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Nature-Based Solutions for Urban Climate Change Adaptation and Wellbeing: Evidence and Opportunities From Kiribati, Samoa, and Vanuatu

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Climate change and urbanisation in combination put great pressure on terrestrial and ocean ecosystems, vital for subsistence and wellbeing in both rural and urban areas of Pacific islands. Adaptation is urgently required. Nature-based solutions (NbS) offer great potential, with the region increasingly implementing NbS and linked approaches like ecosystem-based adaptation in response. This paper utilises three Pacific island nation case-studies, Kiribati, Samoa and Vanuatu, to review current NbS approaches to adapt and mitigate the converging resilience challenges of climate change and urbanisation. We look at associated government policies, current NbS experience, and offer insights into opportunities for future work with focus on urban areas. These three Pacific island case-studies showcase their rich cultural and biological diversity and, importantly, the role of traditional ecological knowledge in shaping localised, place-based, NbS for climate change adaptation and enhanced wellbeing. But gaps in knowledge, policy, and practice remain. There is great potential for a nature-based urban design agenda positioned within an urban ecosystems framework linked closely to Indigenous understandings of wellbeing.

Keywords: nature-based solutions, climate change adaptation, wellbeing, traditional ecological knowledge, urbanisation, Kiribati, Samoa, Vanuatu

INTRODUCTION

Nature-based solutions (NbS) are defined by the International Union for Conservation of Nature (IUCN) as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham et al., 2016). More simply, NbS are solutions to societal challenges that involve working with nature. They aim to enhance the resilience of ecosystems, their capacity for renewal and the provision of ecosystem services

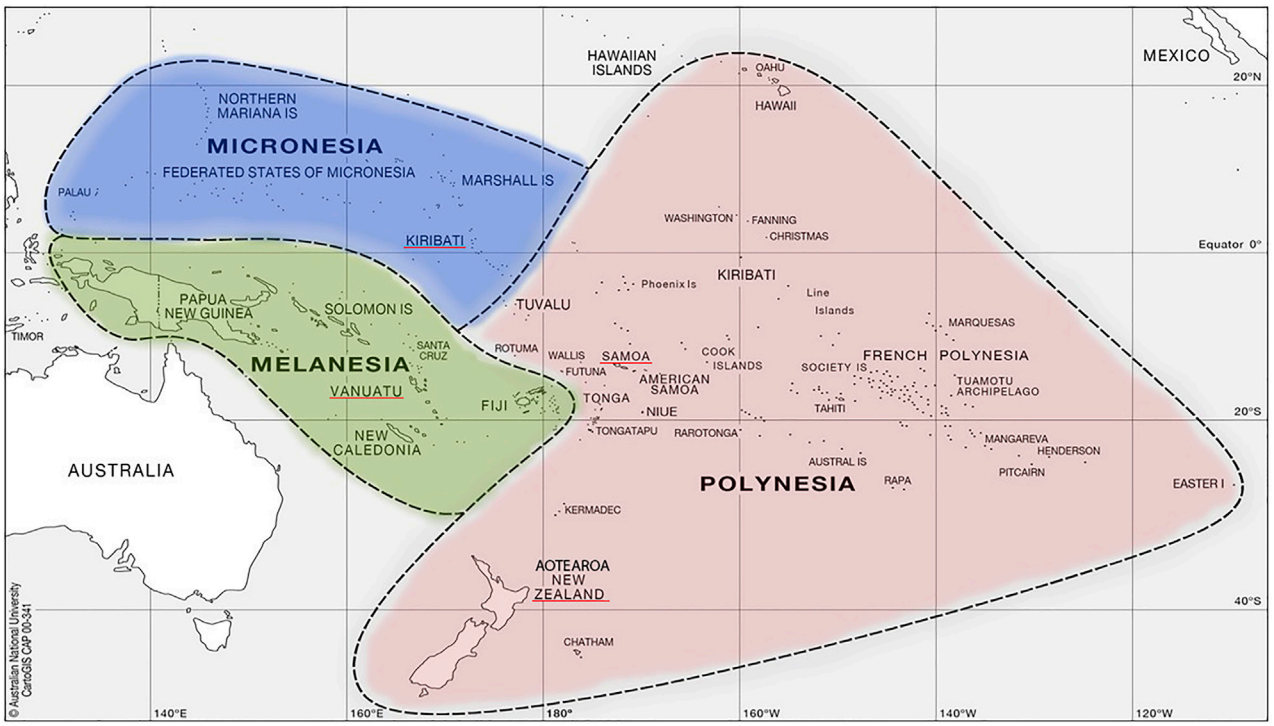

FIGURE 1 | Regions of Oceania. Source: Adapted from Australian National University (CC Licence).

(International Union for Conservation of Nature (IUCN), 2021). NbS have gained popularity globally as an integrated approach for responding to climate change, biodiversity loss, and broad sustainable development challenges. To date, for example, more than 130 countries have included NbS actions in their national plans under the Paris Agreement (International Union for Conservation of Nature (IUCN), 2020a). Critically, however, substantial gaps in the NbS practice evidence base remain, with much more work focused on Europe and other parts of the Global North, despite nations and communities in the Global South, including small island developing states, being more vulnerable to climate impacts (Chausson et al., 2020). In addition, there is also a strong need to increase the evidence base for NbS in urban areas (Kabisch et al., 2016).

The Pacific islands region (see **Figure 1**) is confronted by the twin "mega-trends" of climate change and urbanisation (Trundle et al., 2019). The impacts of climate change and associated increased and intensified extreme weather events in the Pacific region are well documented. In addition, the urbanisation rate across Pacific island small states has increased from 22.5% in 1960 to 39% in 2019 (World Bank, 2021), with further increases inevitable. Overall, climate change and urbanisation combine to place increasing pressure on interconnected island-based terrestrial and ocean ecosystems vital for subsistence, livelihoods, and wellbeing. Accordingly, Pacific island governments are increasingly prioritising NbS and particularly linked approaches such as ecosystem-based adaptation (EbA) in their national climate change policies and associated government priorities. This work, at different geographic scales, is supported by a range of development partners such as IUCN, the Secretariat of the Pacific Regional Environment Programme (SPREP), the Pacific Community (SPC), the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), international and local non-governmental organisations, bilateral donors such as the aid programme of the New Zealand Ministry of Foreign Affairs and Trade, and other multilateral organisations.

We utilise three national Pacific island case-studies; Kiribati, Samoa and Vanuatu, to review current NbS and EbA approaches to adapt and mitigate the converging resilience challenges of climate change and urbanisation. We firstly introduce NbS and EbA and the potential benefits they offer, including as strategies for adaptation in urban areas. We then focus on the island case-studies; introducing the context and then reviewing current NbS and EbA case experience, linked government policy, and discussing implementation challenges and opportunities. In doing so, we highlight the importance of traditional ecological knowledge (TEK) driving NbS and EbA approaches so that they are appropriate and effective for Pacific islands. We also introduce ongoing research, focused on developing a nature-based urban design agenda for Oceania (including Aotearoa New Zealand). This work is positioned within an urban ecosystems framework closely linked to TEK and Indigenous understandings of wellbeing. This is vitally important if NbS are to be grounded locally and thus more likely to be effective both ecologically and culturally.

NATURE-BASED SOLUTIONS IN URBAN AREAS

NbS aim to produce multiple societal, cultural, health and economic co-benefits for people while conserving or generating increased ecological health. Inherent in NbS is the acknowledgement that the health of ecosystems and the biodiversity contained within them is essential for human survival. NbS acknowledge that working with nature, rather than against it or without it, can lead to more effective, economical and culturally appropriate solutions to societal challenges while concurrently conserving or restoring biodiversity (Pedersen Zari et al., 2019). NbS also bring, or offer potential for, multiple other benefits. UNESCAP highlight, for example, that NbS: 1) provide cost-effective environmental, social and economic benefits; 2) can support communities, both rural and urban, in accessing natural resources and using them sustainably to support livelihoods; 3) can build from traditional ecological knowledges; 4) and revitalise cultural connections to nature to raise awareness, educate, and engage urban communities (UNESCAP, 2019).

NbS is an umbrella term for several other concepts growing in use in related professional communities, academic discourse and policy debates such as: EbA; natural climate solutions, ecological restoration; ecological engineering; urban green and blue infrastructure; ecosystem-based mitigation; ecosystem-based disaster risk reduction; natural capital; forest landscape restoration; and potentially biomimicry and biophilic design (Griscom et al., 2017; Raymond et al., 2017). Overall, the precepts fundamental in unifying the NbS concept are: 1) an understanding of the benefits that humans derive from ecosystems and the services that they provide; 2) an acknowledgement that people can learn from nature; and 3) recognition of the strategic importance of strengthening ecosystem health and human relationships with ecosystems to increase human wellbeing and society's ability to adapt to various changes. A wide range of activities can be categorised as NbS. In Oceania, for example, UNESCAP profile the rehabilitation of mangroves (for coastal protection and also biodiversity benefits), combining natural and engineered infrastructure for water management, urban agroforestry and gardening, the establishment of Educational Managed Marine Areas, and rehabilitation of wetlands and forest landscapes (UNESCAP, 2018). However, this is only a limited list. Many other activities can be categorised as NbS, broadly encompassing greenhouse gas reduction, flood and erosion control, coastal defence, cooling/shading, food and water security, water quality improvement, vegetation and habitat restoration, and the integration of built infrastructure including buildings with ecosystems, particularly in urban settings. Seddon et al. (2021) note that to qualify as NbS an action must provide one or more benefits to humans while causing no loss of biodiversity or ecological integrity compared to the pre-intervention state. Ideally, there should be ecosystem improvement–hence a generally strong focus on ecosystem restoration inherent in NbS.

It is now well recognised that NbS offer significant potential to respond to global challenges, including converging climate change and urbanisation pressures. However, application globally remains uneven and fragmented (Li et al., 2021). Recognising this, IUCN has recently focused on identifying core NbS principles for successful implementation and upscaling; highlighting the importance of clarity of the evolution, definition, and key principles of NbS, as well as the links with related approaches (Cohen-Shacham et al., 2019). Central to developing this clarity has been devising evidence-based standards and guidelines to improve and increase the use of NbS interventions worldwide (ibid). IUCN's Global Standard for Nature-based Solutions was launched in 2020, aiming to provide a user-friendly and consistent framework for the verification, design, use and upscaling of NbS (International Union for Conservation of Nature (IUCN), 2020b). There are eight criteria and associated indicators in the Global Standard: 1) NbS effectively addresses key societal challenges (importantly, including ensuring that human wellbeing outcomes arising from NbS are identified and monitored); 2) design of NbS is informed by scale; 3) NbS result in net gains to biodiversity and ecosystem integrity; 4) NbS are economically viable; 5) governance mechanisms are appropriate; 6) trade-offs are balanced; 7) NbS are managing adaptively, from evidence; and 8) NbS are sustainable and "mainstreamed within an appropriate jurisdiction" (ibid). Also important in building a global best practice database on NbS is addressing the global inequities in documented NbS experience, including in urbanism (much focus is on Europe, as are the majority of researchers and authors) (Schröter et al., 2020; Li et al., 2021). This reinforces the importance of examination of NbS experience and findings from other areas of the globe, including Oceania.

EbA is typically thought of as a subset of NbS, specifically applying to the adaptation elements of climate change response, and aims to work with nature to adapt to climate change through strengthening biodiversity and ecosystems (Munang et al., 2013; Pedersen Zari et al., 2017). A key premise of EbA is that if ecosystems are protected, remediated or regenerated this will lead to healthier ecosystems, improved or increased ecosystem services, and thus enhanced human wellbeing and resilience to the impacts of climate change (Pedersen Zari et al., 2019). The unique nature of EbA is twofold: firstly, when considering ecosystem health, the provision of ecosystem services, and human wellbeing holistically, EbA can offer more participatory, flexible, and potentially more cost-effective solutions compared to '"hard"' engineered infrastructure adaptation strategies. Secondly, EbA approaches focus on, and reveal, multiple drivers of ecosystem change; including from *both* climatic changes and the activities of humans (Mackey et al., 2017; McPhearson et al., 2018). In this review we emphasise this potential of NbS to address climate change as well as urbanisation pressures.

NbS and EbA offer potential for both rural and urban areas. The potential of NbS for cities (at least in Europe and other developed nations) was given impetus in the mid-2010s by the European Commission's Horizon 2050 Expert Group on "*Nature-based Solutions and Re-naturing Cities*" (European Commission, 2015). This research and innovation agenda

identified four, overlapping, principal goals that can be addressed by NbS: 1) enhancing sustainable urbanisation; 2) restoring degraded ecosystems; 3) climate change adaptation and mitigation; and 4) improving risk management and resilience (ibid). Seven NbS areas were recommended for prioritisation: (i) urban regeneration through NbS; 2) approaches closely linked to improved human wellbeing; 3) coastal resilience actions; 4) watershed management and ecosystem restoration; 5) NbS for increasing the sustainable use of matter and energy; 6) NbS for enhancing the insurance value of ecosystems; and 7) increasing carbon sequestration through NbS (ibid).

A large number of subsequent academic articles and studies from different disciplines have sought to advance the urban NbS agenda, largely with focus on European cities. Santiago Fink (2016), for example, highlighted the vital role of nature in addressing climate change at the city scale, focusing on green infrastructure as a cost-effective means to contribute to mitigation and adaptation priorities and simultaneously promote human wellbeing. Further, Frantzeskaki (2019) identified a number of key lessons for advancing NbS in European cities, including: 1) the importance of co-creation, and indeed citizen-led initiatives; 2) inclusive narratives and agendas; 3) a willingness and experiment and learn from innovation; 4) the critical role of collaborative governance as embraced by supportive local government; and 5) the importance of input from multiple disciplines and perspectives.

Dushkova and Haase (2020), focusing on urban design, point out that: 1) urban NbS projects have a much greater social, economic and environmental value than often originally understood; and 2) the co-benefits of NbS have the potential for great value when projects address the multiple needs of restoration, protection, and enhancement of ecological functionality and ecosystem services. Dushkova and haase identified five types of urban NbS approaches that could be applied to urban design: 1) NbS that make better use of protected or natural ecosystems in a way that increases urban ecosystem services supply; 2) NbS in conjunction with sustainable management of urban production systems such as urban forestry or farming; 3) NbS approaches that lead to the creation of new ecosystems (such as green walls, green roofs, and green buildings); 4) NbS approaches leading to the creation of new ecosystems from existing neglected, abandoned or brownfield sites; and 5) NbS associated with education and awareness on sustainable actions. These all present options for urban NbS for climate change adaptation and enhanced human wellbeing in Oceania, noting at present *urban* NbS experience is relatively limited in Oceania.

ECOSYSTEM SERVICES AND WELLBEING

As was highlighted and facilitated in terms of policy development by the United Nations' Millennium Ecosystem Assessment (MEA) of the mid-2000s, ecosystem services are fundamental to basic human survival and human wellbeing (Millennium Ecosystem Assessment (MEA), 2005). Ecologists have defined and categorised ecosystem services in various ways, but commonly within the four broad categories of: 1) provisioning services; 2) regulating services; 3) supporting services; and 4) cultural services. Recently, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has developed as an influential alternative or complementary framework to that offered in the MEA. The IPBES approach emphasises human-nature relationships at the heart of an understanding of "nature's contribution to people" (Díaz et al., 2015; Pascual et al., 2017). The concept of ecosystem services is at the heart of both the MEA and IPBES models, but the framing and language are different. For example, the IPBES model highlights that ecosystem services are co-produced by social–ecological systems (Bennett et al., 2015). The IPBES model also acknowledges the bi-directionality between social and ecological systems. For example, human wellbeing can also influence institutional and governance provision of ecosystem goods and services (Leviston et al., 2018). The IPBES approach also highlights the contribution of ecosystem services to the Sustainable Development Goals (SDGs), the key international commitments of the 2030 Agenda for Sustainable Development (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2018). Notably, biodiversity protection is inherent in SDG 14 (conserve and sustainably use the oceans, seas and marine resources for sustainable development) and SDG 15 (protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss). In addition, there are potential contributions and options for policy makers, to ensure an understanding that ecosystem services contribute to all other SDGs. As just one example, focusing on SDG 3 (ensure healthy lives and promote wellbeing for all at all ages), there are clear, well established, links between healthy biodiversity and human health and wellbeing (ibid).

Overall, investigation into wellbeing has evolved across many disciplines including psychology, education, health, economics, ecology and geography among others; although there remains no universally-recognised definition or standard measurement of wellbeing (Pennock & Ura, 2011; Diener and Tov, 2012). The IPBES framework conceptualises wellbeing as comprising access to basic resources, freedom and choice, health and physical fitness, good social relationships, security, peace of mind, and spiritual experience. Wellbeing is considered achieved when individuals and communities can act meaningfully to pursue their goals and enjoy a good quality of life. The ecological connection is key, with living in harmony and balance with nature recognised as central to human wellbeing across cultures (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2021).

Understandings of wellbeing continue to evolve. It is our view that notions of wellbeing must be locally appropriate and nuanced to particular place-based and cultural circumstances in order to be useful. Given the unique region of Oceania (including its huge geographical span and diversity), increasingly pressured by climate change and urbanisation, an important question comes to the fore: "*how can we best conceptualise wellbeing within an ecosystem services approach*

to urban development in the Pacific?" We return to this question in later sections.

PACIFIC ISLAND CASE-STUDIES

Context

Kiribati, Samoa and Vanuatu, amid similarities and differences, showcase the challenges brought by coalescing climate change and urbanisation pressures for Pacific small island nations and also other small island developing states (SIDS) globally. All three Pacific nations have become leading regional and international voices calling for increased global attention to climate change mitigation and adaptation and biodiversity challenges. The capital cities of these nations, described in the following paragraphs, although small in global terms, heavily dominate the population and economy of the islands on which they are situated. More significantly, these cities have all experienced rapid population growth rates in recent decades, much higher than their countries' national and rural growth rates. Population growth has occurred not only within urban administrative boundaries but also in peri-urban peripheries, affecting not only the population distribution of the urbanised areas, but also the provision of infrastructure and social services, food security and the cultural and social institutions of their settings.

Kiribati, in Micronesia, is a nation of 33 islands and approximately 118,000 people living in 21 islands (20 coral atolls and one volcanic island) spread across approximately 3.5 million square kilometres of ocean. Total land area is only 810 square kilometres. In 2019, 54% of the population was urban (World Bank, 2021), with South Tarawa the largest urban centre (population approximately 56,000), regularly reported as one of the densest urban agglomerations in the Pacific, if not the world. Kiribati's population continues to rapidly urbanise (2.9% urban growth in 2019), shaped by movement from outer islands to South Tarawa in particular (ibid). Kiribati's coral atolls only reach a few metres above sea level (on South Tarawa, for example, the highest elevation is 3 m). 35% of the population live within 0–50 m of the ocean, with a further 52% within the 50–100 m band (Kumar et al., 2020). Significant issues for Kiribati, among others, include the potentially existential impacts of sea level rise and increased storm events from climate change, limited freshwater and the salinification of freshwater lenses, and the need for improved sanitation and solid waste management. The incidence of basic needs poverty is highest in urban South Tarawa, affecting 24.2% of the population (Government of Kiribati, 2016a). Overall, Kiribati is confronted by a perfect storm of inherent climate vulnerability, limited land, continuing urbanisation, and overcrowding (Cauchi et al., 2019).

Samoa, in Polynesia, has a population of approximately 198,000 people spread across the two large volcanic islands of Upolu and Savai'i and eight smaller islands. The urban population was 18% in 2019 (World Bank, 2021), with the capital, Apia, the largest urban centre (approximately 36,700 people). Approximately 70% of the population reside in 330 villages along the coasts of Upolu and Savai'i (Government of Samoa, 2013). The natural hazard risk profile, impacted by climate change, is significant–with the country experiencing a number of devastating disasters in recent times, including cyclones and tsunamis as the most damaging. The National Climate Change Policy for Samoa highlights the significant sustainable development challenge: "Samoa shares with other SIDS the characteristics of being economically vulnerable and ecologically fragile because of its geographical location, isolation, limited resources and exposure to global economic crisis. Climate change impacts are [also] an added imposition on the inherent challenges Samoa already faces" (Government of Samoa, 2020).

Vanuatu, in Melanesia, has a population of approximately 282,000 people spread across a large volcanic archipelago of 83 islands. Like other nations of Melanesia, there is huge cultural and linguistic diversity. More than one hundred indigenous languages are spoken, for example. The nation was 25% urban in 2019, with urban growth globally-high at 2.9% in 2019 (World Bank, 2021), and urban and peri-urban growth rates in key administrative divisions reaching more than 8% between 1999 and 2009 (Trundle & McEvoy, 2015). The capital Port Vila, on the island of Efate, is the largest urban centre, with a population of approximately 51,500. Around 43.8% of the population lives within 500 m of the ocean (Kumar et al., 2020). Vanuatu ranks extremely highly in various global natural hazards vulnerability indices. It is exposed to cyclones and other storm events, earthquakes, and volcanic activity in particular. More than half the population, for example, are impacted annually by climate related extreme events or geohazards (Radtke et al., 2018).

Adaptation Priorities

Pacific island nations are insignificant emitters of greenhouse gases. Kiribati's Intended Nationally Determined Contribution document, for example, highlights that the nation's emissions per capita are among the lowest globally (Government of Kiribati, 2016a). As such, the focus of government efforts to respond to climate change in Kiribati, Samoa and Vanuatu has been on adaptation initiatives in various forms, often supported by a large number of partners, including regional organisations, multilateral organisations through various global funds, and bilateral aid programmes.

Climate change adaptation features prominently in high-level policy documentation in all three case-study nations, amongst advocacy for global mitigation efforts. A key aspiration of *Vanuatu 2030: The People's Plan* is "enhanced resilience and adaptive capacity to climate change and natural disasters" (Government of Vanuatu, 2016a). *The Vanuatu Climate Change and Disaster Risk Reduction Policy 2016–2030* provides more specificity on priority actions, bringing focus on the areas of disaster risk reduction (DRR), community-based adaptation (CbA), and ecosystem-based approaches (Government of Vanuatu & Pacific Community, 2015). Similarly, the *Kiribati 20-Year Vision 2016–2036* identifies environment and climate change as a key cross-cutting issue and highlights the critical need to mainstream climate change adaptation and mitigation across government policy and programmes (Government of Kiribati,

2016b). Providing more detail, the recent *Kiribati Development Plan 2016–2019* identifies "environment" as one of six priority areas with an associated goal to "facilitate sustainable development through approaches that protect biodiversity and support the reduction of environmental degradation as well as adapting to and mitigating the effects of climate change" (Government of Kiribati, 2016c).

In Samoa, the recent *Strategy for the Development of Samoa 2016–2020* (SDS) premised four priority areas including "environment" (including the key outcome areas of "environmental resilience improved" and "climate and disaster resilience increased") (Government of Samoa, 2016a). It is notable, however, that the more recent *Samoa 2040: Transforming Samoa to a Higher Growth Path* policy document that complements the SDS does not specify environment or climate-related priorities beyond investment in "climate and disaster resilient infrastructure" (Government of Samoa, 2021).

Have adaptation efforts been successful in Kiribati, Samoa and Vanuatu? Academic literature investigating this question is relatively limited and, overall, the picture is mixed. Webber (2015), for example, investigated the significant World Bank-funded two-phased Kiribati Adaptation Project (KAPI and KAPII) and highlighted that while both focused on hard infrastructure (especially the construction of seawalls), it was ecosystem-based aspects, notably mangrove rehabilitation and planting, that were the more successful elements of both projects (as assessed in formal project evaluations).

More focus in the academic literature has been given to evaluating the success or otherwise of CbA projects, generally critiquing efforts to date. Piggott-McKellar et al. (2020), for example, report on the evaluation of a rural CbA project in Abaiang Island in Kiribati, concluding that outcomes were largely ineffective and unsustained. They highlight the key lesson that local contextual factors such as social norms, environmental, or local governance and decision-making mechanisms must be identified and meaningfully incorporated into the design and implementation of CbA initiatives. Similarly, Cauchi et al. (2021), acknowledging the top-down nature of many adaptation projects, highlighted through a series of participatory focus groups in Kiribati, how critical it is to ensure communities participate in the co-design of adaptation interventions. These CbA findings resonate with research from Samoa that has highlighted that to understand climate change resilience in an island society, careful assessment of islanders' perceptions and actions in the context for their physical locales and socio-cultural systems is required (Latai-Niusulu, 2016). In short, islanders have detailed understanding, awareness and experience of climate changes (ibid) and this knowledge is vital to incorporate into adaptation initiatives.

Evaluations in Vanuatu have also reported the challenges of CbA initiatives to date. Westoby et al. (2020), for example, reviewed research evaluating 15 CbA projects in Vanuatu and concluded they invariably fell short of success, longevity, and sustainability. They argued that CbA projects typically were led by external "experts" working temporarily in local communities in sporadic design and implementation stages, "fitting" efforts to funding requirements and failing to view local communities as best placed to define and shape resiliency agendas. They concluded that localised adaptation efforts must be locally led and implemented across different entry points, and not just necessarily related to individual specific "communities".

Overall, contextual specificities are vital to understand and incorporate in adaptation efforts (Clarke et al., 2019). This is also essential for adaptation and climate resilience in urban areas. Trundle (2020), for example, through case-studies of environment- and climate-vulnerable informal settlement communities in the capital cities of Port Vila (Vanuatu) and Honiara (Solomon Islands), shows how important sub-city analysis provides detail on urban resilience strategies such as informal maintenance of ecosystem services, use of kinship and familial networks, and the translocation of traditional knowledge.

NbS and EbA Approaches

Overall, there are many projects currently operating in the Pacific islands region that are broadly classifiable as NbS and/or EbA. Some are regional initiatives, and some specific to an individual Pacific island nation or territory. A 2019 review commissioned by the New Zealand Ministry of Foreign Affairs and Trade, for example, identified 31 projects aimed at delivering resilient ecosystem services under the broad heading of NbS. The majority of these projects focussed on adaptation to climate change through awareness, conservation, restoration, and sustainable management of natural resources (Douglas et al., 2019). Geographically, projects were focused across a number of different scales or continua, such as: between rural and urban, high volcanic islands and low atolls, and main and outer islands. Eight of the projects (in Samoa, Vanuatu, Solomon Islands, Fiji, and Marshall Islands) were identified as having a specific focus on urban areas (ibid). On the other hand, a policy review conducted for UNESCAP (UNESCAP, 2019) identified a lack of effective urban governance structures and mandate, and weak or fragmented local and national government structures for urban management as significant barriers to implementation of urban NbS. The policy recommendations of this review included measures aimed at elevating a blue urban agenda in responsible levels of government at the local, provincial and national levels.

Regionally, Vanuatu has been a leader in EbA approaches, with EbA featuring prominently in key government policy documentation. For example, the *2016–2030 Climate Change and Disaster Risk Reduction Policy* identifies targeted EbA actions including "ridge to reef" solutions, prioritising "soft" interventions such as coastal revegetation (compared to "hard" engineered infrastructure such as seawalls), advocacy and awareness programmes, and activities that build on existing local "taboos, conservation areas, heritage sites, locally managed areas and vulnerable habitats and ecosystems and carbon sinks" (Government of Vanuatu & Pacific Community, 2015). Notably, the policy also brings considerable focus to the role of TEK into adaptation planning, design and

implementation, while also noting the importance of including TEK into formal and informal school curricula (ibid). Further, the *National Ocean Policy* highlights an ecosystem-based approach as the foundation of ocean management while also acknowledging the important role of TEK (Government of Vanuatu, 2016b). The Government of Vanuatu's focus on incorporating TEK comes from the strongly held and widespread conviction that the traditional economy is vital for subsistence, livelihoods, and wellbeing in Vanuatu (Regenvanu, 2010; Government of Vanuatu, 2016a) and that happiness (or subjective wellbeing) is inherently linked to access to customary land and natural resources, traditional knowledge and practice, and community vitality (Malvatumauri National Council of Chiefs, 2012).

A significant EbA project active recently in Vanuatu (and also Fiji and Solomon Islands) is the Pacific Ecosystems-based Adaptation to Climate Change (PEBACC) project, the first stage implemented by SPREP from 2015 to 2020 with funding from the German Government. PEBACC involved four key stages: 1) ecosystem and socio-economic resilience analysis and mapping; 2) EbA options assessments; 3) development of EbA implementation plans; and then 4) implementation of pilot projects (SPREP, 2020). The PEBACC project included a specifically urban focus in Vanuatu (Port Vila) and Solomon Islands (Honiara).

In Vanuatu, PEBACC evaluation focussed not only on the officially recognised urban area of Port Vila, but also its surrounding peri-urban area and the large water catchment within which both these areas are located, in a ridge-to-reef approach, acknowledging that the terrestrial, freshwater, and coastal ecosystems of small islands are highly interconnected (Pedersen Zari et al., 2020). Application of the first three PEBACC stages identified above resulted in the identification of five EbA priorities: riparian corridor regeneration; restoration and protection of coastal vegetation; intensification of home gardens; urban tree planting; and the use of traditional housing technology in a demonstration sustainable urban housing project. The use of the PEBACC methodology in Port Vila provided a number of important lessons: 1) the needs of local communities must be at the forefront of project planning, requiring a participatory design process; 2) EbA project development must be multidisciplinary and iterative; 3) appropriate data, both quantitative and qualitative, are vital as a basis for EbA project development, and adequate time for data gathering is required; 4) urban and coastal EbA projects must be developed holistically, recognising socio-ecological systems that extend beyond urban areas; 5) the complex overlapping landscape of governmental and international aid financed projects must inform the development of new EbA projects; 6) potential monetary and non-monetary benefits, costs and risks across multiple factors must be carefully assessed; and 7) project implementation requires ongoing engagement and a readiness to adapt to on-the-ground realities that may shift (Pedersen Zari et al., 2020).

NbS/EbA activities also feature highly in the suite of activities that Samoa has prioritised in its climate change adaptation efforts. Chong (2014) notes, for example, that "EbA is well integrated within five of the nine priority projects identified in the NAPA [National Adaptation Programme of Action], which makes explicit the value of ecosystem services to building the adaptive capacity of communities". Within the urban context, the most significant adaptation project incorporating NbS/EbA elements is the US$65 million Global Environment Facility (GEF)-funded and United Nations Development Programme (UNDP) implemented Vaisigano Catchment Project (VCP). The overall purpose of VCP is to strengthen adaptive capacity and reduce exposure to climate risks faced by communities and infrastructure in the catchment area of Apia (Green Climate Fund, 2021a). The project includes significant hard infrastructure components but also includes ecosystem responses such as crop planting, Ecosystem-based Adaptation Enterprise Development (EbAED) (supporting small businesses to engage in activities that will improve ecosystem function and have climate change adaptation benefits), cash for work through green jobs, and payment for ecosystem services (PES) (Green Climate Fund, 2016; Douglas et al., 2019). To date, some 20 EbAED projects are in operation with a further 319 projects approved; cash for work schemes are underway for ecological rehabilitation programmes at three reserve sites and fencing for watershed protection at one further site; and the PES component continues through feasibility stages (Samoa Ministry of Natural Resources and Environment, 2021).

In Kiribati, a number of projects, implemented at various scales (but particularly in rural areas), are broadly classifiable as NbS/EbA interventions, or include NbS/EbA components. The ongoing Food and Agriculture Organization (FAO)-implemented "Resilient Islands, Resilient Communities" project, for example, aims to improve biodiversity conservation and landscape and seascape level management to enhance socio-environmental resilience to climate variability and change. Funded by GEF (US$18 million), the project focuses on ridge-to-reef approaches for food security, sustainable livelihoods, and restoration and conservation of natural resources. Secondly, the UNDP-implemented "Enhancing National Food Security in the Context of Climate Change" (2016–2020) project looked to improve food security and hence the adaptive capacity of vulnerable communities through activities seeking to enhance ecosystem integrity such as coral reef restoration and improved ecosystem management (Douglas et al., 2019).

Opportunities

Climate change adaptation is an absolute priority for Kiribati, Samoa and Vanuatu, as well as other Pacific island nations. But adaptation is difficult. As evaluations of CbA projects have shown, for example, success is not guaranteed. NbS/EbA offer considerable potential for putting healthy ecosystems and biodiversity, crucial ecosystem services, and the key link between healthy ecosystems and human wellbeing at the centre of adaptation efforts, including in and particularly for urban areas. In Oceania, as elsewhere, NbS and EbA present opportunities for cost effective approaches, hybrid solutions, and the support of livelihoods through the restoration, regeneration,

and protection of terrestrial and marine natural resources. Critically, NbS and EbA also offer significant opportunity for incorporating TEK, so rich in the region, into adaptation efforts.

Many projects and partners are already active in NbS/EbA in Oceania. But much more can be done. The New Zealand Ministry of Foreign Affairs and Trade-commissioned review of NbS in Oceania, for example, recommended three broad categories of NbS opportunities that could fill current gaps: 1) restoring traditional gardening and farming practices, where eroded, for ecosystem health, food security, and improved human health benefits; 2) the prospects of traditional food storage methods to support disaster preparedness; and 3) the potential for using bio-indicators as early warning systems for climatic events such as droughts (Douglas et al., 2019). Recognising that significant gaps in implementation persist, a major 35 million euro multi-donor NbS programme was launched in 2020, led by Agence Française de Développement (with support from SPC, SPREP and IUCN), called the Kiwa Initiative. This programme aims to strengthen climate change resilience for Pacific island ecosystems, communities, and economies through NbS that protect, sustainably manage, and restore biodiversity (Pacific Community, 2021a). The Kiwa Initiative will provide grants for a variety of local and regional projects and provide associated technical assistance for project proposal development. These projects are likely to focus on a variety of different geographic scales, including both rural and urban areas. The Kiwa Initiative explicitly puts "people at the heart of its priorities [to] help drive forward socially inclusive project implementation at all levels" (Pacific Community, 2021b)—recognising that those most impacted by climate change, and depending the most on natural resources for their livelihoods, are best placed to develop and implement long lasting NbS (ibid). Future phases of PEBACC in Fiji, Vanuatu and Solomon Islands, focused on the implementation of EbA projects developed in the first phase, are also currently planned to be funded via the Kiwa Initiative. Some are likely to have an urban focus, such as those discussed already planned for Port Vila. Another major initiative in preparation is the Green Climate Fund Melanesian Coastal and Marine Ecosystem Resilience Programme (M-CMERP). This project focused on Papua New Guinea, Solomon Islands, and Vanuatu will look to prioritise and integrate EbA in national planning and decision-making amid long-term (50–30 years) climate impact and resilience scenarios, as well as provide grants to EbA and resilient development investments (Green Climate Fund, 2021b).

Opportunities also exist, or may present, through various government priorities and flagship projects for NbS/EbA in urban areas. In Samoa, for example, the National Adaptation Programme of Action (NAPA) specified zoning and strategic urban management adaptation priorities aiming, *inter alia*, for environmental dividends by strengthening adaptive capacity and urban intensification through an improved urban centre from the promotion of attractive design and heritage (Government of Samoa, UNDP and GEF, 2005). This helped lead to the creation of the Planning and Urban Management Authority (PUMA), responsible for managing Apia's urban growth, and recent work revitalising Apia's waterfront aiming to improve attractiveness, functionality and safety (Government of Samoa, 2016b). Key elements of the Apia waterfront work involve the protection of green spaces, parks, reserves, streetscapes and other recreation spaces (ibid); fertile ground for the potential application of NbS/EbA approaches. In addition, in Kiribati, considerable effort and funds have been directed at planning and feasibility stages of the Temaiku Land and Urban Development project aimed at reclaiming and raising (by 2–5 m) 300 ha of land on South Tarawa to provide a "resilient basis for future land and urban development [with] the potential to house 35,000 people" (Watkin et al., 2019). This project, likely enormously costly and still uncertain, was planned to combine phased hard and soft coastal defence solutions and a range of uses including residential housing, government buildings, infrastructure and utilities, and recreation. NbS/EbA approaches, if prioritised, could be incorporated into this project should it be realised.

As discussed, ecosystem services and their connection to human wellbeing and survival, are central to NbS and EbA approaches. In urban areas, adaptation approaches that premise wellbeing offer great potential. In Vanuatu, for example, where the government has a strong interest in wellbeing and its determinants, research has shown that subjective wellbeing, or happiness, is lower, on average, in urban areas compared to rural areas (Malvatumauri National Council of Chiefs, 2012). As introduced earlier, the same research has highlighted how wellbeing in Vanuatu is linked to three key factors: 1) access to customary land and natural resources; 2) traditional knowledge and practice; and 3) community vitality. Thus, in Vanuatu and likely elsewhere, it is clear that NbS and EbA approaches for climate change adaptation; which work *with* nature at their very core, offer great potential for improving urban wellbeing, particularly when combined with approaches that are driven by or incorporate TEK.

CONCLUSION

Across both rural and urban areas there are critical linkages between ecosystems, ecosystem services, and human health and wellbeing. In the Pacific islands region climate change and urbanisation combine to profoundly impact ecosystems, ecosystem services, and the livelihoods that they support. As described by Cauchi et al. (2021) and Pedersen Zari et al. (2019), climate change can be seen as a multiplier of urbanisation and other environmental pressures. Adaptation to climate change is urgently required, and NbS and EbA approaches offer great potential across different scales. Our three Pacific island case studies showcase the growing evidence base of NbS and EbA approaches in Oceania. But gaps in knowledge, policy, and practice remain, particularly for rapidly growing urban and peri-urban areas. It is also clear that successful adaptation requires careful consideration of the local context and participatory "bottom-up" co-design and implementation with local communities (Kabisch et al., 2017; Narayan et al., 2020; Piggott-McKellar et al., 2020; Cauchi et al., 2021). We believe that

there is great potential for a nature-based urban design agenda positioned within an urban ecosystems framework linked closely to Indigenous, localised, understandings of wellbeing and ecology. The co-design and implementation of urban NbS would be the defining features of this agenda, building from key lessons elsewhere that local communities must be inherently involved in NbS planning, design, and implementation (Kabisch et al., 2017; Frantzeskaki, 2019; Dushkova & Haase, 2020; Li et al., 2021; Seddon et al., 2021). Building such an agenda is an important contribution to nature-based ecological urban design in Oceania, particularly given that spatially explicit urban design policy and practice is often absent in Pacific islands nations.

We posed the question earlier "'*how can we best conceptualise wellbeing within an ecosystem services approach to urban development in the Pacific?*" As yet, the answers to this question are still far from clear. But we suggest that progressing an Oceania urban NbS agenda and responding to this question requires: 1) developing an inventory of innovative urban NbS strategies for the region; 2) more comprehensively exploring the range of existing and potential Indigenous wellbeing frameworks within Oceania; 3) using community co-design to develop future urban NbS strategies centred in TEK and related Indigenous wellbeing frameworks; and 4) ensuring that the wellbeing of Indigenous peoples, however defined locally, is a central pillar of future Oceania urban design and climate change adaptation initiatives.

Indigenous knowledges have long held that human wellbeing is inextricably connected to ecosystem health. We believe that building on Indigenous framings of wellbeing, and partnering TEK and other scientific information with NbS, can lead to place-based, localised, design responses that can offer long-term benefits across different scales, including in urban areas. Further developing an Oceanic urban design agenda is the focus of ongoing research undertaken by a collaboration of Aotearoa New Zealander, I-Kiribati, Samoan, and Ni-Vanuatu researchers and practitioners, including the authors. The recently released sixth assessment report (2021) of the Intergovernmental Panel on Climate Change (IPCC) has highlighted the acute vulnerability of Pacific island nations to climate change (SPREP, 2021). Adaptation efforts are vital, including in urban areas that are instrumental in contributing to global climate and sustainability goals (Santiago Fink, 2016; Li et al., 2021). Urban design responses, including those working with nature and with community co-creation at the core, will be an integral part of efforts to adapt in ways that protect and enhance the wellbeing of people and the ecologies of the region.

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GK lead authorship. TB, AL-N, WM, MPZ, RK, VC, PB, DL equal supporting input.

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