Green or grey pandemic recovery? Revealing the blue-green infrastructure influences in Aotearoa-New Zealand's 'shovel ready' COVID-19 response

Abstract: Globally, there has been much anticipation for a 'green' response to the economic impacts of COVID-19. As governments invest heavily in 'shovel ready' infrastructure stimulus, discourse has focused on the need to use this wisely and 'Build Back Better'. Blue-green infrastructure has much potential here, due to its ability to both create short-term jobs and help address longer term issues, such as climate change, while bringing multifunctional benefits. This paper analyses Aotearoa-New Zealand's 'shovel-ready fund' to assess if, and how, blue-green infrastructure systems were present in bids from its largest city regions. Findings indicate a greater prevalence in areas with existing spatial plans, and while there was some consideration of climate resilience, there was no real acknowledgement of the pandemic or human health. More positively, there was some evidence of unique indigenous influences that have potential to develop more inclusive and holistic blue-green infrastructure initiatives. This includes contribution to international debates to revise what the term means from an indigenous perspective as well as design options. The overall response, however, demonstrates a disjointed approach to blue-green infrastructure related projects, and a missed opportunity for a more transformative response to the climate crisis and human health emergencies.

Keywords: spatial planning, climate change, cities, resilience, adaptation, water, greenspaces

1. Introduction

"Now we have the opportunity to make sure our Covid response does…'double duty' - solutions that solve multiple problems, and get us ready for what the future holds."
(Jacinda Ardern, Speech to Labour Party Congress, 2020)

As governments around the world look to the provision of 'shovel ready' infrastructure as a means of providing rapid economic stimulus to the impacts of COVID-19, globally there has been much discussion of a 'green recovery' (e.g., Figueres, 2020; OECD, 2020). A green recovery aims to stimulate short-term economic activity whilst preserving, protecting and enhancing environmental and natural resource quality, now, and in the future (Strand and Toman, 2010). With pressing global climate and health crises, a green recovery must be responsive to the challenges of the time. Taken together, the COVID-19 economic stimulus packages present a significant opportunity to provide short-term investment to protect jobs, as well as help transition places and

economies to adapt to current and future challenges, in particular climate change. The idea has also received widespread public support. Polling across 14 countries showed 65% of the public agreed with this approach (Ipsos MORI, 2020), a figure that rose to 70% for New Zealand (Morton, 2020). Beyond the environment, a green recovery framing also positions social justice and equity as strong themes. The public health focus on mobility restrictions has exposed and exacerbated a series of localised spatial inequalities that aspects of a green recovery are well placed to address (United Nations, 2020). For example, while there is increasing discussion of nature as essential for health and wellbeing, the lived experience of the pandemic serves to emphasise the significant differences in provision and access to quality urban green spaces (Jenkins, 2020; Wray, *et. al.*, 2020).

More broadly, the green recovery discourse provides a useful lens for questioning what is deemed 'essential' infrastructure, and raising awareness of the distinction between grey infrastructure, with its focus on pipes, sewers, roads, and so on, and blue-green infrastructure, a term designed to capture how natural ecosystems have substantial values and functions too. Recent years have witnessed a growing body of literature emphasising the value of blue-green infrastructure in urban areas (e.g., Ghofrani *et al*., 2017; Lemes de Oliveria & Mell, 2019), which has taken on a new urgency in the context of COVID-19 and its constraints on the ability to travel beyond neighbourhood scales (e.g., Hanzl, 2020; Lennon, 2020; McCunn, 2020). The notion of 'double duty' raised in the introductory quote highlights the need for an infrastructure stimulus package that recognises this complexity and connectivity, such as between current and future crises, the economy, society and the environment, and the differing policy arenas that together comprise the urban.

However, while infrastructure as economic stimulus has proven a key policy direction in many countries, questions remain as to what extent these investment strategies acknowledge wider calls for a green recovery or how decision making practices incorporate infrastructures beyond the typical focus on grey solutions. For instance, not only may blue-green approaches be in tension with the 'grey epistemologies' (Finewood, 2016) that tend to influence how infrastructure is known and value is allocated, but there is concern that the focus on rapid action and decision criteria for job creation may privilege projects that have longer established calculative processes and competencies (e.g., projects whose cost-benefit analyses only capture tangible benefits).

This paper aims to shed light on the extent of this mooted 'green' turn by focusing on Aotearoa-New Zealand's shovel ready[1] COVID-19 response. To this end, the paper analyses the presence, type, form and unique functions of blue-green infrastructure put forward as part of the shovel ready bids, identifying gaps to inform and maximise their future implementation in Aotearoa-New Zealand and elsewhere.

2. Blue-green infrastructure systems: key concepts and spatial planning implications

The use of blue-green infrastructure in urban areas to complement or replace grey infrastructure has been increasingly advocated within both research and practice. Blue-green infrastructure is a relatively new approach and differs from grey infrastructure in a number of distinct ways. Grey infrastructure often comprises built structures such as channelised streams, dams and levees (Soz, Kryspin-Watson & Stanton-Geddes, 2016). Conversely, blue-green infrastructure builds on the green-infrastructure concept by integrating green and water features (Ghofrani *et al*., 2017; Lawson *et al*., 2014). A raft of terms is used to describe blue-green infrastructure alternatives based on differing fields of knowledge and national/ geographical contexts, including low impact development, water sensitive urban design and nature-based solutions (Fletcher *et al*., 2015). In essence, however, they all differ from grey infrastructure by advocating for multifunctional and interconnected networks of natural and artificially constructed features to maintain and enhance natural ecosystem functions and corresponding ecosystem services (Benedict *et al*., 2006; Ghofrani *et al.,* 2017).

The multifunctionality commonly attributed to blue-green infrastructure is highlighted by the many types and design options, ranging from rain gardens, wetlands, or permeable pavement through to urban forestry (Ashley *et al*., 2011; Benedict & McMahon, 2002; Cameron *et al*., 2012). When combined, blue-green infrastructure alternatives have the potential to deliver wider social, economic and environmental benefits for communities (Gómez-Baggethun *et al*., 2013). For example, they can improve physical and mental health of urban residents (Demuzere *et al*., 2014; Wolch *et al*., 2014), reduce flood risks (Meerow & Newell, 2017), increase thermal and noise insulation (Fenner, 2017; Oberndorfer *et al*., 2007), and lower energy costs (Demuzere *et al*., 2014). They can also support intrinsic ecosystem values and ecosystem services by enhancing

[1] Construction ready projects (Crown Infrastructure Partners, 2020).

urban habitat and biodiversity (Roy *et al*., 2008; Norton *et al*., 2015), improve water and air quality, and soil erosion control (Ahiablame *et al*., 2012; Benedict & McMahon, 2002; Demuzere *et al*., 2014). Given this context, it is understandable how the array of co-benefits associated with blue-green infrastructure are increasingly seen as instrumental for the planning of more sustainable, resilient and liveable urban areas (Ashley *et al*., 2011; Kabish *et al*., 2016).

Despite the many advantages presented by blue-green infrastructure, and the promise it brings to people and places, its uptake in practice has been slow. In part, this is due to the relatively novel character of blue-green infrastructure whose efficiency and evidence is still being developed (Thorne *et al.*, 2018). Typically, technocratic spatial planning systems may create preferences among decision-makers for solutions which have easily quantifiable and measurable benefits (Matthews *et al.*, 2015). Blue-green infrastructure benefits however, are not always easily translated into a traditional cost-benefit analysis, particularly where synergies exist between benefits (Haase *et al.*, 2014; Matthews *et al.*, 2015; Meerow & Newell, 2017). Additionally, urban planning has a tendency towards efficient decision making, which while providing speed and a degree of clarity for developers, can cause path dependences as institutions become locked-in to established ways of problem-solving and decision-making (Matthews *et al*., 2015). The prioritisation of short-term actions over long-term goals whose success may be more uncertain exacerbates this issue, making it difficult to systematically implement blue-green infrastructure systems whose value is less easily quantifiable (Kabisch *et al*., 2016; Matthews *et al*., 2015). More broadly, issues of scale are also a challenge. While site-based implementation can be valuable, for blue-green infrastructure to deliver its full potential, it needs to not only integrate ecosystem-based approaches with social and economic aspects of urban development (Lafortezza *et al*., 2013; Lawson *et al*., 2014), but also be implemented in a strategic, long term manner (Marot *et al*., 2015; Pauleit *et al*., 2017). This will require effective national and regional policy integration (Willems *et al*., 2021) and long term stewardship arrangements (Fisher *et al*., 2020).

Implementing blue-green infrastructure in a strategic manner is important to minimise potential maladaptation that may emerge as a result of ill-thought design or location. For example, there could be public safety concerns associated with air pollution traps, bushfire risks of increased urban vegetation, and human-wildlife interactions (Demuzere *et al.*, 2014; Lin, Meyers & Barnett., 2019). The provision of new blue-green infrastructure investment may also catalyse green gentrification, necessitating precautionary policy making to minimise displacement (Anguelovski

et al., 2018; Immergluck & Balan, 2018). This also calls for greater collaboration and public engagement when rolling out blue-green infrastructure strategies to ensure they deliver socially equitable outcomes (Hislop *et al*., 2019; Lemes de Oliveira, 2019). Additionally, blue-green infrastructure projects won't be able to provide solutions to all environmental problems plaguing urban areas such as compounded flood risks due to climate change and urban intensification along floodplains (O'Sullivan, Mell, & Clement, 2020).

More broadly, the contribution of different knowledge systems to blue-green infrastructure design, appears to be an under-investigated area by both research and practice. As blue-green infrastructure approaches directly link ecological and human systems it is important to recognise (and learn from) how biocultural, indigenous and local knowledges can be integrated in blue-green infrastructure design, and contribute to multigenerational stewardship that reflects the spaces and places they are inserted in (McMillen *et al*., 2020; Buizer *et al*., 2016; Svendsen *et al*., 2016).

COVID-19 has demonstrated not only the urgent need, but also an unprecedented opportunity for urban environments to accommodate ecological systems and support human health (Hanzl, 2020). It has stimulated huge state investment in infrastructure that will leave a lasting legacy. The crisis has exposed the limitations of many urban areas with respect to their lack of open spaces and accessibility, highlighting not only poorly planned public spaces but also neighbourhood inequalities (Samuelsson *et al*., 2020). What can be gleaned from the crisis is that public access to blue-green spaces in urban areas needs to be improved. Urban planning has a profound effect on the risks to population health (Barton and Grant, 2013) and blue-green infrastructure is a valuable feature of urban design as 'spatial medicine' (Rice, 2020). Facing a climate crisis and an enduring pandemic, there is a strong argument for blue-green infrastructure systems to be at the forefront of urban design, taking full advantage of their multifunctionality for climate and health sensitive cities.

With global calls for a green transition, and a once in a generation opportunity to invest in infrastructure for tomorrow, we now examine the extent to which Aotearoa-New Zealand's COVID-recovery infrastructure fund is set to help (re)shape the country's urban form. Using Auckland, and the Waikato and Wellington city sub-regions as our case studies, we reveal the types of blue-green infrastructure proposed, the presence of health and climate responsive planning and the unique influences of mātauranga Māori (the Indigenous Māori knowledge system) in the infrastructure bids.

3. Methods

This paper takes a case study approach (Yin, 2003) focusing on analysing bids related to green and blue infrastructure to Aotearoa-New Zealand's COVID-19 Response and Recovery fund. On 1 April 2020, as part of the financial strategy to respond to the economic impact of COVID-19, the New Zealand Government sought to financially and procedurally support 'shovel ready' infrastructure projects to support jobs and deliver broad local and national benefits. Guided by the criteria of the Infrastructure Industry Reference Group, local governments made submissions for funding of 'construction ready' projects, and fast-track consenting[2] under *The COVID-19 Recovery (Fast-track Consenting) Act 2020,* which came into effect on 9 July 2020. Projects such as local public transport programmes, road and cycling infrastructure improvements, wastewater, stormwater and potable water provision, and reserves and community facility upgrades were expected (Crown Infrastructure Partners, 2020). The Government's COVID-19 response budget was the most significant financial commitment in the nation's modern history, valued at NZ$50 billion, with $3 billion initially allocated to this particular fund (Robertson, 2020).

COVID-19 Response and Recovery bids from three of New Zealand's largest city regions were downloaded from council websites with online information requests sent to councils where the bids were not publicly available. These included projects submitted on 14 April 2020 from Auckland Council (a unitary authority), the Wellington sub-region (including the city councils and the regional council), and on 13 April 2020 from the Waikato sub-region (including the 'Future-Proof' collective of Hamilton City Council, Waipā District Council, Waikato District Council and Waikato Regional Council) (see Figure 1). Further screening meant that some proposals were excluded due to lack of detailed information (1 Waikato Regional Theatre), regional focus (1 Auckland Regional Parks, 1 Waikato Regional flood management) and data unavailability (47 Auckland Transport bids). A total of 84 bids were selected for detailed analysis (see Table S1 in the Supplementary Material for the full list).

It is important to note that the presence or lack of blue-green infrastructure components was not a criterion for the assessment process the submitted bids went through. The criteria used by

[2] Resource consent is the authorisation to use, develop or protect natural and physical resources in Aotearoa. It is comparable to the development assessment and approval process in Australian jurisdictions.

authorities to select bids were very broad and generic and primarily focused on construction readiness and material benefits for the economy and employment, including the extent to which: (i) the project was construction ready and able to be implemented within 6-12 months; (ii) comprised an infrastructure piece that benefited the region it applied to; and, (iii) had potential to generate employment opportunities (Crown Infrastructure Partners, 2020). Hence, we relied on the content analysis described below to identify references related to green and blue infrastructure components included in the bids.

The content analysis (Flick, 2014) of the bids was undertaken in three steps. First, we drew from the academic literature on green and blue infrastructure to develop codes relating to their different types (e.g., types often included in the works of Ashley *et al*., 2011 and Fletcher *et al*., 2015). Table S2 in the Supplementary Material details these. Second, we screened the bids to identify if they included any of the principal blue-green infrastructure types. If bids exhibited blue-green features but lacked conclusive detail, related council project webpages were also reviewed. Due to the diversity of terms applied in the New Zealand statutory context, we also searched the bids using sub-codes identified in key local, regional and national planning instruments. Where new terms were found in the bids during the detailed analysis in stage three, these were added to the list and the documents were re-reviewed. Third, we investigated how blue-green infrastructure was incorporated into the bids, including:

(a) whether blue-green infrastructure networks were proposed. This is important as the effectiveness and multifunctionality of blue-green infrastructure is enhanced when they comprise a well-planned network (Benedict & McMahon, 2006). Networked blue-green infrastructure means strategically planned blue-green hubs and corridors, which function as a socio-ecological system to produce multiple benefits to people and the environment;
(b) the extent to which they had a strategic or longer-term focus, in particular recognising the impact of the pandemic on human health and the need for quality urban spaces where people can have access to nature (including good air quality, inclusive access), or the challenge of climate change (e.g., potential exacerbation of the urban heat island effect, flooding) (Demuzere *et al.*, 2014; Meerow & Newell, 2017; Tzoulas *et al.*, 2007); and,

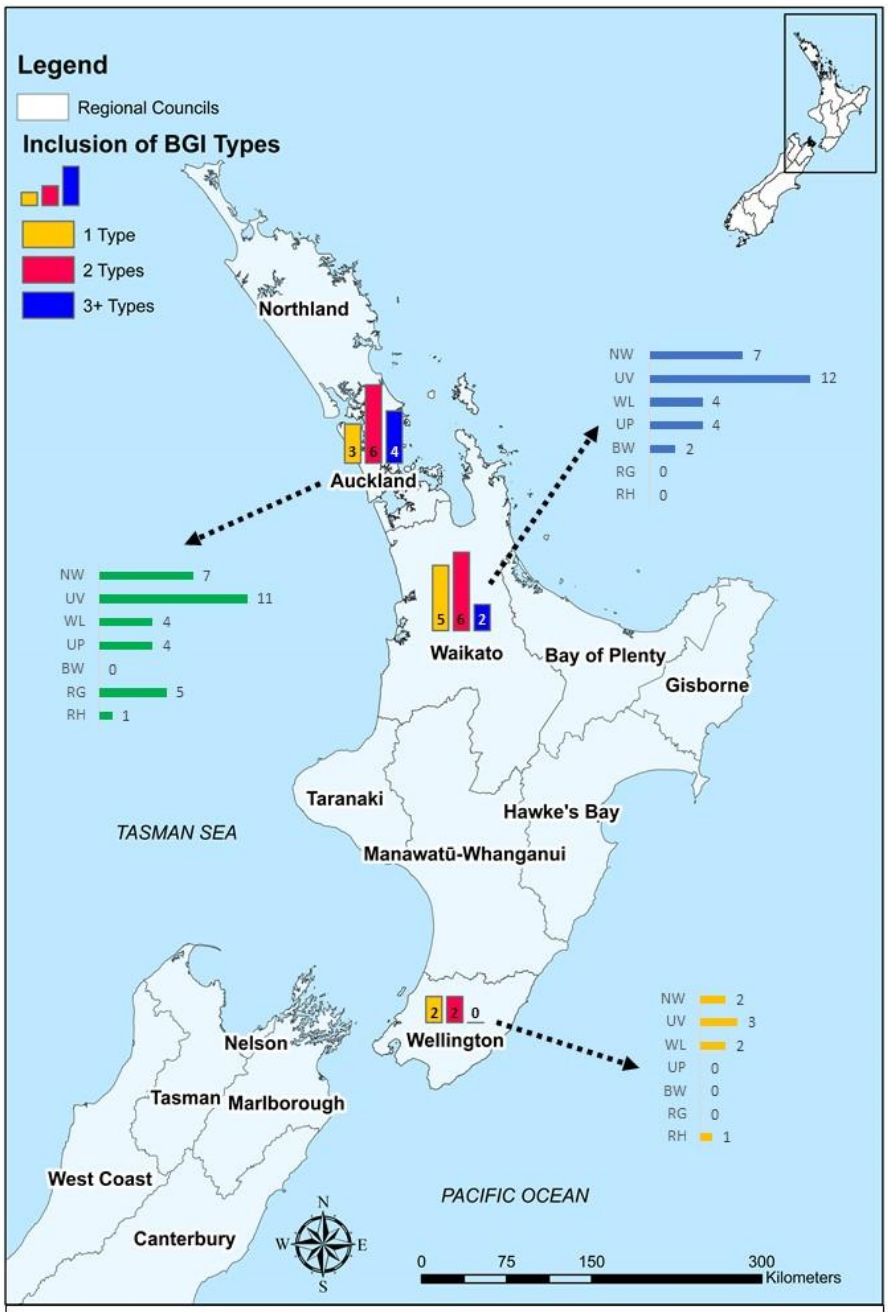
(c) any other features or uniqueness, especially regarding indigenous perspectives and the distinct cultural and spiritual wellbeing context of Aotearoa-New Zealand (Harmsworth & Awatere, 2013).

4. Findings and Discussion

The bids analysed comprised a variety of infrastructure projects, from public transport and cycleway improvements, to diverse community facilities, water supply schemes, local track and park enhancements, and the facilitation of greenfield and intensification developments. An overview of the key types of blue-green infrastructure the projects encompassed is provided next. Based on these results, we then discuss aspects relating to a 'green' turn in spatial planning, especially with respect to contributing to climate resilience, assisting in responses to public health crises, and embracing mātauranga Māori to support its revitalisation and to enhance cultural and spiritual wellbeing.

4.1 Blue-green infrastructure types

The majority (54 out of 84) of the analysed bids did not specifically demonstrate any type of blue-green infrastructure. However, for the Waikato sub-region and Auckland, features associated with blue-green infrastructure appeared in at least 50% of their bids, with a number of projects demonstrating more than one type. Overall, there appears to be limited consideration of blue-green infrastructure as part of a wider system, with bids often including blue-green infrastructure as a singular feature or concept. The most common blue-green infrastructure type included in projects is urban vegetation. Also common are wetlands, as either a constructed asset or enhancement of an existing natural asset. Figure 1 provides a summary of how the types and number of blue-green infrastructure provision differed across the bids from each case study region, and Table 1 shows some examples of types of blue-green infrastructure referred to in the bids.



Total bids and total with BGI included per region (in parenthesis):
Auckland Region – 25 (13); Waikato Sub-Region – 21 (13); Wellington Sub-Region – 38 (4)

Acronyms: BGI – blue-green infrastructures; NW – Networks; UV – urban vegetation; WL – wetlands; UP – urban parks; BW – bioswales; RG – rain gardens; RH – rain harvesting

Figure 1. Blue-green infrastructure types

Table 1. Examples of blue-green infrastructures in bids analysed

Blue-green infrastructure types	Examples from bids analysed
Networks (N)	● Auckland region: Multifunctional blue-green corridor - Te Whau pathway ● Waikato sub-region: Blue-greenway - Rotokauri Growth Cell ● Wellington sub-region: Integrated flood mitigation and water quality improvement system - Porirua CBD Wetland and Flood Mitigation
Urban vegetation (UV)	● Auckland region: Tree planting – Wynyard Central Public Spaces ● Waikato sub-region: Tree planting– Hamilton Pan Pasifika Community Hub ● Wellington sub-region: Tree planting – Riverlink Total Works
Wetlands (WL)	● Auckland region: Wetland construction - Kainga Ora - Tamaki Stormwater and Park Upgrades AC ● Waikato sub-region: Aggregated wetland design - Hamilton Zoo and Waiwhakareke Natural Heritage Park ● Wellington sub-region: Large high quality wetland within Elsdon Park - Porirua CBD Wetland and Flood Mitigation
Urban parks (UP) enhancement or new parks	● Auckland region: Upgrade of Freeland Reserve - Roskill South Housing Infrastructure Upgrades ● Waikato sub-region: Development and significant upgrade of sports parks – Development of Sports Fields
Bioswales (BW)	● Waikato sub-region: 4km long floodway swale - Rotokauri Growth Cell
Rain gardens (RG)	● Auckland region: Rain gardens – Ōtāhuhu Town Centre Upgrade
Rainwater harvesting (RH)	● Auckland region: Rainwater tank installation - Marine Village and promenade Westhaven Marina ● Wellington sub-region: Rainwater harvesting system – Wellington Convention & Exhibition Centre

Blue-green infrastructure types	Examples from bids analysed
Others	● Auckland region: Community gardens - City Centre Infrastructure Development Programme ● Auckland region: Ecological engineering of 'hard' marine environment guided by cultural values - Downtown Infrastructure Development Programme

There were interesting differences between the three case studies. For example, out of the 38 Wellington projects, only 4 included any kind of blue-green infrastructure, and none of these exceeded two types (see Figure 1). In contrast, both Auckland and Waikato used blue-green infrastructure in over half of their proposals, most of which incorporated more than one type. Auckland also displayed the widest variety of types in their bids, which indicates a higher level of awareness of the varying suitability of blue-green infrastructure within differing development proposals. As the same national brief was interpreted in quite different ways at sub-regional levels, it raises further questions relating to the reasons for this imbalance, such as regarding the existing sub-regional institutional or policy direction, the engagement with issues such as climate change, the kinds of proposals that have struggled to win funding in the recent past (and thus were deemed 'shovel ready'), or their particular infrastructure deficits relating to funding constraints. It also highlights a lack of direction in the bid process beyond aspects such as short-term job creation.

Whilst some bids demonstrated more than one blue-green infrastructure type, just 16 of the 30 clearly exhibited elements of a blue-green infrastructure network, integrating multiple functions to produce a more cohesive system or developing blue-green corridors and hubs. Unique projects were of notable interest, these engaged with a systemic perspective more easily, and were typically intricate systems, weaving mātauranga Māori into the blue-green infrastructure network, delivering interconnected social, cultural, spiritual, and environmental benefits across spatial dimensions. In particular, projects proposing wetlands, bioswales, and greenways predominantly demonstrate an awareness of network functions, however most types display limited acknowledgement of multifunctionality or reference to interactions with the wider blue-green infrastructure system.

For example, vegetation planting is generally proposed in an *ad hoc* way, representing a singular function, as part of sports field developments, town centre amenity improvements and

streetscaping, and community facility landscaping. Restoration projects have greater recognition of multifunctionality in terms of producing bank stability via 'green engineering', biodiversity, access to blue-green space and improved freshwater quality. Only a few vegetation based projects demonstrate strategic planning to support a blue-green infrastructure network. Te Whau Pathway in Auckland for example, is a proposed shared cycling and pedestrian path linking the Waitematā and Manukau Harbours. The pathway, which includes vegetation planting, will connect 33 reserves, esplanade reserves, sports parks and nearby communities and schools. This project has elements of networked blue-green infrastructure, but its focus is largely on human connectivity to natural spaces, with ecological initiatives tacked onto the development of pedestrian/cycle ways.

In the case of new wetland projects, all bids of this nature propose their use as multifunctional stormwater management systems. Demonstrating integrated flood mitigation with broad benefits is the Porirua Central Business District Wetland and Flood Mitigation bid (Wellington region). In addition to the mitigation of flood risk, the wetland is expected to provide an educational, aesthetic and passive recreation resource to the community, supporting enhanced safety of the Te Awarua-o-Porirua Harbour for Waka Ama (traditional Māori canoeing), bathing, and gathering of kaimoana (seafood). Also demonstrating strategic networks are two bids, the Rotokauri Growth Cell Link and the Cambridge West C1-C3 Growth Cell (Waikato sub-region). These projects include bioswales to deliver multiple functions which span across community boundaries, providing connections between a range of local environments. The Rotokauri Floodway Swale is designed to facilitate greenfield development via the use of a 3.8km blue-green corridor which functions as the principal stormwater management channel for the growth cell. This is a strategic, multi-purpose network as it also delivers open space and recreational connections for pedestrians and cyclists, and recreates the historical ecological corridor between Waiwhakareke and Rotokauri lakes. In addition to these functions, the proposed greenway incorporates supportive wetland environments to provide water quality treatment and additional flood storage capacity.

A desired outcome for all blue-green infrastructure initiatives is that they form a network which functions as a socio-ecological whole, creating and enhancing functions and connections across socially constructed boundaries (Benedict & McMahon, 2006). Therefore, hubs and corridors should be planned to be scalable and enhance networks of blue-green infrastructure, supporting multiple values and connecting existing and future resources. Attempts to enshrine provisions to support the implementation of these networks in plans and regulations can be

hindered by physical and regulatory constraints, and competing interests. For example, land tenure characteristics can limit the availability of space in urban areas to implement blue-green infrastructure as this becomes dependent on voluntary uptake by landowners to do so within their property boundaries, especially where land resumption costs make it prohibitive (O'Sullivan, Mell, & Clement, 2020). Others may struggle to enforce regulations due to weak institutional capacity and widespread culture of circumventing planning and other legislations (Di Giulio *et al.,* 2019; Nascimento *et al.*, 2019). Many urban areas, including in Aotearoa, are also under increased pressure to increase house supply to deal with housing availability and affordability issues; this can limit the availability of spaces designated for blue-green infrastructure projects (Mell, 2021). This means that the enhancement and implementation of networks of blue-green infrastructure cannot be achieved without strategic, spatial planning. Yet, as seen in many cases, the shovel ready process, with its emphasis on site-based interventions made this difficult to achieve, particularly without spatial plans in place. The differences between areas may be partially explained by this imbalance. Being in draft format, Wellington's draft regional and city spatial plans are not ready to guide infrastructure decisions. However, in Auckland and Waikato, the influence of spatial planning for blue-green infrastructure is reflected in the greater presence of blue-green infrastructure types in the infrastructure bids. Green infrastructure is a key 'focus area' in the Auckland Plan 2050 (Auckland Council, 2018) and the restoration and enhancement of the Waikato River blue-green network is a directive of the Hamilton-Waikato Metropolitan Spatial Plan (Future Proof, 2020a).

Whilst these spatial plans provide broad directions for encouraging blue-green infrastructure, more attention is required towards coordination, multifunctionality, connectivity, multi-scale planning, diversity, and identity (Grădinaru & Hersperger, 2019) to assist planners and stakeholders in developing blue-green infrastructure networks. Ideally, spatial plans identify existing features, networks and opportunities to build ecological cohesion and physical and functional connections between blue-green spaces at different spatial scales, incorporating a variety of types, functions, resources, and values. Without a clear direction, national initiatives like these or local projects may forgo opportunities to strategically build upon and protect key blue-green networks and values.

4.2 Climate and health responsive planning

COVID-19 has exposed a 'crisis of environmental justice and equity in the public realm' where the lack of space for people, and the inequities and insecurities may continue into the future and be exacerbated by other crises (Wray *et al*., 2020). Whilst the Shovel Ready fund applications include some blue-green infrastructure features within projects, a more detailed analysis revealed that, overall, there is limited acknowledgement, strategic oversight, and uptake of opportunities for climate and health responsive urban transformation. Considering how COVID-19 stimulated the fund, it may be surprising to many that not one bid specifically referred to pandemic/health planning and few explicitly incorporated features related to human health, other than indirectly, such as by improving access to open space. For example, the Auckland Ōtāhuhu Town Centre upgrade would enable greater 'social distancing' space by narrowing the existing road and expanding a footpath into a 3.5m shared cycling and walking path instead. Other bids which aim to deliver improved connectivity, and enhancements to open and natural spaces would also support urban populations in future lockdowns, providing greater access for passive recreation and potentially reducing air pollution by enhancing active transport links. Food resilience has also been a clear concern during the global pandemic with demand-side shock (panic buying) and potential supply-side disruptions (Hobbs, 2020) affecting food supply during the lockdown periods in Aotearoa-New Zealand (Neuwelt-Kearns, 2020) and abroad (Keane & Neal, 2021). Only one bid (Auckland City Centre Infrastructure Development Programme) includes provision for community gardens.

The Shovel Ready scope and timeframe has not enabled planners and infrastructure managers to acknowledge the impact of the pandemic and design responsive solutions to future public health crises. Due to the need for 'construction ready' projects, it is clear that many Shovel Ready bids are projects that have been in the pipeline for a number of years. For example, consultation for the Ōtāhuhu Town Centre (Auckland) upgrade occurred in 2017, with interventions designed to accommodate a growing community and visitor numbers. The Hamilton Mode Shift Programme Bid (Waikato) is the exception to this, proving that with vision and diverse collaboration, projects with broad strategic visions can be planned in a short timeframe, however, not in sufficient depth to roll-out immediately. This bid proposed to invest in infrastructure to create a '20 Minute City', with strategic provision of cycling and pedestrian mobility networks and access to a range of necessary services, facilities and blue-green infrastructure within 20 minutes from residents'

homes. Significantly, the specific interventions are 'focused in the most deprived neighbourhoods of the City' to bring 'increased health benefits for those in lower decile areas, providing better access to green space, education and economic employment opportunities.' (Hamilton City Council, 2020). The bid also recognises the importance of reducing reliance on vehicles to improve air quality and lower carbon emissions, demonstrating understanding of the need for urban transformation to mitigate both climate and health related crises. The bid was unfunded, however.

Overall, limited engagement with the notion of 'double duty' or addressing the weaknesses of existing urban forms is evident. Whilst provision for blue-green infrastructure is promoted in some bids, there is little evidence of pandemic planning, such as widening of footpaths for social distancing, reconsidering the use, nature and equitable allocation of urban blue-green spaces, mechanisms to protect communities from virus infected infrastructure failures following extreme events, provision of community gardens to increase local food security and reduce food miles, or strategic bridging of blue-green infrastructure hubs to enhance connectivity and accessibility in the network (Bogler *et al*., 2020).

A number of bids intentionally employ blue-green infrastructure for the purposes of climate change adaptation and risk reduction. Whilst the majority of types include the introduction of urban vegetation, only a few recognise the value of shelter and shade and reducing the urban heat island effect, in addition to enhancing the visual amenity of urban areas. Other projects utilising blue-green infrastructure features to address climate resilience focus on managing the effects of droughts and floods. The Wellington Convention Centre proposes the harvesting of rainwater to reduce water use pressures and a number of other projects incorporate blue-green infrastructure features to mitigate pluvial and river flooding risks. The Rotokauri Greenway supports flood attenuation (Waikato), the Porirua wetland (Wellington) is designed to deliver integrated flood mitigation and water quality improvements, and Auckland's Northcote Development utilises a wetland and lowering of an existing sports field to manage flood risk. The Lower Hutt Riverlink project (Wellington) incorporates a range of outcomes with a master planned package to mitigate river flood risk, revitalise the city with a riverside promenade, and deliver an enhanced ecological riverscape and wetland areas with new pedestrian and cycling connections. While climate related features are present in some bids, it is notable that climate change mitigation and resilience are not core aims of the fund, even with a recently declared national climate emergency. A 'climate resilience package' was delivered separately, however, the majority of those bids for Waikato and

Wellington (Auckland did not apply) include hard protection works, not blue-green infrastructure. As recognised by Gibson, Wannan and Mitchell (2020), not only were climate change impact assessments omitted for the initial Shovel Ready project selection process, some of the 'climate resilience package' projects may in fact make the net zero-carbon transition more difficult, and potentially increase climate related risks in the long-term. Climate change mitigation and adaptation must be central concerns for future investments, especially with immense stimulus spending and thus, debt for future generations. The lack of bid criteria regarding impacts on domestic greenhouse gas emissions and adaptation capacity risks compounding crises (Climate Change Commission, 2020). Furthermore, international and domestic climate change commitments under the Paris Agreement and the Climate Change Response Act 2002 'are so obviously material to Cabinet decisions on stimulus spending that failure to take them into account could render the decisions made unlawful' (Lawyers for Climate Action NZ, 2020). Our findings support the argument that in large, the infrastructure bids in Aotearoa-New Zealand are not transformational, but rather an immediate crisis response, with projects being 'Shovel Ready', but not necessarily responsive to changing urban priorities, disparities, and compounding health and climate related crises.

4.3 Blue-green infrastructure and mātauranga Māori

Blue-green infrastructure is a western concept based on enhancing or delivering ecosystem services in an interconnected, multifunctional way. As the original inhabitants of Aotearoa-New Zealand, indigenous Māori have nurtured a holistic, interconnected and reciprocal relationship with ecosystems, guided by mātauranga Māori, te reo Māori (Māori language) and whakapapa (ancestral lineage) (Harmsworth & Awatere, 2013). Māori are bound to the environment through whakapapa and environmental features are more than 'natural resources', holding significance as ancestors (Makey & Awatere, 2018). Māori developed knowledge systems specific to their environment and this dynamic body of knowledge is collectively known as mātauranga Māori, which includes many concepts that cannot be directly translated to English (Broughton & McBreen, 2015).

One of the most interesting aspects of the study was the emergence of unique blue-green infrastructure types, processes and functions found in some bids, predominantly stemming from the inclusion of Māori values and knowledge (see Table S4 in the Supplementary Material).

Although the government's criteria only required identification of 'economic/social/environmental benefits' (Crown Infrastructure Partners, 2020), several bids detail potential cultural benefits. Cultural benefits are only systematically included in the Waikato bids, and while they are described in terms of each project as a whole, it is possible to identify the benefits directly related to blue-green infrastructure features in some cases. This inclusion is a result of the Waikato sub-regional authorities duly recognising the statutory definition of wellbeing under the *Local Government Act 2002* (Future Proof, 2020b), with local authorities obligated to take into account the likely impact of any decision on social, economic, environmental, *and* cultural wellbeing (Wallace & Holman, 2019). It may also reflect the strength of partnerships between Iwi (Māori tribe) and the sub-regional bodies in this area. The omission of cultural benefits in the government's criteria creates opportunity for cultural wellbeing to be overlooked unless local governments such as those in Waikato proactively and transparently engage with all four wellbeings. Where these cultural values have been considered in relation to blue-green infrastructure however, there is wider potential to inform international discourses and norms on what is blue-green infrastructure and how can it contribute to holistic wellbeing.

Some projects in Wellington and Waikato employ blue-green infrastructure to improve water quality and then describe cultural benefits resulting from this. The Porirua CBD Wetland and Flood Mitigation (Wellington) bid provides a clear example. Wetlands and urban vegetation are proposed to mitigate flood risk and improve water quality in Te-Awarua-o-Porirua Harbour which in turn enhances the safety of waka ama (traditional canoeing) and mahinga kai. Mahinga kai refers to seasonal food gathering areas where, historically, Māori would gather and prepare natural resources (Regenerate Christchurch, 2019). A similar approach is taken in the Peacocke Growth Cell bid (Waikato) which utilises gully enhancement to improve water quality and contribute to safer mahinga kai.

The cultural benefits detailed in the bids generally reflect The 2005 Millennium Ecosystem Assessment framework where cultural ecosystem services involve recreational, aesthetic, and spiritual benefits. Whilst their inclusion is important, these services reflect a narrow interpretation of the breadth of Māori values relevant to the management of socio-ecological systems (Harmsworth & Awatere, 2013). A Māori ecosystem services framework (Harmsworth & Awatere, 2013) to guide the development of blue-green infrastructure would ensure that cultural values underpin all ecosystem services– supporting, provisioning, regulating and cultural. One

project in particular demonstrated such an approach. The Auckland Downtown Infrastructure Development Programme bid aims to enhance the living connection between the land and the sea, applying a range of natural and cultural techniques. As a result of co-production with mana whenua (Māori with territorial rights), this project envisages a living system in the urban marine environment, which delivers connection to the whenua (land), moana (sea) and tāngata (people), encouraging and supporting kaitiakitanga (ethic of stewardship by mana whenua). Ki uta, Ki tai, the guiding vision and framework for this project is a Māori representation of holistic blue-green infrastructure which is more complex than the facilitation of Eurocentric blue-green infrastructure networks, embedding historical, cultural and spiritual realms and values into the system. 'Ki uta, Ki tai' reflects the holistic Māori worldview, pointing to 'the movement of water through the landscape, from mountain to sea, and all the intricacies of ecology and biology in between.' (Landscape Architecture Aotearoa, 2019).

Conceived and co-designed with mana whenua, Te Wānanga, the downtown public space to be transformed, represents a fusion of mātauranga Māori, contemporary design, and ecology (Auckland Council, 2020). A native coastal canopy, kelp beds, tidal pools and a tidal shelf provide space for human and natural ecologies. These features also demonstrate and provide for cultural practices of kaitiakitanga (guardianship), rongoa (medical practices) and raranga (weaving); and use of the maramataka (Māori lunar calendar). Textured surfaces in the tidal pool will encourage the attachment of seaweed, barnacles and periwinkles, and ropes of kutai (green lipped mussels) are designed to support coastal and marine habitats and improve water quality via their natural filtration processes. The nature of this bid is unique to Aotearoa, demonstrating the integrated potential of blue-green systems, weaving Indigenous and western science to enhance multiple layers of urban and marine space, to improve the quality of the environment, educate the community, and restore the mauri (vital essence/spirit) of Te Waitematā (The Waitematā Harbour).

Mātauranga Māori has guided the process, aims and outcomes of the project. Key concepts such as kaitiakitanga and mauri aim to heal and enhance the 'living systems', recognising the notion of the environment as a construct of mental, physical, and spiritual realities (Makey & Awatere, 2018). In this case, the inclusion of blue-green infrastructure is broader than providing ecosystem services. This collaborative project demonstrates the value of Indigenous knowledge and empowerment in developing holistic, reciprocal blue-green infrastructure networks, from

design to delivery. In addition, Māori-led cultural monitoring approaches can assist in the ongoing monitoring and management of blue-green infrastructure (Harmsworth, Awatere & Robb, 2016).

In the Aotearoa context, in addition to revitalising mātauranga and cultural wellbeing, blue-green infrastructure processes and outcomes can be enriched from the integration of Māori ontology and knowledge. Mātauranga facilitates a holistic, networked approach, using centrifugal thinking to understand ecosystems beyond their interfaces (McAllister *et al*., 2019). As recognised by Makey and Awatere (2018, p. 1401), the challenge for practitioners lies in valuing "indigenous management approaches and respecting processes, scope, and practices that involve indigenous peoples more centrally and meaningfully." Whilst such involvement is occurring in some projects, the discourse in the statutory planning context (Ministry for the Environment, 2019) is both non-strategic and Eurocentric, presenting a potential barrier to the development of networked blue-green infrastructure which embraces Indigenous ontology and values and upholds Te Tiriti o Waitangi (The Treaty of Waitangi) responsibilities. The forthcoming replacement of the Resource Management Act 1991 with more strategic and collaborative planning processes may, however, better reflect Te Tiriti partnerships for the integrated management of resources (Resource Management Review Panel, 2020).

4.4 Balancing immediate needs with more transformative responses

The analysis findings are consistent with wider research that, despite having manifold benefits, blue-green infrastructure is often non-strategic or underutilised in planning practice (Kabisch *et al*., 2016; Matthews *et al*., 2015), and that globally, governments are yet to 'build back better' from the pandemic (O'Callaghan, & Murdock, 2021). In Aotearoa-New Zealand, job creation and economic wellbeing appear to be the result of central government's local infrastructure fund priorities, with blue-green infrastructure deemed a 'nice-to-have' rather than an essential system of the urban form, apparently not capable of stimulating the economy (Fonseka, 2020). However, growing evidence (Hepburn *et al*., 2020) supports the argument that green fiscal spending can deliver more robust economic returns than traditional economic stimulus. The government believed it had ticked the green recovery box when it 'addressed the environment' outside of the Shovel Ready fund (Fonseka, 2020), in particular with the separate 'Jobs for Nature' package. However, the evidence here suggests that this demonstrates siloed thinking, where the

'environment', including blue-green systems, exists outside the bounds of the city, rather than as an integral element of the urban form.

It is important to emphasise that cities and urban areas are constantly confronted with competing agendas and demands to accommodate population growth whilst providing quality urban spaces that can assist in times of crises (Mell, 2021). It is also important to acknowledge the limitations of blue-green infrastructure, and other related initiatives such as nature-based solutions, in providing endless social, economic and environmental outcomes, and their contribution to sustainable and climate resilient futures (O'Sullivan, Mell, & Clement, 2020). While these are real limitations that we must acknowledge, they also highlight that planning for them not only requires funding but also time and supporting data. None of these were available as part of the pandemic response and with only 21 days to apply, local governments in Aotearoa-New Zealand had a challenging task to assess, prioritise and develop projects to vie for a piece of the $3 billion shovel ready pie. Although statements about achieving sustainable development goals were present in the call for proposal guidelines, the primary criteria were construction readiness and material benefits for the economy and employment (Crown Infrastructure Partners, 2020).

The need for regaining public confidence in the economic recovery during the height of the pandemic was both immense and imperative. However, short-term speed can result in undesirable outcomes in the long-term, particularly where opportunities to adapt to new priorities and risks are missed. It is thus not surprising to find that the blue-green infrastructure inclusion is limited in extent and in relation to the scale of ongoing climate and health crises. The recovery time-compression has contributed to a narrow focus on greyer infrastructure, while overlooking broader community issues such as economic and social equity and more significant crises, in particular, climate change. Whilst the Aotearoa-New Zealand government was well-equipped for the financial 'rainy day' (Robertson, 2020) caused by COVID-19, by focusing economic stimulus and fast track consents on Shovel Ready infrastructure projects, and an underdeveloped focus on spatial planning, opportunities vital to prepare for future pandemics in a climate changed world have been missed. Once in a lifetime investments must provide both immediate and long-term climate and public health benefits by accelerating resilience investments to reduce future costs and harm. For blue-green infrastructure to be most effective, it requires spatial planning and a strategic vision, and in the Aotearoa context, incorporating Indigenous knowledge and values is essential.

5. Conclusion

Our study revealed that while grey may have been the infrastructure envisioned by central government to quickly create jobs and stimulate the economy, some local authorities sought a more blue-green focus. This was most prominent in areas with existing plans and capacity, highlighting the influence of spatial planning when responses to crises are called upon. For example, Auckland and Waikato spatial plans have guided the integration of blue-green infrastructure in their bids, with some projects comprising intricate networks. This indicates how spatial planning may play a key role in supporting strategic, transformative and innovative projects, especially when decisions need to be made under significant time constraints. As demonstrated in certain projects, blue-green infrastructure can be a transformative strategy that supports the underlying spatial framework, guiding future growth, urban renewal, and ecological and cultural conservation decisions.

While more work is needed to develop spatial planning for blue-green infrastructure in Aotearoa-New Zealand, to maximise its multifunctionality, connectivity, and diversity, and to help guide significant investment decisions, our study raised an important contribution to international debates intrinsically linked to the blue-green infrastructure concept: Indigenous knowledge and perspectives. In Aotearoa-New Zealand, Māori ontology and values not only enrich the spatial planning process and their outcomes, but also the concept of blue-green infrastructure itself. With a holistic world view more aligned to the networked intent of blue-green infrastructure, mātauranga Māori is invaluable to developing nature-based solutions, and as demonstrated in some bids, can produce unique multifunctionality and benefits.

By embedding indigenous knowledge systems in blue-green infrastructure planning, cultural knowledge and values can inform both the process and outcomes, influencing management of the broad socio-ecological system, not just the peripheral ‘cultural ecosystem services’. To meaningfully centre indigenous knowledge and values, local authorities can work with indigenous peoples to better integrate their knowledge systems into local infrastructure planning and design, from development guidelines to their spatial planning processes. Greater partnership in the design and monitoring of blue-green infrastructure may support cultural revitalisation in urban landscapes where Indigenous people have been excluded from customary ecosystem management due to dispossession from their lands. For indigenous knowledge and principles to be integrated into blue-green infrastructure, cultural wellbeing must be valued by governments, and Western science needs to relinquish some power. Finally, the ‘green recovery’ touted by politicians appears only

in traces with regard to urban blue-green infrastructure, falling short of strategic integration and transformation.

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