Nature-based solutions for coastal hazards in Aotearoa New Zealand: results of a nation-wide expert survey on the current state of uptake, barriers, and opportunities

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As governments and communities worldwide scramble for solutions to address coastal hazards exacerbated by climate change, nature-based solutions are gaining traction within coastal science, engineering, and policy. Nature-based solutions are:

> *Actions to protect, sustainably manage and restore natural and modified ecosystems in ways that address societal challenges effectively and adaptively, to provide both human well-being and biodiversity benefits* (IUCN 2016).

Nature-based solutions for coastal hazards (hereafter NbS) are based on the protection, creation, enhancement, and restoration of natural coastal features including, but not limited to, beaches, dunes, saltmarshes, mangroves, seagrass meadows, seaweed forests, and shellfish reefs. These habitats can mitigate coastal hazards such as flooding, erosion, and wave impacts. Inland applications of NbS can also mitigate coastal hazards by attenuating flooding issues inland of the coast. Traditional engineered structures, such as seawalls, will continue to be widely used as part of coastal adaptation, but in many contexts NbS can offer more flexible and resilient approaches, while also providing a range of ecological, social, cultural, and financial benefits (Bridges et al., 2021; Morris et al., 2021).

In Aotearoa New Zealand, the importance of natural defences in reducing coastal hazards is recognised in the New Zealand Coastal Policy Statement 2010 (NZCPS), and their prioritisation is part of the National Adaptation Plan for climate resilience. Natural features such as beaches and coastal dunes have long been utilised to protect our shorelines. However, upcoming legislative changes and global trends toward ecosystem-based approaches for climate change adaptation provide greater potential for a wider uptake of NbS. In the absence of any synthesis of our national track record with NbS, we carried out a nationwide survey of professionals to better understand the practicality of a more systematic use of these methods in Aotearoa New Zealand, and to outline the challenges and opportunities that lie ahead.

Survey design and distribution

The survey targeted professionals with expertise and/or interest in coastal hazards and coastal adaptation. Specific expertise in, or previous involvement with, NbS was not required. The survey was set up in Survey Monkey and advertised across iwi organisations, councils, government departments, tertiary and research institutions, consultancies, professional societies, and non-governmental organisations (NGOs). Respondents were asked a range of questions about their background and their views on the current and future role of NbS for coastal hazards in Aotearoa New Zealand. The survey consisted of a mix of multi-choice and open-ended questions, with specific questions targeting respondents with previous involvement in NbS projects. To increase the accuracy of the results, respondents were allowed to skip questions and to specify when they did not know enough to provide an answer. Responses were anonymous[1].

The results presented here are based on 157 survey responses. For each question there were a number of respondents who did not answer, and we excluded those who declared to be unsure. Respondents represented mostly city, district and regional councils (45), consultancies (39), tertiary institutions (24), government departments (17), research institutes (14), and NGOs (9). Nine respondents represented iwi and other Māori organisations or had expertise in cultural hazard mitigation and mātauranga Māori (traditional knowledge). The most represented disciplinary backgrounds among the respondents included ecology and conservation (50), planning and environmental management (48), coastal processes and engineering (24), landscape architecture and design (11), and climate science (4). We used chi-square analyses to test whether respondents displayed significant preferences among multi-choice options.

Survey results and discussion

Views on our current track record with NbS are mixed

All respondents were asked to rate key components of the implementation of NbS based on their view of the current state of NbS in Aotearoa New Zealand (rather than focusing on individual case studies). Respondents with and without previous involvement in NbS projects were equally represented and provided similar responses. In general, there was an even split among positive, negative and neutral responses (Figure 1A), which indicates that views on NbS are mixed. These mixed feelings may result, at least in part, from gaps in communication and monitoring, as outlined below.

Information about NbS is not shared effectively

Sharing of information about NbS applications was the only item for which negative responses were significantly more numerous than neutral and positive views (Figure 1A). While there are notable exceptions[2], this suggests that not enough is done to raise wider awareness about NbS and inform future applications.

[1] https://bit.ly/3vdndn8

[2] https://www.coastalrestorationtrust.org.nz

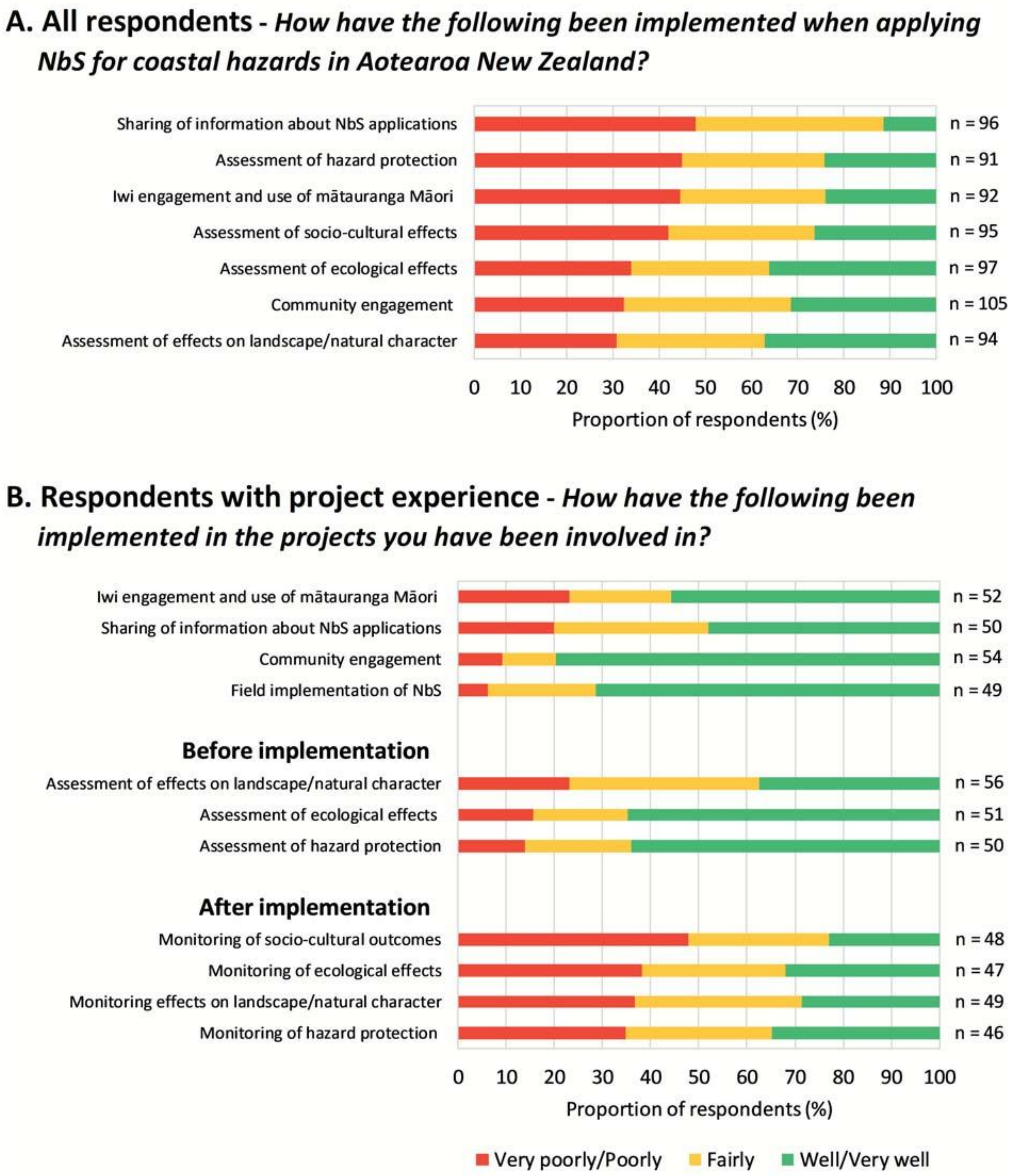

Figure 1: Respondents' views on key components of the implementation of NbS for coastal hazards in Aotearoa New Zealand (n = number of respondents).

Respondents with hands-on experience with NbS shared more positive views when asked to comment based on their own project experience (Figure 1B). Indeed, only 20% of these respondents considered the sharing of information about NbS as poor/very poor (Figure 1B). Respondents with direct project experience were also more positive about iwi and community engagement in relation to their projects than when considering NbS in general terms (Figure 1B). The more positive outlook of respondents commenting based on direct involvement with NbS may result in part from a more benevolent assessment of a respondents' own work, but it also reinforces the need for improving the sharing of information. There is probably a wealth of knowledge developed at the project scale, which is not easily accessible unless one is directly involved.

Better monitoring of the outcomes of NbS applications is needed, including a stronger focus on socio-cultural aspects

Responses based on project experience also show the need for better monitoring following the implementation of NbS. A significantly high proportion of respondents (over 60%) thought that assessment of hazard protection and ecological effects are generally well executed before NbS are implemented. However, only 30% of the respondents maintained the same positive view when commenting on the assessment of hazard protection and ecological effects after NbS are implemented (Figure 1B). This suggests that there is room for improving the assessment of the long-term outcomes associated with NbS.

Regular monitoring and evaluation are important to better understand the potential and limitations of NbS. Furthermore, monitoring ensures that NbS are managed adaptively (IUCN 2020) and can inform future implementations. Our results show that a stronger focus on socio-cultural aspects is particularly needed as part of post-implementation monitoring, as this was the element with the highest proportion of negative views (Figure 1B). This is an area where improvement is critical for Nbs to be associated with sustainable development and align with IUCN standards. A question about socio-cultural assessments pre-NbS implementation is missing in Figure 1B because of an oversight in the setup of the web interface. However, progress in this area is surely being made, and there are encouraging examples of coastal adaptation initiatives, which put social and cultural values at the forefront and incorporate NbS among the proposed strategies[3,4].

Beaches and dunes are dominant features of NbS, but the potential of other natural systems has also been explored

The information provided by respondents with project experience shows that, in line with global trends, beaches and dunes are the most common features of NbS projects, followed by saltmarsh vegetation and inland habitats (Figure 2A). Inland habitats include both habitats adjacent to the sea and further inland. Mangroves and shellfish are less utilised (Figure 2A), despite their ability to provide coastal protection being increasingly recognised worldwide (Bridges et al., 2021; Morris et al., 2021). Certain forms of aquatic vegetation such as seagrass and seaweed beds do not have a well-established track record as NbS internationally, but were mentioned by some of the respondents (Figure 2A). While our survey was not designed to collect information about individual case studies, it would be interesting to find out more about projects based on habitats other than beaches and dunes to better understand the practicality of making a more systematic use of a wider range of NbS in Aotearoa New Zealand.

NbS are often implemented at a small spatial scale, but examples across large areas are available

Responses based on project experience also indicate that, in most cases, NbS are implemented at small spatial scales, with many respondents having experience with work across areas of only a few hectares. A small proportion of the responses indicated that projects spanned across larger areas (Figure 2B). Further information about these large applications would be particularly insightful, as the feasibility of upscaling coastal NbS to large areas is still an area of ongoing debate (Bouma et al., 2014; Morris et al., 2021). In addition, as highlighted by some of the respondents and by recent research, large-scale applications are needed to unlock the full potential of NbS without limiting them simply to small-scale fixes.

Community support and funding availability are key for the implementation of NbS, but legislative provisions are often ignored

Insights from the respondents' project experience show that NbS projects are often driven by communities and by

[3] https://www.dunedin.govt.nz/__data/assets/pdf_file/0003/857505/stclair-stkilda-ctl-plan.pdf

[4] https://ccc.govt.nz/assets/Documents/Environment/Coast/CoastalAdaptationFramework0522.pdf

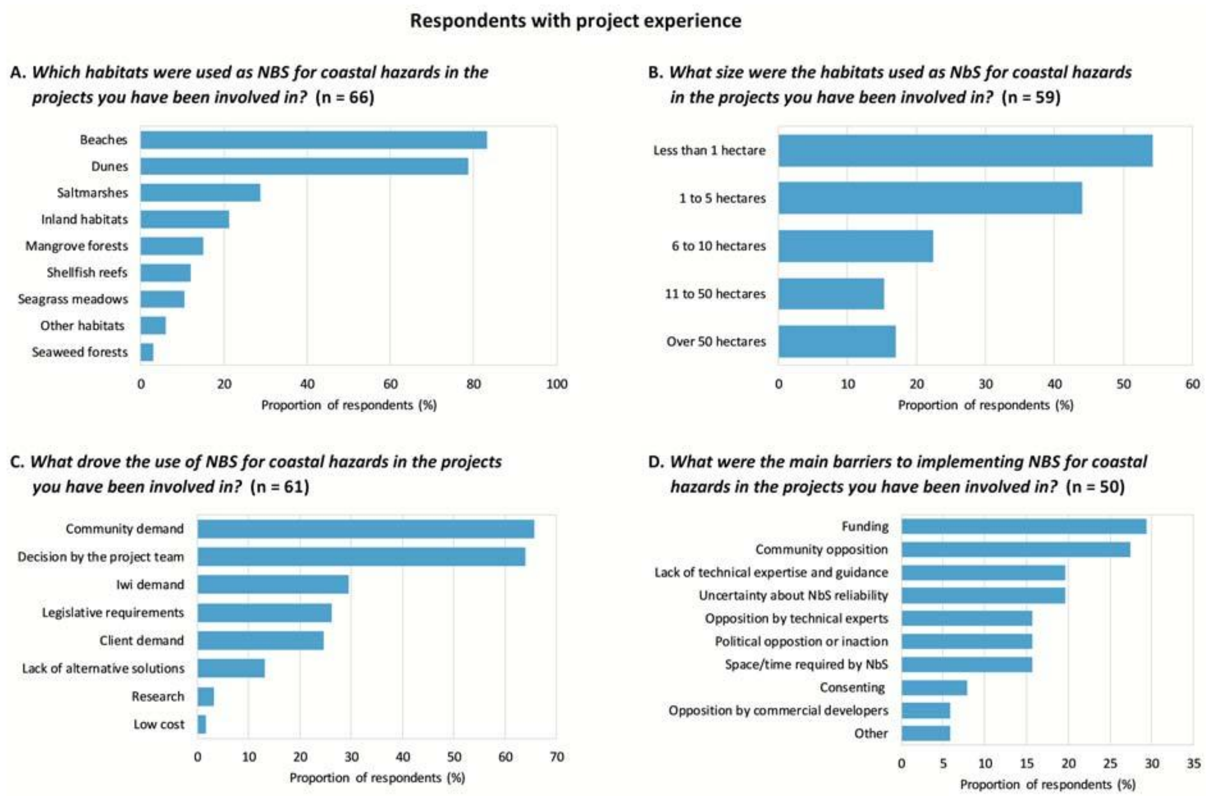

Figure 2: Information about the type and size of habitats used as NbS (A, B), and project drivers and barriers (C, D) provided by respondents with project experience (n = number of respondents).

the initiative of individual project teams, while legislative requirements were indicated as a primary driver in a limited number of responses (26%; Figure 2C). Respondents commented that the provisions of the NZCPS for the use of natural defences to coastal hazards are often ignored. This shows that the current legislative framework is not strong enough to enable a consistent uptake of NbS. The results in Figure 2C also show that very little research is done as part of NbS applications, and respondents lamented a general lack of funding and interest for research in this field.

Funding and opposition by communities were the most cited barriers to the implementation of NbS according to respondents' own project experience (Figure 2D). Many respondents said that there is a widespread lack of understanding of the requirements and potential of NbS, which extends from communities to technical experts and decision makers. The patterns seen here, with communities being both drivers and barriers for NbS outcomes, are not new for coastal adaptation initiatives (Schneider et al., 2020). NbS lend themselves to community-based approaches[5], which can contribute to promoting public awareness and support; however, not surprisingly, the experiences relayed by our respondents indicate that when private assets are on the line, there is strong demand for traditional engineering approaches.

Legislative changes provide opportunities to address challenges to NbS implementation

To look beyond individual project experience, we asked all respondents (with and without project experience) to rate 20 different challenges to the implementation of NbS in Aotearoa New Zealand (ranging from technical matters to aspects of our institutional and societal context) and to comment on the way forward. Funding availability topped the list again as the most significant challenge. Other challenges deemed as significant/very significant by a large proportion of the respondents (over 65%) included: lack of tools for assigning financial value to the co-benefits of NbS, uncertainty about the ability of NbS to adapt to sea-level rise, lack of community support, and poor integration of NbS in the legislative framework.

Many respondents indicated that better integration of NbS in the legislative framework may be key to addressing the main challenges identified here. The National Adaptation Plan and Emission Reduction Plan have prioritised the use of NbS across sectors in response to climate change. In addition, the Resource Management reform process has the potential to embed NbS into decision making and may represent a turning point for the future of NbS in Aotearoa New Zealand. The integration of NbS into well-defined adaptation pathways should open new funding avenues and ensure that NbS are provided with adequate time and space to establish and adapt to changing conditions. In particular, many respondents highlighted the importance of revised land use planning to prevent habitat squeeze as a result of sea-level rise in built-up areas. Another benefit that we see in the upcoming changes in legislation is that the formal inclusion of NbS within adaptation pathways would provide a framework for establishing when and where the use of NbS is appropriate. This should also promote large-scale applications and further research into NbS. Furthermore, the development of adaptation pathways sets the scene for public engagement and consultation, providing opportunities for promoting awareness and acceptance of NbS.

Leveraging on NbS case studies and co-benefits is key to tackling funding and community barriers

In addition to legislative changes, many respondents highlighted the importance of examples of previous NbS applications for building wider trust and understanding. Improving information sharing and long-term monitoring would help to create a visible national track record and to ensure that NbS are not perceived as untested and unconventional. The approach taken in Australia to illustrate precedents for NbS[6] could be replicated here to show communities and decision makers what has been achieved so far in Aotearoa New Zealand and inform a wider uptake of these methods.

Survey participants also suggested that an increasing awareness of the co-benefits of NbS is likely to improve political buy-in and public support. Considering how NbS are connected to the values of different stakeholders is an integral part of their implementation (IUCN 2020). This is an area with tremendous potential for a better consideration of Te Ao Māori and mātauranga Māori to develop a more in-depth appreciation of the potential of NbS and of their benefits within the context of Aotearoa New Zealand.

The uptake of NbS is likely to be assisted also by a clear indication of their benefits and trade-offs in decision-making frameworks. However, respondents pointed out that assigning financial value to the co-benefits of NbS is particularly complicated. This is an area of intensive research, and some examples and guidelines for ascribing non-financial values are starting to appear (Reddy et al., 2015; Morris et al., 2021). However, even when their market value cannot be established, it is critical to account for all services provided by NbS in cost-benefit analyses and other decision-support tools (Sutton-Grier et al., 2015).

Technical challenges are not insurmountable

While respondents saw the financial valuation of NbS co-benefits as a significant technical hurdle, the prevailing view was that, although not insignificant, technical challenges are secondary to institutional and societal barriers for the implementation of NbS. Despite the lack of detailed step-by-step design codes for NbS, which several respondents highlighted as beneficial for NbS to be seen as on par with traditional engineering approaches to coastal defence, respondents pointed out that there is a good amount of in-house knowledge and technical expertise, although this is mainly limited to dune and beach environments. Internationally, there is plenty of guidance on NbS approaches (e.g., Bridges et al., 2021; Morris et al., 2021), and the capacity to predict the hazard mitigation benefits provided by NbS through modelling scenarios is improving (Reddy et al., 2015; Silver et al., 2019).

Conclusions

Despite considerable challenges to a wider uptake of NbS, the prevailing view from the survey was that NbS should be seen as a fundamental part of coastal adaptation in Aotearoa New Zealand. The vast majority of respondents

[5] https://www.coastalrestorationtrust.org.nz/coast-care-groups

[6] https://livingshorelines.com.au

saw great potential in the use of NbS to address both coastal hazards and loss of biodiversity. However, respondents pointed out that the requirements and limitations of NbS needs to be well understood to ensure effective implementation and management. In addition, it is essential to move beyond pitching NbS against hard defences, so that synergies among different approaches can be better explored.

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