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Review

An Oceania Urban Design Agenda Linking Ecosystem Services, Nature-Based Solutions, Traditional Ecological Knowledge and Wellbeing

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Abstract: Many coastal peri-urban and urban populations in Oceania are heavily reliant on terrestrial and marine ecosystem services for subsistence and wellbeing. However, climate change and urbanisation have put significant pressure on ecosystems and compelled nations and territories in Oceania to urgently adapt. This article, with a focus on Pacific Island Oceania but some insight from Aotearoa New Zealand, reviews key literature focused on ecosystem health and human health and wellbeing in Oceania and the important potential contribution of nature-based solutions to limiting the negative impacts of climate change and urbanisation. The inextricable link between human wellbeing and provision of ecosystem services is well established. However, given the uniqueness of Oceania, rich in cultural and biological diversity and traditional ecological knowledge, these links require further examination leading potentially to a new conceptualisation of wellbeing frameworks in relation to human/nature relationships. Rapidly urbanising Oceania has a growing body of rural, peri-urban and urban nature-based solutions experience to draw from. However, important gaps in knowledge and practice remain. Pertinently, there is a need, potential—and therefore opportunity—to define an urban design agenda positioned within an urban ecosystem services framework, focused on human wellbeing and informed by traditional ecological knowledge, determined by and relevant for those living in the islands of Oceania as a means to work towards effective urban climate change adaptation.

Keywords: Oceania; Pacific islands; wellbeing; climate change adaptation; urban design; nature-based solutions; resilience; traditional ecological knowledge

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1. Introduction

Climate change and urbanisation severely pressure the nations of Oceania and their cities and towns. Here we define Oceania, also known as the Pacific region, as the islands of Micronesia, Melanesia and Polynesia (the latter including Aotearoa New Zealand) (Figure 1), together with the vast ocean areas between those islands. Increasingly, it is suggested that nature-based solutions (NbS), including ecosystem-based adaptation interventions, should be utilised to address climate change and other pressing societal issues as urbanisation continues to transform the region [1–3]. Climate change, increased temperature and the resultant sea level rise, along with increases in the occurrence and intensity of storm events, amplify a range of existing ecological and societal issues in Oceania. Rapid urbanisation puts further pressures on Oceanic urban environments, including increased biodiversity decline, and increased stress on vital marine and terrestrial food sources, along with other urban ecosystem services essential for human wellbeing [1].

Combined, these forces place unique pressures on Oceania nations and their urban landscapes, and point to the urgent need for urban adaptation.

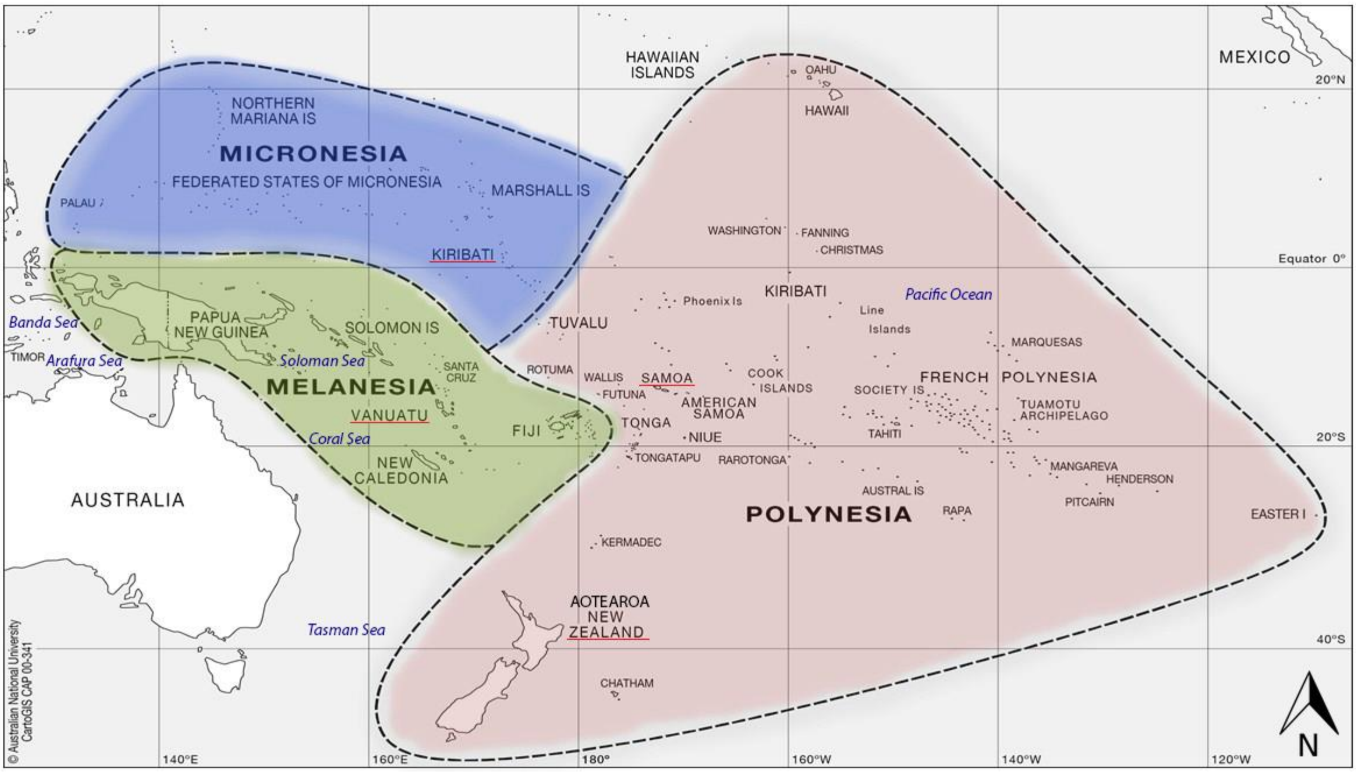

Figure 1. Regions of Oceania. Source: Adapted from Australian National University (CC Licence).

Climate change adaptation experience in the region shows that leveraging the interconnected relationships between ecosystem services and human health and wellbeing is important in the application of ecosystem services approaches [2,4–6]. However, a human wellbeing focus is not currently embedded in Oceanic regional urban planning and design practice, or indeed in most related climate change adaptation efforts in the region. A larger research programme investigating how ecosystem services-based urban design can specifically contribute to wellbeing outcomes in transforming Oceania is therefore needed [7–9]. This review article seeks to contextualise and position that important research agenda, demonstrate where gaps in knowledge and practice exist, and propose important research questions to drive work forward.

The article, using a critical social-sciences based literature review method, briefly introduces the Oceania context, specifically how the twin and intersecting forces of climate change and urbanisation impact the region. Secondly, we review the critical linkages between ecosystem health and human health and wellbeing, with a focus on Oceania. Thirdly, we examine literature and practice related to NbS and linked ecosystem-based adaptation in the Oceania region and climate change context. The article then focuses on urban environments and specifically urban ecosystem services, the importance of traditional ecological knowledge in Oceania and nature-based approaches for urban design. We conclude by introducing our unique Oceania nature-based urban design agenda, which is centred on Indigenous ecological knowledge and wellbeing frameworks.

2. Climate Change and Urbanisation Pressures

Climate change and urbanisation both continue to define modern times, and these ‘mega-trends’ are significantly impacting the Oceania region [10]. The majority of nations across Oceania, and their urban areas, are acutely vulnerable to natural hazards such as cyclones and other storm events, earthquakes, tsunamis and volcanic activity. Indeed, some nations in Oceania, especially those in Melanesia, are among the most exposed globally [11]. Climate change also intensifies a number of risk factors in Oceania, notably rising sea levels, enhanced storm frequency and intensity, ocean acidification, reduced reef health and changing rainfall patterns which can lead to more protracted periods of drought [12]. Overall, significant changes are already occurring in Oceania, a region where the opportunities to significantly contribute to climate change mitigation are limited, given small island states are such low greenhouse gas emitters. A programme of active climate change adaptation for Oceania is urgently needed.

The islands of Oceania are rapidly urbanising. Data from 2018, for example, shows that Micronesia was 69% urban (with some Micronesian countries more than 80% urbanised), Polynesia 44% urban and Melanesia 19% urban. Within the region, it is the Melanesian urban areas that are growing particularly fast, with annual percentage increases of urban population approaching 4%—some of the fastest rates of urbanisation globally [3,13]. In nearly every Pacific island nation urban population growth rates now exceed national population growth rates [14]. The pace of urbanisation in Oceania means that climate change adaptation strategies must focus on the unique needs of urban areas. What is particularly significant in Oceania is the acute, and increasing, pressure on terrestrial and marine resources created from environmental and climate change pressure and the increasing per capita resource demands of growing populations. Other stresses as influenced by both climate change and urbanisation (as detailed in following sections) combine to further pressure the urban areas of Oceania.

2.1. Informal Settlements and Peri-Urban Environments

Informal settlements, particularly in the Melanesian nations, are a feature of the urban environments of the island nations of Oceania [15]. For example, it is estimated that around 20–45% of those living in the Melanesian capitals reside in informal settlements without legal security of tenure on state, customary and sometimes freehold land [16]. The growth of informal settlements is influenced by the rapid expansion of urban populations, accompanying expansion of urban areas, combined with a lack of affordable, formal housing [17]. Informal settlements are often located in environmentally marginal, hazardous locations such as riverbanks, coastal and inland floodplains, and steep slopes [15]. Informal settlements are also often located outside of municipal boundaries on the peri-urban fringe on customary land. Although the most well-known peri-urban settlements are on the outskirts of the largest Melanesian cities of Port Moresby (Papua New Guinea), Suva (Fiji), Honiara (Solomon Islands) and Port Vila (Vanuatu), peri-urban areas are often relatively extensive even around small towns [3]. As well as the resilience stresses on the fragile urban environments of these settlements, it is likely that their growth has also compromised the food-producing potential of what were often formerly peri-urban customary land gardens. Overall, increasing human populations in many Oceania urban areas place particular stresses on often already fragile areas of local urban and peri-urban ecosystems.

2.2. Ocean Resource Pressures

Oceania communities and economies are highly dependent on healthy coastal and ocean resources, both physically and culturally, but these are depleted in many places and under stress by increasing human populations. Across many urban areas of Oceania, for example, the heavy harvesting of fish and other reef species exerts significant pressure on reef and coastal ecosystems [12]. In addition, pollution from industry and agriculture, the damage or removal of mangrove and other coastal forest habitat from development projects, and the direct effects of climate change, such as increased lagoon temperatures and acidity levels, impact island communities, both rural and urban [18].

2.3. Food and Water Security

There is significant pressure on food and water security in the island nations and territories of Oceania. Many urban residents, especially those living in informal settlements, are highly dependent on subsistence methods to obtain resources, both terrestrial such as from gardens and coastal fisheries [5,12,19,20]. The terrestrial and inshore marine ecosystems providing these resources are increasingly pressured by the demands and effects of increased and denser human populations and climate change, but many residents still do not have sufficient resources to provide full food security. In Solomon Islands, for example, there is widespread recognition that critical reef fisheries across the archipelago are less productive than in the past [21]. Recent data also shows that Oceania is the only global region where undernourishment has increased since 2007 [22]. In addition, especially in the numerous low-lying coral atolls of island Oceania, damage and loss of natural coastal barriers and ecosystems have increased risks of saltwater inundation of freshwater lenses through wave action and storm surges, reducing food-producing habitats and escalating water security pressure [23].

2.4. Waste and Pollution

The challenges of waste management are also pressuring many urban centres in the islands of Oceania [24,25]. Shortages in land and resources for the development of technically sound sanitary landfills, limited recycling facilities and options and a general lack of waste management awareness mean that the islands of Oceania are inundated with solid waste that their waste management systems cannot manage effectively. Inadequate waste management in coastal settlements often means that solid waste can easily enter the ocean (exacerbated by frequent storms) [26]. Further, deforestation of mangroves as natural filters of pollution and discharge of untreated wastewater in some urban areas also compounds the pressures on coastal ecosystems [18]. The links between these factors and negative impacts on ecological and human health are clear.

3. Linking Ecosystem Services, Human Health, and Wellbeing

3.1. Ecosystem Services and Social–Ecological Systems

In a traditional Western science model, ecosystem services are the benefits that humans and other life derive, either directly or indirectly, from the functions of ecosystems [27]. Despite the seemingly human-centred values integral to the concept of ecosystem services, the notion is also useful in helping people to understand and appreciate the fundamental importance of ecosystems as a basis of human and other life. It is also acknowledged that ecosystems do have intrinsic value independent of the ability of humans to exploit them [28–30]. The intrinsic values of ecosystems are particularly culturally relevant in the Oceania context.

A focus on ecosystem services as a key basis for assessment and policy development has been widely adopted among ecologists and policy-makers [31] and was formalised by the United Nations' Millennium Ecosystem Assessment (MA) of ecosystems and human wellbeing [32]. Ecologists have defined and classified ecosystem services in various ways [33,34], commonly from within the MA's four broad categories of: (1) provisioning services; (2) regulating services; (3) supporting services; and (4) cultural services.

Ecosystem services are fundamental to human survival and wellbeing [33]. However, ecosystem services are under increasing pressure globally. Human appropriation and use of ecosystem services is expanding rapidly due to human population increase and sharp increases in per capita rates of consumption [35]. It was estimated in the MA that approximately 60% in total, including 70% of all regulating and supporting services, were degraded by the activities of humans [33]. Overall, globally, including in many of the countries of Oceania, the state of the majority of ecosystem services, except for the provisioning of food and raw materials, has declined significantly [31,36,37].

The recent Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has developed as an influential alternative or complementary framework to the MA. The IPBES framework emphasises human-nature relationships as central to 'nature's contribution to people' [38,39]. In our understanding, ecosystem services are at the heart of both the MA and IPBES models, but the language and framing are different. A key feature of the IPBES model is acknowledgement that ecosystem services are co-produced by social–ecological systems [40], and of the bi-directionality between social and ecological systems. For example, human wellbeing can also influence institutional and governance provision of ecosystem goods and services [41]. This bi-directionality is central to our concepts of the ecosystem services, health and wellbeing nexus in Oceania. Furthermore, it is widely accepted that integrating ecosystem services, in terms of the benefits nature provides to people, into sustainability strategies such as the Sustainable Development Goals (SDGs, see below) can help achieve wellbeing while also protecting ecologies [42].

The IPBES Summary for Policymakers [43] highlights the key contribution of ecosystem services to the SDGs, the flagship global commitments of the 2030 Agenda for Sustainable Development. Notably, the protection of biodiversity is inherent in both 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). Further, there are potential contributions and options for policy makers to ensure an understanding that ecosystem services contribute to all other SDGs. For 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).

3.2. Health and Wellbeing Linked to Ecosystem Services

Before delving deeper to focus on Oceanic notions of wellbeing within an ecosystem services framework, it is important to address the broad question 'what is wellbeing?' Wellbeing research and focus has evolved over time across many disciplines including psychology, education, health, economics, ecology and geography, among others. However, there is no universally-recognised definition or standard measurement of wellbeing [44,45] and many different approaches are taken. The IPBES model conceptualises wellbeing as comprising of 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 are able to act meaningfully to pursue their goals and enjoy a good quality of life. Notably, ecological connection is central, with living in harmony and balance with nature highlighted as fundamental to human wellbeing across cultures [46].

Overall, investigation into wellbeing has evolved from a typically narrow focus on objective measures (such as income levels and education and health indicators) to more complex, multidimensional models of wellbeing comprising both objective and subjective measures. 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. Manuela and Sibley [47] and Pratt [48] provide two regional examples from Aotearoa New Zealand and then Solomon Islands and Tonga respectively.

Focusing on Oceania, an ecosystem services approach to development and climate change adaptation responds to the key pressures in the region as outlined in Section 2, the need for holistic approaches, and international best practice as advocated by the United Nations [3] in understanding, leveraging and working with human/nature relationships. However, how to translate ecosystem services approaches into urban contexts, including with urban design, is not fully clear—although nature-based solutions, both current and future, offer potential.

McFarlane et al. [7] review the linkages between ecosystem services and human health in Oceania, noting that the small island states of the region increasingly face a 'triple burden of disease'. This triple burden recognises the traditional scourges of: (1) infectious disease; (2) non-communicable diseases; and (3) how climate change escalates the threats from both infectious and non-communicable diseases, and also the risk of loss of life and harm. The impacts of increased frequency and intensity of extreme weather events also include physical and mental health harm and a number of indirect impacts such as changed distribution of arthropod vectors, intermediate hosts and pathogens, and increased rates of food and water-borne diseases (ibid).

McFarlane et al. [7] also note that freshwater quality and quantity, increasingly stressed by population growth, catchment degradation and saltwater intrusion from rising sea levels, are among the most acute short and long-term threats to health and wellbeing in the islands of Oceania. In addition, droughts and water shortages can lead to increased transmission of pathogens, exacerbated by increased average temperatures; typhoid being just one example that has seen increased rates in the island Pacific in recent years (ibid). Further, changing diets, increased obesity and increased non-communicable diseases rates are closely linked. This highlights the importance of traditional food production and the promotion of physical activity.

In Oceania, much of the research on the health impacts of climate change has focused on physical health. The mental health impacts of climate change have only more recently been recognised by public health experts. These include the impact of natural disasters on existing mental health issues and the disruption to health services, as well as impacts on the physical environment which alter social and community connections to place, potentially bringing economic burden, inducing stress, anxiety and possible displacement [49–52]. 'Solastalgia' is a term applied to the human distress caused by environmental change affecting a home environment [53,54]. It has been included as a contributing concept to the impacts of climate change on human health and wellbeing [55] and has come into increasing use globally as increased ecosystem distress is matched by a corresponding increase in human distress [54]. Solastalgia may be particularly useful in describing the nexus between climate change, ecosystems and mental health and wellbeing for Pacific peoples [52]. However, there remains significant gaps in the research and a lack of data on how climate change is affecting mental health in the region [56,57], particularly as understood through world view lenses self-determined by the people of Oceania themselves. The question remains, therefore, 'how do the people of Oceania react to and understand distress induced by climate change?' [52]. This is a question that is relevant for people residing in the smaller islands of Oceania but also for Pacific peoples (Indigenous Pacific Islanders) who have immigrated to or been born in the larger nations of the region such as Aotearoa New Zealand and Australia.

4. Nature-Based Solutions for Urban Climate Change Adaptation

Nature-based solutions (NbS) aim to increase human wellbeing and resilience by working with, conserving and restoring nature. Understanding ecological systems and ecosystem services across and within interconnected landscapes, ocean ecologies and socio-cultural contexts is central [3,58]. We suggest also that NbS offer potential to assist in translating ecosystem services approaches into urban design and urban climate change adaptation efforts.

The overall aim of any NbS approach is to generate multiple societal, cultural, health and economic co-benefits for people while conserving or providing improved ecological health. Inherent in NbS is the acknowledgement that the health of ecosystems, and the biodiversity within those ecosystems, is essential for human survival. Central to NbS is the view that working with nature, rather than against it or without it, will lead to more effective, economical and culturally appropriate responses to societal challenges while at the same time conserving or restoring biodiversity. The International Union for Conservation of Nature (IUCN), housing the Commission on Ecosystem Management, define

NbS as "actions to protect, sustainably manage and restore natural or modified ecosystems, which address societal challenges effectively and adaptively, while simultaneously providing human wellbeing and biodiversity benefits" [58] (p. 2). This definition emphasises that conserving and/or restoring and regenerating ecosystems should be central to NbS.

NbS is an umbrella term for several other concepts increasingly prominent in related professional communities, academic discourse and policy debates. These include ecosystem-based adaptation, ecosystem-based management, urban green and blue infrastructure, ecological restoration, ecological engineering, forest landscape restoration, ecosystem-based mitigation, ecosystem-based disaster risk reduction, natural capital and potentially biomimicry and biophilic design. Overall, what is central in unifying NbS as a concept is: (1) understanding the benefits that ecosystems provide to people; (2) acknowledgement that humans can learn from nature; and (3) recognition of the strategic importance of improving ecosystem health and human relationships with ecosystems to increase human wellbeing and our ability to adapt to changes and pressures. Recently IUCN has focused on identifying core NbS principles for successful implementation and upscaling. This highlights the importance of clarity on the evolution, definition, key principles and links with related approaches to develop evidence-based standards and guidelines. These NbS standards will provide clear parameters for defining NbS and a common framework to help benchmark progress, with the intention of improving and increasing the use of NbS interventions globally [59–61].

Ecosystem-based adaptation (EbA) is an important NbS subset. EbA works to adapt to climate change through the strengthening of biodiversity and ecosystems [19,62]. EbA holds that if ecosystems are protected, remediated or regenerated this will lead to healthier ecosystems, increased ecosystem services and therefore increased human wellbeing and resilience to climate change impacts [2]. EbA is unique in two key ways. Firstly, when looking holistically at ecosystem health, the provision of ecosystem services and human wellbeing, EbA can present more participatory, flexible and potentially more cost-effective solutions when contrasted to 'hard' engineered infrastructure adaptation strategies. For example, with regards to coastal erosion, comparing 'softer' protection measures such as the restoration of reefs, mangroves, dunes and salt marshes to 'harder' engineered seawalls (ibid). Secondly, EbA approaches can reveal multiple drivers of ecosystem change, including from both climatic changes and human activity [12,63,64].

The focus of many EbA activities and projects, certainly within Oceania, has been on rural areas. Thus, the body of EbA experience in urban areas is smaller. Brink et al. [65] provide a thorough review of urban EbA concepts and global experience highlighting how EbA experience is multi-disciplinary, drawing together concepts from ecology, conservation, ecosystem services, climate change adaptation, development studies, architecture, urban design, landscape architecture and risk management fields. They note the rapid growth in EbA experience but argue that it has been fragmented to date. They identify three major areas requiring a more integrated approach with EbA: (1) a more holistic, systems perspective utilising multi-disciplinary knowledge: (2) better integration of people into EbA practice and research (they highlighted how issues of equity, including gender issues and stakeholder participation, received little attention in EbA experience to date, for example); and (3) a more future-focused approach (the review highlighted how EbA experience to date has focused on current climate variability rather than projected climate change). For the Oceania context, including in urban areas, we propose a further area related to the need for culturally appropriate approaches that are driven by traditional ecological knowledge (see Section 6).

Responding to climate change and natural disaster impacts as well as those of rapid urbanisation, the United Nations Office for Disaster Risk Reduction (UNDRR) has focused on ecosystem-based approaches to disaster risk reduction and response. A recent report [66] has outlined these approaches and their benefits, the key roles of DRR for reducing natural disaster and climate change risks into increasing the resilience of infrastructure, and provides approaches for integrating NbS into policies, plans and programmes. The report makes the central point that EbA, and specifically ecosystem-based disaster risk reduction (Eco-DRR), can play a key role in reducing disaster and climate risk. The report highlights that Eco-DRR approaches are efficient, cost-effective, and flexible when compared to other approaches (ibid). From Oceania, the report highlighted that the Vanuatu Climate Change and Disaster Risk Reduction Policy 2016–2030 [67] adopts ecosystem-based approaches as a central pillar of policy—notably highlighting the importance of hybrid approaches to disaster control infrastructure that prioritise 'soft' measures such as coastal vegetation over 'hard' engineered solutions such as seawalls.

4.1. Experience from Oceania

From Oceania there is a growing NbS evidence base of experience from which to draw from (see Figure 2). This includes ridge-to-reef restoration projects, reforestation and afforestation initiatives, coastal and estuarine mangrove restoration, urban food production and the rehabilitation or establishment of urban green spaces [1,3,4]. Overall, the Oceania region is emerging as a global leader in the practical application of NbS/EbA approaches. A 2019 review of NbS projects in Oceania commissioned by the New Zealand Ministry of Foreign Affairs and Trade, for example, identified 31 initiatives aimed at delivering resilient ecosystem services under the broad heading of NbS, including eight in urban areas [68]. Some NbS investment is large scale. The Kiwa Initiative, for example, launched in 2020, is a major 35 million euro multi-donor NbS programme led by the Agence Française de Développement that will fund various NbS projects at different scales across Pacific islands, expecting to include urban areas [69]. NbS initiatives in Oceania have showcased feasible approaches to a number of broad challenges including: climate change mitigation and adaptation; biodiversity conservation; disaster risk reduction; management of coastal areas; water, food and energy security; human physical and psychological health issues, such as air quality, green space management, and public health; poverty reduction; social justice; participatory planning and governance; and sustainable economic and social development in general (ibid).

A major Oceanic initiative to address some of the challenges discussed here is the Pacific Ecosystem-based Adaptation to Climate Change programme (PEBACC) developed by the Secretariat of the Pacific Regional Environment Programme (SPREP) [70]. The programme has been running since 2015, with the support of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. PEBACC is focused on Fiji, Solomon Islands and Vanuatu in Melanesia, with urban-focused projects in Honiara (Solomon Islands) and Port Vila (Vanuatu). Initial work was focused on reviewing ecosystems and undertaking socio-economic resilience analysis and mapping (ESRAM) studies which were the foundation for the development of EbA options in the three countries. The initial ESRAM studies clearly showed the reliance of even urban dwellers on land and sea-based natural resources, and the vulnerability of the ecosystems providing those resources to the pressures placed on them by rapidly growing urban and peri-urban populations, as well as direct and indirect impacts of climate change and natural disasters. Later studies identified opportunities for pilot projects to improve resilience and adaptation to those pressures [71,72]. A range of those projects are now being implemented [70], but at this stage the outcomes of the projects for health and wellbeing have not been investigated in depth.

Figure 2. Oceania urban environments indicative of NBS themes and potential. upr L: Aerial photo of Port Vila, Vanuatu, catchment setting (S Chape, SPREP); upr mid L: community data gathering, Port Vila (D Loubser, SPREP); lwr mid L: traditional fishing methods used in peri-urban village, Port Vila (P Blaschke); btm L: hybrid engineered river stabilisation with riparian planting, Port Vila (P Blaschke); upr R: informal settlement within garden area, Suva, Fiji (GL Kiddle); mid R: tsunami evacuation planning, Port Vila (P Blaschke); lwr R: colonial botanical garden used as modern forest reserve, Honiara, Solomon Islands (B Toki, BMT).

In Port Vila in Vanuatu, under PEBACC, a deliberative process resulted in detailed proposals for a number of potential EbA projects utilising a 'ridge to reef', whole watershed approach acknowledging that terrestrial, freshwater, and coastal ecosystems of small islands are highly interconnected [72]. The EbA projects identified ranged from urban street planting, home gardening and sustainable housing development, to coastal and riparian zone revegetation [19]. A number have been selected to continue as demonstration projects under the second phase of PEBACC [70]. The work in Port Vila, Vanuatu, as well as parallel work undertaken in Honiara, Solomon Islands [20], also highlighted the multiple and diverse drivers of change to ecosystems that come from climatic changes and additionally from the activities of people. Populations in both cities are growing rapidly (up to 9% annual increase) but remain highly dependent on local food and other resources. Frequently the local human caused drivers of change of ecosystems were as significant as the ongoing climate change induced changes to ecosystems [19]. Appropriate EbA projects, while seeking to reduce the negative impacts of climate and associated ecosystem changes, also typically concurrently address other issues that can lead to reduced human wellbeing. Overall, urgent action is required to maintain and then increase human wellbeing, and also to increase resilience to climate change impacts. EbA projects, tending to be cheaper, flexible and having multiple additional benefits, represent one way to do this through strengthening ecosystems. In both Port Vila and Honiara it was found that such initiatives are of great importance to safeguarding local living standards and customs across different time scales, as well as those with a more direct environmental focus [12,20]. Common themes in the proposed pilot projects included catchment (ridge-to-reef) management, urban and coastal vegetation protection, riparian and waterways protection and housing and food security.

As we have noted, EbA works with ecosystems to adapt to climate change. Many EbA activities and projects to date, including within Oceania, have focused on rural areas. The body of EbA experience in urban areas is significantly smaller, and in Pacific Islands largely limited to those undertaken for PEBACC in Honiara and Port Vila. Urban EbA activities can be subtly different. Pedersen Zari et al. note, for example, that an urban EbA approach "seeks to integrate urban ecologies more effectively with naturally occurring ecosystems by working towards linkages between living and built urban environments and their surrounding peri-urban areas" [2] (p. 2) (see Figure 3). Their reference to peri-urban areas reinforces the significance of these areas in Oceania.

Figure 3. Peri-urban villages, greater Port Vila, Vanuatu (M. Pedersen Zari).

5. Linking Urban Ecosystem Services and Wellbeing

5.1. Introduction to the Urban Human/Nature Nexus

Urban ecosystem services are the benefits that humans derive from ecosystems within cities, including peri-urban areas. Urban ecosystems are diverse. In an early article on urban ecosystem services, for example, Bolund and Hunhammar [73], using Stockholm as a case-study, categorised seven distinct urban ecosystems: street trees; lawns/parks; urban forests; cultivated land; wetlands; lakes/sea; and streams. These urban ecosystems provided a number of ecosystem service benefits including: air filtering; micro-climate regulation at both the street and city level; rainwater drainage; sewage treatment; and recreational and cultural values. Bolund and Hunhammar concluded that urban ecosystem services are essential to the quality of human life and thus must be understood and valued by city planners and political decision-makers (ibid).

Elmqvist et al., provide a summary of urban ecosystem services in the context of their view that "ecosystem dynamics in urban landscapes are [still] poorly understood, especially when it comes to designing, creating and restoring ecological processes, functions and services in urban areas" [74] (p. 101). They also note that urban green and blue spaces are often characterised by high intensity of demand and use (compared to those in rural areas, although not always), meaning cities are a key nexus of the relationship between people and nature. Elmqvist et al., (ibid) also investigated the monetary and non-monetary benefits of urban ecosystem services. Their review of 25 global studies estimated the monetary value of benefits (for example, from pollution removal, carbon sequestration and storage, stormwater reduction, and energy savings) and showed that investing in restoring, protecting and enhancing green space in cities is economically viable, provided that multiple services and all their associated benefits, for the typically large numbers of urban beneficiaries are appropriately quantified and recognised. Elmqvist et al., are also careful to point out, given that not all the benefits from ecosystem services can be easily captured by monetary means, the importance of recognising the more subtle non-monetary benefits from restored and enhanced ecosystems. These broad benefits include health, aesthetic, and educational benefits, as well as enhanced social cohesion and creation of a sense of place.

Pedersen Zari [75] examined ecosystem services for an urban design context and identified seven key ecosystem services that could be provided through built or hybrid grey/green infrastructure, or through buildings themselves in addition to urban green or blue space. These were: habitat provision; climate regulation; purification of air, water, and soil; nutrient cycling; provision of food; provision of energy; and provision of fresh water. Relationships between ecosystem services were also identified and illustrated so that designers would be better able to identify synergies and trade-offs in design for ecosystem services [75,76]. Ongoing work seeks to catalogue and map existing strategies and the methods that designers can employ to increase ecosystem service provision through the medium of architecture and urban infrastructure [4,77,78].

To summarise, urban dwellers' wellbeing benefits greatly from urban ecosystem services, and in many aspects depends upon it [73,74,79]. Elmqvist et al. [74], for example, note that access to green space was shown to benefit longevity, recovery from surgeries, reduce stress, improve mental health and self-reported perception of health, all of which translates into enhanced human wellbeing. Hartig et al. [80] provide a fuller picture of the links between natural places and greenspace and human health and wellbeing—noting three principal ways that this occurs: (1) direct restorative mental and physical effects (such as improved moods, better recovery from stress, reduced blood sugar levels, and improved immune system functioning); (2) through providing opportunities to undertake physical activity; and (3) by facilitating the development of social capital/cohesion.

When investigating urban ecosystem services, overall, it is clear that socio-ecological relationships in cities and towns are multi-layered and complex, but need to be better understood to support urban resilience and climate change adaptation efforts [74,81]. Urban areas are hubs of human activity, and in 2018 comprised 55% of the world's population [13]. Cities thus concentrate the demand for ecosystem services and 'resources' in general, which has both direct and indirect impacts on the quality of local ecosystems. Urban areas therefore operate within a network of ecosystem service dependencies with feedback processes between ecosystems and human wellbeing operating across a number of different temporal and spatial scales [82].

5.2. The Urban Human/Nature Nexus in Oceania

Ecosystem services in the urban areas of Oceania have received relatively little attention, despite the fact that many residents in the region—particularly those in small island nations and territories—are highly reliant on them. In the islands of Oceania urban ecosystem services are contextualised within a context of rapidly expanding urban areas, largely unplanned growth, dual formal and informal settlement, and the existence of peri-urban informal settlements; all of which Komugabe-Dixson et al., argue form a "mosaic of tenure arrangements, community subgroups, and migratory and historically-established customary systems" [5] (p. 1).

In Port Vila, Vanuatu, Komugabe-Dixson et al. [5] mapped urban ecosystem services within 'hotspot' communities, as based on crop-use, marine and terrestrial resources, energy, water and sanitation realities, land tenure, livelihoods data, and population growth forecasts. This study showed that terrestrial ecosystems in Port Vila provide critical services including forest resources such as food crops, firewood, building materials, handicraft materials and ornaments, traditional medicines and key traditional wealth items such as kava and pigs. Freshwater ecosystems around the city provide river water for drinking and washing, play an important role in spiritual and cultural wellbeing, recreation, and tourism, and provide subsistence food such as fish, eels and prawns. Coastal and marine ecosystems such as mangroves, beaches, seagrass beds, reefs and offshore areas continue to be critical for urban livelihoods because they provide fish, shellfish, sand, dead coral, crabs and other resources important for subsistence, commercial sale and other domestic purposes. Mangroves, notably, are very important sources of firewood, medicine and wind and storm surge protection. Overall, the study concluded that the selected Port Vila communities, both peri-urban villages and informal settlements, relied heavily on ecosystem services for subsistence, income, shelter, protection and social benefits, but these were under increasing pressure from urbanisation, terrestrial and marine pollution, and climate change. Findings highlighted the critical need to "better understand, and account for, complex socio-ecological relationships when developing adaptation policies and urban development plans" (ibid, p. 1). These findings relate to Vanuatu specifically, but are also relevant for across many other urban areas of small islands of Oceania. In Solomon Islands, for example, similar work undertaken within the same project highlighted the critical importance of ecosystem services from forests, waterways, lakes and wetlands, and coasts and reefs (see Figure 4). With specific regard to capital city, Honiara, land was critical for subsistence and backyard gardens, urban greenspace for shade and recreational use, and urban springs providing drinking water [71]. In both Vanuatu and Solomon Islands, these findings were used to inform resource dependencies and vulnerabilities, and hence the priorities for selection of EbA pilot projects for implementation [19,71,72].

Figure 4. Fishing Village, Honiara, Solomon Islands (GL Kiddle).

6. Traditional Ecological Knowledge in Oceania and Its Relationship to Wellbeing

Widespread use of NbS terminology is relatively recent. However, working closely with nature to create effective human settlements while maintaining healthy ecosystems has been a cornerstone of many very old Indigenous belief systems [83,84]. This is certainly true of many communities in Oceania, despite rapid urbanisation. Overall, many traditional practices, particularly among communities that retain a strong sense of Indigeneity, kinship and close intergenerational connection to specific places, continue to contribute to strengthening links between ecosystems, biodiversity and human wellbeing.

We believe that incorporating elements of traditional ecological knowledge (TEK) and customary practices into NbS are likely to offer more acceptable, place-specific and long-term solutions in the Oceania context (Figure 5). NbS represent an opportunity for the preservation of, or renaissance in, TEK and practice. As UNESCAP point out: "[NbS] could be an opportunity to revitalise a cultural connection to the ocean, which is weakening in cities in the process of urbanisation, and to raise awareness, educate youth and engage communities." [85] (p. 6). Important questions in tailoring NbS to Oceania, and its urban areas, are therefore, 'how can NbS work with or be integrated with traditional concepts and practices, and how can NbS best be driven by local knowledge?' These questions are important in directing future research agendas and working with local communities to better document traditional practices and knowledges, many of which remain strong but tend to be undocumented in standard forms of published academic literature.

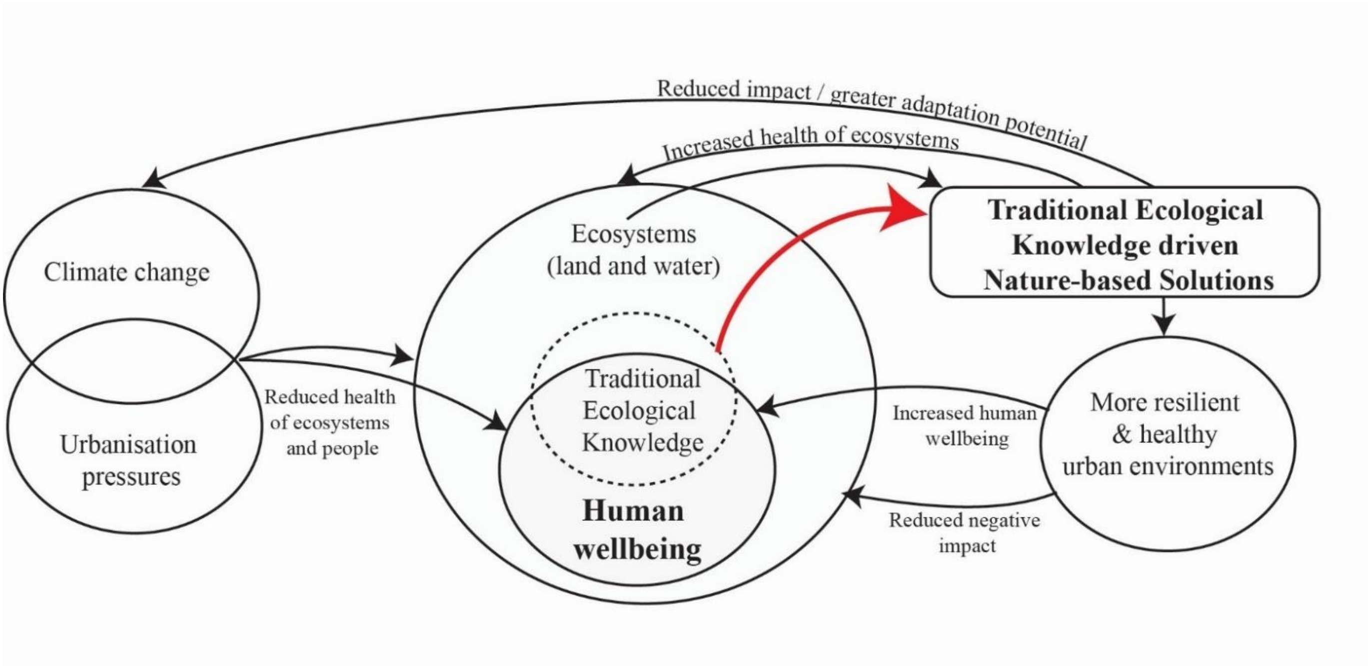

Figure 5. Relationships between drivers of change, wellbeing, ecosystems, TEK, NbS and urban environments.

While it is often posited that the inclusion of TEK is critical for successful climate change adaptation, there remains relatively little investigation into how TEK is being defined and incorporated into EbA and other NbS or ecosystem-based initiatives [86,87]. Nalau et al. [87], for example, after reviewing relevant Oceania literature and case studies, contend that while there is widespread recognition that TEK is important for local communities, and can be used successfully in activities like EbA, this recognition remains more aspirational than practical. They argue that TEK, rather than being used as local environmental knowledge that merely augments Western scientific knowledge, should be regarded as part of nested knowledge systems (or 'information practices/worldviews') including local natural resource management practices, traditional governance structures, social norms and spiritual beliefs. Overall, they argue, there is significant potential for researchers and TEK holders to co-produce knowledge (and action) that is well placed to assist in climate change adaptation efforts that are more effective because they incorporate multiple knowledge systems, are more participatory and are culturally appropriate and affirming. We agree, and see the integration of TEK with NbS as unique and timely and the cornerstone of future research (red arrow in Figure 5).

Aotearoa New Zealand is an appropriate case study to learn from in this regard. There has been notable ecological, restoration and nature rights work in Aotearoa New Zealand that has been driven by or conceived alongside the form of TEK known as mātauranga Māori. Mātauranga Māori has many definitions but can be understood as dynamic and evolving beliefs, practices and knowledge or understanding of everything visible and invisible, including TEK, that is indigenous to Aotearoa New Zealand and traces back to trans-Pacific migrations [88]. As Harmsworth and Awatere [88] note, Māori aspirations and wellbeing are interdependent on the health of ecosystems and ecosystem services, and that some "Māori wish to use these ecosystem approaches and frameworks to increase participation and inclusion in decision-making, to achieve multidimensional aspirational goals and desired Indigenous outcomes" (ibid, p. 274). Most project and research examples have related to freshwater and wetland ecologies and in some cases incorporate cultural health concepts, and novel indicators, monitoring and restoration strategies. Examples include the Cultural Health Index, Māori wetland indicators and the Mauri Assessment model [88,89]. Some influential work also exists in oceanic ecology [90,91], and is especially significant in the context of NbS in wider Oceania because of the huge influence of the oceanic realm of the Pacific both ecologically and culturally.

Work has been undertaken in Aotearoa New Zealand in relation to Indigenous approaches to climate change [84], and some urban design and architecturally focused work also exists [84,92–94]. Much discusses the importance of creating meaningful relationships and partnerships and understanding power dynamics and structural biases. As is appropriate, much of this work is led by tangata whenua (Indigenous people of Aotearoa), but through this some non-Māori researchers, scientists and practitioners are beginning to understand other value frameworks and world views and opportunities to work in complementarily ways [95]. Two of many key concepts which have driven or influenced many Aoteaora mātauranga Māori oriented projects include whakapapa (human genealogy lineages that trace back to landscape features including mountains and rivers and areas of ocean, and the origins of the beginning; Māori literally are related to the lands and waters they are from) and kaitiakitanga (an obligation through kinship to actively protect the mauri (essential life force) of living systems and waters) [88].

These considerations lead us to suggest further investigation of the value that cultural knowledge, specifically mātauranga, can add to NbS urban climate adaptation for enhanced human wellbeing in Oceania. Such investigation potentially offers benefits to the collective identity and health of the whole region, including to tangata whenua and Indigenous Pacific peoples communities in Aotearoa New Zealand.

7. NbS Approaches for Urban Design

The rapid growth of many urban areas and informal settlements (see Figure 6) of many Oceania nations suggests the need for a strategy of increased urban NbS/EbA applications that addresses densification and rapid development in a way that supports everyday interactions with nature and natural processes. Brink et al. [65] propose framing urban EbA based on ecological function, ecological structure, adaptation benefits and ecosystem management practices. Dushkova and Haase [96] observed that new NbS interventions that support socio-ecological benefits are positively perceived by communities. They point out that: (1) urban NbS projects have greater social, economic and environmental benefit than often originally understood; and (2) the co-benefits of NbS have the potential for significant value when projects look to focus on the multiple needs of restoration, protection, and enhancement of ecological systems and ecosystem services. Dushkova and Haase highlighted five categories of urban NbS approaches that could be applied to urban design: (1) NbS that made better use of protected or natural ecosystems to increase the supply of ecosystem services; (2) NbS alongside the sustainable management of urban food systems such as urban gardens and farming; (3) NbS approaches for the creation of new ecosystems (such as green roofs, walls, and buildings); (4) NbS approaches that lead to the creation of new ecosystems from existing abandoned, neglected or brownfield sites; and (5) NbS for education and awareness on sustainability. These all present design opportunities for urban and peri-urban NbS for climate change adaptation and enhanced human wellbeing in Oceania.

Figure 6. Dense informal settlement housing, Caubati Topline, Nasinu, greater Suva, Fiji (GL Kiddle).

Urban and architectural proposals for EbA work in Port Vila, Vanuatu, for example demonstrate some of these strategies in practice [19,72]. Proposed Port Vila projects from the PEBACC project included strategic urban street tree replanting, a project to intensify home gardens and a pilot project for ecosystem integrated sustainable housing development. This last project is an example of a hybrid EbA project and was included because of the identified relationship between increased informal housing, partially near riparian areas in Port Vila and the negative impacts from that on river, reef and human health leading to decreased resilience to climate change [12]. As demonstrated by the Port Vila work, urban focused NbS must consider how built infrastructure, including buildings, interact with and could support and effectively integrate with living ecosystems.

8. Conclusions: Towards an Oceania Nature-Based Urban Design Agenda

The unique challenges of the Oceania region posed by climate change and urbanisation showcase the critical linkages between ecosystems, ecosystem services and human health and wellbeing. Climate change also exacerbates several risk factors in Oceania. NbS offer considerable potential for climate change adaptation and associated enhanced health and wellbeing for the people of a very diverse region. The overlapping issues contextualised by the unique growth and settlement patterns for urban areas in Oceania, particularly those in small islands, questions the appropriateness of applying a 'one size fits all' version of urban resilience. We believe that tailored frameworks for human health and wellbeing, driven by TEK and based on ecosystem services, need to be developed to address urban climate change concerns in Oceania. Given climate change exacerbates several risk factors in Oceania, this suggests that the significant co-benefits of measures primarily designed for climate change response (both mitigation and adaptation responses but primarily the latter) can also make an important contribution to addressing those other risk factors. Examples that have been touched on in previous sections and PEBACC studies from Melanesia include increased food security for the health and wellbeing of urban dwellers, better coastal protection for disaster response management and better riparian protection for quality of life in marginal urban settlements.

In this review we have mainly focused on Pacific Island Oceania, excluding the two largest land masses of Aotearoa New Zealand and New Guinea. We have, however, briefly referenced concepts and aspects of te ao Māori (the Māori world from Aotearoa New Zealand) which are important to the Oceania ecosystem/wellbeing nexus, especially the role of mātauranga Māori. The work of Dacks et al. [97] and Sterling et al. [98] on the application of biocultural indicators is also relevant here, drawing on local understandings of knowledges, skills, practices, values and worldviews, to develop meaningful and locally relevant indicators of resilience. This has relevance to developing locally and regionally relevant dimensions of Oceania wellbeing that can then be related to the SDGs. We also see a significant and worthwhile challenge in how to use mātauranga Māori and TEK in conjunction with Western science and design approaches where appropriate.

Given the unique and very diverse region of Oceania, including the large land masses and populations of Papua New Guinea and Aotearoa New Zealand, we ask: 'how might an NbS framework associated with human health and wellbeing inform an urban design agenda that allows for place-based solutions for Oceanic communities'? A number of related questions also require attention: (1) 'what NbS strategies, projects, and research show promise in an Oceania context?' (2) 'how can we translate the application of NbS to informal neighbourhoods in urban areas of Oceania?' (3) 'how can we shift NbS from a policy context to practical urban design and planning practice?' (4) 'what are the levers to best engage governments?' (5) 'what aspects of the nature of wellbeing, or other contextual aspects, are most relevant to the application and assessment of ecosystem services and NbS approaches to enhancing human health and wellbeing in Oceania?'.

In our view responding to these questions and progressing an urban NbS agenda for Oceania requires: (1) developing an inventory of innovative urban NbS for the region; (2) more comprehensively exploring existing and potential Indigenous wellbeing models and understandings from the region; (3) undertaking community co-design to develop future urban NbS strategies centred in TEK and Indigenous wellbeing frameworks; and (4) ensuring that the wellbeing of Indigenous peoples, however it is understood locally, is central within future Oceania urban design and climate change adaptation. Progressing such an agenda, including the use of systematic assessment [99], will be an important contribution to Oceania nature-based ecological urban design. In Oceania identity and environmental understandings and stewardship, particularly for Indigenous people, are rooted and moored in very close traditional relationships to land and ocean. Indigenous knowledges have long premised that human wellbeing is inextricably linked to ecosystem health. We believe that building on Indigenous understandings of wellbeing, and partnering TEK and other scientific information with NbS, can lead to appropriate, place-based, urban design practice that present long-term benefits in diverse and unique Oceania settings. Further developing this urban design agenda for Oceania is the focus of ongoing research, in early stages, undertaken by a collaboration of Aotearoa New Zealander, I-Kiribati, Samoan, and Ni-Vanuatu researchers and practitioners, including the authors. Progressing nature-based forms of urban design is important as part of wider efforts to adapt to climate change and protect and promote human wellbeing and the ecologies of the region.

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