SMART guide and briefing paper

A methodology and results paper on the Strategic Mitigation Adaptation Resilience Tool (SMART) for planning

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ClimateWorks AUSTRALIA

Founding partners Monash University and The Myer Foundation

About us

ClimateWorks Australia

ClimateWorks Australia is an expert, independent adviser, acting as a bridge between research and action to enable new approaches and solutions that accelerate the transition to net zero emissions for Australia and Asia Pacific.

It was co-founded in 2009 by The Myer Foundation and Monash University and works within the Monash Sustainable Development Institute. ClimateWorks Australia also benefits from strong relationships with an international network of affiliated organisations that support effective policies, financing and action for greenhouse gas emissions reductions.

Since launch, ClimateWorks has made significant progress, engaging key decision makers from all tiers and sides of politics and business. Our collaborative, end-to-end approach to solutions that will deliver greatest impact is informed by a thorough understanding of the constraints of governments and the practical needs of business. This, combined with philanthropic funding and university ties, has earned the organisation an outstanding reputation as a genuine and impartial adviser.

In the pursuit of its mission, ClimateWorks looks for innovative opportunities to reduce emissions, analysing their potential then building an evidence-based case for action through a combination of robust research and analysis, clear and targeted engagement, and effective capacity strengthening. We support decision makers with tailored information and the tools they need, as well as work with key stakeholders to remove obstacles and help facilitate conditions that encourage and support the transition to a prosperous, net zero emissions future.

Acknowledgments

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We also acknowledge the insights shared by key stakeholders during development of this tool, some of whom participated in a peer review process. In particular, Ministerial representatives from Fiji, technical consultants working with The Republic of the Marshall Islands, as well as technical experts within the Pacific Island Forum Secretariat, United Nations Development Program, Global Green Growth Institute, Secretariat of the Pacific Regional Environment Programme, Pacific Community (SPC), Pacific Island Development Forum, IDDRI, Climate Analytics, World Resources Institute, Griffith University, Dr. Mark Stafford Smith (CSIRO), Evan Davies, Charlotte Sterrett (Oxfam Australia), Tu Tangi (Plan Pacific), Prof. John E. Hay (University of the Pacific), Richard Baron (European Climate Foundation), Trevor Ole (AECOM) and Prof. Nigel Tapper (Monash University).

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1. Introduction

1.1 Background

Representing some of the countries' most vulnerable to the impacts of climate change, most Pacific Island Countries (PICs) rely on an iterative process of adaptation planning. Each has highly ambitious emissions targets enshrined within their Nationally Determined Contributions, and each now aims to meet these and energy security needs through implementing a range of mitigation actions. Adaptation and mitigation both aim to reduce the negative impacts of climate change, however they have typically been addressed separately in different policy and institutional contexts and sometimes thought of as competing priorities. Whilst PICs make a negligible contribution to global greenhouse gas emissions, developing long-term low emissions development strategies (LT-LEDS) provides an opportunity for these countries to achieve other development objectives, such as energy security, avoiding 'lock-in' and 'lock-out', and showcasing potential and economic resilience[1]. By undertaking mid-century planning for LT-LEDS across the key policy areas of mitigation, adaptation, climate resilience and sustainable development, countries can design and implement a pathway that considers the interactions, synergies and trade-offs of all their national priorities.

However, integrated planning between adaptation and mitigation objectives may pose some challenges. Actions to mitigate or reduce a country's contribution to climate change can enhance or at times undermine efforts to adapt to climate change or boost climate resilience. The Strategic Mitigation Adaptation and Resilience Tool (SMART) matrix and the associated Briefing Paper highlight key interactions between mitigation actions and adaptation and resilience outcomes in a Pacific Island context, showing where countries can expect to find co-benefits and trade-offs.

1.2 Why use SMART matrix for planning?

The SMART Matrix and Briefing Paper (henceforth referred to as Tool) have been developed under the 'Pacific Package' funded via the 2050 Pathways group and aiming to support and build capacity within PICs to develop long-term low emissions pathways. By helping to identify the interlinkages between mitigation approaches and adaptation or resilience outcomes, this will help PIC planners and policy makers to identify where there are co-benefits to be realised and trade-offs that need to be considered or minimised in planning.

It is hoped that this Tool will assist in reducing some of the planning burden currently experienced among some PICs by enabling the quick identification of synergies between mitigation and adaptation related plans and activities. In this way, the Tool can also be used for other planning processes, such as national adaptation plans, energy roadmaps, national development plans and even project pipelines for climate finance. By building on existing strategies and processes, decision-makers can pursue more efficient use of resources.

[1] See more description of these advantages in 'Horizon to Horizon: A Pacific Island country guide to creating long term climate resilience, net zero emissions development and a sustainable future'

Decision makers can use the matrix to identify which mitigation actions can be expected to enhance or support key adaptation or resilience actions, indicating the potential for 'no regrets' or 'least regrets' actions in support of robust and integrated planning objectives. It also can be used to identify where interactions may vary over time, or change from positive to negative, depending on the country or technology choice, indicating an area for further investigation to inform planning processes. Finally, it highlights where interactions can be expected to be negative, and will therefore require a 'trade-off' choice, where either the mitigation action or the adaptation or resilience outcome is prioritised.

As impacts will vary over time scales and depending on the context of each Pacific island country, indicators are intended to provide high-level guidance flagging where further consideration of the technology choice or mitigation action may be required. Provided in Excel format, the tool can be downloaded and should be modified to suit specific country contexts and needs.

This Tool is to be used as part of a participatory process when undertaking:

- National Low Carbon / LT-LEDS Planning Strategies
- National Determined Contributions (NDCs)
- Global Greenhouse Gas (GHG) Inventories

The Tool can also provide further benefits to the following planning process:

- LT-LEDS processes
- NDC Implementation planning
- Framework for Resilient Development in the Pacific (FRDP)
- National strategic planning assessments
- National development planning
- Climate finance planning and project assessment frameworks

A note on terminology

The developers acknowledge that there are a number of different definitions for the terms Mitigation, Adaptation and Resilience, however the Tool and paper rely on the following definitions:

- Mitigation - is defined as actions taken to reduce, avoid or sequester greenhouse gas emissions
- Adaptation - is defined as any action taken to adjust to climate change
- Resilience - is defined as the ability to recover from climate events

1.3 Methodology

The Tool responds to a gap for a mechanism that can assess the quality and evidence base of the mitigation, adaptation and resilience interactions that are specific to the Pacific Island context. From the outset, there has been a deliberate focus on mitigation to inform the 'anchor' actions as the Tool has been developed under the 'Pacific 2050 Pathways Package' which seeks to support the development of long term, low emissions pathways. SMART was developed in four stages:

Firstly, the Mitigation actions (See Annex B) were grouped into broad categories, based on the pillars of decarbonisation from the Deep Decarbonisation Pathways Project, listed below:

REDUCE ENERGY USE

Choose equipment and assets that use less energy and get more out of the energy that is used in areas such as buildings, manufacturing, transport and infrastructure.

SWITCH TO CLEANER FUELS

Once electricity is powered by clean energy, switch every energy-using activity you possibly can to electricity and everything else to low emissions alternatives (e.g. from diesel to biodiesel in transport).

PRODUCE CLEANER ELECTRICITY

Transition electricity generation away from imported fossil fuels to cleaner, locally produced low emissions sources such as solar, wind, hydro and bioenergy.

SORT OUT AND STORE THE REST

Reduce non-energy emissions like agriculture and refrigerant gases and capture and store remaining emissions through actions like restoring forests and blue-carbon ecosystems.

Then, the corresponding adaptation and resilience indicators (see Annex A) were summarised from evaluation of Pacific Island Countries Nationally Determined Contributions (NDC) indicators. The developers acknowledge that these indicators could be more detailed, and include social, cultural, environmental and economic factors. However, these were considered beyond the scope and focus of this Tool.

Then, each mitigation action was then considered against each adaptation and resilience indicator. Desktop-based research was undertaken to review potential co-benefits, barriers and trade-offs on both a Pacific regional scale and a global scale. Where available, specific case studies have been detailed. For the global evidence-base, benefits and trade-offs were sense checked against interactions with relevant Sustainable Development Goals (SDGs) identified in the New Climate Institute's SDG Climate Action Nexus tool (SCAN-tool). The Tool contains a full set of references for both Pacific and global research.

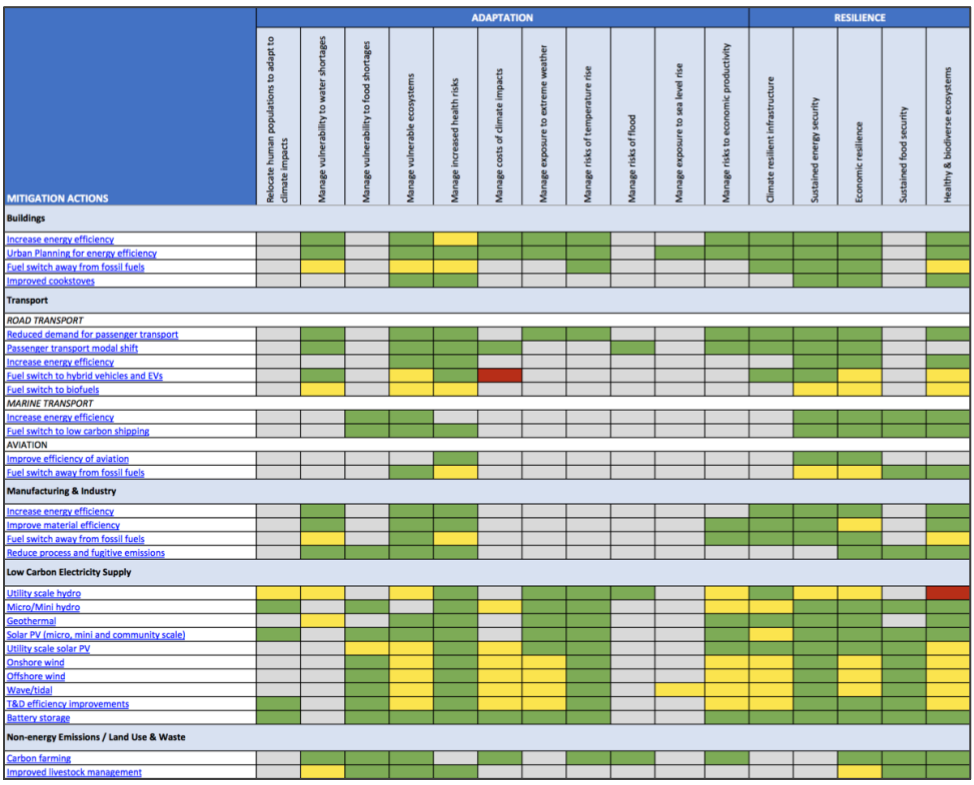
Finally, after careful consideration of evidence base and qualitatively weighing the range of co-benefits, barriers and trade-offs, each mitigation action was assigned a status and colour base applying the following classification:

Table 1. Key to Indicators

+	Positive ("no regrets" actions)	Where these positive correlations exist, the planning task can then focus on ensuring these co-benefits are maximised.
+ or -	Varies + or - over temporal or spatial scales or dependent on technology choice	Trade-offs may not apply consistently across all countries or locations (spatial scales), may change over time, for example as climate impacts increase (temporal scales), or may be avoided or managed by technology choice. These interactions can often be managed or minimised with proper planning.
-	Negative	Some mitigation actions will always interact negatively with a given adaptation or resilience action, indicating a trade-off will need to be made. Depending on a Pacific Island Country's unique circumstances, either the mitigation outcome or the adaptation/resilience outcome must be prioritised.
	No known interactions	Based on desktop-based research, no known interactions have been identified. Due to knowledge and data gaps however, an interaction may potentially exist.

Mitigation actions were then further considered against each adaptation and resilience indicator in the SMART Matrix or 'heat map' that offers a quick assessment of the potential for different mitigation actions to deliver co-benefits against priority adaptation or resilience focus areas ('no regrets' or 'least regrets' actions). It also highlights where there are no interactions, or any that require further consideration.

Table 2. SMART Matrix



1.4 How to use the SMART Matrix

The SMART Matrix has been developed as an Excel-based tool to make it easily accessible and editable. While the Tool is specific to the Pacific, it is expected that users will make further modifications to suit their country context and need.

The Tool is divided into four sections:

1. **How to use this Tool** provides instructions on how the Tool should be used

2. **The SMART Matrix** provides a high level overview of the interactions of each mitigation action against each adaptation and resilience indicator. This 'heat map' allows for a quick assessment of the potential for different mitigation actions to deliver co-benefits against priority adaptation or resilience focus areas ('no regrets' or 'least regrets' actions). It also highlights any interactions that require further consideration.

3. **Sector tabs** (Buildings, Transport, Manufacturing, Low Carbon Electricity, Non-energy emissions) provide more granular detail on these interactions, along with a detailed evidence base to support the assessment of interactions. The evidence base draws on both Pacific and global evidence, along with anecdotal expert input gathered through an expert review process for the tool. At the sector level each mitigation action is also assigned an overall indicator (based on Key Indicators in Table 1).

4. **Assumptions** are located in the final tab as a record of both the common and sector-specific assumptions that were made in assessing the interactions. These are also captured in Section 3 of this paper.

There are still potential interactions where caution must be taken, as well as potential knowledge gaps where, although no interactions are currently known, they do potentially exist. Where barriers exist for a 'no regrets' action, efforts to overcome these barriers will be needed in order to deliver potential multiple co-benefits.

Our approach and research findings were peer-reviewed by leading adaptation and mitigation experts from academia, government and non-government organisations. However, this Tool is a 'live' document that will be revised and adapted as it is utilised. We will endeavour to continue to test this Tool via various Pacific and global forums such as the Framework for Resilient Development in the Pacific (FRDP) and the SDG taskforce.

2. Summary of findings

A number of sector based findings were identified in the development of this Tool:

2.1 Buildings sector

There are a range of opportunities to undertake 'no regrets' or 'least regrets' actions in the building sector in PICs. These include improvements in energy efficiency, urban planning, fuel switching and improved cook stoves. In particular, energy efficiency in buildings can provide a wide range of socio-economic benefits such as:

- Managing health risks through improved indoor environmental quality,
- Reducing exposure to temperature rise,
- Direct savings on energy bills,
- The creation of jobs through investments in upgrading existing buildings and through increasing the energy efficiency of new buildings, improving economic productivity and resilience.

However, significant capacity constraints and other barriers are likely to hamper future efforts. For example, while the World Bank found that increasing the standards of new buildings can be considered a 'no regret' strategy (World Bank, 2017), addressing energy efficiency in buildings through building code regulations may not necessarily be the best option for the Pacific, given compliance is often difficult to enforce (ADB, 2011). Additionally, factors including a range of building types across the Pacific (including traditional structures using lightweight materials and prefabricated homes), as well as an increase in informal settlements, it may be difficult to apply one building code across a diverse range of construction types (Sharma, 2017).

Some PICs already have building codes, such as in Vanuatu and Fiji, but they have typically been designed after a series of extreme weather events in order to increase resilience to future disasters, with less focus on addressing mitigation and adaptation needs. In the case of Fiji, the building code does not mention adaptation or low carbon development. Therefore, there is an opportunity to integrate adaptation and mitigation into existing codes, as well as improve urban planning - it is generally cheaper to keep economic assets out of vulnerable areas than to build defences to protect them (World Bank, 2017). Currently, lack of technical capacity and harmonisation across urban planning agencies are key barriers to planning for efficient, resilient buildings.

The tropical climate in most of the Pacific means demand for heating is generally low, though significant amounts of energy are used for cooling and often, hot water. Passive energy efficiency achieved through cool roof technologies and the use of traditional building design to allow for natural airflow presents an opportunity to reduce energy demand for cooling. For example, biomass is already being used for water heating in Samoa and Tokelau (a territory of New Zealand). With significant cost reductions over the past few years, solar hot water systems also provide an opportunity for energy and cost savings in both commercial and residential applications (NREL, 2012). Nonetheless, there is still a need to find sustainable heating and cooling solutions in particular for one of the biggest energy users (and economic contributors); the tourism sector (Lucas et. al., 2017).

Reducing energy demand from buildings is also being pursued, as it is far less costly for PICs to import more efficient refrigerators, air conditioners and lights than to import diesel fuel (Farrell, 2015). There have been a range of appliance standards and labelling projects to increase energy efficiency across the Pacific Island region. It is estimated these will save PICs US$525 million in fuel, generation & maintenance, 630 million litres of diesel and 1.7 million tonnes of emissions by 2025 (Farrell, 2015).

Where the capacity for biomass may be low for use at a large scale, there is enough biomass for traditional household cooking, which remains the largest component of overall energy use in rural areas throughout PICs (IRENA, 2013a). While some PICs have access to clean cooking technologies and fuels, in countries such as PNG, only 12.1 % of households having access to modern cooking fuel sources. Increasing the uptake of clean cook stoves is a win-win action as it can prevent respiratory disease from indoor air pollution, increase economic resilience and energy security while reducing CO2 emissions.

Table 3. Buildings sector 'no regrets' or 'least regrets' actions

- Increase energy efficiency
- Urban planning for energy efficiency
- Improved cook stoves

2.2 Transport sector

With transportation accounting for an average 75% of oil consumption in Pacific Island countries (Holland et. al., 2014), there is an urgent need for low carbon solutions in the sector, particularly in shipping. Using renewable energy technologies for commercial ships in the Pacific region would allow for fleets of smaller vessels to reach small ports and remote communities, which are currently not serviced by large ships (Holland et. al., 2014). This provides multiple economic, environmental, social, and cultural benefits. A reduction in marine pollution will help conserve ocean ecosystems such as mangroves and coral reefs that are critical in adapting to the impacts of climate change and increasing natural resilience to rising sea levels and extreme weather events. Further, reduced reliance on imported fossil fuel will contribute to macroeconomic growth, stability, aid poverty reduction, help in avoiding large balances of payment deficits and increase energy security. As PICs further rely heavily on imported foods and are vulnerable to rising food prices, reduced transport and fuel costs will alleviate compounding economic effects.

Current barriers to transitioning away from fossil fuel dependency in domestic shipping include a lack of sufficient incentives to adopt new technologies and a lack of research and working models of viable alternatives (Nuttel et. al., 2014). Additionally, the costs of retrofitting existing vessels with alternative technologies are likely to be prohibitive to most government and private shipping providers in the region without external assistance (Holland et. al., 2014).

As tourism dominates many PIC economies - accounting for 78.5% of GDP in the Cook Islands - the air transport industry is also crucial to the region (Nuttel et. al., 2014).

Reducing jet fuel use via improved efficiency measures would have economic benefits for PICs which would in turn, support the tourism industry. There are a range of simple changes in airline procedures such as reducing tarmac idling that can reduce jet fuel use, cut emissions and improve environmental health conditions and air quality for airport workers at little or no cost.

In terms of road transport, the Pacific Island region has seen second-hand vehicle imports rise exponentially over the last 60 years, largely occuring in a virtually deregulated environment. Improving the efficiency of imported vehicles, for example by introducing minimum CO2 emissions standards, can deliver quick wins in improving energy security, improving air quality and reducing operating costs for vehicle owners, as can incentivising further adoption of hybrid vehicles. There is a notable potential for the conversion of diesel fuel to biofuels, particularly from coconut oil (copra) and biomethanes, especially for isolated communities, which could eliminate transport costs and increase economic resilience through stimulating local markets and job creation. While most PICs have the resources to produce large amounts of coconut oil based fuels or bioethanol (SOPAC, 2007), and some successful trials have been conducted, an increase in the production of biofuels risks a range of significant trade-offs and may increase air pollution and water use, negatively impacting ecosystems. Shifting to biofuel blends requires costly engine modifications and can also increase costs and frequency of engine maintenance. Reducing demand for passenger transport has been identified as a no regrets action, though will require addressing behavioral change, cultural perceptions around the use of bicycles and motorbikes and increased incentives for public transport use and non-motorized transport.

Considering the small distances travelled via road in PICs, electric vehicles (EVs) powered by renewables present a significant potential and can be profitably deployed in urban areas and also within the many tourist resorts spread across the Pacific islands (Datt et. al., 2015). However, EVs also currently come at a significantly higher upfront cost, a key barrier to wide adoption. Further study of the current gaps and implications of a transition to electric transport is needed to assess how to ensure sufficient renewable energy supply, so that coverage of electric transportation is technically and economically feasible, and to assess the requirements for charging infrastructure and for the regulation of tariffs for electric transport. Recycling and disposal solutions for hybrid and EV batteries is also needed to avoid increasing waste emissions.

Table 4. Transport sector 'no regrets' or 'least regrets' actions

<u>Road transport:</u>

- Reducing transport demand
- Passenger transport modal shift
- Increase energy efficiency

<u>Marine transport:</u>

- Increase energy efficiency
- Fuel switch to low carbon shipping

<u>Aviation:</u>

- Improve efficiency of aviation

2.3 Manufacturing and Industry sectors

Global evidence indicates that improvements in energy and material efficiency, as well as carbon capture and storage (CCS) in industry and manufacturing sectors may be identified as 'no-regrets' actions, with a wide range of adaptation, mitigation and sustainable development co-benefits and few negative trade-offs. However, due to small economies of scale and minimal industrialisation in the Pacific Island region greenhouse gas (GHG) emissions associated with the sector remain low. Further, the exact emissions contribution of industrial processes is difficult to estimate due to sectoral data gaps. Across the region, industry constitutes only 16% of regional electricity sales and is limited to those islands with forestry, agricultural and fishery industries (IRENA, 2013a). High transportation and raw material costs make entrepreneurship difficult to sustain, dampening economic growth opportunities. Poor energy access and high energy prices have also meant less investment in industry and manufacturing.

In Fiji, sugarcane processing makes up one third of industrial activity and is the country's primary export product (UNEP, 2013). FIji already uses bagasse (the residue from sugar cane processing) for most of its energy requirements within the sugarcane sector (UNEP, 2013). Though biofuel resources vary across the PICs, Fiji is one of the few countries with the capacity to produce commercial scale bioethanol from sugarcane that could replace diesel fuel based generators currently used in the manufacturing sector. There are opportunities for other industries, such as cement where kilns are often fired with imported coal, to switch to biomass (Rosillo-Calle, 2003). This would greatly help manage health risks and reduce air pollution. For high Pacific Islands, other forms of biomass resources derived from waste from agricultural and forestry industries such as palm oil and wood products offer suitable sources of energy to replace fossil fuels (IRENA, 2013a).

Though fuel switching offers a range of benefits, including economic savings from reduced reliance on imported fossil fuels, sugar cane production is known to have a wide range of negative environmental impacts. Water pollution from chemicals used in cane growing, sedimentation through soil erosion and waste from sugar production not only threaten the biodiversity of river systems and coastal areas but the cultures and livelihoods of the communities who rely upon them. Sugar cane production is additionally vulnerable to the impacts of climate change. The burning of sugar cane prior to harvesting may also produce more GHG emissions and reduces bagasse fibre availability (Davies, 1998).

For low lying islands with a natural abundance of coconut palms, coconut oil production could potentially contribute to biofuel should it become economically viable at a large scale. Sufficient biomass waste in the form of coconut shells and husks may become cost effective for generating heat for manufacturing purposes (IRENA, 2013a). However, most PICS do not have the land area available for large-scale palm plantations and come with additional environmental concerns (SOPAC, 2007). Biomass gasification is further being used on some islands for commercial copra, cocoa, coffee and tea drying (Marconnet, 2007). A key barrier is the current lack of quality standards for biofuels in the region.

In terms of natural resource extraction, with the exception of Papua New Guinea (PNG), which has substantial gas reserves, most Pacific Islands have no indigenous sources of natural gas or oil. In PNG's liquefied natural gas plant, energy efficiency measures are already in place to ensure that waste heat is recovered and used as an energy source. Overall, for the industry and manufacturing sector in the Pacific, the potential for emissions reduction is negligible (UNEP, 2013). Where relied upon, a transition away from any existing diesel based generators in industry to electrification would have significant health benefits for workers though improvements in air and water quality and contribute to the protection of natural ecosystems.

Table 5. Manufacturing & Industry sector 'no regrets' or 'least regrets' actions

● Increase energy efficiency ● Improve material efficiency ● Reduce process and fugitive emissions

2.4 Electricity supply

Providing energy that is low carbon and also reliable, efficient and affordable underpins a wide range of both Pacific regional and national policies and plans, notably the Majuro Declaration, the Framework for Action on Energy Security in the Pacific 2010-2020 (FAESP) and the Framework for Resilient Development in the Pacific (FRDP). Increasing the uptake of renewable energy in the region can decouple economic growth from environmental degradation and reduce reliance on imported fossil fuels, in turn saving on energy costs, increasing economic resilience, increasing energy access and improving energy reliability. Barriers include:

- Unreliable grid systems on which to expand.
- PICs small size and isolated nature making it difficult to build, operate and maintain renewable energy systems.
- Expensive inter-island transportation for repairs and materials.
- The physical environment—storms, floods, salt-laden winds etc— stresses electronics and equipment, requiring more frequent repair and replacement.
- A lack of human resources and trained personnel for managing the systems limits local capacity for repairs and maintenance.
- Uncertainties, particularly around the costs and benefits around certain renewable technologies, including environmental impacts require further research.

Despite a range of barriers to renewable energy (RE) uptake, PICs are emerging as renewable energy champions. Although PICs have considerable renewable energy potential, viable technology options are dependent on national circumstances, limited by land area, geological and hydrological attributes, wind and rain patterns, technical capacity, existing infrastructure and costs. This is particularly relevant for geothermal potential, which is only feasible on a few Pacific Islands (SPC, 2009b). There is a further notable gap in knowledge regarding the potential for wave / tidal energy development in the region, with more research needed. Although there are huge potential ocean energy resources, it has yet to be proven that wave or tidal energy can be tapped in a cost-effective manner to produce electricity for island grids. Similarly, offshore wind has not yet been developed in the region due to prohibitive cost barriers and lack of infrastructure. For onshore wind energy, adoption has been comparatively small, even though the relatively minor physical footprint of a wind energy system, low production costs and carbon neutral benefits make the technology appropriate for small island countries.

While not all PICs have hydro potential (UNESCAP, 2012), the technology has the potential to generate sufficient electricity to supply entire countries and is already supplying over 50 percent of electricity demand in Fiji, Samoa and the Solomon Islands. This has significantly decreased the costs of power generation and reduced reliance on oil, saving hundreds of millions of dollars on fossil fuel imports alone (ADB, 2017). Hydroelectricity generation is dependent on rainfall patterns and is vulnerable to periods of drought, which in turn can negatively affect water security and undermine energy security benefits (Goundar & Appana, 2017). Large scale hydro projects can have a further range of negative trade-offs and therefore require deeper investigation at a country level. Village scale hydro systems have notably fewer trade-offs, however the relatively high cost of maintenance and lack of local capacity has seen many remote mini hydro systems decommissioned (UNDP, 2017).

Solar photovoltaic (PV) is by far the most common renewable technology in the region, with its competitive price and proven wide range of adaptation, mitigation and disaster risk reduction benefits, notably in maintaining critical services after extreme weather events. However, as rooftop solar can be vulnerable to extreme weather when installed on non-traditional housing and roofing materials, community scale mini-grids may be more suitable for remote PICs. Though most renewable technologies are, to varying degrees, susceptible to natural hazards and extreme weather events, high quality, tested systems that have taken local contexts into consideration during the design process can demonstrate adequate resilience and minimise trade-offs. There are also opportunities for emerging cross-cutting solutions to clean energy supply through floating solar PV, which provides co-benefits for water resource management, by preventing water shortages through reduced evaporation.

With the addition of battery storage, solar PV has the potential to meet both peak and fluctuating demands for electricity. Battery storage also has the benefit of enabling resilient power system designs which allows upscaling of private sector investment in renewable energy (ADB, 2017). Disposal and recycling of solar PVs and batteries after their life-cycle remains an issue for remote PICs. Although many regions in the Pacific are already connecting large solar installations to their utility grids, without added controls, many grids and will soon reach maximum penetration levels (GIZ, 2016). Investment in upgrading transmission and distribution lines can reduce electricity losses, which are up to 50 percent in some PICs (UNDP, 2013) and enable a greater uptake of renewables.

Table 6. Electricity supply sector 'no regrets' or 'least regrets' actions

- Micro / mini hydro
- Geothermal
- Micro, mini and community scale solar PV
- Transmission and distribution efficiency improvements
- Battery storage

2.5 Non-energy / Land use

Mitigation actions in the land use sector have few trade-offs overall and can generally be considered 'no regrets' actions. Though most countries in the Pacific have become net food importers, agriculture remains an important source of income and employment in the majority of Pacific island countries (UNESCAP, 2006). Food availability and accessibility are also among the first to be affected following climate disasters.

Traditional agricultural systems, including agroforestry and intercropping, have been practiced in the region for thousands of years (Shah et. al., 2016), ensuring food supplies were resilient to hazards and extreme weather events. However, a shift to a more modern food system in PICs has seen rising vulnerability to food insecurity and has contributed to deforestation. Education is critical to enable adoption of climate resilient agricultural techniques and ensure traditional knowledge of sustainable practices is retained, shared and implemented. Though there are a range of low-cost options both over the short and long-term that both improve productivity and provide resilience to extreme weather (World Bank, 2017), land tenure issues and potential time lags in agroforestry crops producing marketable products are key barriers.

The livestock sector similarly contributes significantly to the economies of PICs in terms of food security, employment opportunities and foreign exchange savings (SPC, 2009b). Demand for livestock products is growing due to population increases, increases in disposable income, rapid rates of urbanisation and the growth of the tourism industry, creating significant opportunities and challenges for PICs. Improvements in livestock management through provision of higher quality, climate tolerant feed quality and grazing management can improve pastoral productivity and animal health, resulting in improved economic resilience and food security while also reducing methane emissions from livestock.

Climate-smart agriculture can generate climate adaptation, resilience and mitigation benefits, such as improved food security, economic resilience, reduced vulnerability of ecosystems through reduced fertilizer use and increased carbon stores in soils.

One of the most effective methods to adapt to the impacts of climate change in the land use sector is through ecosystem based adaptation. Reforestation under REDD+ programs and avoided deforestation, including the protection and restoration of mangroves, can provide natural buffers to extreme weather events, prevent coastal erosion and sea level rise and sequester large amounts of carbon. Though Pacific Islands have small land and forest areas, reforestation projects form an important component of national mitigation actions. Not only do such projects reduce and remove carbon from the atmosphere, they can also provide additional income through the sale of forest carbon and will help to maintain ecosystem services including stable water supply, preventing soil erosion and biodiversity conservation benefits (SPC, 2103). The protection and restoration of mangroves additionally provides coastal Pacific communities with essential livelihood safeguards including improved fisheries and other subsidence opportunities. A weakening of traditional mangrove management systems and lack of capacity are key challenges to mangrove management in the Pacific (IUCN, 2009).

A further significant opportunity for no-regrets action lies in the waste management sector. Increases in waste levels in the Pacific Island region has resulted in illegal dumping, inadequate management of landfills, increases in the import and disposal of used cars, lack of adequate handling of medical and hazardous waste, poor economic viability of recycling and contamination of groundwater and seawater from sewerage (Pacific ACP, n.d). Well-managed landfill and wastewater treatment can not only lead to environmental protection and healthier communities, but also the capture and utilisation of biogas, which can be used to generate electricity, improve energy security and economic resilience.

Table 7. Land-use & waste sector ‘no regrets’ or ‘least regrets’ actions

• Carbon farming • Improved livestock management • Reforestation • Avoided deforestation • Protect and restore mangroves • Improved waste management

3. Assumptions underpinning the SMART Matrix

3.1 Common assumptions

Classification of interactions:

- The intensity and scale of the specific interaction (i.e. green, grey or yellow) between a mitigation action (y axis) and the associated adaptation or resilience outcome (x axis) is unquantified and based on the published Pacific or global evidence base contained within the Sector tabs. A green designation indicates that an interaction is positive (whether strongly or weakly positive), while a red designation indicates an interaction is either strongly or weakly negative.

Technology choices:

- It is assumed that technologies improve over time in both cost and energy efficiency, thereby reducing negative impacts.
- The lifecycle of technology choices is considered and it is assumed that technologies meet global standards for quality and durability.
- Technology choices are based on the operational context, are designed, installed and properly maintained to withstand predicted increases in the intensive and frequency of potential natural hazards (i.e. have undergone cyclone testing or water emersion where possible).
- Local capacity is available to install and maintain technology infrastructure as needed.

Barriers to implementation:

- It is assumed all barriers to implementation of mitigation actions (such as technology costs, capacity constraints, and supply chain limitations) can be addressed to capture the mitigation potential and adaptation and resilience co-benefits over the long term.
- Barriers therefore have not been considered in the assessment of interactions.

3.2 Sectoral assumptions

Buildings:

- Energy efficiency measures that improve the thermal efficiency of buildings also improve their resilience to extreme weather events.
- Urban planning for efficiency is only considered in relation to the mitigation outcomes it can deliver; broader socio-economic outcomes are excluded from the analysis.
- It is assumed that urban planning for efficiency is effective.
- Heating, ventilation, and air conditioning (HVAC) has been installed to meet global best practice protocols.
- Biofuels do not compete with land required to maintain food security and related livelihood activities.

Transport:

- A switch to electric vehicles (EVs) does not increase overall vehicle imports.
- EVs are powered by renewable energy and therefore do not result in an increase in emissions from electricity generation.
- Introducing energy efficiency measures for transport does not cause increased reliance on combustion engines where EV options may exist.
- Given land constraints, for the majority of PICs a high uptake of biofuels for road transport and aviation will be dependent on imported biofuel manufactured in other countries.
- Biofuels therefore do not compete with land required to maintain food security and related livelihood activities.
- For shipping, if there are no methane fugitive emissions from fuel switching to Liquefied Natural Gas (LNG). Switch to biofuels not included (covered in low carbon electricity).

Manufacturing and industry:

- For manufacturing and industry, increases in efficiency do not increase productivity in a way that increases use of natural resources.
- Biofuels do not compete with land required to maintain food security and related livelihood activities.
- Where possible, second generation biofuels are preferred, which can also support waste management efforts.

Low carbon electricity:

- Additional renewable energy capacity can be provided to meet increased electricity demand from fuel switching to electricity across all sectors.
- Interventions are implemented to global best practice standards.
- All new infrastructure is assumed to meet global standards in relation to design, installation and maintenance to withstand predicted increases in the intensive and frequency of potential natural hazards (i.e. have undergone cyclone testing or water immersion where possible)
- For geothermal is assumed that no fracking is involved.
- For transmission and distribution efficiency, impacts vary significantly depending on whether constructed underground or above ground.

Land use and non-energy emission sequestration through LULUCF:

- Arable or forest land is not converted to landfill.
- Reforestation and pastoral/agricultural improvement activities will not compete with critical agriculturally productive land without thorough consideration (for water and soil quality gains).
- For livestock management, although productivity increases, the number of animals does not.

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Annex A: Adaptation indicators

Adaptation - is defined as any action taken to adjust to climate change.

Adaptation Action	Description
Relocate human populations to adapt to climate impacts	Supporting the relocation of human populations in response to rising sea level and related salt water inundation, or changes in flooding regimes and natural hazard occurrences.
Manage vulnerability to water shortages	Managing exposure to water shortages predicted through slow onset climate events such as drought or variable and unpredictable rainfall.
Manage vulnerability to food shortages	Managing potential for food shortages, particularly regarding reduced local and agricultural productivity, exposure to volatile food prices associated with imported food products or ability to extend the perishable life of food market chains via freezing, refrigeration or processing.
Manage vulnerable ecosystems	Managing vulnerable ecosystems and related food ecosystems that are sensitive to slow onset climate change or natural hazards.
Manage increased health risks	Managing the risk of preventable disease that may increase with excess temperatures and flooding events (e.g. vector-borne diseases such as malaria, water-borne diseases and increased heat-related health vulnerability)
Manage costs of climate impacts	Managing the cost of recovering from climate impacts such as cyclones and potential human relocation, including the costs associated with delayed action.
Manage exposure to extreme weather	Manage risks associated with increased frequency and intensity of climate-related extreme weather events such as cyclones, droughts, flooding and extreme heat days.
Manage risks of temperature rise	Manage multifaceted risks associated with global temperature rise (e.g. increased need for air conditioning, changes in seasonal weather patterns, agricultural and natural resource harvest timing and yields, crop suitability, ocean acidification and reduced fishery stocks).
Manage risks of flood	Manage risks associated with unpredictable and variable rainfall, including flash flooding.
Manage exposure to sea level rise	Manage risks associated with a rising sea level including salt water intrusion of bore water supply
Manage risks to economic productivity	Manage risks associated with current national economic activities, ensuring these market chains are compatible with IPCC predictions of future climate changes.

Annex B: Resilience indicators

Resilience - is defined as the ability to recover from climate events.

Resilience	Description
Climate resilient infrastructure	The ability of infrastructure systems to absorb disturbance and still retain their basic function and structural capacity.
Sustained energy security	The uninterrupted availability of energy sources at an affordable price. In a Pacific context, this includes a reduced reliance on imported fossil fuels, which in turn, saves import energy costs, creates economic growth dividend and can increase available income.
Economic resilience	The ability of the economy to withstand and recover from shocks.
Sustained food security	The adequacy, availability, stability, utilisation, safety and nutrition of food.
Healthy & biodiverse ecosystems	The capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly.

Annex C: Mitigation actions

Mitigation - is defined as actions taken to reduce, avoid or sequester GHG emissions

Mitigation Action	**Description**
Buildings	
Increase Energy Efficiency	Improved building fabric; more efficient systems, electronics and appliances.
Urban Planning for Energy Efficiency	Urban planning to enable efficiency
Fuel Switch away from fossil fuels	Shifting from gas / oil boiler to biomass or electric boiler; shifting from fossil fuels to solar thermal or electricity for HVAC, and from fossil fuels to solar or electricity for water heating
Improved Cookstoves	More efficient cookstoves that consume less fuel
Transport	
Road - Reduced demand for passenger transport	Sustainable urban planning to reduce need to travel; behaviour change
Road - Passenger transport modal shift	Improved public transport (metro, bus rapid transit etc); cycling infrastructure.
Road - Fuel switch to hybrid or EVs	Switch from internal combustion engine vehicles to hybrid of electric vehicles
Road - Fuel switch to biofuels	Shifting petrol and diesel use to biofuels, either by increasing the proportion of biofuel in the fuel blend, or by converting existing internal combustion engines
Road - Increase energy efficiency	Reducing fuel consumption of existing vehicles by improved maintenance or replacing with new more efficient internal combustion engine vehicles
Marine - Increase energy efficiency	Implement measures to improve the efficiency of marine fleet
Marine - Fuel switch away from fossil fuels	Low carbon shipping options include switching to low GHG emissions fuels such as methanol, LNG, hydrogen, wind or nuclear
Aviation - Improve energy efficiency	Improve efficiency of aviation
Aviation - Fuel switch away from fossil fuels	Fuel switch to biofuels or solar
Manufacturing and Industry	
Increase energy efficiency	Improve efficiency of processes, systems, equipment and appliances
Improve material efficiency	Material efficiency in design and production; longer lasting

	products
Fuel switch away from fossil fuels	Moving from diesel and coal to biomass for process heat; shifting from diesel or gas to electricity.
Reduce process and fugitive emissions	Reducing process and fugitive emissions e.g. fugitive emissions from LNG production; process emissions from fertiliser production; clinker replacement in cement production; reduced refrigerant leakage
Low Carbon Electricity Supply	
Utility scale hydro	Provision of baseload electricity through utility-scale hydro
Micro/Mini hydro	Small scale hydro suitable for provision of electricity to a village or industrial precinct
Geothermal	Electricity generated from underground thermal energy.
Solar PV (micro, mini and community scale)	Electricity generated from the installation of solar PV on domestic or commercial buildings
Utility scale solar PV	Large scale solar PV system designed to supply electricity into the main grid.
Onshore wind	Large scale wind electricity generation on land.
Offshore wind	Large scale wind electricity generation, constructed in large bodies of water such as an ocean.
Wave / Tidal	Harnessing wave or tidal energy to generate utility-scale electricity
Transmission and distribution (T&D) efficiency improvements	Improving the efficiency of transmission and distribution infrastructure to reduce energy leakage and increase the ability to absorb greater levels of intermittent renewables
Battery storage	Battery storage to complement renewable energy and reduce issues associated with intermittency
Non-energy emissions / Land use	
Carbon farming	Best practice agriculture to increase carbon stores in soils, and reduce carbon emissions
Improved livestock management	Improved feed quality to reduce livestock enteric emissions
Reforestation	Reforestation under REDD+
Avoided deforestation	Protect existing forests from deforestation
Protect and restore mangroves	Protect existing mangroves or replant new mangroves.
Improved waste management	Improved waste management to reduce illegal dumping; aerobic landfill to significantly reduce methane emissions; landfill gas capture and utilisation

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