps define the spatial context and show the extent to which buildings, land parcels and infrastructure are exposed to various hazards and scenarios, albeit indicatively. These insights provided a clear idea of potential effects, enabling marae to pinpoint their most vulnerable or resilient on-site assets. This supported better-informed decisions in terms of resource allocation and strategic planning. One participant stated, 'I think the maps confirm that it was a wise choice; it wasn't by chance that they (ancestors) placed it (marae) here'.

The interview process stimulated reflection and prompted whānau to identify infrastructure deficiencies and gaps in processes related to future natural hazard events. Throughout the questionnaire process, the notion of redundancy or back-up options emerged on multiple occasions as a priority for marae infrastructure, particularly in the context of natural hazard events. For example, installing on-site water tanks for water storage in the event of council water main failures or exploring the use of solar or diesel generators for energy supply during power outages. Another participant stated, 'As a result of that survey, you know… they've put in 3 extra water tanks… It gives you an idea of the resources and where they might be expended'.

Insights gained from publicly available datasets helped to develop and refine marae emergency preparedness plans. This research heightened awareness within Te Arawa marae communities that contributed to improved communal understanding of resilience, preparedness and proactive planning in the face of natural hazards and climate change. Another participant stated:

> *Resilience to me means that we're prepared and that we have a plan of how we would respond to any emergency or any request… that we're probably aware of what might impact us and have a planned approach rather than a reactive one.*

A critical element is the concept of 'marae space, marae pace', which stresses the importance of patience and flexibility when working with marae and Māori communities. Unlike the rigid, deadline-driven approaches in conventional engineering practice, this approach adopts an adaptive and organic timeline. Because most marae roles are voluntary and whānau members often have demanding schedules, accommodating whānau availability and working at a pace that respects existing commitments is essential. Despite its simplicity, maintaining regular contact and providing ongoing updates to whānau throughout each phase of the project was critical to inclusion and active participation. Another unique aspect of the approach was the dual role of the researcher who acted as the investigator and also held a genealogical connection to the research, occupying an insider position within the communities of interest. The presence of Māori engineers, particularly those with well-established community relationships and a deep understanding of Māori values, creates a common space. Fluency in and frequent use of Te Reo Māori was observed as a positive factor in making whānau feel at ease during interviews and general interactions while providing a sense of trust and security throughout the research process. This bridges the gap between engineering practices and cultural needs, leading to informed decision-making and culturally appropriate solutions. In instances where direct involvement is not possible, providing the tools, education and awareness is a useful to increase capacity within the community.

Conclusion

This paper introduces a novel approach for engineers to collaborate with marae and Māori communities through a model that promotes flexibility, patience and understanding the voluntary nature of marae roles. The findings highlight several factors that are conducive to successful engagement of an engineering analysis within Māori and marae contexts. The following actions are critical to achieve meaningful and successful outcomes:

- building genuine, long-term relationships is instrumental throughout the project lifecycle and beyond
- identifying and acknowledging pre-existing genealogical ties or common links to strengthen connections and build trust
- taking kai [food] and koha to hui is a practical way to fulfil tikanga obligations, show respect and make the process a positive experience
- following project initiation and keeping whānau, hapū and marae regularly updated with progress fosters active participation, establishes mutual trust and ensures transparency in the research process
- going for multiple 'cups of tea' in the form of hui, visits or engagements demonstrates patience, commitment to the process and builds rapport as opposed to an extractive single-contact research model or one-off engagement
- using visuals such as photographs or maps could increase engagement as Māori are a visual and oral people
- using Te Reo Māori in presentations and interactions reduced barriers and provided a sense of comfort for whānau.

This research represents a process for whānau, hapū and iwi to bring to life aspirations that have long been held within communities. What sets this approach apart is the integration of engineer and community as one, where both roles coalesce with a common objective. The convergence of engineer and community unlocks opportunities for meaningful engagement, effective solutions and richer outcomes benefiting all parties. This approach holds broader implications beyond the immediate iwi. The learnings could be applied to other iwi, Indigenous communities and engineers facing similar challenges. The intent is to share these findings for others to benefit and lay the groundwork for those pursuing similar initiatives. Looking ahead, the findings from this work will contribute to the national dialogue on marae resilience and hazard exposure.

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[Te Arawa, Tūwharetoa, Te Āti Haunui-a-Pāpārangi, Ngāti Kahungunu, Ngāti Pāhauwera, Ngāti Raukawa, Ngāi Tahu]

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[Te Arawa, Ngāti Uenukukōpako, Ngāti Whakahemo]

Professor Liam Wotherspoon is a professor in the Department of Civil and Environmental Engineering at the University of Auckland. He leads national research programmes that explore the natural hazards resilience of the built environment, with a focus on Aotearoa New Zealand.