Chapter 1
An Introduction and Overview to Building Water, Energy, and Food Security in the Pacific Using a Nexus Approach

Andrew Dansie, Heidi K. Alleway, and Benno Böer

An integrated approach to improve progress towards the UN SDGs and a Net Zero Future that supports environmental, societal and economic prosperity in the Pacific.

Abstract The Pacific is not on track to achieve any of the SDGs by 2030 with major progress needed across each of the environmental, societal, and economical realms. Progress towards certain SDGs should not come at the expense of others and adding further complexity, new methodology are now also being developed to meet more recent national targets under the 2050 Paris Agreement net zero greenhouse gas emission aspirations. A water, energy, food (WEF) nexus approach provides a framework with which to increase the security of each of the three sectors, underpinned by a healthy environment and recognizes the role and need for functioning ecological services. The blue carbon market offers a particularly well-suited opportunity for the Pacific to combine sound environmental stewardship with economic opportunity and follow-on societal benefits. This unique 'blue continent' of islands and archipelagos spread across the Pacific Ocean requires a regional-specific consideration of the WEF nexus often overlooked as part of the larger 'Asia–Pacific'. However, applying a WEF nexus approach in the Pacific is not a one-size-fits all undertaking. Discussed in chapter-specific detail in this volume, it requires country- or territory-specific

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consideration of existing water resources, food systems, energy needs, and traditional knowledge while addressing challenges from anthropogenic climate change, human population growth, and ever-increasing demands for resource consumption.

Keywords Pacific · Water · Energy · Food · Nexus · Blue Carbon · WEF

1.1 Overview of Securing Water, Energy, and Food in the Pacific

The Asia and Pacific region is home to over 4.3 billion people, or 60% of the world's population, and some of the most pressing global challenges for sustainability and human prosperity. This volume considers the "water, energy, food (WEF) nexus" in the Pacific and is a part of a three-volume book series, accompanying 'East and Southeast Asia' and 'Central and South Asia'. 'This Pacific volume comprises the regions of Micronesia, Melanesia, Polynesia, and Australasia. Geographically and culturally diverse, this part of the world requires dedicated focus if sustainable development across environmental, societal, and economical aspirations is to be made at a pace rapid and responsive enough for those that live here.

Seventeen sovereign countries (Australia, Cook Islands [*Kūki 'Āirani*], Federated States of Micronesia [FSM], Fiji, Kiribati, Marshall Islands, Nauru, New Zealand [*Aotearoa*], Niue, Palau, Papua New Guinea [PNG], Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu, and Vanuatu) and seven territories (American Samoa, French Polynesia, Guam, New Caledonia, Northern Mariana Islands, Tokelau, and Wallis and Futuna) are spread across the northern and southern hemispheres of the Pacific Ocean, a blue expanse that covers a fifth of the world's surface area but contains only 1% (44.5 million people) of the Asia Pacific population or 0.5% of the global population. All of these countries and territories are characterized by small populations, high transportation costs and, with the exception of Papua New Guinea and Timor-Leste, a geographical remoteness stemming from no land borders with another country. The authors note that Timor-Leste is not geographically a Pacific Island Country but for the scope of this book has more in common with the challenges of the Pacific compared to Southeast Asia and is included in this volume.

In this volume the current state of water resources, energy security, and food security in the Pacific are considered in Part I. This foundation then allows attention to be given to regional issues associated with the major challenges and importance of climate trends and change, infrastructure, trade, and waste (Part II). Here, water security and its intersectionality each with the energy and food sectors in the Pacific highlights the significance of both land and marine food systems and connectivity between water and energy. It is shown that these systems cannot be separated from challenges associated with infrastructure, transport, and waste that are unique to the vast archipelagic region.

Throughout this volume particular focus is on the Pacific Island Countries and Territories (PICTs) of the region because Small Island Developing States (SIDS) face urgent and shared regional challenges. To address these challenges the WEF nexus offers a coordinated approach to managing water, energy, and food sectors centred on cooperation between sectors to ensure a healthy environment and functioning ecosystem services needed by all. Cross-cutting themes for water, energy, and food security—those that are essential for meaningful and sustained improvement in the environmental, societal, and economic aspirations of the United Nations Development Goals (UN SDGs)—are then explored (Part III). Developing solutions that are cognizant of the world's colonial past and the global inequalities that persist today is essential for meaningful change. The path forward is one that brings traditional knowledge and awareness of the Pacific water and food systems. Conversely, national energy demands need to look to the future and the need to hasten energy transition away from fossil fuels is clear, true in both the Pacific and globally. Such solutions need to lessen inter- and intranational economic and demographic inequalities. To do this we must ensure that a gendered, equitable, and inclusive approach underpins all that we set to achieve. An integrated manner to improving water, energy, and food security using a nexus approach is presented in Part IV, including two case study chapters that demonstrate proven and potential WEF nexus approaches in the Pacific.

Fossil fuels have played a major role in supporting the tremendous economic and industrial growth seen (unequally) across the globe. The technical advances they have allowed has supported human population growth of almost 6 billion people in the last 100 years, with 50% of this growth having been since the 1990s, to a total global human population that now exceeds 8 billion people. The resulting carbon dioxide emissions, along with other greenhouse gases and emissions from human activity, are responsible for the anthropogenically altered climate we now all live in. Anthropogenic climate change threatens environmental, social, and economic security worldwide with particular urgency faced by many people of the Pacific due to sea level rise, increasing cyclone intensities, and changing rainfall regimes (IPCC 2021). But carbon also offers to be part of the solution, with nature-based solutions (NbS) and Blue Carbon presenting tremendous opportunity in the Pacific to provide environmental and socio-economic outcomes. Blue Carbon in the Pacific is especially well-placed to support a WEF-approach in the region due to there being no additional pressures on freshwater resources or productive agricultural lands.

1.2 The Water, Energy, Food Nexus

The nexus is a useful concept to consider and address the complex and interrelated nature of water, energy, and food systems (Fig. 1.1). In practical terms, as defined by FAO (2014), it presents a conceptual approach to better understand and systematically analyze the interactions between the natural environment and human activities, and to work towards a more coordinated management and use of natural

resources across sectors and scales. This approach allows for a more informed way to identify and manage trade-offs and to build synergies through our responses as societies and nations, allowing for united and cost-effective planning, decision-making, implementation, monitoring, and evaluation.

The nexus concept was launched at the 2011 World Economic Forum through the lens of water security in a session titled 'Water Security: The Water-Energy-Food-Climate Nexus'. That forum laid out the complex challenges faced in managing future water needs towards 2030 and the imperative of accounting for social, political, and economical considerations. Later in the same year, the Bonn Conference on 'The Water Energy and Food Security Nexus—Solutions for the Green Economy' applied the nexus lens to both water and food with emphasis on understanding interdependencies and linkages. In 2012 the German delegation to the Rio+20 conference used the nexus approach as a method to enhance transition towards a greener economy. Operating within planetary boundaries is part of the nexus-concept (Fig. 1.1) but something industries and communities are currently a long way from achieving.

Since 2012 the WEF nexus approach has gained a firm foothold in multilateral development agencies, national dialogues, and academia. The nexus itself is still

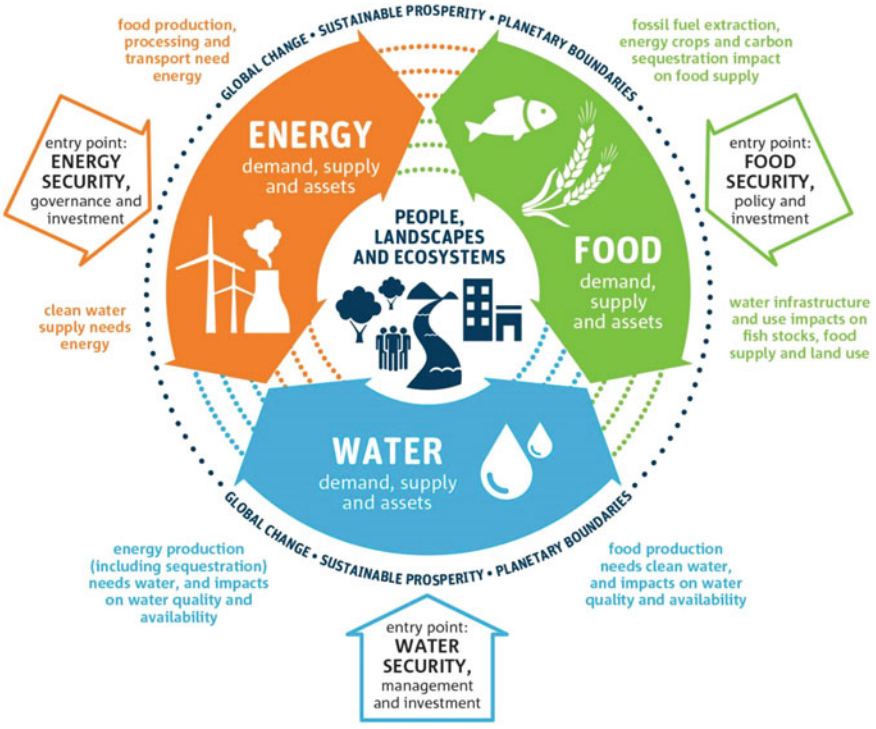

Fig. 1.1 An example of the water, energy, and food nexus concept showing examples of the linkages between sectors, the central role of people and ecosystems, and the outer sustainability principles within which the nexus approach operates (CSIRO 2015)

broadly interpreted by different users of the concept but agreement is seen in its calls for transdisciplinary integration of efforts, greater focus on inter-sectoral analysis, and improvements in policy coherence. The FAO nexus definition and approach is not unique, but has roots in other strategies including Integrated Water Resources Management (IWRM), Ridge to Reef (R2R), Integrated Coastal Zone Management (ICZM) and other multisectoral and multistakeholder approaches that seek to balance the water needs of society, the environment and the economy (Wichelns 2017). The unique aspect of the nexus approach, however, is the use of clear terminology of 'water', 'energy' and 'food'. These immediately tangible concepts provide direct connectivity into existing federal agencies and ministerial and regulatory portfolios. The nexus approach that encourages interlinkages between the sectors fosters a dialogue of reciprocity on key issues across legislative and government branches and, therefore, encourages decisions that are appreciably multisectoral.

Importantly, the nexus approach examined in this book builds on the evolution of approaches and terminology made prior to 2011 as well as the progress made in the international development sector since the 1950's. For example, more than 80% of UN member states have laid the foundations for IWRM (UN Environment 2018) with 54% of the countries having made some degree of implementation of IWRM (SDG6 Target 6.5.1) at the global level by 2020 (UN Water, n.d.). Taking a nexus approach can further assist with the implementation of such efforts and enhance the integration of investment and development decisions within the water, energy and food sectors. Further, taking a water, energy and food nexus approach also allows progress to be planned and implemented across a suite of SDGs, minimizing the unintended advance of certain SDGs at the expense of others. It is this call to interdisciplinarity and integration that the nexus approach uniquely brings to sustainable development, and building resilient environmental systems, societies and economies to 2030 and beyond.

1.3 The Pacific Region

The Pacific region is also referred to as Oceania, and this perfectly captures the essence of the region. It is comprised of island nations, ranging from the continent-sized Australia to atoll nations such as Kiribati (Fig. 1.2). The 44.5 million people that live in the region belong to either Micronesia, Polynesia, Melanesia, or Australasia sub-regions. The cultural backgrounds of these sub-regions are distinct, yet, with geographical similarities, and they all face regionally unique challenges for the provision of secure water, energy, and food resources in this ocean-dominated portion of the globe. In facing the these challenges the countries that comprise the Pacific (Table 1.1) also have vastly different capacities, ranging from high-income countries of the Global North (Australia and New Zealand) to four of the world's UN Least Developed Countries (Kiribati, Solomon Islands, Timor-Leste, Tuvalu). The remaining countries fall into the category of low-middle income countries (World Bank 2022) with major progress to be made against the SDGs; as a region the Pacific is not

on track to achieve any of the SDGs by 2030. At the current rate they will not be achieved until 2065 (ESCAP 2022) and much remains to be done. Lack of progress is common across all 17 Goals but SDG 13 Climate Action (SDG 13) and Responsible Consumption and Production (SDG 12) has actually gone backwards, for the Asia–Pacific as a whole as reported by UN ESCAP (2022). Affordable and Clean Energy (SDG 7) has made the most progress of any Goal, but increased energy demands in the Pacific is still seeing increased fossil fuel imports as well as renewable energy installation. Access to Clean Water (SDG 6) progress is approximately one-sixth of where it should currently be and Zero Hunger (SDG 2) a bit over a third of progress required to be on track for 2030 Goal attainment.

In the PICTs the diverse cultural landscape shares two main island geomorphology types: low-lying coral atoll islands, some average just 1.5 m above sea level at their highest point (e.g., Kiribati), and high volcanic islands that can rise up to heights of 2,000 m (Solomon Islands)—4,000 m (PNG). In between these two extremes lay all kinds of assemblages of low and high islands, with approximately 30,000 islands across the Polynesia, Micronesia, and Melanesia sub regions of the Pacific

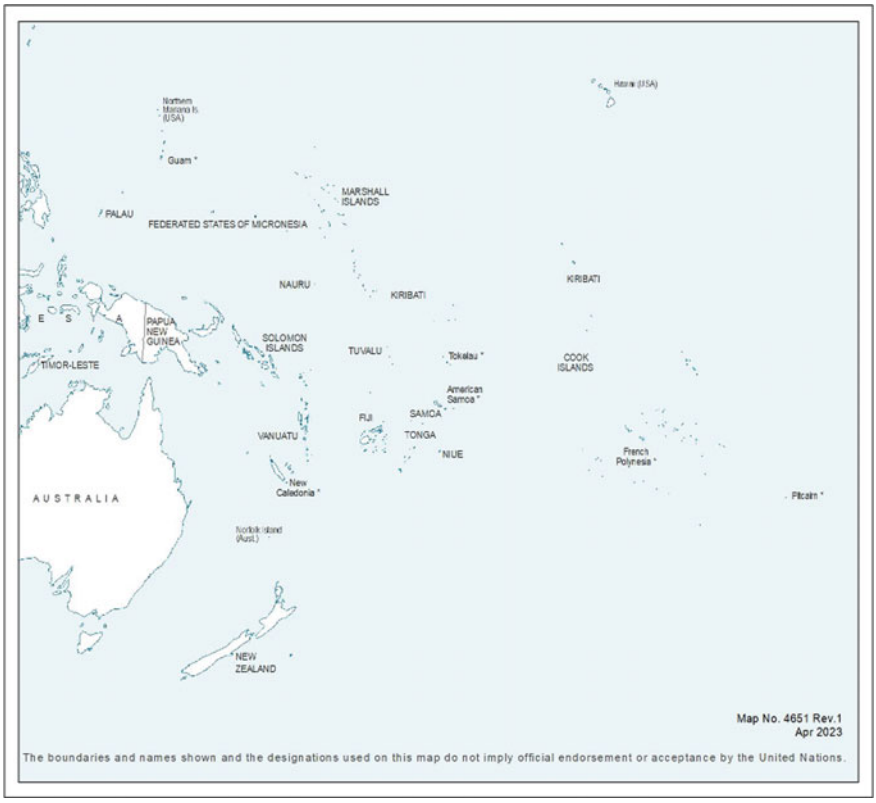

Fig. 1.2 Pacific regional map, adapted from UN Geospatial (2023)

Table 1.1 National social, economic, and development factors in the Pacific compared to with access to safe drinking water, gigajoules of energy production per capita, and agricultural contribution at national level (blank cells equate to no data available)

	Population [a]	Surface Area [a] (km^2)	GDP (million USD) [a]	GDP per capita (USD) [a]	HDI value [b]	Water [a] (% access [urban/rural])	Energy [a] (GJ per capita)	Agriculture [a] (% of GVA)
Australia	25,788,000	7,692,024	$1,380,208	$54,763	0.994	99/–	217	2
Papua New Guinea	9,119,000	462,840	$24,970	$2,845	0.555		19	18.4
New Zealand	4,861,000	268,107	$206,936	$43,229	0.931		199	6.1
Timor Leste	1,344,000	14,919	$2,018	$1,560	0.606		6	14.1
Fiji	903,000	18,272	$5,504	$6,185	0.743		28	13.2
Solomon Islands	704,000	28,896	$1,303	$1,945	0.567		12	26.1
Vanuatu	313,000	12,189	$907	$3,023	0.609	56/–	12	22.9
New Caledonia	288,000	19,100	$9,880	$34,941			262	2
French Polynesia	282,000	3,687	$6,023	$21,566			43	3.6
Samoa	200,000	2,842	$845	$4,286			27	10.1
Guam	170,000	541					1	
Kiribati	121,000	726	$195	$1,657	0.630	21/06	14	27.1
Federated States of Micronesia	116,000	702	$414	$3,640	0.620		19	27.4
Tonga	107,000	747	$508	$4,866	0.725	50/21	19	23.4
Marshall Islands	60,000	181	$237	$4,038	0.704		39	16.1
Northern Mariana Islands	58,000	457						
American Samoa	55,000	199						

(continued)

Table 1.1 (continued)

	Population [a]	Surface Area [a] (km^2)	GDP (million USD) [a]	GDP per capita (USD) [a]	HDI value [b]	Water [a] (% access [urban/rural])	Energy [a] (GJ per capita)	Agriculture [a] (% of GVA)
Palau	18,000	459	$280	$15,573	0.826	96/70	166	3.4
Cook Islands	18,000	236	$379	$21,604			62	2.7
Tuvalu	12,000	26	$47	$4,036		50/–	12	21.4
Wallis and Futuna	11,000	142				– /58	31	
Nauru	11,000	21	$133	$12,351			70	
Niue	2,000	260					64	
Tokelau	1,000	12						

[a]UN Data (2021)
[b]UNDP (2020)

(Shea et al. 2001). The type of island influences the relative importance of water source type for water security, for example, there is more groundwater and surface water resources on high volcanic islands and less-to-none on atoll islands causing a greater reliance on rainfall collection for atoll islands. Similarly for food, rich soils on volcanic soils support a higher agricultural contribution to the diet while limestone coral reef atolls have less productive soils and leave a greater reliance on coastal and marine food sources to satisfy caloric and nutritional needs. Energy sources also differ; solar power is ubiquitous in its suitability to all countries in this sunny equatorial region whereas geothermal energy is only an option for islands with suitable geological make-up, largely related to the volcanic history of the island. It is important to remember that none of these attributes are absolutes and a water, energy, and food nexus approach needs to operate along a sliding scale of characteristics applied within the specific context of the island or combination of island types that are the focus.

Major differences in population size, land area, and national wealth across the region (Table 1.1) require that tailored and country specific WEF approaches are developed. For example, variation in the ratio of urban to rural populations across countries, from one extreme to the other (Fig. 1.3), provides important context for local water, energy, and food needs. Access to safe drinking water ranges from barely any (6% in rural Kiribati) to almost complete urban coverage (96%) and very high rural coverage (70%) in Palau (Table 1.1). The Human Development Index (HDI) provides further insight into where improvements in quality of life and livelihoods are needed. HDI considers three dimensions to measure human development at a national scale, considering life expectancy at birth, expected and mean years for schooling, and GNI per capita (PPP$). Countries with low HDI values (e.g., FSM, Kiribati, Solomon Islands, Timor-Leste) and a lack of data (e.g., Tuvalu, Niue, Samoa) require the most "development" to be made and face the greatest challenges (Table 1.1). These countries also possess the greatest opportunity to 'leapfrog' with advances in technological and/or resource management systems and potentially benefit most from a WEF nexus approach. This is because where major infrastructure is not already in place then decentralized and water-energy-food interconnected projects can take precedence, learning from mistakes and knowledge in Global North countries as well as PICT neighbours. Countries with higher proportions of urbanized population will have different needs for their water resources, and energy and food sectors, with a general trend of more centralized systems of production and transport required as more of the population is consolidated within urban environments. In contrast, rural areas of a country, and countries or territories with a largely rural populations generally, are more reliant on the small-scale and household level means of production. These more agricultural PICTs, those with a higher percentage of agricultural gross value added (GVA), have lower GDPs, both overall and per capita, and also lower energy needs (Table 1.1). The connectivity between industrialization as a wealth generator for the economy and development is well understood but small land areas, small populations, and geographical isolation (Fig. 1.2) make large-scale industrialization of the economy unlikely for PICTS to any great extent.

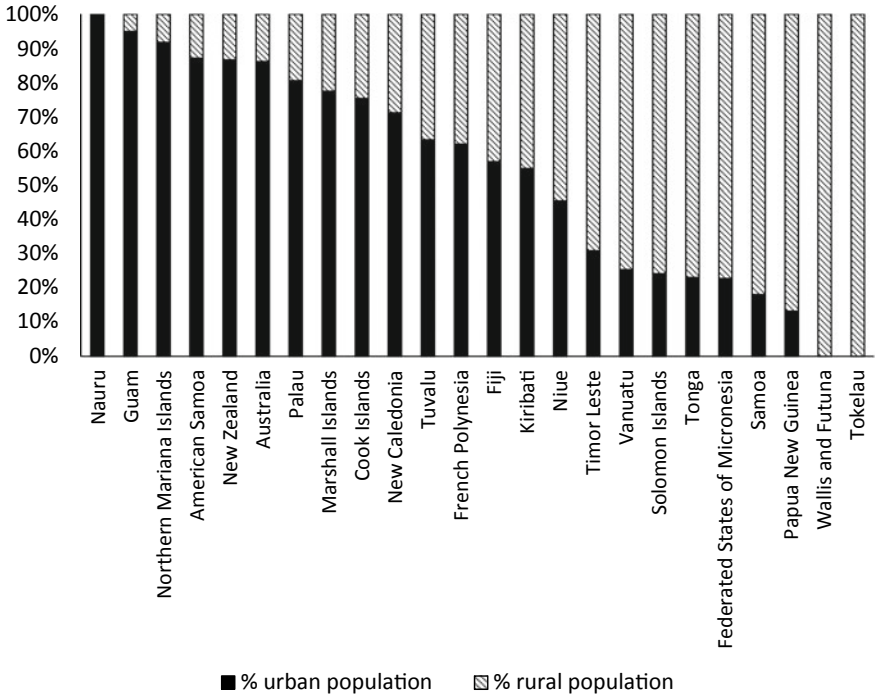

Fig. 1.3 Urban and rural populations in Pacific countries (UN Data 2021)

1.3.1 The Community of the Pacific—Geopolitics, Aid, and Trade

What the Pacific does have in spades is environmental resources and ambition, this 'blue continent' as it was recently referred to for the 2050 strategy endorsed by the Pacific Island Forum Leaders in July 2022, offers opportunity to lead the world, with some of it kicking and screaming, towards a net zero carbon emissions planet by 2050. To follow the last millennia's path of growth and "development", one tied to energy production and high energy consumption and CO_2 emissions per capita from fossil fuels, is folly at this crucial last stand against catastrophic temperature rise and long-term effects from anthropogenic driven climate change. Development is important as a means to increase water, food, and energy security, especially for the underprivileged and disadvantaged. But it must be de-coupled from continued use of fossil fuels. The PICTs have long shown leadership in highlighting and advocating for the urgency of this issue. They also have and continue to be frustrated by politicization of the science behind climate change globally, and perhaps most damagingly by the regional economic and carbon emitting per capita heavy weight, Australia.

The Pacific faces the two main global challenges of human population and climate change caused by anthropogenic global warming pressures like everywhere else,

but the unique geographical traits of the region, comprised largely of island and archipelagic nations, make the impacts of sea level rise and changing climate especially acute. These impacts are disproportionately felt, in most cases, to national contribution of greenhouse gas emissions and natural resource consumption. The outliers here are Australia and New Zealand, producing 15.5 and 6.6 tons of CO_2e per capita respectively (UN Data 2021) making them the 14th and 37th CO_2e contributors per capita globally. Australia also sits as the 14th overall producer of CO_2e globally, producing 492 million tons in 2021 (Australian Government 2021). The problem of climate change was not caused within any one national border and the solution must similarly be found in international cooperation.

Unification among PICTs has shown solidarity and ambition to improve global progress in addressing climate change. The former Fijian Prime Minister, and at the time Chair of the Pacific Island Forum, Frank Bainimarama, clearly stated this in the lead up to the 2021 Glasgow Climate Talks when he drew specific reference to Australia and New Zealand in that "The developed world must deliver on the $100 billion dollars promised in climate finance"(O'Malley 2021). This lays bare the division in the region and the unfair burden of climate change that is placed on low and middle-income countries while high-income countries have been the major contributors to greenhouse gas emissions. The fossil fuels and natural resource consumption required to build the economies and industries of the Global North, of which Australia and New Zealand are a part, are responsible for the climate impacts that affect all of us, but PICTs are especially vulnerable due to their small size, reliance on sea freight and increasing coastal damage and marine intrusion due to higher intensity cyclones and storm surge in the region. Preceding the Glasgow Climate Talks, the Republic of the Marshall Islands demonstrated some deft diplomacy at the Paris negotiations to bring a 'as close to 1.5 °C', rather than a broader 'below 2 °C' target to the ultimately successful talks that resulted in the Paris Convention. This is especially important for PICTs and SIDS in other regions due to, amongst others, the increased threat of sea level rise associated with rising global average temperatures (IPCC 2021). The PICT-originating group garnered support of 90 countries to form the High Ambition Coalition (HAC) that was ultimately successful in making the Paris Agreement target more ambitious. The $100 billion referred to was funds committed to be mobilized during United Nation talks in Copenhagen 2009 that is now managed under the Green Climate Fund. The commitment has not been met by donors from the Global North and more financial support is needed in an attempt to balance the inequality of climate change impact and mitigation efforts.

International funds have a large impact on PICT economies and activities. The smaller population and economies of PICTs make the Pacific the most aid-dependent region in the world, when aid contribution is considered as a proportion of GDP. Aid money therefore has great influence over international development through the sectors that it prioritizes, which can be influence by the political interests of the countries that providing this support. The region receives approximately USD2 billion each year in aid. However, the most up to date reporting of complete data of aid funds spent in the Pacific is 2019; 2000 onwards is not reported for all donors. Looking at the 2019 data, Australia is the largest donor (USD864 million) followed by New

Zealand (USD254 million) and then Japan (USD179 million (Lowy Institute 2022). The three largest lenders are Asian Development Bank (USD169 million, China (USD113 million), and the World Bank (USD69 million) (Lowy Institute 2022). Remittances are also playing a larger role in the regions with family members working overseas sending money back to support their family. In 2020 this has exceeded 10% of PICT GDP (World Bank 2020), with some countries remittance incomes representing a large percentage of their GPD, in particular Tonga (39%) and Samoa (25%) (World Bank 2020). China is the largest trading partner in the region and many PICTs are signatories to China's Belt and Road Initiative. Trade commitments and agreements have, similar to aid, influence over national priorities and natural resource management. Current ongoing unsustainable logging practices by foreign companies in the Solomon Islands (Kabutaulaka 2000; Hameiri 2012) or PNG (Marshall 1990) serves as an example of history repeating itself. Most extreme is the collapse of Nauru's economy and destruction of already limited water resources and arable land due to foreign discovery and exploitation of phosphate. The phosphate resource, in the form of thousands of years of bird guano accumulation since fossilized, was discovered by the British at the turn of the 20th Century. Strip mining, foreign exploitation, and corruption saw much of the wealth sent overseas and corruption and mismanagement at the national level squandering chances of effective royalty management since independence in 1968, albeit after much of the finite resource had been extracted.

Geopolitics in the Pacific is a major influence in aid, trade, and policy that facilitates the movement of people for paid labour and education. The major global economic powers of China, the US, and the EU are increasing their attempts of influence and partnership with PICTs, with the scarcity of land in the Pacific Ocean making the small Countries and Territories of immense military and security interest. The shared challenges and priorities of PICTs to address the critical challenge of climate change provide unification, in the most part, for PICTs to increasingly have influence above what might otherwise be expected for their individual small country "weight" in international forums. Geopolitical allies that heed the urgency of the High Ambition Coalition, Pacific Islands Forum, SAMOA Pathway and other regional bodies and cohesive stances should urgently consider domestic greenhouse gas emission shortcomings the same time as seeking to build aid, trade, migration or other bridges with PICTs.

1.3.2 Water, Energy, and Food in the Pacific

In the Pacific freshwater resources are highly variable, comprising some of the global extremes in terms of availability and access. This region, covering approximately a fifth of the planet's surface, supports extensive biomes from arid deserts to lush tropical forests so also is home to tremendously diverse food systems. The diversity in food systems sees an array of animal and plant species that have been important to

food security for millennia, and traditional knowledge that has enabled this security. But again, traditional knowledge is diverse, as distinct as the biomes that have supported people living in this region. Human society presence ranges from estimates of over 50,000–60,000 years in Australia to more recent estimates of 3,000 years ago in remote parts of Polynesia. In the last few hundred years these natural and societal systems have been upended through the global impacts of colonialization and an increasingly industrialized world. Water and food security in this region now face major challenges, and the need for energy now greatly exceeds household requirements and is a driver of concern for national security and economic stability and growth. It is in this post-colonial period of globalization that the water, energy, and food nexus approach offers opportunity to pivot as quickly as possible to a more sustainable use of water resources, a more sustainable use of land and sea for food production, and a more sustainable generation of energy by looking both to the past and to the future. In order to manage sustainably across water, food, energy, and the environment a holistic approach that leverages the diverse and location-specific traditional knowledge is essential. Addressing the sectors of water, energy, and food simultaneously must be absolute in that the underpinning biomes and environment that support them are healthy and functioning.

1.3.3 Air Quality

Alongside broader trends in climate change and its impact an emerging issue of concern in PICTs is increasing rates of respiratory illness. Energy and food are intrinsically tied to this through expanding road infrastructure allowing more and more combustion engine-powered transport, diesel generator-powered grid electricity, agricultural practices for export crops such as sugarcane burn off, indoor cooking using wood burning, industrial processes such as cement production, and waste burning due to lack of effective municipal collection and management practices.

Globally the story is similar, the harmful effects of air pollution on human health (Kampa and Castanas 2008; Dominski et al. 2021) are becoming increasingly apparent in our progressively populated and industrialized world. However, like the effects of climate change it is often the poorest people that are most impacted by air pollution from indoor and outdoor sources (Emmelin and Wall 2007; World Health Organization 2021a). In September 2021, the World Health Organisation (WHO) updated their recommended limit for air pollution from the burning of fossil fuels and issued a statement that clean air is a "fundamental human right" (World Health Organization 2021b). Clean air and energy generation are therefore intrinsically linked, even in "tropical island" places we may not think of having polluted air: low- and middle-income PICTs. These island nations are at the forefront of climate change impacts of sea level rise and increasing weather severity (IPCC 2021), with transition away from fossil fuels to provide both climate and human health benefits. However, the increasing awareness of the need for cleaner air is focussed on research in cities in high income countries and there is a dearth of data from the Global South.

This emerging health problem and the need to monitor air quality has been identified by the Governments of the Solomon Islands, Fiji, Vanuatu, and Tonga and the Pacific Regional Office of the WHO. It is women and children in poor households that are the most vulnerable to negative impacts of poor air quality and a gendered and demographical approach is to be taken to identify those at most risk. Empirical data is needed to support government partnership with multilateral agencies for investment in renewable energy and international development activities that improve air quality thought energy transitions and livelihood improvements.

It is in this context it is perhaps interesting to pause and note that there are SDGs dedicated to water, as well as to food, but none to air. One cannot help but to ask '*Why is there no SDG for Clean Air to Breathe? Has this simply been forgotten?*', considering humans can survive weeks without food, days without water, but only minutes without air. However, there are recent developments with The United Nations General Assembly declaring on the 29th of July 2022 that everyone on the planet has a right to a healthy environment that included clean air, a move backers say is an important step in countering the alarming decline of the natural world. In a resolution passed at UN headquarters in New York City, the General Assembly said climate change and environmental degradation were some of the most pressing threats to humanity's future. The resolution is not legally binding on the 193 UN Member States but "the resolution sends a message that nobody can take nature, clean air, and water, or a stable climate away from us—at least, not without a fight" said Inger Andersen, Executive Director of the UN Environment Programme (UNEP). The resolution comes as the planet grapples with what Andersen called a triple planetary crisis of climate change, nature and biodiversity loss, and pollution and waste. Left unchecked, the new resolution said those problems could have disastrous consequences for people around the world, especially the poor, and women and girls. The UN General Assembly stated they were encouraged by the increasing interest of the international community in clean air and emphasizing the need to make further efforts to improve air quality, including reducing air pollution, to protect human health, and in December 2019 designated 7 September as the International Day of Clean Air for blue skies.

1.3.4 A Nexus Approach in the Pacific

Applying a WEF nexus approach in the Pacific is not a one-size-fits all approach and as discussed in chapter-specific detail in this volume, requires careful consideration of existing water resources, food systems, energy needs, and supplies. It must also consider population demographics and a design that assists and empowers those most in need that are suffering from poverty, inequality, or injustice. The nexus approach must be forward looking to build resilience for projected populations and resource consumption requirements associated with development, as well as current and projected climate change impacts. Infrastructure and long versus short term return on investment decisions must be made to facilitate a WEF approach and large

multilateral financial support will be needed to achieve such transitions. For 2030 SDG climate and climate-related targets and 2050 Net Zero targets energy transition will be especially key, and investment in major infrastructure to support non-fossil fuel energy production, such as geothermal, solar, hydrogen, kinetic, wind, will be needed in both PICTs and as part of all Nationally Determined Contributions (NDCs). Abundant sources of clean, affordable energy will support increased provision of safe drinking water and nutritious food. Effective and integrated water and natural resources management will be needed to ensure the security of both terrestrial and coastal food systems. Traditional knowledge and staple foods are especially important in building resilience against climate change and increasing food security, most so in the poorer and rural environments and PICTs.

Underpinning all of this is the need for a healthy environment and functioning ecosytem services. Without addressing the environmental targets of the SDGs displayed in Fig. 1.3, and ensuring this environmental base, societal and then economical aspirations will be unsustainable, if not completely unachievable. Central to achieving true sustainability for PICTs and broader Pacific region is the role of carbon, in both the problems it creates and solutions it supports. NDCs provide a roadmap for national carbon emissions (in reality a suite of greenhouse gases that include carbon-dioxide, methane, nitrous-oxide, and others, referred to as CO_2e or CO_2 equivalent emissions) and while reducing emissions in the first place is preferrable to CO_2e sequestration, both are now needed to keep global warming below 2 °C and as close to 1.5 °C as possible.

1.3.5 The Role of Carbon as a Particularly Pacific-Specific Solution

The international carbon market was established under the Kyoto Protocol in 1997, in an effort to reduce greenhouse gases. Carbon credits are now tradable on the international market to offset national or private sector greenhouse gas emissions where reduction is not possible or desirable. The last decade has seen the prominence of 'blue carbon', that which is stored within coastal ecosystems such as mangroves, seagrass, salt marsh, and tidal habitats, regarded as a particularly effective form of carbon sequestration. The large CO_2e potential sequestration in the form of blue carbon lies in both the biomass and sediments of the marine and tidal ecosystems. Tropical forest CO_2e storage potential is 800 tons per hectare (ha) comprising 600/200 in biomass and in the soil respectively (Wetlands International 2022). Mangroves in comparison have a total (biomass/soil) CO_2e storage potential of 3,767 (928/2,839) tons per ha (Wetlands International 2022)—over four times as much. Salt marshes have a potential of 949 (32/917) tons per ha and seagrass meadows a potential of 511 (11/500) tons per ha (Wetlands International 2022). Given the Pacific is the 'blue continent' blue carbon, consequently, provides a timely and pivotal opportunity for PICTs to apply a WEF nexus approach centred around

a healthy environment (Fig. 1.1), and a foundation to then sustainably address societal and economical SDG and development target aspirations (Fig. 1.4). Importantly, the highly effective blue carbon capturing ecosystems offer opportunities to capture carbon and generate carbon credits for sale with no additional pressures on freshwater resources, especially important in water-scarce PICTs. Further, rather than rows of monoculture timber plantations that compromise some terrestrial carbon capture approaches, the coordination of environmental management with food systems (fisheries and terrestrial), water resources, and energy development, as well as coastal infrastructure offers major return on investment on top of the value of the carbon credits sold. Examples of the additional return of investment include better fish stocks due to mangrove, seagrass, or near-shore reef habitat that supports the varying life-cycle stages of commercially targeted or community-reliant fish species, salt marsh that supports bird and insect life, and vegetated shorelines that protect against storms overtopping event that salinize groundwater and soils and aid to capture and attenuate shore-based pollution. This added on return on investment can be maximized through coordinated management, which can be enhanced using a WEF Nexus approach.

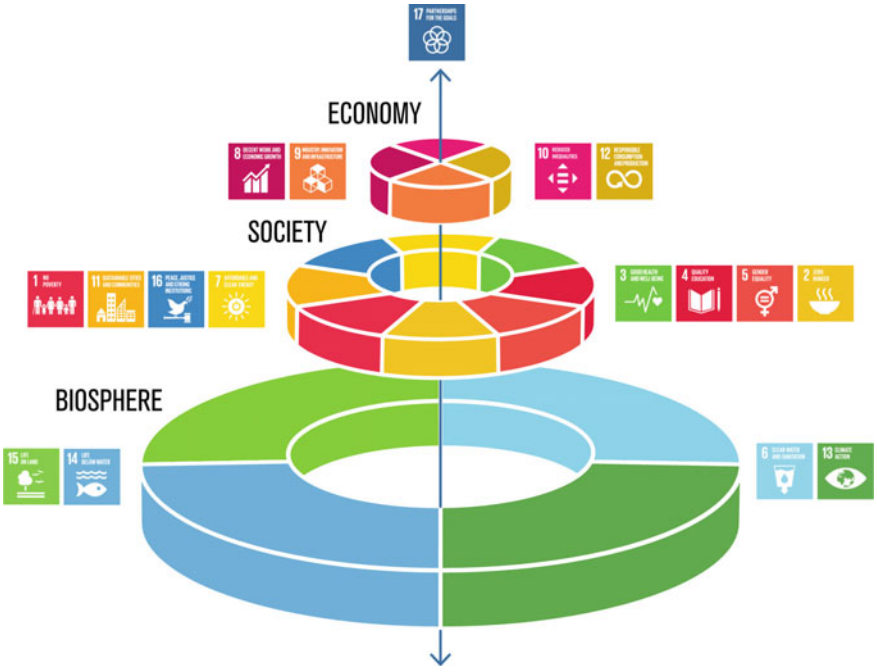

Fig. 1.4 Environmental systems and functions are essential to supporting subsequent societal and economical SDG aspirations (Stockholm Resilience Center 2016)

1.4 Addressing Future Challenges Using a WEF Nexus Approach

Socioeconomic advances in the Pacific are a challenge, with progress on eradicating extreme poverty and reducing national poverty hindered due to low public investment in education and health services (ESCAP 2022). COVID-19 has increased inequalities worldwide and negatively impacted progress toward achieving the SDGs. It is no different in the Pacific. The geographical isolation initially held back COVID-19 outbreaks in Australia, New Zealand, and many of the PICTs, but this isolation has not been enough, and the impact of COVID-19 is now being felt throughout the region. Impacts on GDP, trade, remittances, tourism, and food imports have all negatively affected Pacific countries.

Importantly, a WEF nexus approach builds on and does not negate the integrated and coordinated efforts to date in the Pacific through IWRM, Ridge to Reef, Source to Sea, UNESCO Biosphere Reserves, Integrated Coastal Zone Management, and similar approaches. Areas of most concern in the Pacific, those showing regression rather than advancement of SDG targets, are clean water and sanitation (SDG 6), reduced inequalities (SDG 10), sustainable cities and communities (SDG 11), responsible consumption and production (SDG 12), climate action (SDG 13) and life below water (SDG 14) (ESCAP 2022). Limited progress has been made towards good health and well-being (SDG 3), affordable and clean energy (SDG 7), industry, innovation and infrastructure (SDG 9), life on land (SDG 15), and partnerships for the goals (SDG 17) (ESCAP 2022). These areas of most concern would all benefit from a WEF nexus approach and are detailed in the chapters of this regional volume.

Globally, major greenhouse gas emitters need to step up for the environmental and economic benefit of all, including themselves. Within the region some Australian private sector companies are closing coal-fired power plants earlier than planned due to purely financial rationale, much to the political chagrin of some and jubilation of others. Nexus solutions that hasten the rate of transition away from fossil-fuels are needed and renewable energy generation and storage technology advances are thankfully providing economic incentives where political cohesion has been lacking. The energy transition includes energy generation for the provision of water, food, and transport services as well as households and industrial processes. Energy independence and removing reliance on fossil fuel imports will strengthen national security and the ability for self-determination of national development objectives. This is especially critical for low- and middle-income PICTs that are now seeing an unprecedented push for geopolitical influence in the region.

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