FIJI LOW EMISSION DEVELOPMENT STRATEGY 2018 - 2050

LIVING DOCUMENT

The Fiji Low Emission Development Strategy (LEDS) 2018-2050 shall be considered a "living" document in that information expressed in this publication represents the Fijian Government's current understanding of greenhouse gas (GHG) emissions from relevant sectors and current understanding of mitigation actions (including technology, finance, capacity building, and technical assistance needs), which can contribute to meeting the GHG reductions articulated in the four scenarios presented. The Fijian Government reserves the right to periodically update the Fiji LEDS, as may be needed, to ensure validity, transparency, and accuracy over time. Most notably, the Fijian Government understands that not all data relating to GHG emissions from the different sectors in the LEDS are currently fully known, nor are all mitigation actions fully investigated. As such, the collection of additional data and the inclusion of new or improved technology, and its costs over time, will have an impact on future national planning.

The Fiji Low Emission Development Strategy 2018-2050 was developed under the guidance of the Ministry of Economy with support from the Global Green Growth Institute.

GGGI

Hon. Voreqe Bainimarama

FOREWORD

For a Small Island Developing State (SIDS) such as Fiji, global temperature changes of 1.5°C above pre-industrial temperatures and beyond would have catastrophic impacts on our environment, infrastructure, and livelihoods. As the President of the 23rd Conference of Parties (COP23), Fiji put the global spotlight on the escalating impacts that SIDS, as the world's most vulnerable populations, are facing today.

This mission, like climate change itself, is not temporary; we continue to lead the world in climate action and will carry that torch by finding new ways to raise the bar for climate action and lead by example. While Fiji's national carbon dioxide equivalent emissions make up a statistically-insignificant 0.006% of global emissions, the Fijian Government and other non-government stakeholders in the country have already taken bold steps to achieve deep decarbonisation in all sectors of the Fijian economy.

This collective national initiative takes form through long-term emissions reductions strategies, known together as the Fiji Low Emission Development Strategy (LEDS). Fiji's LEDS came together through extensive national, sectoral, and bilateral consultations between the authors, Government ministries, civil society organisations, and the private sector. But in the end, this strategy proved to be more than a policy, and more than a grand coalition – it is our Fijian Story of raising ambition and climate action.

Our LEDS is a visionary one, outlining long-term sustainable and resilient economy-wide mitigations pathways for more than the decades ahead, through to 2050. Its development was an inclusive process which ensured that the modelled pathways had credible mitigation targets and provided synergies with sustainable economic growth.

We all should be proud of the Fiji LEDS as it is among the first long term emission reductions strategies in the world to address the Blue Carbon Sector – and in our case, that "blue" focus is particularly honed on Fiji's vital mangrove ecosystems. We've seen the wide-ranging benefits of cultivating the blue sector first-hand: reviving and restoring our mangroves not only sequesters carbon, but it allows sustenance of our people's livelihoods with a constant supply of fish and other marine organisms.

The Fiji LEDS builds onto existing mitigation and adaptation actions that are being undertaken by the Fijian government and will inform Fiji's future Nationally Determined Contributions (NDCs) reported to the United Nations Framework Convention on Climate Change (UNFCCC). The strategy will be a key tool, a guiding light, and a fundamental pillar to enhancing and raising ambition in our NDCs.

It remains absolutely critical that we take urgent action, on a worldwide scale, to limit global temperature rise to 1.5°C if life as we know it is to continue on planet earth. Warming beyond that level would be disastrous and irreversible for future generations. We urge nations to follow Fiji's lead by immediately and ambitiously reducing greenhouse gas (GHG) emissions and by aiming to achieve net zero emissions by 2050. The future of our planet – and of our children and grandchildren who will inherit it – depends on it.

Hon. Voreqe Bainimarama
Prime Minister of the Republic of Fiji and President of COP23

EXECUTIVE SUMMARY

The Fiji Low Emission Development Strategy (LEDS) 2018-2050 is a living document compiled in 2018 to define pathways to achieve low emission development in Fiji until 2050. Fiji is highly vulnerable to climate change due to its position as a Small Island Developing State (SIDS), which leaves the country exposed to sea-level rise, cyclones of increasing intensity, and flooding, among other potential consequences. It is therefore imperative to take ambitious and rapid action to address climate change, through greenhouse gas (GHG) emission reductions. Through this LEDS, Fiji will continue its climate leadership which, to-date, has included serving as the President of the 23rd Conference of the Parties (COP23) of the United Nations Framework Convention on Climate Change (UNFCCC) and the ambitious near-term targets Fiji committed to under its first Nationally Determined Contribution (NDC).

> "As the central goal of this LEDS, Fiji aims to reach net zero carbon emissions by 2050 across all sectors of its economy"

As the central goal of this LEDS, Fiji aims to reach **net zero carbon emissions by 2050 across all sectors of its economy** through pathways defined in this LEDS. To achieve this core objective, the LEDS has elaborated four possible low emission scenarios for Fiji:

- A "Business-as-Usual (BAU) Unconditional scenario," which reflects the implementation of existing and official policies, targets, and technologies that are unconditional in the sense that Fiji would implement and finance them without reliance on external or international financing.
- A "BAU Conditional scenario," which reflects the implementation of existing and official policies, targets, and technologies that are conditional in the sense that Fiji would rely on external or international financing to implement mitigation actions, thus this scenario would have higher ambition than "BAU Unconditional."
- A "High Ambition scenario" projects ambitions beyond those already specified in policies, relying on the adoption of new, more ambitious policies and technologies and availability of additional financing to implement mitigation actions, and achieves significant emission reductions by 2050 compared with the business-as-usual scenarios.
- A "Very High Ambition scenario" projects ambitions well beyond those already specified in policies, thus relying on the adoption of new, significantly more ambitious policies and availability of new technologies and additional financing to implement mitigation actions, and in which most sectors achieve net zero or negative emissions, by 2050.

These scenarios were elaborated for each sector, including: electricity and other energy use; land transport; domestic maritime transport; domestic air transport; agriculture, forestry, and other land use (AFOLU); and waste. Coastal wetlands (blue carbon) was also considered. The scenarios were then aggregated to build a whole-of-economy emission reductions pathway for each scenario.

Following extensive stakeholder consultations, analysis, and modelling of different scenarios for each sector, the LEDS shows that under the Very High Ambition scenario net zero emissions can be achieved during the year 2041, after which emissions would increasingly be net negative. The most significant mitigation of emissions would result from complete transformation of Fiji's energy sector to one based on a wide variety of on-grid and off-grid renewable energy generation. This transformation in the energy sector would involve the adoption of clean energy for commercial, industrial, and household use, as well as the conversion of most of Fiji's land transport systems to electric vehicles. The domestic aviation and maritime sectors will also convert to electricity at a more modest scale, while introducing other measures which will drastically reduce emissions. Under the Very High Ambition scenario, Fiji's energy sector itself will be virtually GHG emission free by 2050. Similarly, emissions from the waste sector will be reduced to nearly zero due to full methane capture and utilization for organic waste and extensive waste reduction and recycling programs. Fiji is able to ultimately achieve net negative emissions as a result of extensive afforestation measures, reduced deforestation, and increased use of sustainable forest plantations in the AFOLU sector.

The LEDS estimates that Fiji's emissions would more than double under BAU Unconditional scenario, grow incrementally under the BAU Conditional scenario, drop by nearly 31% under the High Ambition scenario, and achieve net negative emissions during the year 2041 under the Very High Ambition scenario. See Table 1 and Figure 1 below.

Table 1. Total Net Emissions for Fiji under four LEDS scenarios
(all values in metric tonnes CO_2e).

Scenario	2020	2025	2030	2035	2040	2045	2050
BAU Unconditional	2,344,868	2,511,395	2,812,491	3,204,777	3,602,674	4,047,357	4,544,058
BAU Conditional	2,279,948	2,200,437	2,232,885	2,259,745	2,300,641	2,286,008	2,363,344
High Ambition	2,259,578	2,032,107	1,897,665	1,732,042	1,592,815	1,499,357	1,399,040
Very High Ambition	2,250,564	1,712,595	1,264,809	637,601	136,430	-422,128	-782,767

Figure 1. Total Net Emissions for Fiji under the four LEDS scenarios
(all values in metric tonnes CO_2e).

Each of the emission reduction scenarios detailed for each sector in this LEDS is underpinned by a range of key policies and actions that must be undertaken in each sector to achieve the emission reductions. A non-exhaustive list of prioritised actions, with high-level costing and timeline, linked to the achievement of the LEDS sector scenarios is outlined in Annex A. Some of the key actions for decarbonisation in each sector are given below.

For electricity and other energy use:

- Economy-wide energy efficiency measures, capacity building, and education;
- Capacity building for renewable energy and smart grids; and
- New solar, hydro, biomass, wind, waste-to-energy, biogas, geothermal, and energy storage installations.

For land transport:

- A national electric mobility strategy;
- Transition to hybrid-electric and electric vehicles; and
- Promotion of public transport and non-motorized transport systems.

For maritime transport:

- A national action plan for decarbonisation of maritime transport;
- Transition from 2- to 4-stroke engines; and
- Revitalisation of traditional sailing culture and development of low carbon vessels.

For domestic aviation:

- Replacement of the domestic fleet with more efficient aircraft;
- Transition to solar power for all off-grid airports with solar gate power; and
- Transition to biojet fuel.

For AFOLU:

- Reduced deforestation and increases in plantation productivity;
- Extensive afforestation; and
- Reduced enteric fermentation, manure management and measures to train farmers in the use of synthetic fertilisers.

For waste:

- A national reduce-reuse-recycle (3R) policy;
- Waste-to-energy systems at wastewater and landfill facilities; and
- Waste management awareness programs.

While not directly incorporated into the net total emissions (or net negative) projections for the different scenarios, the LEDS also considers emission scenarios resulting from efforts to protect and restore **coastal wetlands**, which have the potential to sequester significant amounts of carbon dioxide. In protecting and promoting coastal wetlands, it will be critical for Fiji to adopt a mangrove management plan, to develop and implement policies and plans to replant mangroves, and to conduct extensive mapping and establish field studies of mangroves as well as seabed grasses. The inclusion of mangroves and other coastal wetlands in future updates to Fiji's LEDS could add significantly to the potential to achieve deep decarbonisation in Fiji's economy.

Achieving Fiji's Very High Ambition scenario will be challenging but it is possible with the establishment of a comprehensive enabling environment, sufficient access to technology and climate financing, and extensive capacity building and education programmes. Reducing emissions to net zero by 2050 is critical to meeting the Paris Agreement goal to keep the global average temperature increase to below 1.5°C. Fiji aims to lead the way, with this LEDS, which serves as a roadmap towards carbon neutrality by 2050.

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Steering Committee

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Government, private sector, academic institutions, development partners, and civil society

Office of the Prime Minister, Ministry of Health and Medical Services, Ministry of Rural and Maritime Development, National Disaster Management Office, Ministry of Education, Office of the Attorney General, Asco Motors Fiji Limited, Asian Development Bank, Carpenters Motors Limited, Clay Energy, Climate Works, Conservation International, COP23 Secretariat, Delegation of the European Union for the Pacific, Department of Civil Aviation, Department of Foreign Affairs and Trade, Department of Town and Country Planning, GIZ, Fiji Airports Limited, Fiji Bureau of Statistics, Fiji Bus Owners Association, Fiji Competition and Consumer Commission, Fiji Crop and Livestock Council, Fiji Development Bank, Fiji Environmental Law Association, Fiji Fishing Industry Association, Fiji Hotels and Tourism Association, Fiji Maritime Academy, Fiji Motor Traders Association, Fiji National University, Fiji Pine Limited, Fiji Ports Corporation Limited, Fiji Revenue and Customs Services, Fiji Roads Authority, Fiji Ships and Heavy Industries Limited, Fiji Television Limited, Government Shipping Services, Greenco Energy Solutions, HG Leach Fiji Limited, International Renewable Energy Agency, International Union for Conservation of Nature, Irwin Alsop Pacific Limited, Japan International Cooperation Agency, Korea International Cooperation Agency, Labasa Town Council, LajeRotuma, Land Transport Authority, Leleuvia Island Resort, Maritime Technology Cooperation Centre – Pacific, Nadi Town Council, Namosi Joint Venture, Nausori Town Council, Niranjans Motors Limited, Pacific Feeds Limited, Pacific Island Development Forum, Paradise Technologies Fiji Limited, Ramsar Convention on Wetlands, Reserve Bank of Fiji, Savusavu Town Council, Sea Quest Fiji Limited, The Pacific Community, South Pacific Waste Recyclers, Duavata Sustainable Tourism Collective, Suva City Council, Talanoa Treks, Tebara Transport Limited, The REDD Desk Fiji, The World Bank, The University of the South Pacific, Tropik Woods, United Nations Development Programme, University of Fiji, Uto ni Yalo Trust, Waste Clear Fiji Limited, Waste Recyclers Fiji

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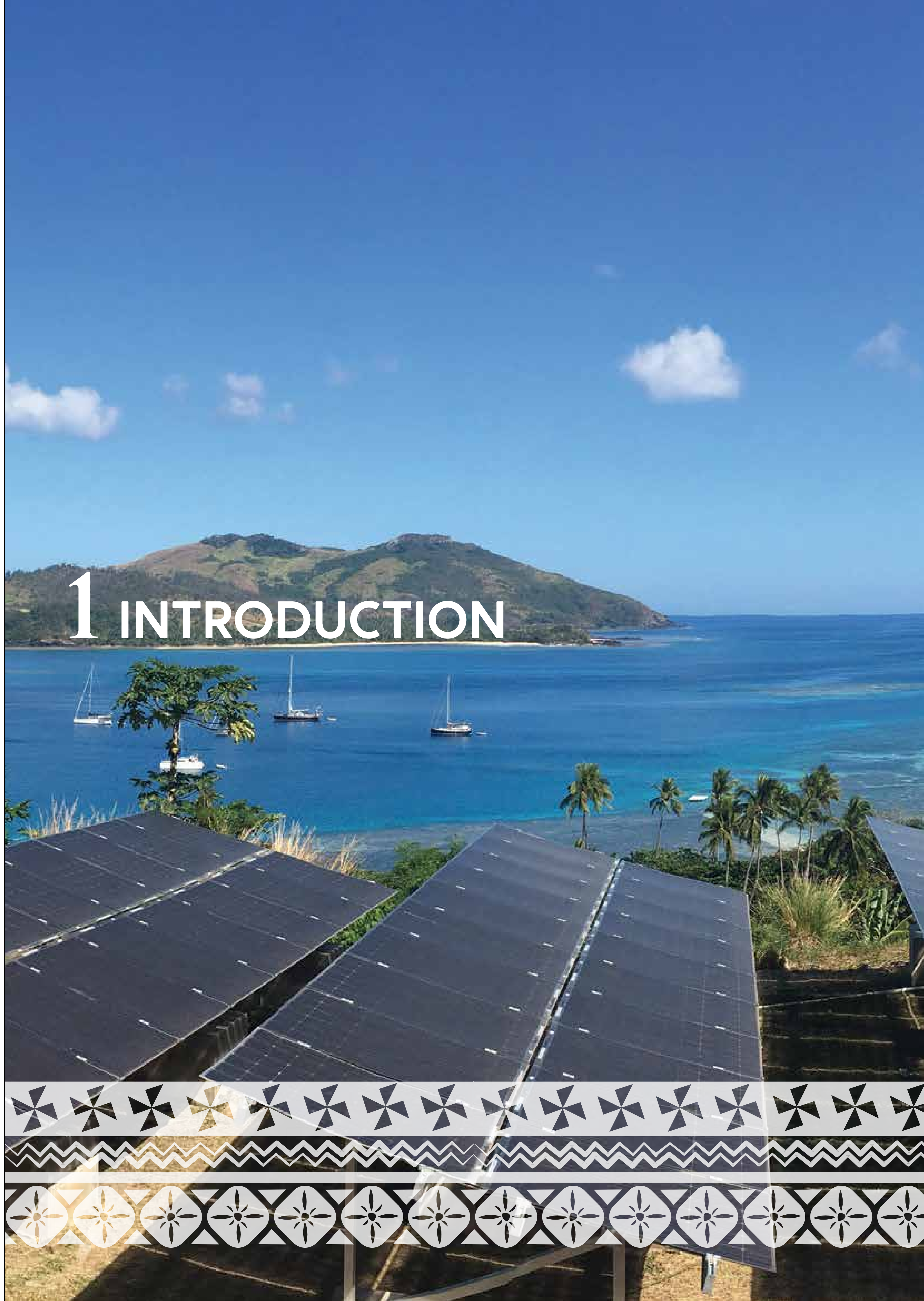
ACRONYMS AND ABBREVIATIONS

3R	Reduce, reuse, recycle
AAGR	Annual average growth rate
AC	Alternating current
ADB	Asian Development Bank
AFL	Airports Fiji Limited
AFOLU	Agriculture, Forestry, and Other Land Use
AHP	Animal health and production
AR5	Fifth Assessment Report of the Intergovernmental Panel on Climate Change
ATLB	Air Transport Licensing Board
B5	Biofuels
BAU	Business as usual
BC	Black carbon
BOD	Biological oxygen demand
BY	Base year
C	Carbon
CAA	Civil Aviation Act
CAAF	Civil Aviation Authority of Fiji
CAAFA	Civil Aviation Authority of Fiji Act
CAGR	Compound annual growth rate
CAPEX	Capital expenditure
CARA	Civil Aviation (Reform) Act
CCICD	Climate Change and International Cooperation Division
CDL	Container Deposit Legislation
CDM	Clean Development Mechanism
CERs	Certified Emission Reduction
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COP	Conference of Parties to the United Nations Framework Convention on Climate Change
CORs	Coefficient of resistances
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CSA	Climate smart agriculture
DC	Direct current
DCA	Department of Civil Aviation
DOC	Degradable organic content
DoE	Department of Energy
DSM	Demand-side management
EBA	Ecosystem-based adaptation
ECAL	Environment and Climate Adaptation Levy
EEA	European Environment Agency
EEZ	Exclusive economic zone
EFL	Energy Fiji Limited
EIA	Environment impact assessment
EPR	Extended producer responsibility
ER-PIN	Emission Reduction Program Idea Note
EV	Electric vehicle
FAO	Food and Agriculture Organisation
FAOSTAT	Food and Agriculture Organisation Corporate Statistical Database
FBoS	Fiji Bureau of Statistics
FCEF	Fiji Commerce and Employers Federation
FCPF	Forest Carbon Partnership Facility
FEA	Fiji Electricity Authority
FHTA	Fiji Hotel and Tourism Association
FIR	Flight information region
FiT	Feed-in-tariff
FJD	Fijian dollar
NCCP	National Climate Change Policy
FNTPC	Fiji National Training and Productivity Centre
FNU	Fiji National University
FOD	First order decay
FRA	Fiji Roads Authority
FRCS	Fiji Revenue and Customs Service
FSC	Fiji Sugar Corporation
GCF	Green Climate Fund
GCPV	Grid-connected photovoltaic
GDP	Gross domestic product
GEF	Global Environment Facility
GGFF	Green Growth Framework for Fiji
GGGI	Global Green Growth Institute
GHG	Greenhouse gas
GIS	Geographic information system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GLEAM	Global livestock environmental assessment model
GMBM	Global market-based measure
GOF	Government of Fiji
GPS	Global Positioning System
GSS	Government Shipping Service
GSTS	Greater Suva Transportation Strategy
GVW	Gross vehicle weight
ha	Hectares
HEVs	Hybrid electric vehicles
HFCs	Hydrofluorocarbons
HFO	Heavy fuel oil
HH	Household
ICAO	International Civil Aviation Organisation
ICT	Information and communications technology
IDO	Industrial diesel oil
ILO	International Labour Organisation
IMO	International Maritime Organisation
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent power producer
IRENA	International Renewable Energy Agency
ISO	International Organisation for Standardisation
ISWM	Integrated solid waste management
ITS	Intelligent Transport System
IUCN	International Union for Conservation of Nature
kg	Kilogram
km	Kilometre
KPI	Key performance indicator
KSTP	Kinoya Sewage Treatment Plant
kt	Kilotonnes
kWh	Kilowatt hour
LEAP	Long-range Energy Alternatives Planning system
LED	Light emitting diode
LEDS	Low Emission Development Strategy
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
LTA	Fiji Land Transport Authority
LUC	Land use change
M&E	Monitoring and evaluation
MA	Mitigation action
MAC	Marginal abatement cost
MAI	Mean annual increment
MEPS	Minimum energy performance standards
MEPSL	Minimum Energy Performance Standards for Appliances and Lighting programme
MESCAL	Mangrove Ecosystems for Climate Change Adaptation and Livelihoods
MJ	Megajoule
MLTP	Maritime and Land Transport Policy
MMC	Mangrove Management Committee
MMP	Mangrove Management Plan
MOA	Ministry of Agriculture
MoIT	Ministry of Infrastructure and Transport
MRV	Measurement, reporting and verification
MSAF	Maritime Safety Authority of Fiji
MW	Megawatt
N O	Nitrous oxide
NAP	National Adaptation Plan
NCAMP	National Civil Aviation Management Plans
NCCCC	National Climate Change Coordination Committee
NCV	Net calorific value
NDC	Nationally Determined Contribution
NDP	National Development Plan
NEP	National Energy Policy
NGO	Non-governmental organisation
NIWMS	National Integrated Waste Management Strategy
NMT	Non-motorized transport
OTEC	Ocean thermal energy conversion
PHEVs	Plug-in hybrid electric vehicles
ppm	Parts per million
PT	Public transport
PV	Photovoltaic
RE	Renewable energy
REDD+	Reducing Emissions from Deforestation and Forest Degradation
REN21	Renewable Energy Policy Network for the 21st Century
RoRo	Roll on/roll off
SDGs	Sustainable Development Goals
SE4All	Sustainable Energy for All
SEIAPI	Sustainable Energy Industry Association of the Pacific Islands

SIDS	Small Island Developing State(s)
SPC	The Pacific Community (formerly the Secretariat of the Pacific Community)
SPTO	South Pacific Tourism Organisation
STP	Sewage treatment plant
SWD	Solid waste disposal
SWDS	Solid waste disposal site
T&D	Transmission and distribution
tCO_2	Tonnes of carbon dioxide
TCs	Tropical cyclones
TNC	Third National Communication
TV	Television
TVET	Technical and vocational education and training
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
USP	University of the South Pacific
V2G	Vehicle to grid
VGM	Vatukoula Gold Mines
WAF	Water Authority of Fiji
WiG	Wing-in-Ground
WTE	Waste to energy
WTTC	World Travel and Tourism Council
WWF	World Wildlife Fund
WWT	Wastewater treatment
WWTP	Wastewater treatment plant



1 INTRODUCTION

1 INTRODUCTION

***Fiji's vision is ... to forge a grand coalition to accelerate climate action before 2020 and beyond between civil society, the scientific community, the private sector and all levels of government, including cities and regions. I repeat: We are all vulnerable and we all need to act.* – Fijian COP23 Presidency**

1.1 A MID-CENTURY LOW EMISSION DEVELOPMENT STRATEGY FOR FIJI

As a Small Island Developing State (SIDS), Fiji is one of the countries most vulnerable to the impacts of climate change, while also being among those countries least responsible for contributing to the problem. Yet Fiji has in many ways demonstrated leadership in international climate action, by being the first country to ratify the Paris Agreement and serving as President of the 23rd Conference of the Parties (COP23) of the United Nations Framework Convention on Climate Change (UNFCCC). Fiji has adopted ambitious targets in its first Nationally Determined Contribution (NDC) under the Paris Agreement and was among the first countries, and the first SIDS, to develop an NDC Implementation Roadmap. Fiji is submitting this long-term low emission development strategy (LEDS) as an extension of that leadership, outlining an ambitious path towards mid-century decarbonisation.

Fiji is at a crossroads in deciding its development trajectory in the 21st C entury. The 5-year and 20-year National Development Plan (hereinafter National Development Plan or NDP) recognizes this in its vision of transforming Fiji, stating that "Consistent with the goal of the Paris Agreement to achieve climate neutrality and a low-emission world, [Fiji] will develop a 2050 Pathway to decarbonise the Fijian economy."[1] The mid-century targets that Fiji identifies as part of its LEDS vision will serve to dramatically reduce its greenhouse gas (GHG) emissions.

This LEDS serves as Fiji's vision of, and pathway towards, a sustainable, resilient low carbon economy. In addition, it is Fiji's contribution to achieving the global climate action goal articulated in the Paris Agreement to hold "the increase in the global average temperature to 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change."[2]

Preparation of Fiji's LEDS has been led by the Climate Change and International Cooperation Division (CCICD) at the Ministry of Economy with support from the Global Green Growth Institute (GGGI). CCICD convened and chaired a LEDS Steering Committee composed of government ministries and major public utilities representing all relevant sectors in Fiji. CCICD then engaged members of the Steering Committee as well as numerous national and international experts and stakeholders from private sector, academia, and civil society through a participatory process to develop the LEDS (described in section 1.5 below).

1.2 FIJI'S VISION

Fiji aims to reach net zero carbon emissions by 2050 across all sectors of its economy. This is consistent and aligns directly with Fiji's objective stated above to ensure that net zero emissions is achieved globally by 2050[3]. It also answers the urgent call issued by the Intergovernmental Panel on Climate Change (IPCC) in the newly released report, Global Warming of 1.5°C, an IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global GHG emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (hereinafter IPCC SR 1.5°C). This report urges countries to undertake immediate and sustained GHG emissions reductions, reaching net zero in 2050, in order to have the possibility of limiting global warming to 1.5°C.[4]

Fiji's transition to a low carbon economy is critical to meeting the government's development objectives, including those elaborated in the NDP (2017) and the Green Growth Framework for Fiji (2014), as well as the internationally agreed Sustainable Development Goals (SDGs) and the 2030 Sustainable Development Agenda.

While Fiji's share of global GHG emissions is negligible compared to developed and major emerging economies, Fiji is committed to leading by example and aims to contribute to emission reductions by fully decarbonising its economy by 2050. This LEDS outlines ambitious scenarios to deeply decarbonise all sectors of Fiji's economy by or before 2050. The scenarios elaborated in the LEDS are expected to not only decarbonise the economy, but also to make Fiji's economy more innovative, sustainable, and resilient by leveraging a variety of sustainable development and adaptation co-benefits of mitigation actions.

[1]Government of Fiji. (2017a). *5-Year & 20-Year National Development* Plan.
[2]UNFCCC. (2015a). *Paris Agreement.*

[3]Government of Fiji. (2017a). *5-Year & 20-Year National Development Plan.*
[4]IPCC. (2018). Special Report on Global Warming of 1.5°C.

The vision elaborated in this LEDS, and the pathways to achieve it, will provide a benchmark against which short- and medium-term planning can be measured, including national development planning, and new or revised NDCs to be submitted to the UNFCCC. The LEDS is, however, designed to be a living document that evolves as national circumstances change over time, as data becomes available to improve modelled pathways, and as new decarbonisation options emerge.

Fiji's 2050 LEDS vision is underpinned by similar visions contained in national development frameworks, including "a better Fiji for all," which guides A Green Growth Framework for Fiji (2014) and aims for accelerated green growth that is innovative, integrated, inclusive, inspires, and creates investment for transformational change,[5] and "transforming Fiji," the vision of the NDP (2017). The concept of LEDS integrates emission reduction and sustainable development objectives into sustainable, low carbon, and resilient pathways.

"The LEDS adopts a pragmatic approach to developing sector-by-sector pathways to decarbonisation"

1.3 THE APPROACH TO FIJI'S LEDS

Fiji's LEDS takes a systematic top-down and bottom-up approach to developing an economy-wide plan to decarbonisation. The LEDS identifies a strategic high-ambition net zero vision for 2050 as established in the NDP. The LEDS then adopts a pragmatic approach to developing sector-by-sector pathways to decarbonisation, providing modelled baseline scenarios, as well as scenarios associated with Business-As-Usual (BAU) Unconditional pathways (undertaken domestically), BAU Conditional pathways (requiring international support), and High Ambition and Very High Ambition scenarios to achieve decarbonisation in each sector. The LEDS is primarily focused on mitigation, rather than adaptation, which is the primary focus of Fiji's National Adaptation Plan.

The LEDS examines the following sectors:

- Electricity and other energy generation and use;
- Land transport;
- Domestic maritime transport;
- Domestic air transport;
- Agriculture, forestry, and other land use (AFOLU);
- Wetlands (i.e., coastal wetlands, also referred to as blue carbon);
- Waste; and
- The cross-cutting sectors of tourism, commerce, industry, and manufacturing.

Apart from the last item above, the sectors are defined based on those identified in the 2006 IPCC Guidelines for National GHG Inventories, which include: energy, industrial processes and product use, AFOLU, and waste. The sectors were further selected and disaggregated to better fit key contributors to both Fiji's economic and GHG emissions profile. Sector-specific methodologies are described in Chapter 4. It should be noted that industrial process emissions were not considered in this LEDS as total emissions from this sector in Fiji are marginal.

[5]Government of Fiji. (2014a). *A Green Growth Framework for Fiji.*

1.4 WHY A LEDS?

The concept of Low Emission Development Strategies emerged in the lead-up to the climate negotiations under the UNFCCC in Copenhagen at COP15. The Copenhagen Accord notes that "a low emission development strategy is indispensable for sustainable development."[6] LEDS have since emerged as a key tool to bridge countries' sustainable development and climate mitigation objectives. While some LEDS are sectoral, the objective is an economy-wide, country-driven, national-level development strategy that promotes economic growth and long-term decarbonisation. A LEDS identifies specific pathways towards decarbonisation, and describes specific programs, policy recommendations, and implementation and financing strategies to get there.

While LEDS have never been a mandatory component under the UNFCCC, the Paris Agreement encourages Parties to submit a LEDS saying they "should strive to formulate and communicate long-term low GHG emission development strategies… taking into account their common but differentiated responsibilities and respective capabilities, in the light of different national circumstances."[7] In the decision accompanying the Paris Agreement, this is further clarified by an invitation to Parties "to communicate, by 2020, to the secretariat mid-century, long-term low GHG emission development strategies in accordance with Article 4.19 of the Agreement, and requests the secretariat to publish on the UNFCCC website Parties' low GHG emission development strategies as communicated."[8]

Fiji committed to responding to the call for mid-century LEDS in the Paris Agreement in its National Development Plan, which notes that "Fiji will strive to formulate and communicate long-term greenhouse gas emission development strategies …. As such, Fiji will develop by 2020 mid-century long-term low greenhouse gas emission development strategies, laying out a plan to deeply decarbonise the Fijian economy by 2050."[9] This LEDS will be submitted to the UNFCCC secretariat in fulfilment of both the invitation in the Paris Agreement and in alignment with the commitment made in the National Development Plan.

The adoption of an ambitious LEDS by Fiji is important as it will help to link the national climate change policy to national development plans and sectoral planning processes, engage stakeholders across the economy to enhance buy-in and ownership of climate mitigation strategies, enable Fiji to meet international climate commitments through nationally appropriate actions, and leverage public and private climate finance, both domestically and internationally.

As it concludes its Presidency of the COP, Fiji also embraces the opportunity to demonstrate leadership, as one of the first comprehensive LEDS of any SIDS and among developing countries in general, in applying the LEDS towards achieving the critically important goal of limiting global temperature increase to 1.5°C.

> "LEDS have since emerged as a key tool to bridge countries' sustainable development and climate mitigation objectives"

1.5 PROCESS FOR DEVELOPING FIJI'S LEDS

The Ministry of Economy engaged GGGI to support the LEDS in early 2018 and a workplan was jointly developed to complete the LEDS by COP24 in Katowice, Poland, including a comprehensive process for conducting stakeholder consultations, preparing economy-wide low emission scenarios, and identifying priority policies and mitigation actions.

[6]UNFCCC. (2009). *The Copenhagen Accord.*
[7]UNFCCC. (2015a). *Paris Agreement.*
[8]UNFCCC. (2015b). *Decision 1/CP.21.*
[9]Government of Fiji. (2017a). *5-Year & 20-Year National Development Plan.*

The Fiji LEDS work plan encompassed five primary tasks to complete the national LEDS:

- Task 1: Organise the LEDS Process: Institutional Arrangements, Coordination, and Multi-Stakeholder Engagement Process (conducted during the entire duration of the LEDS preparation process);
- Task 2: Assess the Current Situation: Strategies, Policies, Practices, and Capacities (conducted during March to May 2018, and included preparation of the Fiji Low Emission Development Strategy Policy Background Report);
- Task 3: Analyse Options - Identify and Analyse BAU and Low Emission Development Scenarios (conducted during June to October 2018);
- Task 4. Prioritise actions: Identify Policy, Financing, and Other Implementation Options and Priorities (conducted during June to October 2018); and
- Task 5. Prepare Fiji LEDS Document (conducted during August to October 2018).

To identify and develop both the top-down and bottom-up approaches, CCICD engaged both a LEDS Steering Committee and sector-specific stakeholders, including civil society, through committee meetings and a series of national stakeholder consultation workshops.

Steering Committee

In late February, CCICD invited 14 government ministries and agencies to the Fiji LEDS Steering Committee.[10] The Steering Committee serves as an advisory group, providing guidance, information, recommendations, and advice to CCICD and partners providing technical assistance in developing the LEDS. In March 2018, one-on-one briefings were conducted with members of the Committee to introduce and describe the LEDS process. The Committee later met twice (in March and August) and was consulted via written procedure in October 2018 to provide guidance and to review the sectoral analyses, proposed emissions reduction pathways, and the final LEDS document before it was submitted to the Cabinet for approval in November 2018.

Stakeholder Consultations

CCICD convened three National Stakeholder Workshops with key national and sub-national government, non-governmental, academic, and private sector stakeholders to inform them about the LEDS process and progress, and to solicit feedback to incorporate into the LEDS itself. The three workshops addressed: the development of Fiji's 2050 vision for low emission development, both economy-wide and for each sector; scenario development in each sector, including business-as-usual (BAU), high ambition, and very high ambition mitigation scenarios; and validation of findings for each sector.

Key stakeholders for each sector are identified in Chapter 4 (see below). Other national, regional and international stakeholders consulted during the LEDS preparation process included: the Fiji Revenue and Customs Services; the Fiji Bureau of Statistics; the Fijian Competition and Consumers Commission; the Ministry of Health; the Ministry of Women, Children, and Poverty Alleviation; the Fiji Consumer Council; Fiji Development Bank, Pacific Islands Climate Action Network; Reserve Bank of Fiji; Pacific Islands Development Forum; the Delegation of the European Union for the Pacific; KOICA; JICA; GIZ; the Australian High Commission; the New Zealand High Commission; the Fiji COP23 Secretariat; the Fiji Environmental Law Association; The Pacific Community; Westpac Banking Corporation; and the International Labour Organization, amongst others.

Approximately 100 stakeholders attended the First National Stakeholder Consultation Workshop on the Fiji LEDS on the 23rd of May, 2018. The workshop informed stakeholders on the LEDS process to date and described overall global climate change trends and considerations for achieving net zero and net-negative decarbonisation towards limited global warming to 1.5°C above preindustrial levels. The workshop also engaged participants in discussion on Fiji's long-term vision for low emission development to 2050. Sector-specific presentations were given by responsible government ministries and agencies, describing relevant current policies, sector development goals and targets, GHG reduction opportunities, and both short-term and

[10]The Fiji LEDS Steering Committee is composed of: the Climate Change and International Cooperation Division (CCICD) of the Ministry of Economy; the Ministry of Infrastructure and Transport, Department of Energy and Transport Planning; Energy Fiji Limited; the Maritime Safety Authority of Fiji; the Land Transport Authority; the Ministry of Agriculture; the Ministry of Forestry; the Ministry of Lands and Mineral Resources; the Ministry of Sugar; the Ministry of Industry and Trade, and Department of Tourism; the Ministry of Environment and Waterways, ; the Fiji Bureau of Statistics; the Fiji Revenue and Customs Services; the Water Authority of Fiji; and the Fijian Competition and Consumers Commission. CCICD Chaired the Steering Committee, while GGGI supported CCICD in serving as the Secretariat.

long-term low emission projects and financing needs. Participants developed vision statements for each sector as well as outcome-oriented, measurable, time limited, specific, and practical near- and long-term low emission development goals (as applicable). Sectors covered in the workshop included: electricity and other energy; land transport; domestic maritime transport; agriculture; forestry; waste; blue carbon and wetlands; and tourism, the commercial sector, manufacturing, and industry.[11]

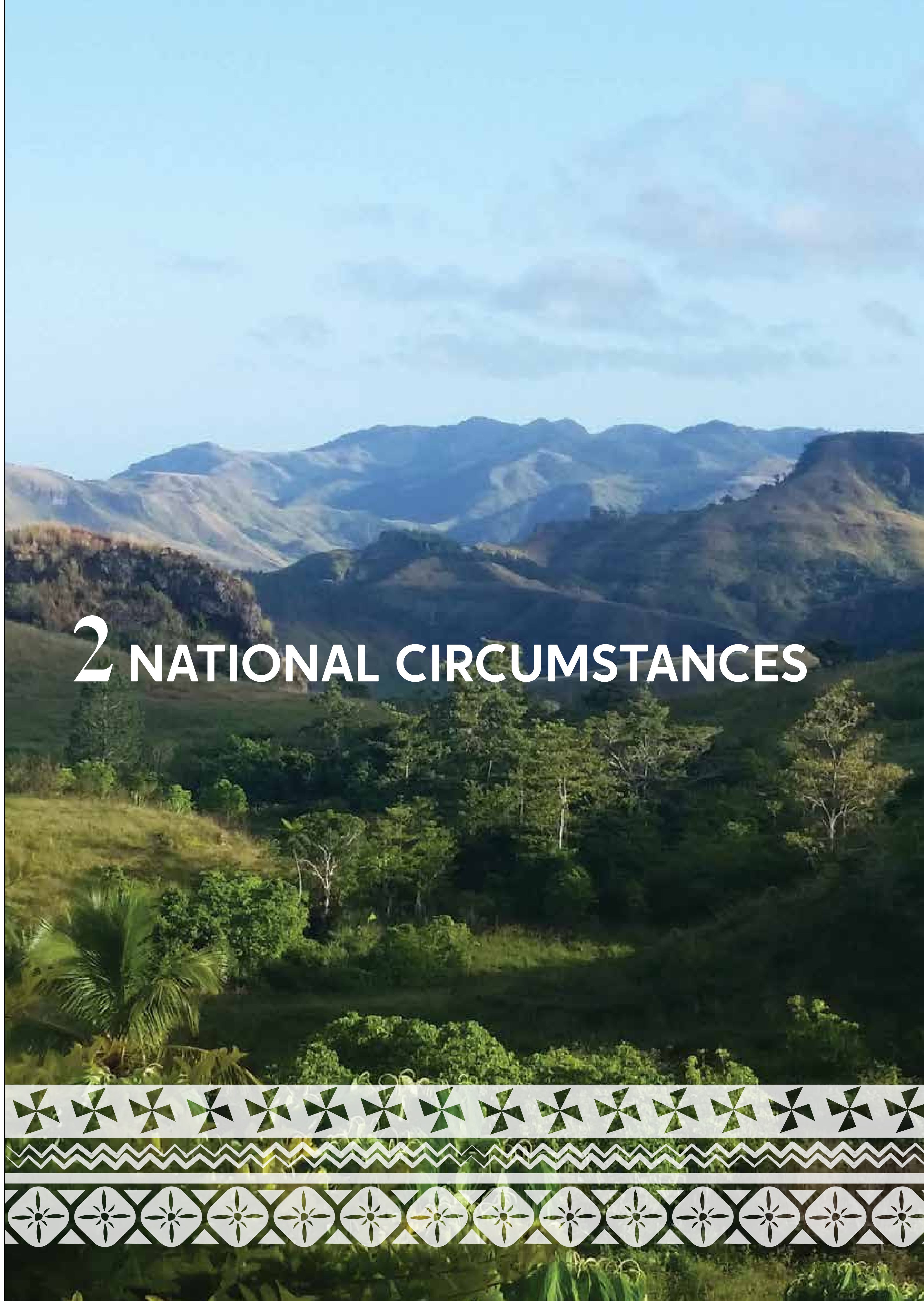
The Second National Stakeholder Consultation was arranged as a series of separate half-day workshops focusing on individual sectors during June and July 2018 on the topics of electricity and other energy, land transport, domestic maritime transport, domestic air transport, AFOLU, waste, and tourism and industry.[12] These workshops provided stakeholders with sector-specific presentations on the current emission trends and low emission ambitions (based on the first consultation workshop) and on the analysis and modelling work conducted to date, considering BAU, high ambition, and very high ambition mitigation scenarios and policy recommendations.

The Third National Stakeholder Consultation Workshop was held on the 28th of August, 2018, serving as the final stakeholder consultation in the LEDS development process. The objective was to inform stakeholders on final emission scenarios and actions that had been developed to achieve net zero emissions, receive final feedback, prioritise actions, and discuss opportunities for implementing the LEDS. For each sector, the four low emission scenarios and associated actions were presented including Very High Ambition scenarios aimed at achieving net zero emissions. Participants provided feedback by prioritising actions while considering a broad range of social, economic, and environmental criteria. This workshop also offered the first opportunity to see the effects of mitigation actions across all sectors, and, when considering all sectors in combination, demonstrated a clear pathway for Fiji to achieve net zero emissions overall by the year 2050.

1.6 OVERVIEW OF THE FIJI LEDS DOCUMENT

The Fiji LEDS is structured to progress from the domestic and international context to sector-specific low emission scenarios, then to linkages with adaptation, social, environmental, and economic considerations, and finally to governance and monitoring and evaluation (M&E) for the LEDS. Chapter 2 describes the national circumstances underlying the LEDS, including the national context, global warming context, international and regional action to address climate change, Fiji's overall efforts to achieve sustainable development, and the national legal and institutional frameworks. Chapter 3 explores pathways towards low emission development and deep decarbonisation in Fiji, looking at economy-wide scenarios for achieving Fiji's net zero vision through multi-level climate action. Chapter 4 elaborates targets and measures in detail, including emission pathways and scenarios, for each of the seven target sectors as well as considering cross-cutting sectors, such as tourism. Chapter 5 examines the climate change adaptation and resilience dimensions of implementing the LEDS, including synergies between sectoral decarbonisation pathways and adaptation, as well as adaptation in the context of Fiji's economy-wide LEDS vision. Chapter 6 explores economic, social, and environmental dimensions of the LEDS activities in Fiji. Chapter 7 provides an overview of key education, capacity building, and awareness raising actions needed to implement emission reductions for each sector of the LEDS. Finally, Chapter 8 outlines the proposed governance structure for implementing the LEDS over the coming decades, including the process for periodically updating the LEDS and also outlines a framework for monitoring and evaluation of the implementation of the LEDS. Annex A provides a list of prioritised actions to be implemented based on the low emission development scenarios presented in the LEDS.

[11]Due to lack of representation, domestic air transport was not specifically addressed in the first stakeholder workshop.
[12]Additional consultation meetings were also arranged to discuss wetlands in August 2018.



2 NATIONAL CIRCUMSTANCES

2 NATIONAL CIRCUMSTANCES

Fiji's vision is … to harness innovation, enterprise, and investment to fast track the development and deployment of climate solutions that will build future economies with net zero greenhouse gas emissions, in an effort to limit the rise of global temperatures to 1.5 degrees Celsius above pre-industrial levels. – Fijian COP23 Presidency

2.1 NATIONAL CONTEXT

Fiji is a Small Island Developing State (SIDS) in the South Pacific, encompassing an area of 18,725 km^2, and includes 332 islands in total, 110 of which are inhabited. Its population is 884,887, according to the 2017 national census, with most of the population located on the islands of Viti Levu and Vanua Levu. Fiji has a large exclusive economic zone of approximately 1.3 million square kilometres.[13] Fiji's current per capita income stands at approximately USD 5,000. The economy of Fiji has been growing since 2009, with an average growth rate of close to 4% from 2011 to 2015.[14] Growth has been driven by robust tourism and construction industries, with increasing manufacturing, finance, and transportation sectors. Investment in Fiji increased to 26% of GDP in 2015, primarily in association with private sector investment, and growth is expected to continue.[15]

In order to ensure sustainable development, it is critical to decouple economic growth from carbon emissions, while at the same time ensuring that Fiji meets its development objectives. This LEDS presents deep decarbonisation pathways across all major sectors of Fiji's economy, including: electricity and other energy use; transport (land, maritime, and domestic aviation); agriculture, forestry, and other land use (AFOLU); coastal wetlands (blue carbon); and waste.[16]

"It is critical to decouple economic growth from carbon emissions, while at the same time ensuring that Fiji meets its development objectives"

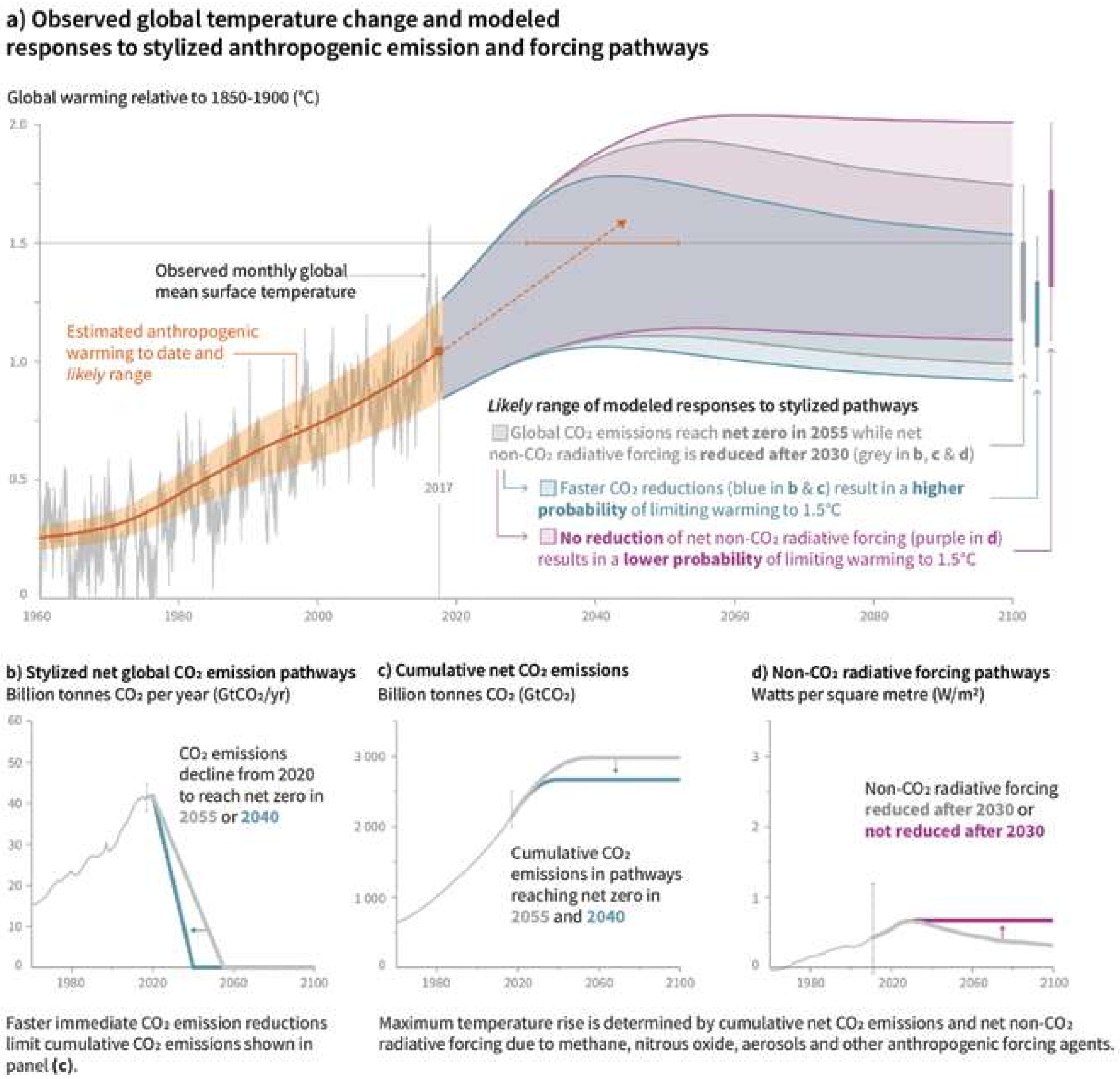
2.2 A WARMING PLANET

In February 2016, one of the strongest recorded tropical cyclones in history, Cyclone Winston, made landfall in Fiji, with peak sustained winds of 233 km per hour. The storm caused 80% of the population to lose power, while nearly 40% of the population was significantly affected by the storm, facing loss of life, property, and livelihoods. Damage amounted to more than USD 0.9 billion.[17] It is increasingly possible to attribute extreme weather events, such as Cyclone Winston, in part to climate change.

In a warming world, Fiji will face cyclones of increasing intensity, as well as other significant impacts. The Fifth Assessment Report (AR5) of the IPCC reiterates that human impacts on the climate system are incontrovertible, and that anthropogenic GHG emissions will cause and, indeed, already have caused significant impacts, including warming of the oceans and atmosphere, decreasing snow and ice, and rising sea levels, among others.[18] Figure 2 presents warming trends from 1850 to present with emission scenarios associated with different levels of emission reductions.

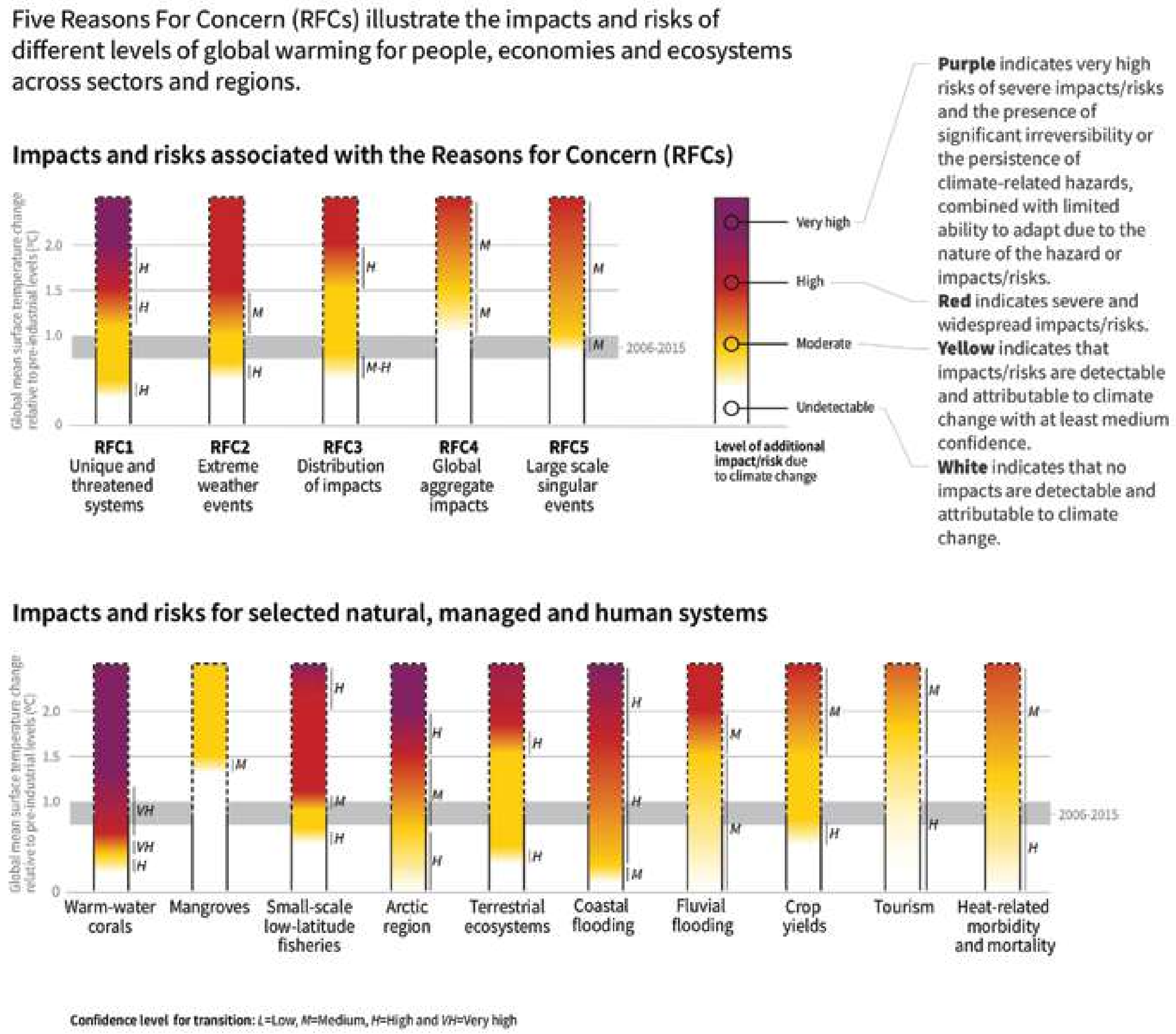
[13]Government of Fiji. (2014a). *A Green Growth Framework for Fiji.*
[14]Government of Fiji. (2017a). *5-Year & 20-Year National Development Plan.*
[15]Government of Fiji. (2017a). *5-Year & 20-Year National Development Plan.*
[16]Note, industrial process emissions are not considered in this LEDS due to a shortage of relevant data and the assumption, as in Fiji's Third National Communication, that total emissions from this sector are minimal.
[17]Government of Fiji. (2018a). *National Adaptation Plan.*
[18]IPCC. (2014). *AR5 Synthesis for Policy Makers (SPM).*

Figure 2. Cumulative Emissions of CO_2 and future non-CO_2 radiative forcing determine the probability of limiting warming to 1.5°C.



The recently released IPCC Special Report on Global Warming of 1.5°C emphasises that there are significant negative impacts at even a 1.5°C temperature increase above preindustrial levels and highlights that the observed warming in 2017 already reached 1°C above preindustrial levels. Figure 3 illustrates the level of risk associated with different levels of warming. Warming of even 1.5°C is associated with extreme weather events and poses a high risk to unique and threatened systems, while risk rapidly and significantly increases with additional warming.

Figure 3. How the level of global warming affects impacts and/or risks associated with Reasons for Concern and selected natural, managed, and human systems at a Global Scale for Increasing Levels of Climate Change.



The exact consequences of climate change for Fiji are difficult to predict as it is challenging to assess the implications of global climate models for specific localities, in particular because many of the islands comprising SIDS are significantly smaller than global circulation model grid squares (typically 200-600 km²).[19] Fiji's Climate Vulnerability Assessment does, however, identify a number of predicted impacts, including the following:

- While overall frequency of cyclones is not expected to increase, and may in fact decrease, the proportion of high-intensity cyclones (Category 4 and 5) will rise;
- Coastal flooding due to storm surges combined with sea-level rise will increase;
- Fiji experiences high flood frequency, which will increase further, with 1-in-20-year flooding events becoming 1-in-9 or 1-in-4-year events;
- Risk of landslides will increase; and
- Sea-level rise will increase exposure to unrelated risks such as tsunamis.[20]

The IPCC, in its Special Report on Global Warming of 1.5°C, reiterates that even limiting warming to 1.5°C will result in high risk of extreme weather events, high risk to unique and threatened ecosystems (including very high risk to warm water corals), and high risk of coastal flooding – all of which are of particular consequence to Fiji as a SIDS.[21]

While adaptation to climate change impacts, both globally and within Fiji, is essential, it is critical for all countries to adopt ambitious NDCs in the near-term and long-term LEDS. In order to have a chance to meet the Paris Agreement objective of keeping the temperature increase to 2°C, while pursuing efforts to limit the temperature increase to 1.5°C, warming must peak as soon as possible and must be reduced to nearly zero between 2040 and 2060, depending on the scenario (see Figure 2 above). The earlier emissions peak and the more rapidly emissions are curtailed, the more likely the earth is to avoid critical and unpredictable tipping points and the less impact vulnerable countries, such as Fiji, will experience. Pathways to achieve both 1.5°C and 2°C scenarios require ambitious action across all sectors of the economy, including energy, industry, forestry, transport, agriculture, and buildings.[22]

2.3 INTERNATIONAL ACTION TO ADDRESS CLIMATE CHANGE

Global action to address climate change began with the adoption of the UNFCCC in 1992, which requires Parties to "achieve … stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[23] Fiji has been a Party to the Convention since 1993 and has played a leading role in the evolution of the international climate regime. Most recently Fiji served as the President of COP23 to the UNFCCC in 2017, the first SIDS to do so, providing critical leadership in advancing negotiations on operationalising the Paris Agreement.

The Paris Agreement, adopted in 2015, significantly advanced the global climate objective, making the first reference to the 1.5°C goal. The Agreement provides the formal basis for a pledge and review system, in which Parties will provide, on a regular basis, new NDCs containing their national climate mitigation and adaptation targets. These near-term targets are complemented by the voluntary LEDS process, which encourages Parties to elaborate mid-century targets and associated emission reduction pathways that can guide elaboration of new or revised NDCs.

A number of parallel international processes address specific sources of emissions, which have implications for emission reductions in Fiji either because they are likely to effect technology development or market conditions in Fiji. These include: the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) adopted under the International Civil Aviation Organization (ICAO) in 2016, which creates a Global Market-Based Measure (GMBM) to promote carbon neutral growth in the international aviation sector;[24] the Initial Strategy on Reduction of GHG Emissions from Ships adopted by the International Maritime Organization (IMO) in 2018, which aims to reduce the carbon intensity of international shipping;[25] and the Kigali Amendment to the Montreal Protocol to the Vienna Convention for the Protection of the Ozone Layer, which was adopted in 2016 and establishes a pathway to phase out the use of hydrofluorocarbons (HFCs), potent GHGs, between 2036 and 2047.[26] Fiji has already ratified, or is in the process of ratifying, all of these parallel agreements.

2.4 ACHIEVING THE SUSTAINABLE DEVELOPMENT GOALS

International and national commitments to sustainable development will be difficult to achieve without addressing climate change impacts and achieving deep decarbonisation by the mid-twentieth century. At the same time, actions taken to effect deep decarbonisation have consequences, both positive and negative, on livelihoods, health, and wellbeing, as well as efforts to reduce poverty.

The international process to achieve sustainable development culminated in the 2030 Sustainable Development Agenda and the Sustainable Development Goals (SDGs) adopted in 2015.[27] While Goal 13 on climate change provides a direct link between climate mitigation and the global effort to achieve sustainable

[19]Government of Fiji. (2017c). *Climate Vulnerability Assessment.*
[20]Government of Fiji. (2017c). *Climate Vulnerability Assessment.*

[21]IPCC. (2018). *Special Report on Global Warming of 1.5°C.*
[22]UNEP. (2017a). *Emissions Gap Report; and IPCC. (2018). Special Report on Global Warming of 1.5°C.*
[23]UN. (1992). *United Nations Framework Convention on Climate Change, Art. 2, 4.*
[24]ICAO. (2016). *Environmental Report 2016 – Aviation and climate change.* International Civil Aviation Organization.
[25]International Maritime Organization. (2018). *Initial GHG Emissions Reduction Strategy.* London: IMO.
[26]UNEP. (2017b). *Kigali Amendment.*
[27]The SDGs set goals to: eliminate poverty; end hunger; ensure health and wellbeing; ensure quality education; achieve gender equality; ensure clean water and sanitation for all; ensure access to sustainable and modern energy for all; promote sustained, inclusive economic work and ensure decent work for all; build resilient infrastructure and promote sustainable industrialization; reduce income inequality; make cities and human resources sustainable; ensure sustainable consumption; take urgent action on climate change; conserve and sustainable use the oceans; protect, restore and promote sustainable terrestrial ecosystems; promote peace and access to justice; and strengthen means of implementation and revitalize the global partnership for sustainable development.

development, climate change is a cross-cutting issue across all of the SDGs.

The LEDS, as a plan to achieve long-term low carbon emissions development, provides the opportunity to integrate national sustainable development objectives into the context of deep decarbonisation and vice versa. The LEDS aims to support Fiji in meeting the SDGs at the national level by supporting country-driven processes, enhancing integration of decarbonisation strategies into national planning, aligning development and climate change and strengthening coordination, and improving multi-stakeholder engagement and action.

It is important to keep in mind that the shift to decarbonisation of the economy presented in this LEDS aims to result in emissions reductions without threatening the national long-term development objectives, as outlined in the National Development Plan (NDP) 2017-2036, and without limiting the achievement of the SDGs. The IPCC Special Report on Global Warming of 1.5°C outlines the significant risks to sustainable development of overshooting 1.5°C but notes that there are also potential trade-offs between sustainable development and net zero emission pathways. However, the IPCC acknowledges that those trade-offs can be minimised through careful and robust planning processes that integrate sustainable development and mitigation actions.[28] The LEDS will therefore be a key reference document for all stakeholders involved in national planning and low carbon pathway initiatives for Fiji.

2.5 CLIMATE ACTION IN THE PACIFIC REGION AND WITH SIDS

Fiji has also demonstrated climate leadership through engagement in regional processes that address, in particular, the impacts of climate change in the Pacific and among SIDS, in general. Fiji is a signatory to the 1994 Barbados Plan of Action, the 2005 Mauritius Strategy for Implementation, the 2005 Pacific Disaster Risk Reduction and Disaster Management Framework of Action, the 2005 Pacific Islands Framework for Action on Climate Change, and the 2016 Framework for Resilient Development in the Pacific. These focus on the vulnerability of SIDS and Pacific Island States to climate change and, in particular, to sea-level rise and increased frequency of cyclones and droughts. In addition to emission reductions, they address adaptation needs. Fiji is also the host country and a Steering Committee member for the recently established Pacific Regional NDC Hub, which aims to support Pacific Island countries to enhance and implement their NDCs, thus driving sustainable and resilient development and transition to a low carbon development pathway. The LEDS further aligns Fiji to these agreements by making a commitment, at a national level, which complements and promotes regional action.

2.6 FIJI'S LEGAL AND INSTITUTIONAL FRAMEWORKS

At the national level Fiji has a robust framework of institutions, laws, regulations, and policy and planning documents that govern economy-wide and sector specific aspects of GHG emission reductions. Fiji is a parliamentary democratic republic, governed by the Constitution of the Republic of Fiji, which came into effect on the 6th of September, 2013. The development of Fiji is guided by a series of national development planning documents, including the National Development Plan, adopted in 2017, and A Green Growth Framework for Fiji, elaborated in 2014, which set both economy-wide and sector-specific development targets for Fiji as shown in Table 2 below. Emission reduction-related targets contained in existing economy-wide and sector specific policies are described in detail in the Fiji Low Emission Development Strategy Policy Background Report, 2018, which has been published as a companion to this LEDS.

Fiji also has many climate specific policies including the 2012 National Climate Change Policy (NCCP), the initial NDC submitted in 2015, the 2017 NDC Implementation Roadmap, the 2017 National Adaptation Plan (NAP) Framework, and the 2017 Climate Vulnerability Assessment. In 2018, Fiji has finalised its NAP, as well as produced a revised 2018 NCCP aimed at scaling up adaptation and mitigation actions and strengthening sub-national climate planning.

Fiji submitted an ambitious first NDC, which aims to reduce emissions 30% from a BAU scenario by 2030, 10% of which is unconditional and achieved through implementation of the Green Growth Framework for Fiji 2014, while 20% is conditional on external funding estimated at USD 500 million in 2015.[29] The NDC Implementation Roadmap further analysed the actions needed and estimated a total cost of USD 2.97 billion for Fiji to reach its NDC targets.[30] The NDC covers the renewable energy and energy efficiency sectors and the specific actions to achieve the NDC are elaborated in the NDC Implementation Roadmap. Efforts are underway to elaborate an enhanced NDC with targets for the AFOLU and transport sectors, and the LEDS assists in this process by defining emission reduction pathways in all major sectors of Fiji's economy.

Fiji has numerous sector-specific regulations and policies. These are described in detail in the Fiji Low Emission Development Strategy Policy Background Report and, as relevant, in the sector specific sections in Chapter 4. A summary of key development goals and climate targets in Fiji's existing policies and strategies, which have been taken into account in the development of the LEDS, is given in Table 2 below.

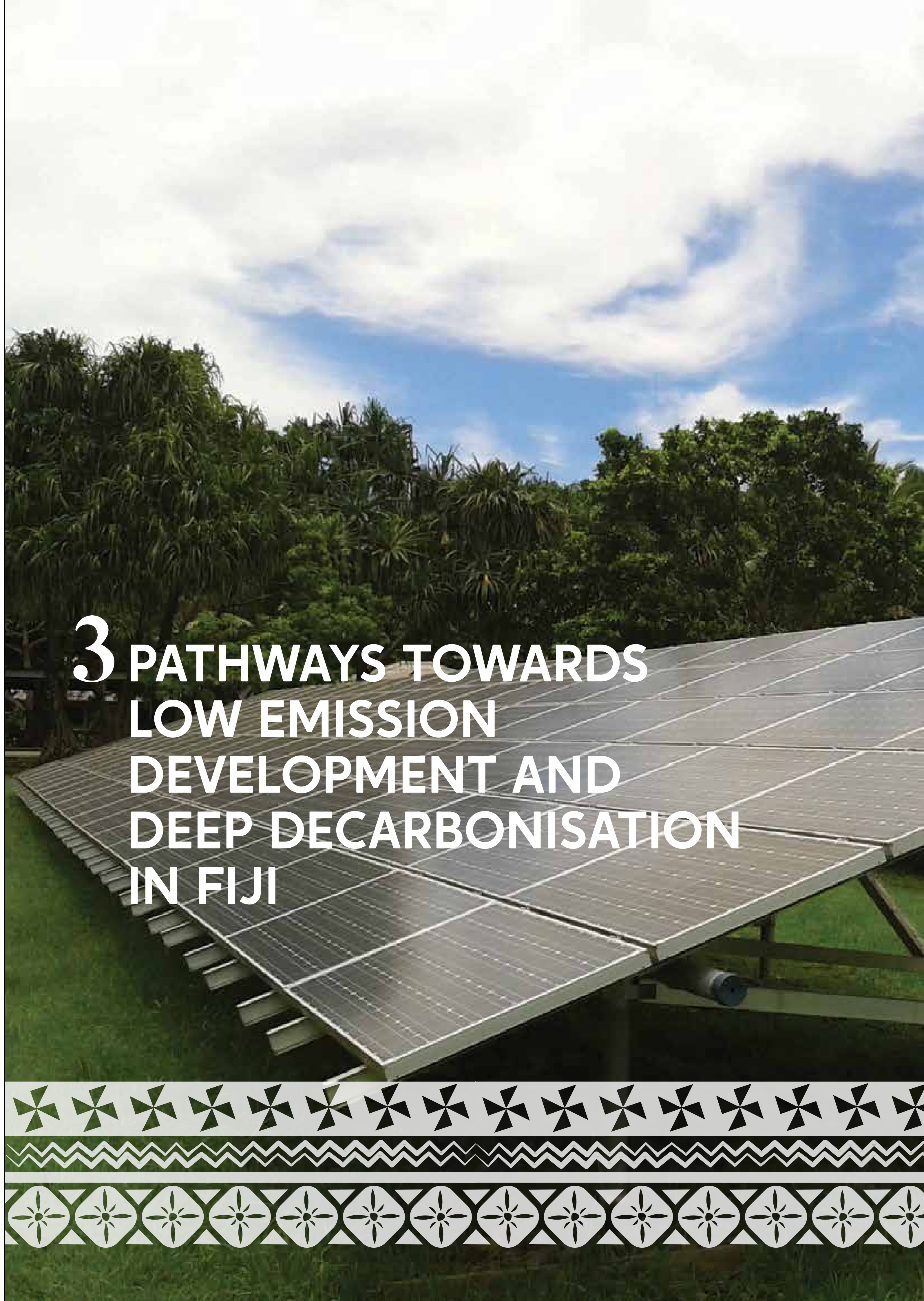
Table 2. Key Development Goals and Climate Targets in Fiji's Policies and Strategies.

Year	Target	Trajectory				
		2015	2021	2026	2031	2036
	Economic Targets					
	Goals/Targets					
2036	Fourfold increase in GDP per capita*					
2036	Average annual real GDP growth 4-5% (%)*	3.6	4-5	4-5	4-5	4-5
2036	Government debt 35% of GDP (%)*	48.7	47.7	45	40	35
2036	Unemployment rate ←4% (%)*	6.2	4	4	4	4
2030	Reduce people in poverty to 150,000 from 259,554 in 2008-2009**				150,000	
	Economy-wide Climate Targets					
	Economy-wide Climate Goals/Targets					
2050	Net-zero global GHG emissions*					
2050	Deep economy-wide decarbonisation (from 2013 base year)*				30% (energy sector)	
	Sector Specific Climate Targets					
	Energy Sector Targets/KPIs					
2021	Access to electricity (% of population) *, ***	90	100	100	100	100
2036	Population with primary reliance on wood fuels for cooking (% of population) ***	18	12	6	→1	0
2036	Reduced consumption of imported fuel per unit of GDP (MJ/FJD)***	2.89	2.86		2.73	
2036	Reduced power consumption per unit of GDP (kWh/FJD)*, ***	0.219	0.215		0.209	
2036	Renewable energy share in electricity generation (%)*, **, ***	67	81	90	99	100
2035	Increase renewable energy share in total energy consumption (%)*, ***	13	18		25	
2022	Installed solar household systems (No. households)*		1,100			
2022	Installed hybrid systems*		10			
2022	Installed mini-hydro systems*		10			
	Transport Sector Targets/KPIs					
***	Move from Euro 2 emissions standard to Euro 5 emissions standard*, **					
2021	Reduce dependence on imported fossil fuel/km travelled (%)*	42	32			
2030	Reduce final energy consumption dependence on imported fossil fuel (%)**	42	32		22	
2021	Reduce vehicle emission levels (%)*	50	40			
2021	Container port traffic (million tonnes)*	1.76	1.87			
2022	Biofuel (Ethanol/Biodiesel) plant installed*		4			

[28] IPCC. (2018). *Special Report on Global Warming of 1.5°C.*
[29] Government of Fiji. (2015). *Nationally Determined Contributions.*
[30] Government of Fiji. (2017b). *NDC Implementation Roadmap 2017-2030.*

2022	Biogas facilities, plants installed*		24			
2022	Domestic aviation passenger growth (%)*	20%	30%			
2022	Domestic aircraft landing growth (%)*	15%	20%			
2022	Increase in maritime GSS shipping vessels (No.)*	9	13			
2022	Increase registered ships/vessels (number)*	15	25			
2022	Increase registered boats*	370	490			
	AFOLU Sector Targets/KPIs					
2036	Forest area under long-term conservation (%)*	3	5			16
2022	Reforestation of degraded forests total (hectares)*	500	5,300			
2036	Increased share of food domestically produced (%)*	32	42	TBD	TBD	TBD
2022	Sugarcane production (Total No. hectares of fallow land planting and replanting)	6,000	33,000			
2022	Sugarcane production (million tonnes)*	1.39	3.0			
2022	Livestock production (% increase per annum)*	5%	5%			
	Waste Sector Targets/KPIs					
2036	Access to central sewerage system (% of population)*	25	40	50	60	70
2036	Access to central sewage system, urban (% of population)*	25	40	50	60	70
2036	Access to central sewage system, rural (% of population)*	0	40	50	60	70
2022	Wastewater system extension (km)*		141.3			
2022	Upgrading of wastewater treatment plants (number of plants)*		11			
2022	Rural sewerage plants installed*		36			
2022	Improved final disposal sites (number)*	1	5			

*Government of Fiji 2017b; ** Government of Fiji 2014; ***Government of Fiji 2014



3 PATHWAYS TOWARDS LOW EMISSION DEVELOPMENT AND DEEP DECARBONISATION IN FIJI

3 PATHWAYS TOWARDS LOW EMISSION DEVELOPMENT AND DEEP DECARBONISATION IN FIJI

3.1 FIJI'S ECONOMIC AND SOCIAL PRIORITIES AND TRENDS TO 2050

This LEDS provides not only a collection of long-term low emission development scenarios for Fiji, but also a strategy for transforming this South Pacific Island nation into one with a robust, modernised economy which has incorporated goals and targets for decarbonisation. As such, this LEDS provides an opportunity for Fiji to demonstrate international leadership and help compel nations around the world to achieve the global-level objective of limiting atmospheric warming to 1.5°C above pre-industrial levels and minimise climate risks. Fiji aspires to implement deep economy-wide decarbonisation and achieve at least net zero GHG emissions by the year 2050.

Simultaneously, as outlined in its NDP and other national policies, over the next three decades Fiji sets out to achieve a four-fold increase in GDP per capita, an annual real GDP growth rate of 4-5%, poverty reduction of 43%, and an unemployment rate of under 4%. Along these lines, Fiji aims to increase access to electricity to 100% of the population by the year 2021, convert 100% of electricity generation to renewables by 2036, and eliminate all wood consumption for cooking by 2036.[31] Therefore emission reductions envisioned in this LEDS will be achieved while supporting national development goals and working to ensure safety, access and affordability of key infrastructure services (energy, transport, water, and sanitation) to all.

As called for in its Green Growth Framework, Fiji envisions a broad transformation in its economic and social development towards low carbon, resource efficiency through measures that respond to international and regional priorities, are participatory, collaborative, and socially inclusive, promote environmental stewardship and civic responsibility, effectively manage risk, promote fair competition, and incentivise investment in the sustainable use of natural resources. [32] Fiji's approach, as laid out in the Green Growth Framework, aims to integrate efforts across ministries and sectors (avoiding "silos"), and considers 10 key development areas and environment, social, and economic pillars that work to promote disaster and climate resilience, address waste and ecosystem management challenges, promote inclusive social development, food security, and improved water and sanitation, as well as promote sustainable energy and transportation, innovation, and greener tourism and manufacturing.[33]

As reflected in the more ambitious scenarios in this LEDS, Fiji's long-term development aspirations reflect coordinated action domestically and significant international engagement. A key aspect of this is the need for considerable financing and investment – especially for the most ambitious scenarios – for adopting (and, in many cases, importing) low emission technologies and significantly improved management practices in low or zero emission energy, transport, waste management, agriculture, forests, and coastal wetlands.

Through these measures, Fiji expects to achieve a number of key benefits, including increasing GDP and revenue (for example, by valuing ecosystem services), diversifying the economy (and thus reducing economic risks), technology innovation and increased adoption of green technology, increased productivity and efficiency in using natural resources, protection of natural capital, reduced environmental impacts, improved livelihoods and quality of life for the poor, decent jobs, enhanced human and social capital, and increased equality. [34]

Fiji has established targets through its NDP and NDC Implementation Roadmap to reduce reliance on imported fossil fuels in the near- and medium-term, reduce pollution from vehicles, promote the development of biofuel and biogas production, increase adoption of biofuels, expand domestic air travel (to accommodate increased tourism), expand long-term conservation of forest areas and reforestation of degraded forests, increase domestic food production, and increase sugarcane and livestock production. By 2036, Fiji also aspires to expand access of urban and rural households to central sewerage from 25% and 0% respectively to 70%, along with upgrades to wastewater treatment plants and new rural sewerage plans.

As described in Fiji's NDP, implementation of the entire plan, which spans 2017 to 2036, is expected to require more than USD 23.4 billion (FJD 50 billion) of investment in Fiji's economy and social development over the next 20 years, including both capital expenditures and provision of social services. The Fijian Government envisions mobilising both domestic revenues (tax and non-tax) and international financial resources, including funding from multilateral development partners, as well as an increasing core source of financing from private sector and climate finance sources.[35] As a subset of these investments, as noted above, the government estimates that the total cost of implementing Fiji's NDC Implementation Roadmap will be USD 2.97 billion.

3.2 ECONOMY-WIDE LEDS PATHWAYS

This LEDS document presents a comprehensive description of the range of options and priorities for Fiji to achieve net zero emissions by mid-century. Detailed descriptions of the pathways are discussed in each of the subsections of Chapter 4, below. These scenarios are largely based on existing and proven technologies; although, given the long timeframe, some basic assumptions have been made about technological advances as well as the economic and financial feasibility of adopting technologies that are currently not yet widely commercialised.

This LEDS presents four possible low emission scenarios for Fiji to consider adopting. These include:

- A "BAU Unconditional scenario," which reflects the implementation of existing and official policies, targets, and technologies that are unconditional in the sense that Fiji would implement and finance them without reliance on external or international financing (largely based on the approach taken in the NDC Implementation Roadmap).
- A "BAU Conditional scenario," which reflects the implementation of existing and official policies, targets, and technologies that are conditional in the sense that Fiji would rely on external or international financing to implement mitigation actions (similar to those described in the NDC Implementation Roadmap), thus this scenario would have higher ambition than "BAU Unconditional."
- A "High Ambition scenario" projects ambitions beyond those already specified in policy, thus relying on the adoption of new, more ambitious policies and technologies and the availability of additional financing to implement mitigation actions. This scenario aims to achieve significant emission reductions by 2050 compared with the business-as-usual scenarios.
- A "Very High Ambition scenario" projects ambitions well beyond those already specified in policy, thus relying on the adoption of new, significantly more ambitious policies and technologies and the availability of new technologies and additional financing to implement mitigation actions. Under this scenario, the aim is to achieve at least net zero emissions, if not net negative emissions, by 2050 or earlier in most sectors.

Following extensive stakeholder consultations, analysis, and modelling of different scenarios for each sector, the LEDS estimates that net zero emissions is achievable under the Very High Ambition scenario in the year 2041, after which emissions would increasingly be net negative. Under the BAU scenarios total emission levels are expected to stay more or less at the same level between 2020 and 2050 – initially declining due to increased adoption of mitigation measures, and then rising again as Fiji's economy and population continue to grow. However, much more significant emissions mitigation will be possible under the High Ambition scenario, and dramatically lower emissions under the Very High Ambition scenario. The most significant mitigation of emissions results from complete transformation of Fiji's energy sector to one based on a wide variety of on-grid and off-grid renewable energy generation. This transformation of the energy sector would involve the adoption of clean energy for commercial, industrial, and household use, as well as the conversion of most of Fiji's land transport systems to electric vehicles. The domestic aviation and maritime sectors will also convert to electricity at a more modest scale, while introducing other measures which will drastically reduce emissions. Under the Very High Ambition scenario, Fiji's energy sector itself will be virtually GHG emission free by 2050. Similarly, emissions from the waste sector will be reduced to nearly zero as a

[31] Government of Fiji. (2017a). *5-Year & 20-Year National Development Plan;* and Government of Fiji. (2017b). *NDC Implementation Roadmap 2017-2030.*
[32] Government of Fiji. (2014a). *A Green Growth Framework for Fiji.*
[33] Government of Fiji. (2014a). *A Green Growth Framework for Fiji.*
[34] Government of Fiji. (2014a). *A Green Growth Framework for Fiji.*
[35] Government of Fiji. (2017a). *5-Year & 20-Year National Development Plan.*

result of full methane (CH_4) capture and utilization for organic wastes and extensive waste reduction and recycling programs.

The primary emissions offsets envisioned under the LEDS will be achieved through AFOLU-related measures, including reducing deforestation and investing heavily in sustainable tree plantations and extensive afforestation. While currently difficult to calculate, due to limited local data, significant additional offsets are also envisioned through mangrove restoration and protection programs.

Table 3 provides an overview of total emissions for each sector and for each scenario (note, values for all gases have been converted to metric tons CO_2e). Detailed descriptions of all emission projections (by source), data and assumptions, and policy priorities are provided for each sector in Chapter 4.

Table 3. Summary of Low Emission Scenarios for All Sectors
(metric tonnes CO_2e).

BAU Unconditional	2020	2025	2030	2035	2040	2045	2050
Electricity and Other Energy Use	237,124	219,734	282,652	430,975	603,157	834,329	1,121,791
Land Transport	817,396	937,084	1,112,908	1,277,184	1,416,260	1,531,237	1,623,846
Domestic Maritime Transport	198,500	229,900	267,200	317,500	379,100	454,000	545,300
Domestic Air Transport	21,000	27,000	34,000	41,000	50,000	58,000	68,000
AFOLU	870,681	870,729	864,670	858,614	852,554	846,498	840,439
Waste	200,167	226,948	251,061	279,504	301,603	323,293	344,682
Total	**2,344,868**	**2,511,395**	**2,812,491**	**3,204,777**	**3,602,674**	**4,047,357**	**4,544,058**

BAU Conditional	2020	2025	2030	2035	2040	2045	2050
Electricity and Other Energy Use	218,687	167,135	189,934	243,896	325,654	342,695	425,242
Land Transport	801,483	850,057	868,969	829,826	775,607	718,293	672,287
Domestic Maritime Transport	195,600	204,500	205,900	221,000	245,300	288,100	340,500
Domestic Air Transport	21,050	25,763	31,484	37,449	44,099	49,945	56,537
AFOLU	870,681	815,412	784,561	753,711	722,859	692,008	661,157
Waste	172,447	137,569	152,037	173,863	187,122	194,967	207,621
Total	**2,279,948**	**2,200,437**	**2,232,885**	**2,259,745**	**2,300,641**	**2,286,008**	**2,363,344**

High Ambition	2020	2025	2030	2035	2040	2045	2050
Electricity and Other Energy Use	213,250	164,719	170,922	184,073	184,121	220,646	240,262
Land Transport	791,991	784,501	768,410	701,325	626,637	549,649	477,104
Domestic Maritime Transport	190,100	170,500	145,400	147,600	153,400	172,800	197,400
Domestic Air Transport	21,109	25,863	31,634	36,374	41,485	44,790	48,638
AFOLU	870,681	748,954	663,852	578,752	493,652	408,552	323,453
Waste	172,447	137,569	117,447	83,918	93,520	102,919	112,183
Total	**2,259,578**	**2,032,107**	**1,897,665**	**1,732,042**	**1,592,815**	**1,499,357**	**1,399,040**

Very High Ambition	2020	2025	2030	2035	2040	2045	2050
Electricity and Other Energy Use	208,577	137,565	100,663	80,788	31,476	24,276	2,695
Land Transport	790,929	712,473	640,285	368,761	215,399	60,590	0
Domestic Maritime Transport	187,200	152,300	102,600	70,200	31,600	1,000	0
Domestic Air Transport	21,109	25,863	31,634	36,395	41,536	39,971	37,937
AFOLU	870,302	546,824	272,180	-2,461	-277,101	-551,743	-826,386
Waste	172,447	137,569	117,447	83,918	93,520	3,778	2,987
Total	**2,250,564**	**1,712,595**	**1,264,809**	**637,601**	**136,430**	**-422,128**	**-782,767**

Figure 4. BAU Unconditional scenario.

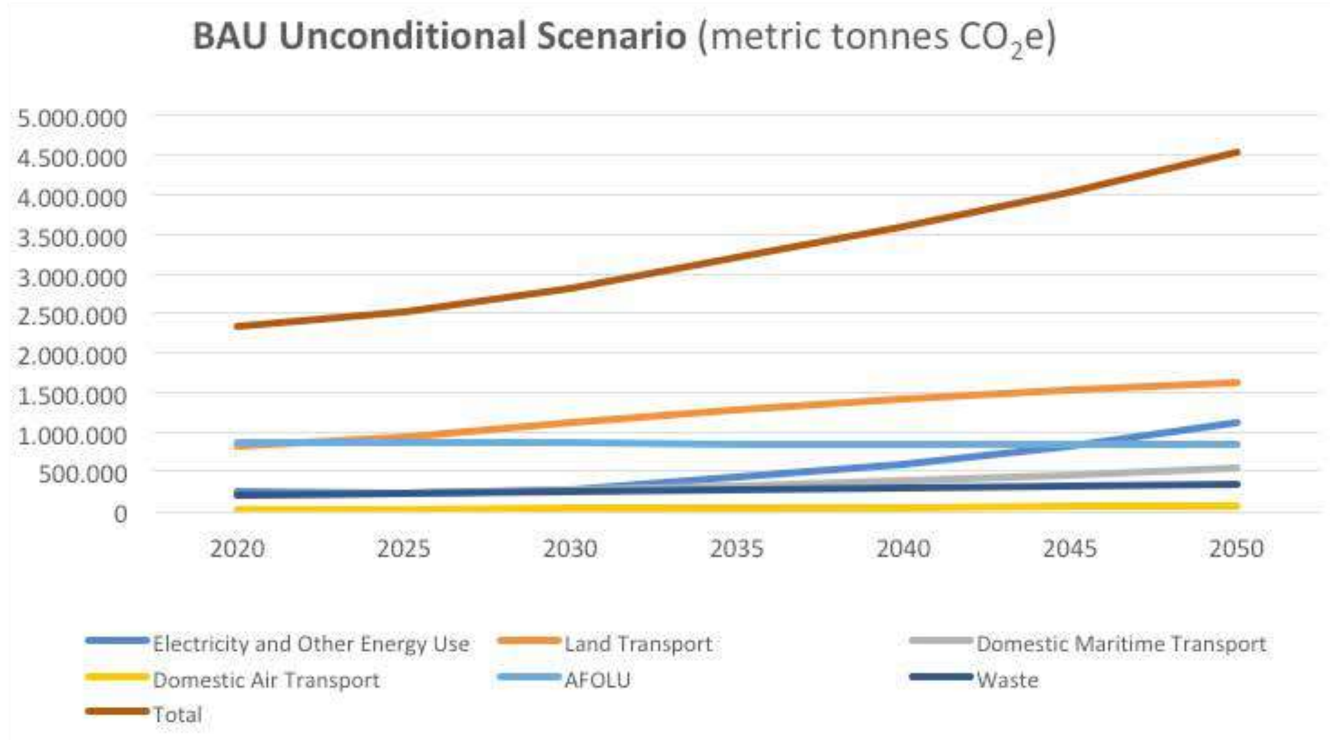


Figure 5. BAU Conditional scenario.

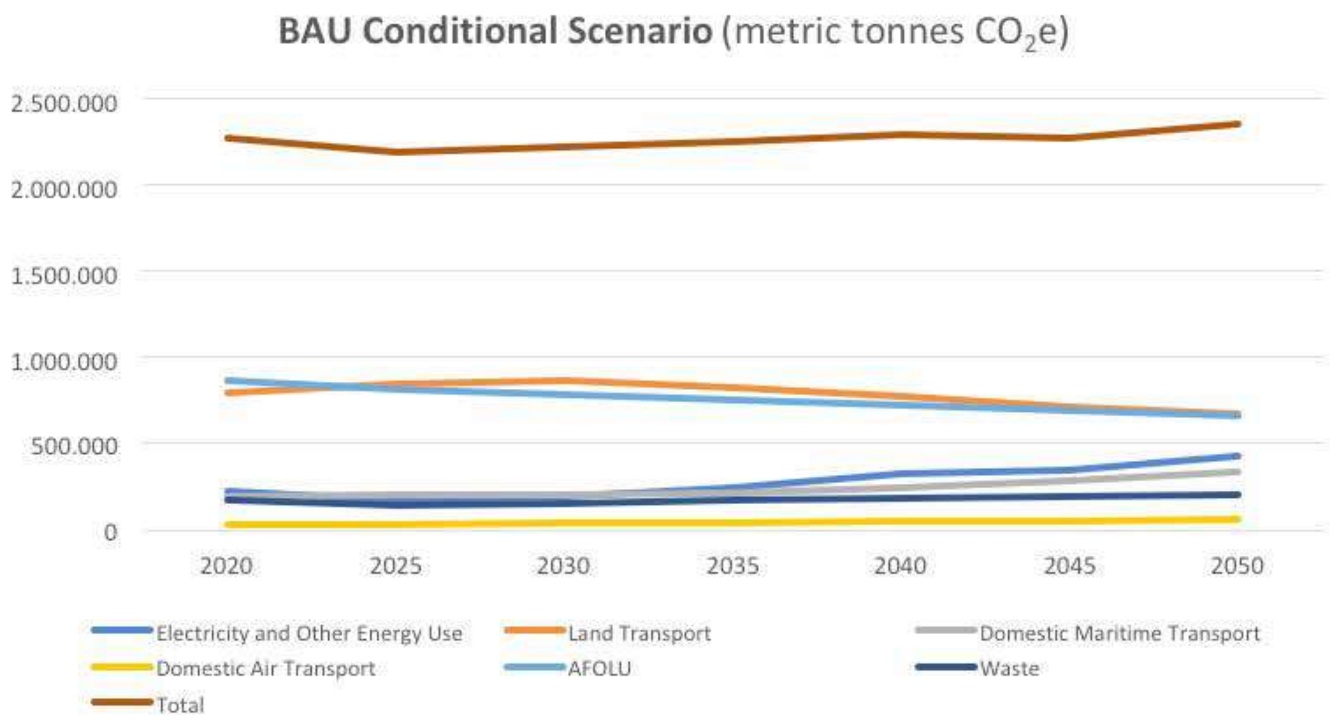


Figure 6. High Ambition scenario.

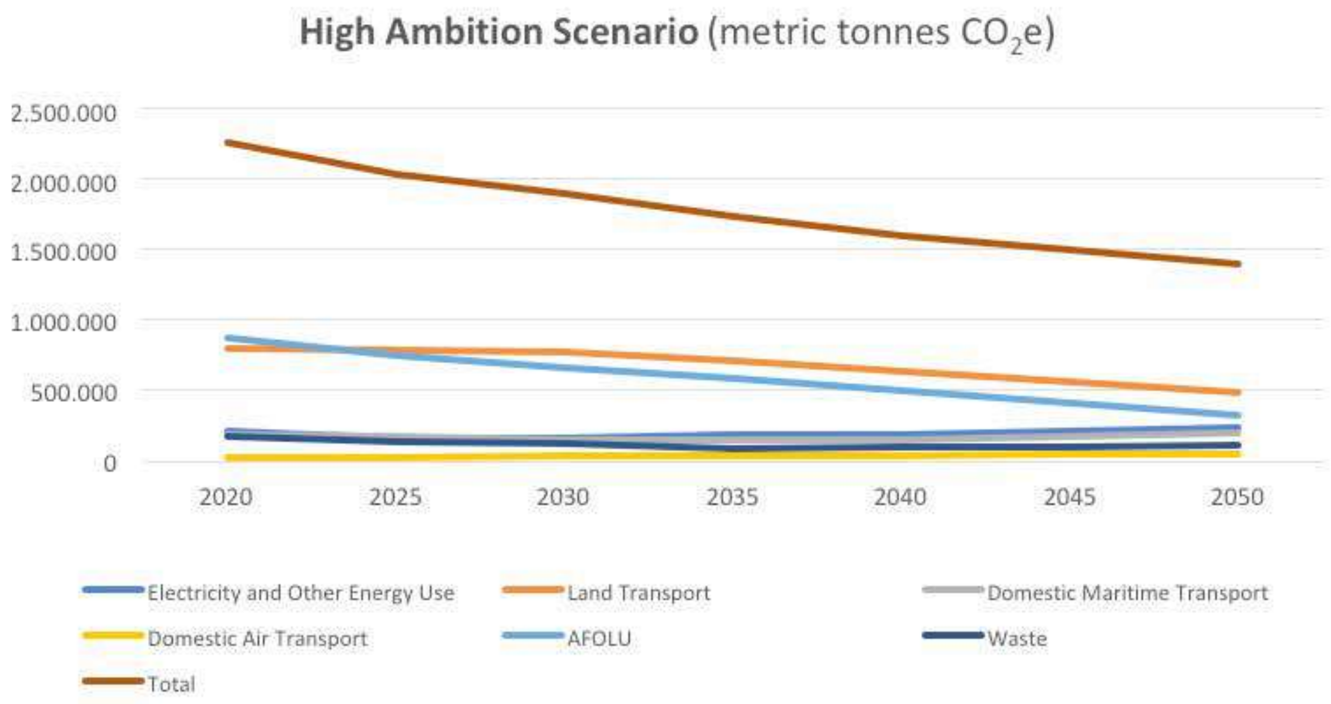
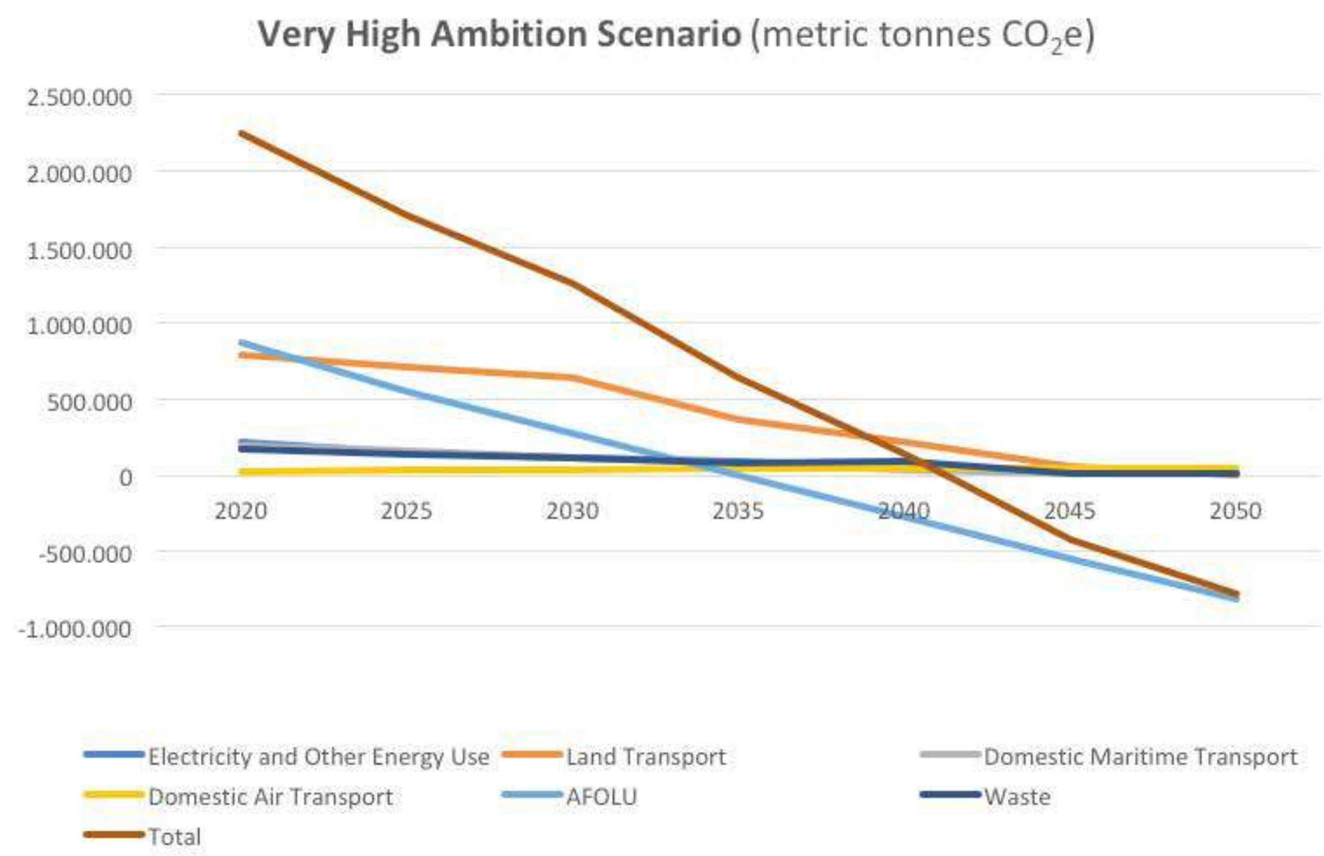


Figure 7. Very High Ambition scenario.



Consideration of Coastal Wetlands

As noted above, whereas the values presented in Table 3 are increasingly ambitious, particularly in the High and Very High Ambition scenarios, the totals do not include the estimates for Coastal Wetlands, provided in section 4.6 below, as the methodology used is simpler than for the other sectors (due to a lack of data). Nevertheless, it is worth noting that stopping the removal of mangroves and promoting mangrove recovery and replanting has the potential to provide dramatic sequestration benefits. With the inclusion of Coastal Wetlands, under the BAU Unconditional scenario, due to continued conversion, total emissions are projected to increase by an additional 297,106 tCO_2e to a net total of 4,841,164 tCO_2e in 2050 for Fiji. Under the BAU Conditional scenario emissions would increase by an additional 231,189 tCO_2e to a net total of 2,594,533 tCO_2e. With the noteworthy sequestration benefits provided in the High Ambition and Very High Ambition scenarios, by 2050 net national emissions could decrease by an estimated 531,204 and 939,672 tCO_2e, respectively, to total net emissions of 867,836 under High Ambition and net negative emissions of an estimated 1,722,440 tCO_2e under Very High Ambition. While still based on limited information, this analysis suggests that Fiji could achieve net negative emissions much earlier if it were to adopt a highly aggressive mangrove restoration program.

"Stopping the removal of mangroves and promoting mangrove recovery and replanting has the potential to provide dramatic sequestration benefits"

4 SECTOR-SPECIFIC TARGETS AND MEASURES

"Today hydropower is the mainstay of Fiji's electricity supply"

4.1 ELECTRICITY AND OTHER ENERGY GENERATION AND USE

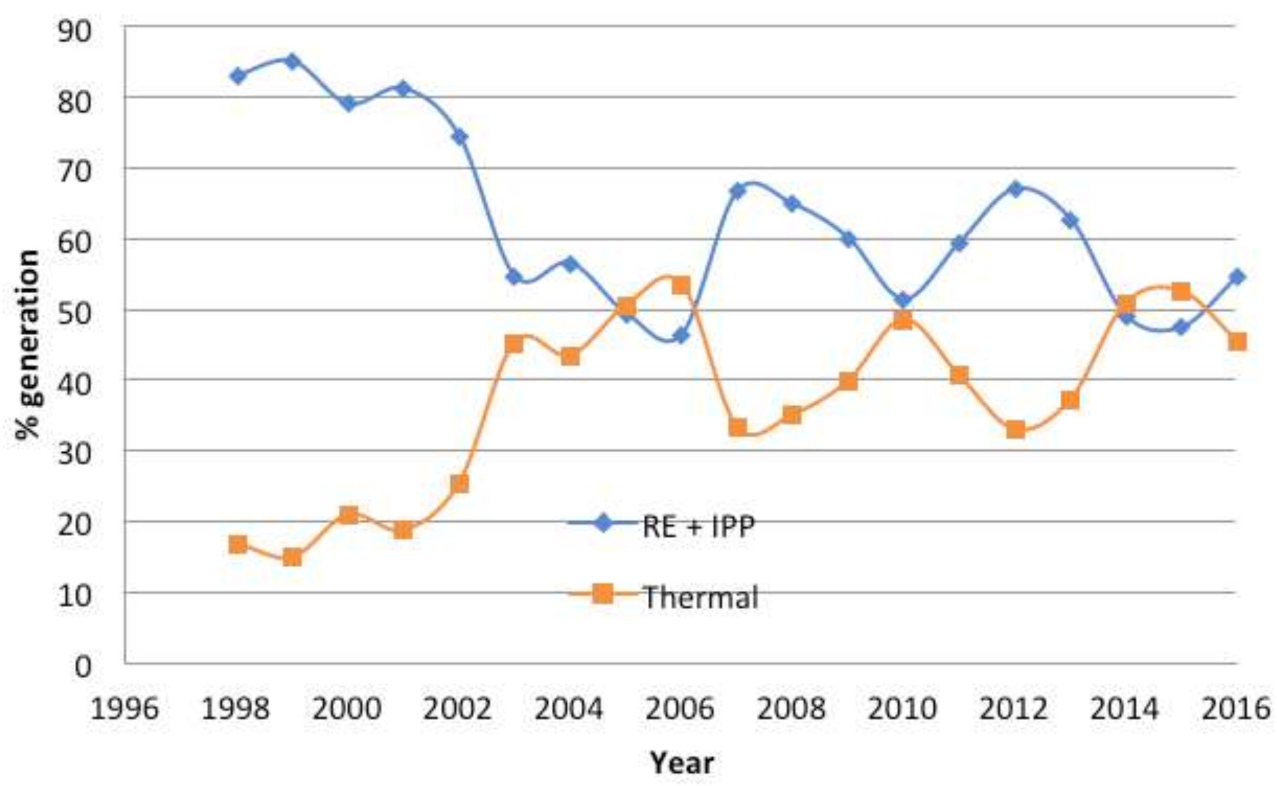
4.1.1 Overview

This section examines the electricity and other energy use component of Fiji's LEDS including grid electricity on the major islands, domestic cooking fuels, and LPG usage in commercial and industrial sectors. It also deals with the electricity generation and usage as well as cooking fuel consumption for off-grid locations, including off-grid tourism resorts and the Vatukoula Mine.

Fiji's sole utility Energy Fiji Limited (EFL), formerly Fiji Electricity Authority (FEA), provides grid electricity to the three major islands, Viti Levu, Vanua Levu, and Ovalau, and has recently established a fourth utility grid network system in Taveuni in 2016. EFL is a vertically-integrated utility providing generation, transmission, distribution and sales services. The energy mix for electricity generation comprises mainly hydropower (varying between 45-65% over the last 10 years depending on annual rainfall and other factors) and thermal (industrial diesel oil, or IDO, and heavy fuel oil, or HFO) with some contributions from biomass and wind power (1-3%) and under 1% contributed by solar during 2005-2015. Fiji regulations do not allow more than 500 ppm of sulphur in IDO. [36] The total installed capacity in 2016 was 316 MW with contributions from hydropower (130 MW), wind and biomass (21 MW), and diesel (164.9 MW).[37] A 12 MW biomass plant near Sigatoka and approximately 3 MW grid-connected PV (GCPV)[38] were added in 2017. EFL's major installations include: Monasavu hydro (80 MW),[39] Nadarivatu hydro (40 MW), and approximately 112 MW of diesel generators. As can be seen in Figure 8, hydropower is the mainstay of Fiji's electricity supply with weather patterns being a factor in actual annual generation.

[36]Isley et al. (2016). Managing Air Quality in Suva. *European Journal of Sustainable Development*. https://research-management.mq.edu.au/ws/portalfiles/portal/16812097/mq-57690-Publisher+version+%28open+access%29.pdf.
[37]Parliament of the Republic of Fiji. (2016). *Standing Committee on Economic Affairs. Report on Fiji Electricity Authority Annual Report 2016*. Department of Legislature. *http://www.parliament.gov.fj/wp-content/uploads/2018/03/FEA-2016.pdf*.
[38]The GCPV systems are owned and operated by Sunergise.
[39]Also called the Wailoa Hydro.

Figure 8. Electricity generation by source (EFL).[40]

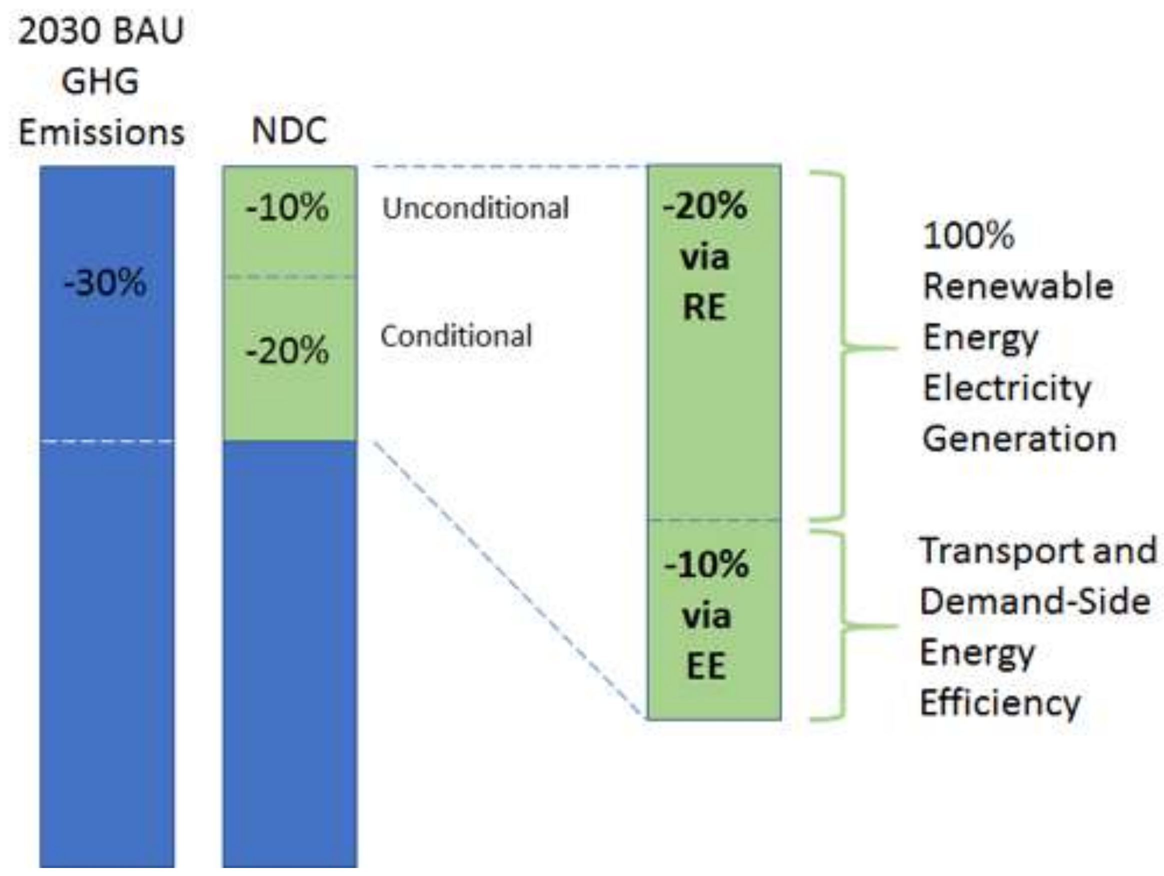


EFL's current long-term development plan (2018-2030) includes new hydropower installations (120 MW), solar PV (25 MW), and biomass (10 MW) together with the improvement and extension of transmission and distribution networks.

Fiji's NDC envisions a 100% renewable energy-based electricity future by 2030, which, combined with economy-wide energy efficiency measures, will help reduce Fiji's carbon emissions by 30%.[41] This target is similar to that stipulated in Fiji's Green Growth Framework[42] and SE4All Gap Analysis Report.[43] One third of these emissions reductions (10%) are expected to be achieved through the implementation of the Green Growth Framework (unconditional), while the rest would require external funding (conditional). Figure 9 below represents Fiji's NDC targets and the split between electricity generation and energy efficiency measures.

[40]http://efl.com.fj/wp-content/uploads/2017/08/fea-annual-report-2016.pdf
[41]Government of Fiji. (2015). *Nationally Determined Contributions.*
[42]Government of Fiji. (2014). *A Green Growth Framework for Fiji.*
[43]Department of Energy. (2014b). *Sustainable Energy for All (SE4All): Rapid Assessment and Gap Analysis.*

Figure 9. Fiji's NDC emission reduction targets.[44]



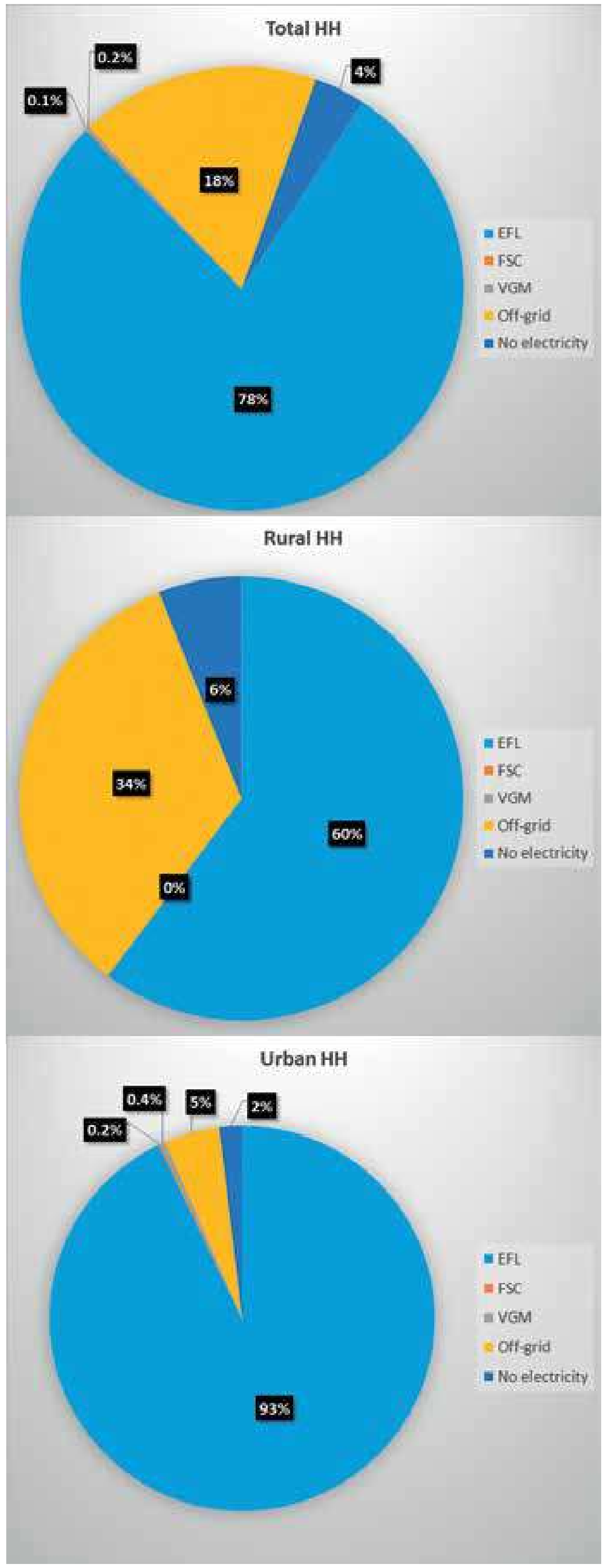
Fiji's National Development Plan aims to achieve 100% electrification of the Fiji population by 2021 and estimates that Fiji's electricity sector will become fully renewable energy-based by 2036.[45] The 100% electrification will be achieved through grid extension on the four main islands and rural electrification schemes (solar home systems and hybrid mini-grids) on the smaller islands.

There have been recent investments in the electricity grid sector in Fiji by Independent Power Producers (IPPs), notably by Sunergise, Eltech Ltd., and also Fiji Sugar Corporation (FSC).[46] There is an ongoing effort to provide electricity to most of the population living in rural areas on larger islands through grid extension funded by the Fijian Government and implemented by EFL, while smaller islands are being served with mini/micro grids and solar home systems managed by the Government.

According to the 2017 national census, almost 18% of total households are dependent on off-grid electricity. Figure 10 shows the breakdown of the source of electricity for urban and rural households which ranges from EFL to home generators to electricity supplied by the FSC power system.

[44]Government of Fiji. (2017b). *NDC Implementation Roadmap 2017-2030.*
[45]Government of Fiji. (2017a). *5-Year & 20-Year National Development Plan.*
[46]GGGI. (2018). *Fundamental assessment report, Development of Fiji's NDC Energy Sector Implementation Roadmap.*

Figure 10. Electricity providers to households.



Fiji has the natural resources to make the electricity sector fully renewable and reduce its carbon footprint significantly. However, in order to make economy-wide emission reductions, deep decarbonisation policies and strategies are required across all sectors. The transport sector (land, marine, and domestic aviation) is the primary consumer of fossil fuels in Fiji. It will be imperative to electrify the transport sector using renewable energy if a zero emission energy future is envisaged. This is discussed under the High Ambition and Very High Ambition scenarios below and in sections 4.2, 4.3, and 4.4 of the LEDS on land transport, maritime transport, and domestic air transport, respectively.

4.1.2 Emission Sources

Summary of Emission Sources

The main emission sources are diesel and HFO generators, household fuels (fuel wood and kerosene), and LPG use in households, commercial, and industrial sectors. It is assumed that LPG usage in tourism is also included in commercial and industrial data obtained from the Third National Communication (TNC).

Type of Emissions

Although the GHGs emitted by the fuels under consideration are CO_2, CH_4, and NOx, CO_2 is the dominant GHG for this sector.

4.1.3 Existing Policy, Institutional, and Regulatory Framework

Fiji continues to seek alternative energy sources to supplement its heavy dependence on imported fossil fuels, with the goal of being fully reliant on renewable energy by 2030. The Electricity Act of 2017 provides for an independent regulator for the electricity industry with powers to make regulations and grant licenses to ensure the efficient running of the electricity industry.[47] The government's reform of the electricity sector is on-going and includes restructuring of EFL and establishing the new electricity industry regulator – the Fijian Competition and Consumer Commission.

The Department of Energy (DoE) is responsible for energy policies and plans, energy efficiency and conservation, renewable energy (RE) research, and rural electrification. The draft 2013 National Energy Policy (NEP) provides guidance on promoting access to affordable and sustainable energy services to rural areas, grid-based electricity supply and renewable energy development, transport, petroleum, and biofuels, and energy efficiency.

The NDP has an overall goal of "a resource efficient, cost effective and environmentally sustainable energy sector." Fiji has a target of 100% electrification by 2021 and has a rural electrification programme in place funded by the Fijian Government and development partners. The target of reaching close to 100% renewable electricity by 2030 is stated in Fiji's NDC and supported by the NDP and other policy documents such as the Green Growth Framework. Detailed actions for exploration and implementation of renewable energy sources are laid out in the Fiji NDC Implementation Roadmap 2017-2030.[48] The Fijian Government is supporting research and development in biofuels and biogas applications. The main policy documents for the Fiji energy sector include: The National Energy Policy, 2013 (draft); Fiji's First NDC, 2015; the Fiji NDC Implementation Roadmap, 2017; the Fiji Green Growth Framework, 2014; and the NDP, 2017.

"The NDP has an overall goal of a resource efficient, cost effective, and environmentally sustainable energy sector"

4.1.4 Methodology

Model and Methodology Used

The Long-range Energy Alternatives Planning (LEAP) tool was employed for modelling the four scenarios for the energy sector. LEAP software is utilized by a number of countries for integrated resource planning and GHG mitigation assessments and developing LEDS.[49] A bottom-up approach is used in the demand structure which was divided into household, commercial, industrial, and streetlights components. Tourism has been included commercial and industrial demand. The base year for modelling is 2013 and end year is 2050. Default emission factors from the 2006 IPCC Guidelines for National GHG Inventories were used for each emission source.

[47]http://www.parliament.gov.fj/wp-content/uploads/2017/03/Act-13-Electricity.pdf
[48]Government of Fiji. (2017b). *NDC Implementation Roadmap 2017-2030.*
[49]https://www.energycommunity.org/default.asp?action=introduction

The following describes the key data sources and assumptions for estimating various sub-sector demands. It should be noted that, because the household section was disaggregated, it was not possible to show the effect of GDP on household demand. For commercial and industrial demands, the demands elasticity with respect to GDP are not accurately known and, hence, future annual average growth rate (AAGR) was used based on the past trends.

Commercial and Industrial Demand. Both electricity and LPG demand are considered within commercial demand and industrial demand in this LEDS.

Households. The main input datasets used in developing this LEDS are the number of households and energy intensity of each fuel in demand. Using a bottom-up approach, household demand is divided into urban and rural. Urban households were further divided into electrified and non-electrified households, while rural households were divided into grid electrified, off-grid electrified, and non-electrified. Refrigeration, lighting, air-conditioning, TV, cooking, and other uses have been used in the demand structure for households. Household cooking is further divided into electric stoves, LPG stoves, kerosene stoves, open fire, wood stoves, and biogas stoves.

Transmission and Distribution. Using grid electricity production and sales data available from the Fiji Bureau of Statistics (FBoS),[50] transmission and distribution (T&D) losses are assumed to be 10%.

Electricity Generation. Grid electricity generation considers existing generators (using both non-renewable and renewable sources of energy) with new additions based on Fiji's NDC Roadmap until 2030, after which further capacity enhancements are proposed to meet additional future demand in line with data currently available regarding Fiji's renewable energy resource options.

> "Refrigeration, lighting, air-conditioning, TV, cooking, and other uses have been used in the demand structure for households"

Data Used, Data Sources, and Assumptions

Number of Households and Efficiency Measures. The 2017 preliminary households census survey data provided by FBoS was used for calculating household demand. The demand projections are as follows and these numbers are used in all four scenarios:

- The overall number of households in Fiji in 2013 was 182,282. It is assumed that there were 4.75 persons in each household which is taken from 2007 census report.[51]
- The projected fraction of urban households are based on FBoS data:

Year	2013	2020	2025	2030	2035	2040	2045	2050
% urban	52.98	55.57	57.37	58.97	60.51	62.01	63.46	64.93

- Assumptions for the energy efficiency measures are taken from reports by Fiji's Energy Labelling and Minimum Energy Performance Standards for Appliances and Lighting (MEPSL) programme.[52] It is further assumed that the Minimum Energy Performance Standard (MEPS) for refrigerators and freezers were implemented starting in 2012. For the other products' efficiency, measures are assumed to be in place from 2015.

Table 4 shows the domestic energy efficiency measures considered in the modelling.

[50]FBoS obtains data from EFL.
[51]FBoS. (2010). *Fiji Facts and Figures as at July 2010.*
[52]GWA. (2014). *Energy Labelling and Minimum Energy Performance Standards for Appliances and Lighting in Fiji: Expanding the Coverage of the Program to Additional Products.* Accessed 17th June 2018. Available at https://www.reinfofiji.com.fj

Table 4. Household efficiency measures. Adapted from MEPSL programme.

Product	Base year load per HH per year	With efficiency kWh/HH/year	Base year % household with existing product	Year MEPSL programme start	End year MEPSL % household with efficient product	Price to energy (P/E) ratio from MEPSL 2014	Demand cost (average), FJD
Domestic Refrigerators and freezers	480	440[53]	75%	Assume start in 2014.	2030 with 100% household having efficient product	0.25[54]	Assume average price to be FJD 2000. For efficient refrigerators it is about FJD 2050. Lifetime is taken as 10 years.
Domestic lighting	301	243	100%	2015	2030 - 100% of households with efficient lighting	0.75	Assume each household has 5 lights. Normal light lasts for 1 year while efficient light last up to 3 years. One incandescent bulb costs about FJD 2 while efficient lamps cost around FJD 9.
Domestic Air conditioners	1,500	1,300	5% of urban electrified have air conditioners	2020	2030 – 30% of household with air con have efficient product 2050 – 100% of households with aircon have efficient product	0.20	Normal air conditioners cost FJD 1500 with a lifetime of 10 years while efficient air conditioners cost around FJD 2,500 with a lifetime of 15 years.
Domestic TVs	240	150[55]	90% of all grid electrified households have TV	2020	2030 – all households have efficient TV	0.10	Normal TVs cost around FJD 1000 with a lifetime of 10 years with efficient TVs costing around FJD 2000 with lifetime of 15 years

[53]9% decrease by considering Table 17 in: GWA. (2014) *Energy Labelling and Minimum Energy Performance Standards for Appliances and Lighting in Fiji: Expanding the Coverage of the Program to Additional Products.*
[54]This means that a 10% increase in efficiency would increase price by 2.5%.
[55]EnergyStar rating of EPA reports the most efficient TV, Samsung UN50J5500AF has energy consumption of 66.3 kWh/year.

Household Demand. The LEDS draws on the following assumptions for calculating household energy demand to address data gaps for energy intensity in households.

It has been assumed that household refrigerators consume 480 kWh/year[56] (in comparison, the EnergyStar rating provided by the United States Environment Protection Agency[57] assumes household refrigeration annual usage of around 500 kWh/household/year). Lighting energy consumption is estimated at 301 kWh per household, and 5% of all households in Fiji have air conditioners. For this LEDS, it is assumed that these households are urban with an intensity of 1,500 kWh/household based on the MEPSL 2014 report. It is assumed that televisions consume 240 kWh/household/year in electrified households, based on the MEPSL 2014 report, and that electricity consumption for cooking is 400 kWh/household/year.[58]

Heltberg[59] reports that an average rural household uses about 80 kg of firewood per month while urban households use 5-60 kg of firewood per month depending on the income level. In the LEAP model used for this LEDS, it is assumed that electrified urban households use 32 kg of wood per month in open fires and 25 kg per month in wood stoves. Rural households are assumed to use 70 kg of fuelwood per month in open fires and 50 kg per month in wood stoves.

Purohit et al[60] report that typical energy usage per household per day for cooking is 12.13 MJ, and this value is used for biogas and solar cookers. For all other electrical appliance consumption, the LEDS assumes 500 kWh/household/year for urban grid electrified households, 500 kWh/household/year for rural grid electrified households,[61] and 50 kWh/household/year for off-grid electrified households.

Cooking fuel intensity for rural grid connected households is assumed to be the same for urban grid-connected households. The share of cooking fuel activity is based on 2007 census data since the disaggregated data was not available from the 2017 census at the preparation of this LEDS. Annual LPG consumption is estimated to be four cylinders per household, or around 50 kg LPG per annum per household. Average kerosene consumption for cooking is assumed to be 140 litres/household/year.[62]

Emission factors for LPG, kerosene, and biogas for cooking are obtained from IPCC 2006 emission factors datasets. For open fire stoves and wood stoves, IPCC tier 1 wood residential emission factors are used. For kerosene for lighting, the IPCC 2006 oil residential emission factor is used.

For rural off-grid electrified households, Nand and Raturi[63] report that each solar home system has three 9W DC lamps and one 7W DC LED lamp. This yields an approximate value of 49.64 kWh/household/year. As a result, the model assumes existing lamps consume 50 kWh in rural off-grid electrified households and efficient lamps consume 40 kWh/household/year.

For all other uses such as washing machines, computers, laptops, phone charging, etc., in off-grid electrified households the LEDS assumes 50 kWh/household/year.

Lighting in rural non-electrified households is provided using kerosene, benzene, and solar lamps. These households are assumed to be electrified by 2020, so the kerosene light demand is zero after 2020. The Energy Use Survey reports spending of FJD 9.04/month/household on kerosene lighting, or around FJD 108.5/year. Assuming a price of FJD 2.00/litre for kerosene, annual consumption is estimated to be 54.2 litres/household. Benzene expenditure per month per household is reported to be FJD 9.90, or FJD 118.80 per year. Assuming a price of FJD 2.00/litre for benzene, annual consumption is estimated to be 59.2 litres/household. Energy intensity of cooking fuels in non-electrified households is assumed to be same as off-grid rural households.

[56]GWA. (2014). *Energy Labelling and Minimum Energy Performance Standards for Appliances and Lighting in Fiji: Expanding the Coverage of the Program to Additional Products.*
[57]United States Environment Protection Agency. (2018). *SEPA. ENERGY STAR Most Efficient 2018 — Medium, Large, and X-Large Refrigerators.* https://www.energystar.gov/most-efficient/me-certified-refrigerators
[58]This value is assumed based on data collected informally using student questionnaires, as well as average values used by LEAP developers.
[59]Heltberg, R. (2003). *Household Fuel And Energy Use In Developing Countries - A Multicountry Study.* Accessed 1st May 2018. Available at http://siteresources.worldbank.org/INTPSIA/Resources/490023-1120845825946/FuelUseMulticountryStudy_05.pdf.
[60]Purohit P., Kumar A., Rana S., Kandpal T. (2002). *Using renewable energy technologies for domestic cooking in India: a methodology for potential estimation.*
[61]Cooking fuel intensity is assumed to be same for grid-connected urban and rural households because it is assumed that each household will cook for the same amount of time with the same kind of technologies.
[62]Overall kerosene consumption will change depending on the number of households using this fuel. Nevertheless, this LEDS assumes that its intensity remains the same. See Isley, C.F., P.F. Nelson, and M.P. Taylor. (2016). Managing air quality in Suva, Fiji. *European Journal of Sustainable Development.* 5 (4): 242-254. https://research-management.mq.edu.au/ws/portalfiles/portal/16812097/mq-57690-Publisher+version+%28open+access%29.pdf
[63]Nand R, Raturi A. (2015). *Rural Electrification Initiatives in Fiji – A Case Study of Solar Home Systems. Solar World Congress 2015.* Daegu, Korea: International Solar Energy Society.

Energy intensity of 61 kWh/household/year is assumed for solar lamps for non-electrified households.

"It makes a significant difference in emissions if energy intensive industries are connected to the grid or not"

Commercial and Industrial. Electricity demand data was obtained from EFL and LPG demand data was taken from Fiji's TNC data.

For the commercial sector, it is assumed that grid electricity demand will grow at a rate of 2.6% per annum in the BAU Unconditional scenario. For the other three scenarios, the annual growth rate, with implementation of increased energy efficiency measures, is assumed to be 2%. LPG demand is assumed to grow at a rate of 5% per annum in the Unconditional, Conditional, and High Ambition scenarios. For the Very High Ambition scenario, LPG demand is assumed to increase at a rate of 5% annually until the year 2020 and to decrease linearly to zero by 2040, as LPG-fuelled appliances will be replaced by electric appliances.

For the industrial sector, grid electricity demand is assumed to increase by a rate of 2% annually for all scenarios. LPG demand is assumed to increase by a rate of 5% annually for Unconditional, Conditional, and High Ambition scenarios. For the Very High Ambition scenario, LPG demand is assumed to increase at a rate of 5% growth annually until 2020 and to decrease linearly to zero by 2040, as LPG-fuelled appliances will be replaced by electric appliances.

It is worth noting that it makes a significant difference in emissions if energy intensive industries are connected to the grid or not. For instance, Vatukoula Gold Mines PLC (VGM) has been in operation for 75 years. The mine is located near Tavua and is not connected to the Viti Levu grid but is fully dependent on diesel generators on site. These diesel generators are the primary source of energy for VGM and emit CO_2, CH_4, and N_2O from running 19 MW of diesel generators. The 2014 annual production is 80.4 GWh from SPC data.[64] Figure 11 below displays the emissions from VGM for the four scenarios, and Figure 12 displays the total investments required to achieve long-term deep decarbonisation for the scenarios. The grid-connection of the Vatukoula mine alone has the potential to mitigate 55,000 tCO_2 per year[65] as the mine would automatically switch from 100% diesel to the hydro, wind, and solar mix of the Viti Levu grid. As the grid moves to 100% renewable electricity all the emissions from the electricity usage at the mine would be eliminated automatically, avoiding more than 70,000 tCO_2 per year.

Generation. The amount of grid electricity generated in 2013 is based on EFL's annual report for 2013 while the average availability factor for each of these generation processes was calculated based on the installed capacity and production over 2005-2015. For technologies to be included in the future, values drawn from EFL and the literature[66] have been used.

[64]http://prdrse4all.spc.int/data/content/fiji-islands-sep-2014-oct-2015-vatukoula-gold-mines-power-generation-fuel-consumption
[65]Government of Fiji. (2017b). *NDC Implementation Roadmap.*
[66]Taylor, M, Daniel K, Ilas A, So EY. (2015). *Renewable power generation costs in 2014.* Germany: International Renewable Energy Agency (IRENA); and Patel, H. (2015). FEA's strategies & plans and opportunities in Fiji's renewable energy sector. Renewable Energy Investment Forum for Fiji.

Limitations and Uncertainties

One of the main limitations of the modelling was that the LEAP model does not yet have a module to account for grid storage as large-scale use of storage on utility grids is a relatively recent phenomenon. This was addressed in three ways:

- The solar availability curve has been modified to incorporate battery storage and assumes an increase in the cost of solar PV;
- The capacity credit of wind farms has been increased to reflect firmer capacity and the cost of wind farms were increased; and
- The system load curve has been adjusted to show overall grid storage (pumped hydro storage).

Considering the assumptions stated above and the quality of data used, the model applies a sector-wide uncertainty of +/- 10% (as suggested in the TNC).

Stakeholder Consultation Process

Key stakeholders focusing on electricity generation and other (non-transport-related) energy use who participated in the stakeholder consultation workshops included: officials from the Department of Energy, IRENA, Reserve Bank of Fiji, Sunergise, EFL, development partners, industry representatives, and regional climate change-focused NGOs, among others. In addition to the stakeholder workshops, a number of face-to-face consultations were held with EFL, the Department of Energy, the Department of Environment, FBoS, the Department of Transport Planning, the Ministry of Sugar, and the Fiji Sugar Corporation.

As part of the visioning exercise during the First National Stakeholder Consultation Workshop on the 23rd of May, 2018, stakeholders described two possible visions: (1) 100% sustainable, resource efficient, inclusive, affordable, resilient energy access to all Fijians; and (2) a resource efficient, cost effective, and environmentally sustainable energy sector for all Fijians. The Second National Stakeholder Consultation Workshop for electricity and other (non-transport) energy took place on the 28th of June, 2018 to present the initial results of the LEDS analysis and scenario development. During that session, stakeholders discussed the future costs of clean energy technologies (likely to go down), whether the LEDS may slow down or increase economic growth, the need to raise awareness when introducing new cooking and cookstove technologies, the possibility of making the ambitious scenarios even more ambitious, the value of a carbon tax, the need for financing schemes to support communities with transition, and the need to incorporate biofuels into the scenarios. Among the main issues raised during the Third National Stakeholder Consultation Workshop on the 27th of August, 2018 included the transition for households towards electric cooking, particularly for rural households which would transition from wood to kerosene and LPG to electric stoves, and how agricultural offsets contribute to electricity demands.

4.1.5 Low Emission Development Scenarios

Base Year (BY)

The base year used for the energy sector, excluding transport, is 2013 as the NDC Implementation Roadmap also starts from this year. In addition, most of the input data were available for this year.

BAU Unconditional Scenario

In the unconditional BAU scenario, no specific international financing support is expected, and Fiji will bear the cost of all applicable mitigation actions.

For Households, the number is expected to grow based on the population growth rate projected by FBoS (0.38%/annum). Other elements in household demand structure are described as follows:

- Non-electrified households are all expected to be electrified by 2020. While urban households would be electrified through the EFL grid, rural households would be electrified using off-grid electrification measures.
- Urban electrified households are expected to increase adoption of refrigeration from 75% in 2014 to 80% in 2030 and to 90% by 2050.
- For rural grid-electrified households, the adoption of refrigeration is expected to increase from 66% in 2014 to 70% in 2030 and to 80% in 2050.
- The share of urban electrified households with air conditioning systems is expected to increase from 5% in 2020 to 20% by 2050.
- With respect to cooking fuels, open fire and wood stoves are expected to be phased out with electric stoves in urban electrified households. For rural grid-electrified households, open fire usage is expected to drop to zero by 2030 and be replaced with LPG and electric stoves. For rural off-grid electrified households, from 69.6% of households using open fire, it decreases to 50% of households in 2030; for kerosene stoves, 9% of households are using in 2013 which increases to 20% by 2030; and LPG stoves usage is expected to increase from 8% in 2013 to 10%[67] by 2030. To promote demand-side management, energy efficiency measures are only in place for refrigerators and freezers, TV, lights, and air conditioners as shown in Table 4. Only grid-connected households are considered in the unconditional scenario since off-grid households may not have larger electrical appliances, like those found in grid-connected households.

There are no significant efficiency measures affecting commercial and industrial sectors under this scenario. For commercial demand, the annual growth rate of electricity is estimated as 2.6% with 349 GWh of electricity consumed in 2013. The annual growth rate for LPG is estimated as 5% with 7,218 metric tonnes consumed in 2013. For industrial demand, the annual growth rate for electricity is estimated as 2% with 202 GWh consumed in 2013. The annual growth rate for LPG is estimated as 5% with 3,573 metric tonnes consumed in 2013.

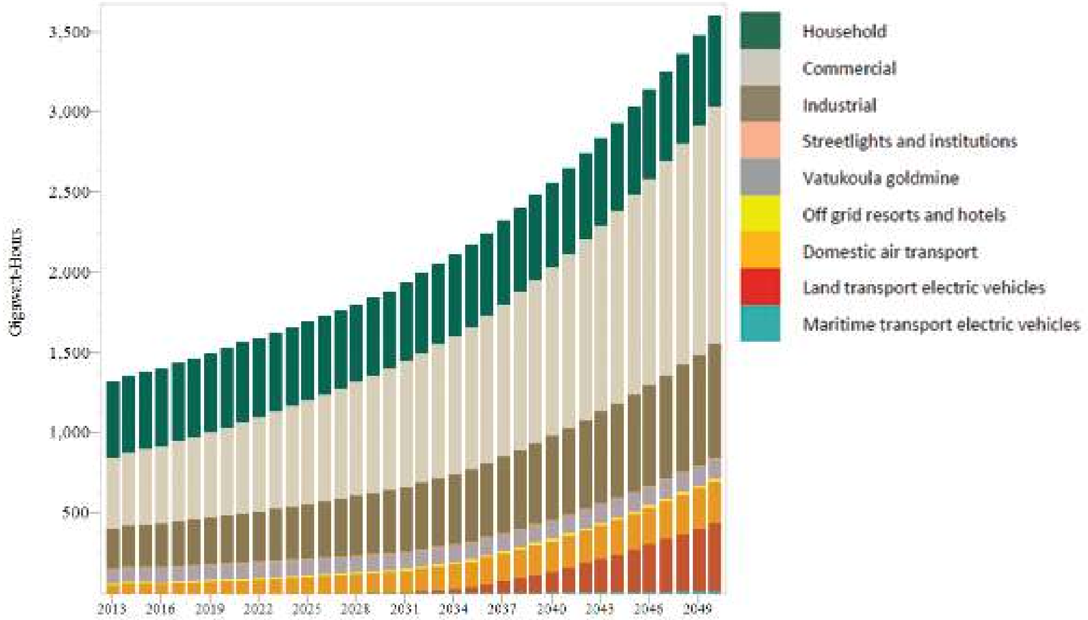
For streetlights, the annual growth rate for electricity demand is estimated as 0.25%. For both land and maritime transport, the demand data is generated by the modelling for each respective sector (sections 4.2 and 4.3).

"The share of urban electrified households with air conditioning systems is expected to increase from 5% in 2020 to 20% by 2050"

[67] The small increase is noted because of affordability of LPG in remote islands.

Overall demand for the unconditional scenario is shown in Figure 11 below. The transport sector demand is introduced from 2025 and accelerates from 2030 onwards due to electric vehicles.

Figure 11. Energy Demand in GWh: Unconditional scenario.



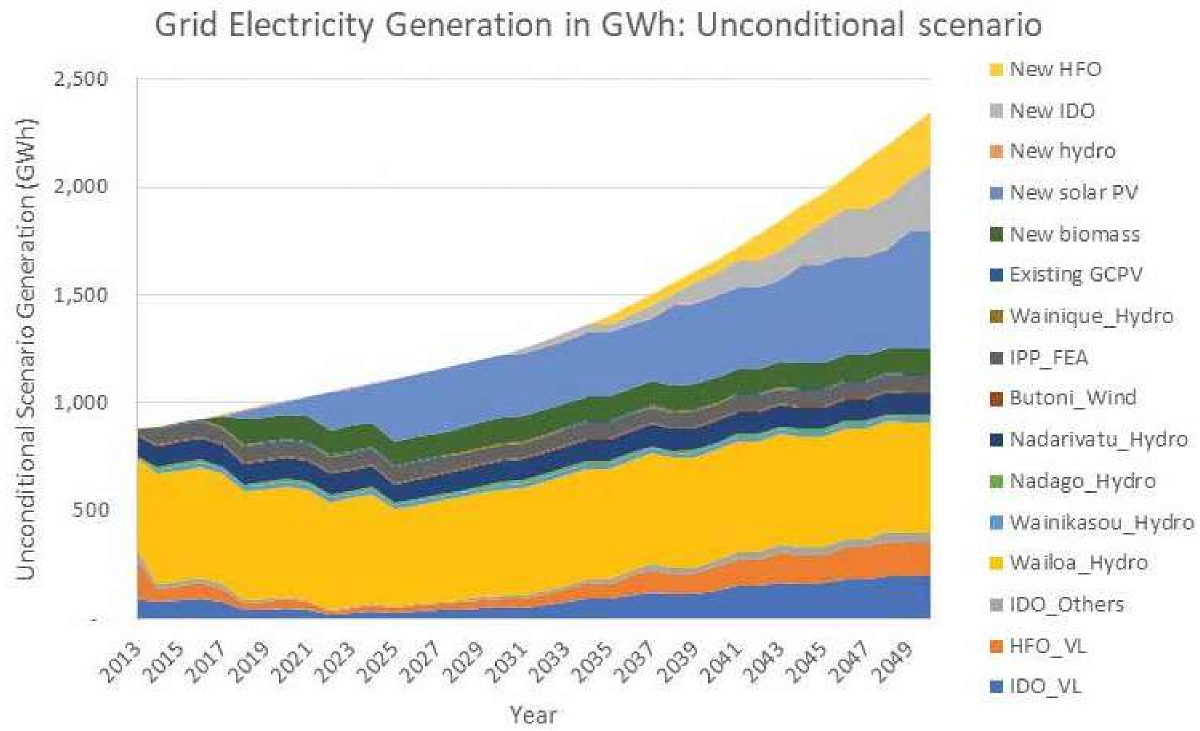
With respect to on-grid generation, the unconditional BAU scenario assumes no grid storage and existing technologies include: Industrial Diesel Oil (IDO) and Heavy Fuel Oil (HFO) generators, biomass, wind farms, hydropower, Grid-connected PV (GCPV), Fiji Sugar Corporation (FSC), and Tropik Wood. New solar PV is expected to be added based on targets set in the NDC Implementation Roadmap, as well as new IDO and HFO to further supplement supply when needed post 2030 and up to 2050.

In this scenario, solar PV is considered the only renewable technology used for additional generation capacity from 2018 onwards as the cost of solar PV has fallen by almost 70% between 2010 and 2018[68] and it would be the most competitive option for Fiji under current circumstances.

[68]REN21. (2018). *Renewables 2018: Global Status Report*. Accessed on 19th June 2018. Available at http://www.ren21.net/wp-content/uploads/2018/06/17-8652_GSR2018_FullReport_web_-1.pdf.

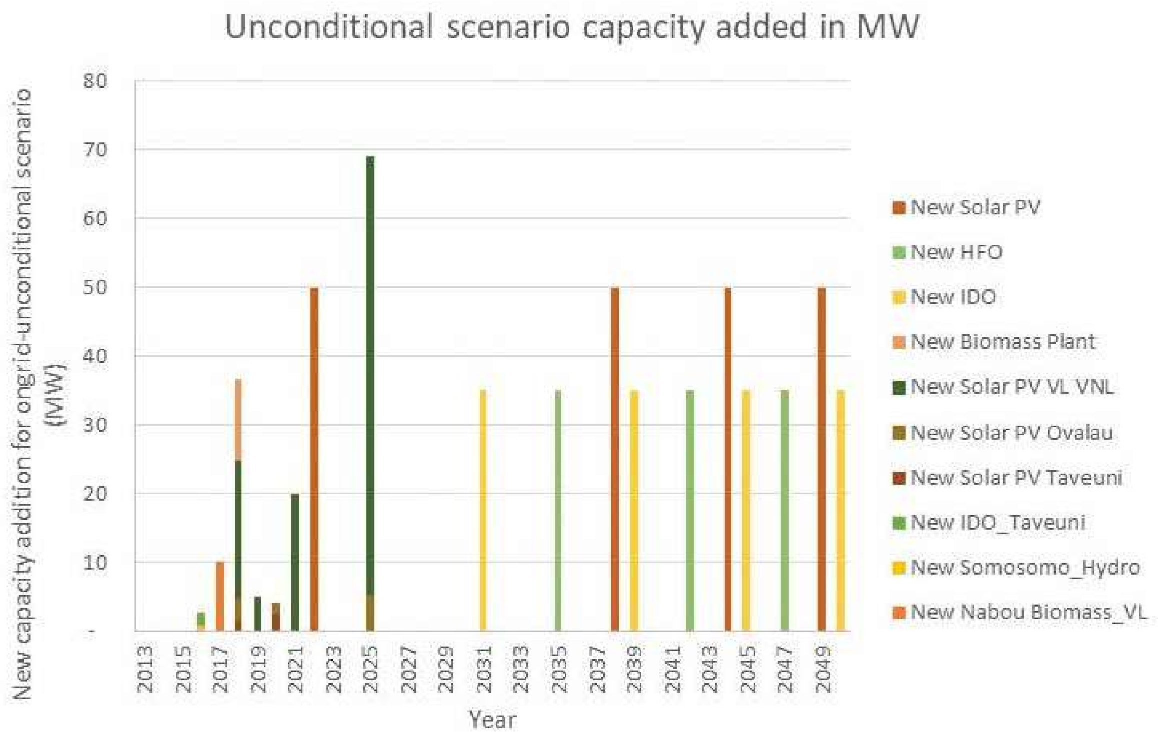
After taking into account some new additions of hydro, biomass and solar between 2013 (the baseline year) and 2018, new IDO and new HFO generators will have to be added to meet the demand, particularly from 2030 onwards, as shown in Figures 12 and 13 below[69] because under a BAU unconditional scenario sufficient financing will not be available for the solar energy generation capacity required to cover all the increasing demand.

Figure 12. Grid Electricity Generation in GWh: Unconditional scenario.



[69]These factors were added endogenously into the LEAP model; this means that the year is not specified in advance, and generation technology is added when the need arises by the model.

Figure 13. Unconditional scenario capacity added in MW.



Since the renewable energy sources alone will not be sufficient to fulfil the demand posed by the transport sector as electric vehicles (EV) are introduced from 2030 along with some electric outboard motors (see also sections 4.2 and 4.3 on land and maritime transport respectively), the unconditional scenario includes new IDO and HFO generators as shown in Figure 13 above.

With respect to off-grid generation, the unconditional scenario incorporates the existing technologies of solar home systems and diesel generators. Under this scenario, it is assumed that solar home systems will remain, but diesel generators will be retired and scaled down from 5.5 MW in current (2013) capacity to 3.0 MW in 2020, to 2.0 MW in 2030, and 1.0 MW in 2040.[70] The scenario also reflects the addition of new solar home systems and new solar PV hybrid systems (e.g., solar PV, diesel, with battery storage).

The Vatukoula mine is also assumed to operate as normal and demand is assumed to grow at 1% per annum and there are no energy efficiency measures adopted. Generation at the mine is assumed to be from existing diesel generators, to be gradually replaced in the future with new diesel generators.

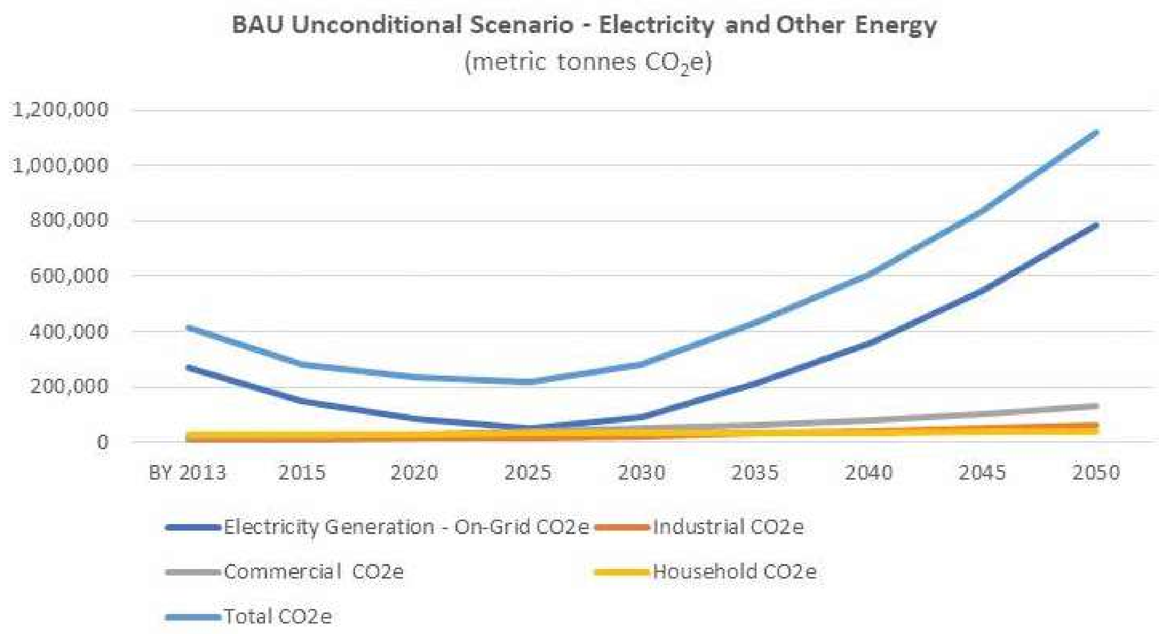
Table 5 shows the emissions from on-grid and off-grid energy (electricity and cooking fuels) sector.

[70]Based on conversation with the Department of Energy, July 2018.

Table 5. BAU Unconditional scenario for Electricity Generation and Other Energy Use.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
Electricity Generation - On-Grid										
IDO	CO_2	117,445	88,713	53,163	31,870	56,252	121,940	218,831	321,474	446,795
	CH_4	100	75	45	27	48	104	186	273	380
	N_2O	295	223	134	80	141	306	549	807	1,122
HFO	CO_2	154,822	58,830	34,139	19,980	36,515	92,793	135,803	224,702	337,669
	CH_4	126	48	28	16	30	76	111	183	275
	N_2O	372	141	82	48	88	223	326	540	811
Subtotal		273,160	148,031	87,591	52,022	93,073	215,441	355,806	547,979	787,052
Electricity Generation - Off-Grid										
Vatukoula Gold Mine	CO_2	71,900	66,300	69,700	73,200	77,000	80,800	84,900	89,100	93,600
	CH_4	100	100	100	100	100	100	100	100	100
	N_2O	200	200	200	200	200	200	200	200	200
Off-Grid Resorts	CO_2	8,706	3,770	3,801	4,120	4,475	4,857	5,269	5,725	6,212
	CH_4	8	3	3	4	4	4	5	5	5
	N_2O	22	10	10	11	11	12	14	15	16
Subtotal		80,936	70,383	73,814	77,635	81,790	85,973	90,488	95,145	100,133
Industrial										
LPG	CO_2	10,667	11,761	15,010	19,157	24,449	31,204	39,826	50,829	64,872
	CH_4	4	4	5	6	8	10	13	17	22
	N_2O	11	12	15	19	24	31	40	50	64
Subtotal		10,681	11,776	15,030	19,182	24,482	31,246	39,878	50,896	64,958
Commercial										
LPG	CO_2	21,546	23,755	30,318	38,694	49,384	63,028	80,442	102,667	131,031
	CH_4	36	40	50	64	82	105	134	171	218
	N_2O	11	12	15	19	24	31	40	50	64
Subtotal		21,593	23,806	30,383	38,777	49,491	63,164	80,615	102,888	131,314
Household										
Biogas	CO_2	433	448	490	522	552	580	606	631	653
	CH_4	1	1	1	1	1	1	1	1	1
	N_2O	0	0	0	0	0	0	0	0	0
Kerosene	CO_2	15,034	15,088	15,360	16,543	17,678	18,343	18,945	19,460	19,900
	CH_4	44	44	45	48	52	54	55	57	58
	N_2O	39	39	40	43	46	47	49	50	51
LPG	CO_2	9,239	9,713	10,968	12,126	13,247	13,883	14,478	15,010	15,495
	CH_4	15	16	18	20	22	23	24	25	26
	N_2O	5	5	5	6	7	7	7	7	8
benzene	CO_2	15	11	0	0	0	0	0	0	0
	CH_4	0	0	0	0	0	0	0	0	0
	N_2O	0	0	0	0	0	0	0	0	0
Wood	CH_4	3,281	3,157	2,824	2,348	1,848	1,849	1,840	1,821	1,790
	N_2O	646	621	556	462	364	364	362	358	352
Subtotal		28,751	29,143	30,307	32,118	33,816	35,152	36,369	37,421	38,335
Total	CO_2e	**415,121**	**283,138**	**237,124**	**219,734**	**282,652**	**430,975**	**603,157**	**834,329**	**1,121,791**

Figure 14. Unconditional scenario – Electricity and Other Energy.



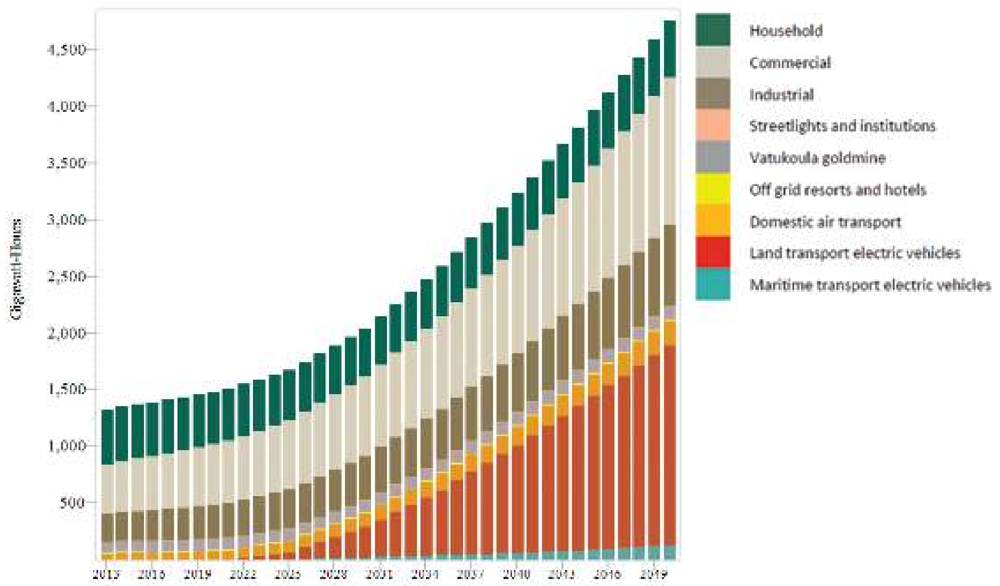
BAU Conditional Scenario

In the conditional BAU scenario, it is expected that Fiji will receive international financing support. For demand, the household sector will have the same demand structure and efficiency measures as described in unconditional scenario.

Efficiency measures are also anticipated to be introduced in the commercial sectors (including tourism), such as through efficient lighting, ACs, freezers, and refrigerators, and other MEPSL measures are expected to reduce the growth in demand by 0.6% per annum. Hence, in the BAU Conditional scenario, on-grid electricity demand is expected to increase by only 2.0% as compared to 2.6% in the BAU Unconditional scenario. It must be noted that EFL uses its own definition of commercial and industrial consumers based on the power consumption of each customer.

As shown in the Figure 15, as a result of the rapid increase of EVs starting in 2030, the electricity demand for land transport is going to rise steeply and there will be a need for significant additional generation capacity to address this demand.

Figure 15. Demand (GWh) under Conditional scenario.



With respect to on-grid generation, this scenario incorporates grid storage and is based on the use of existing technologies including: IDO and HFO generators, wind farms, hydropower, GCPV, FSC, and Tropik Wood. Figure 16 below shows the years where new solar PV, hydropower, and biomass are added, as indicated by the NDC Implementation Roadmap, as well as additional solar, wind, new IDO, new HFO, and geothermal.

Figure 16. Generation Technologies in GWh under Conditional scenario.

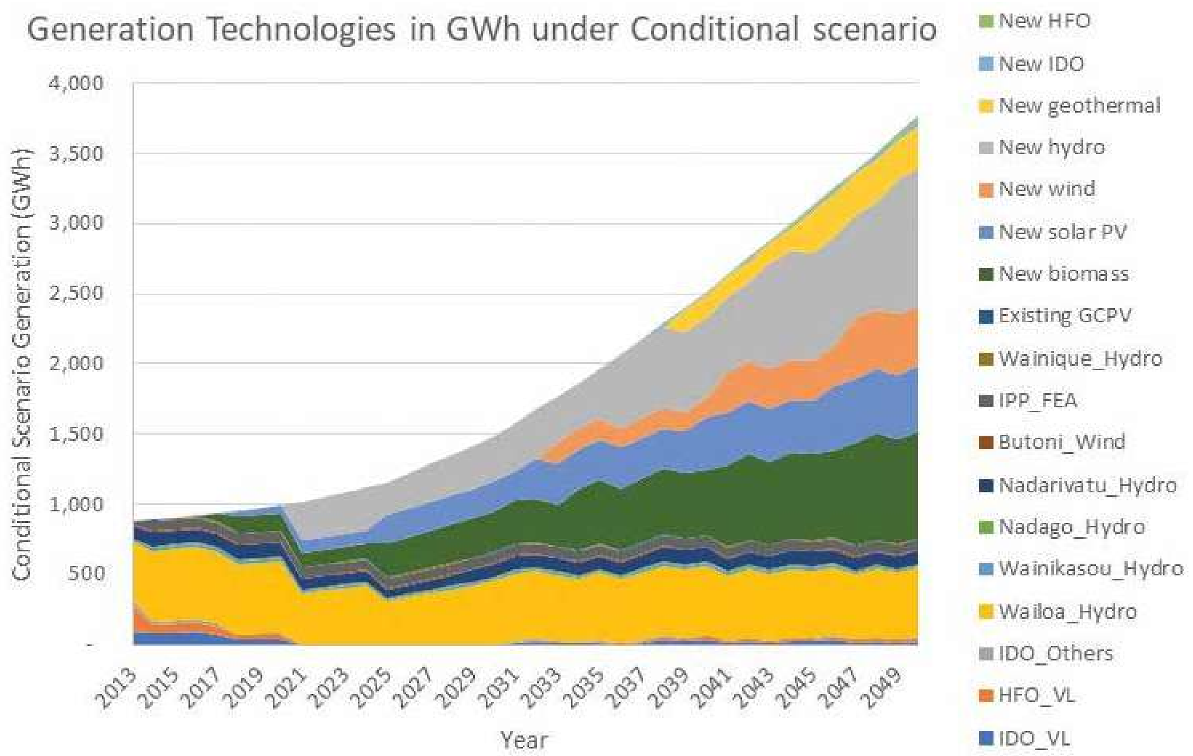
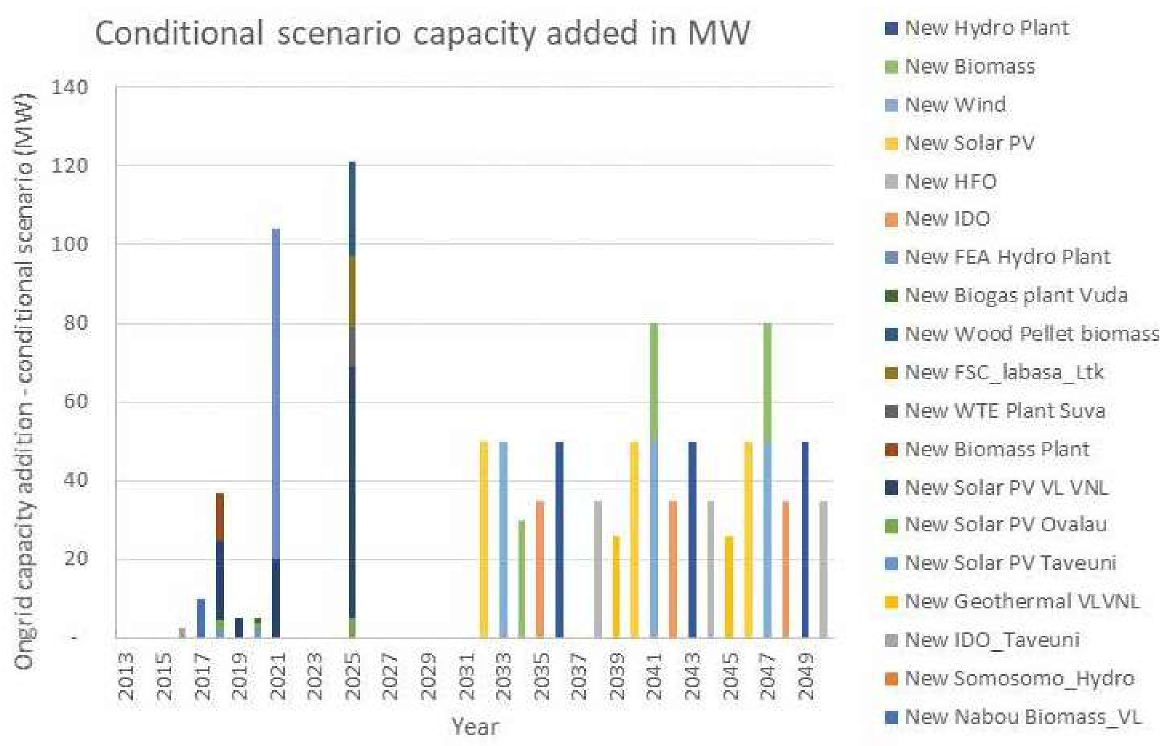


Figure 17. Conditional scenario capacity added in MW.



Regarding off-grid generation, the conditional BAU scenario is based on the continued use of existing technologies, namely solar home systems and diesel generators. The diesel generators are gradually retired from 5.5 MW capacity in 2013, to 3 MW in 2020, to 1 MW in 2030, and 0 MW in 2040. The scenario also envisions the addition of new energy generation in the form of new solar home systems and new solar PV hybrid systems (solar PV and diesel with battery storage). The Vatukoula mine is assumed to adopt new energy efficiency measures. Energy demand is assumed to grow at 0.8% per annum giving rise to almost a 7% reduction in energy demand by 2050 compared with the BAU Unconditional scenario. Generation at the mine is assumed to be from existing diesel generators, to be gradually replaced in the future with new solar PV and new diesel generators. Table 6 shows the projected emissions from on-grid and off-grid energy (electricity and cooking fuels).

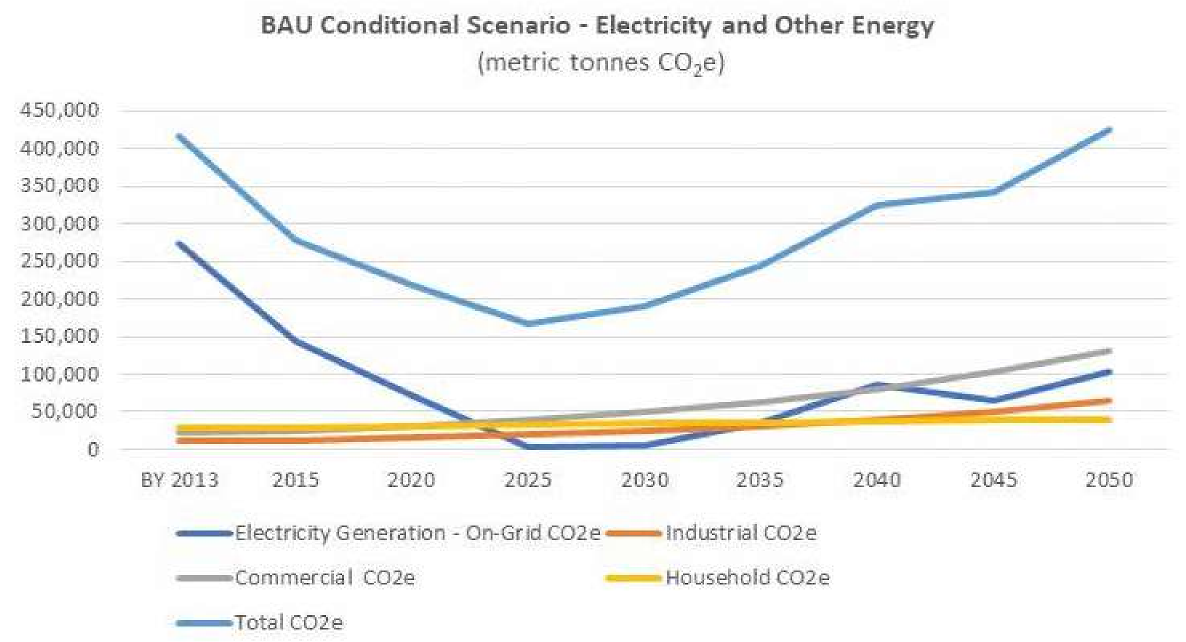
Table 6. BAU Conditional Scenario for Electricity Generation and Other Energy Use.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
Electricity Generation - On-Grid										
IDO	CO_2	117,445	86,381	42,837	1,816	2,418	21,933	47,916	35,153	53,875
	CH_4	100	73	36	2	2	19	41	30	46
	N_2O	295	217	108	5	6	55	120	88	135
HFO	CO_2	154,822	57,251	27,271	0	1,064	10,736	36,624	29,069	47,053
	CH_4	126	47	22	0	1	9	30	24	38
	N_2O	372	138	66	0	3	26	88	70	113
Biogas	CO_2	0	0	862	526	760	805	831	823	825
	CH_4	0	0	0	0	0	0	0	0	0
	N_2O	0	0	0	0	0	0	0	0	0
WTE power plant	CH_4	0	0	0	91	132	139	144	142	143
	N_2O	0	0	0	179	259	274	283	280	281
Subtotal		273,160	144,107	71,203	2,619	4,645	33,997	86,078	65,681	102,510
Electricity Generation - Off-Grid										
Vatukoula Gold Mine	CO_2	71,900	66,000	68,700	71,500	74,400	77,400	79,900	83,100	85,700
	CH_4	100	100	100	100	100	100	100	100	100
	N_2O	200	200	200	200	200	200	200	200	200
Off-Grid Resorts	CO_2	8,706	2,953	2,405	2,022	1,924	1,764	1,651	1,561	1,300
	CH_4	8	3	2	2	2	2	1	1	1
	N_2O	22	8	6	5	5	5	4	4	3
Subtotal		80,936	69,264	71,413	73,829	76,631	79,471	81,856	84,966	87,304
Industrial										
LPG	CO_2	10,667	11,761	15,010	19,157	24,449	31,204	39,826	50,829	64,872
	CH_4	4	4	5	6	8	10	13	17	22
	N_2O	5	6	7	9	12	15	20	25	32
Subtotal		10,676	11,770	15,022	19,173	24,470	31,230	39,858	50,871	64,925
Commercial										
LPG	CO_2	21,546	23,755	30,318	38,694	49,384	63,028	80,442	102,667	131,031
	CH_4	36	40	50	64	82	105	134	171	218
	N_2O	11	12	15	19	24	31	40	50	64
Subtotal		21,593	23,806	30,383	38,777	49,491	63,164	80,615	102,888	131,314
Household										
Biogas	CO_2	433	448	490	522	552	580	606	631	653
	CH_4	1	1	1	1	1	1	1	1	1
	N_2O	0	0	0	0	0	0	0	0	0
Kerosene	CO_2	15,034	15,088	15,360	16,543	17,678	18,343	18,945	19,460	19,900
	CH_4	44	44	45	48	52	54	55	57	58
	N_2O	39	39	40	43	46	47	49	50	51
LPG	CO_2	9,239	10,028	12,223	14,293	16,334	16,971	17,551	18,051	18,484
	CH_4	15	17	20	24	27	28	29	30	31
	N_2O	5	5	6	7	8	8	9	9	9

Source	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
Household (Continued)										
Benzene	CO_2	15	11	0	0	0	0	0	0	0
	CH_4	0	0	0	0	0	0	0	0	0
	N_2O	0	0	0	0	0	0	0	0	0
Wood	CH_4	3,281	2,968	2,072	1,050	0	0	0	0	0
	N_2O	646	584	408	207	0	0	0	0	0
Subtotal		28,751	29,233	30,665	32,737	34,697	36,033	37,246	38,289	39,189
Total	CO_2e	**415,116**	**278,180**	**218,687**	**167,135**	**189,934**	**243,896**	**325,654**	**342,695**	**425,242**

Table 6 shows that the GHG emissions will decline and then rise as new fossil fuel-based technologies are added in order to fulfil the increasing demand from the transport sector.

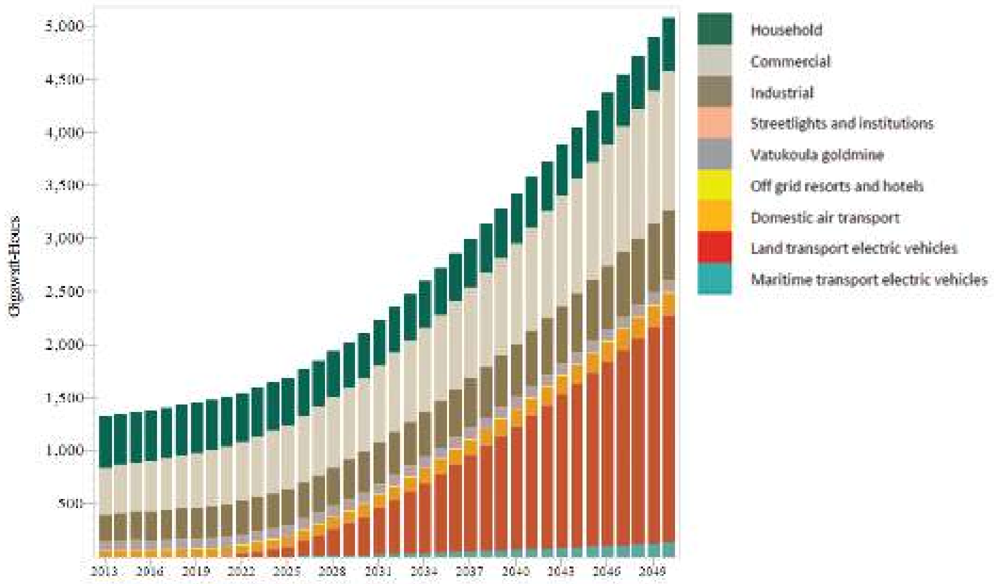
Figure 18. BAU Conditional scenario – Electricity and Other Energy.



High Ambition Scenario

In the High Ambition scenario, the main objective for electricity generation is to reduce emissions to near zero. This requires further incorporation of renewable energy-based measures, compared to the BAU Conditional scenario. For demand, energy efficiency measures are same as for the BAU Conditional scenario, except that commercial and industrial electricity demand will increase. For commercial demand, the annual growth rate is assumed to be 2% (more efficient systems) based on 349 GWh electricity generated in 2013. This leads to 20% demand reduction by 2050, compared to the BAU Unconditional scenario. In addition, the annual growth rate for LPG is assumed to be 5% based on 7,218 metric tonnes used in 2013. For industrial demand, the annual growth rate for electricity demand is assumed to be 1.7%, which leads to 10% reduction in demand by 2050, when compared to BAU Unconditional scenario, and the annual growth rate for LPG is assumed to be 5% based on 3,573 metric tonnes used in 2013.

Figure 19. Demand (GWh) under High Ambition scenario.



To further reduce emissions, this scenario envisions adoption of higher levels of renewable energy generation capacity.

To reduce emissions from on-grid generation, the LEDS envisions using considerable grid storage to integrate large components of intermittent resources like solar and wind. The generation mix will be expanded to include: new solar PV, hydropower, and biomass (in accordance with the Fiji NDC Implementation Roadmap), as well as additional new solar, wind, and geothermal – as detailed in Table 7. To take this effort further, it will be necessary for Fiji to explore other renewable energy technologies, like wave and tidal energy.

According to the available literature,[71 72] there is excellent potential for geothermal energy development in Fiji. However, developing this resource would require extensive exploratory work at significant expense. The World Bank has recently requested an Expression of Interest for conducting a resistivity survey for a geothermal energy project in Fiji,[73] which is a step forward. For solar PV, it is expected that GCPV rooftop systems, including for domestic, government, commercial, and industrial buildings, will be widespread in this scenario as well. The Vatukoula mine is assumed to adopt new energy efficiency measures. Energy demand is assumed to grow at 0.6% per annum giving rise to almost a 14% reduction in energy demand by 2050 compared with the BAU Unconditional scenario. Generation at the mine is assumed to be from existing diesel generators that will be retired, starting from the 19 MW in capacity in 2013, reduced to 18 MW by 2025, 15 MW by 2030, 12 MW by 2040, and 9 MW by 2050. Capacity will otherwise be replaced with new solar PV, new geothermal, and new wind technologies.

[71] McCoy West et al. (2011). *Proceedings, Thirty-Sixth Workshop on Geothermal Reservoir Engineering.*
[72] http://fijisun.com.fj/2013/04/06/ensuring-a-sustainable-energy-hard-talk/
[73] http://www.thinkgeoenergy.com/request-for-eoi-world-bank-resistivity-survey-for-geothermal-project-in-fiji-pacific/

Figure 20. Generation Technologies in GWh for on-grid generation under High Ambition scenario.

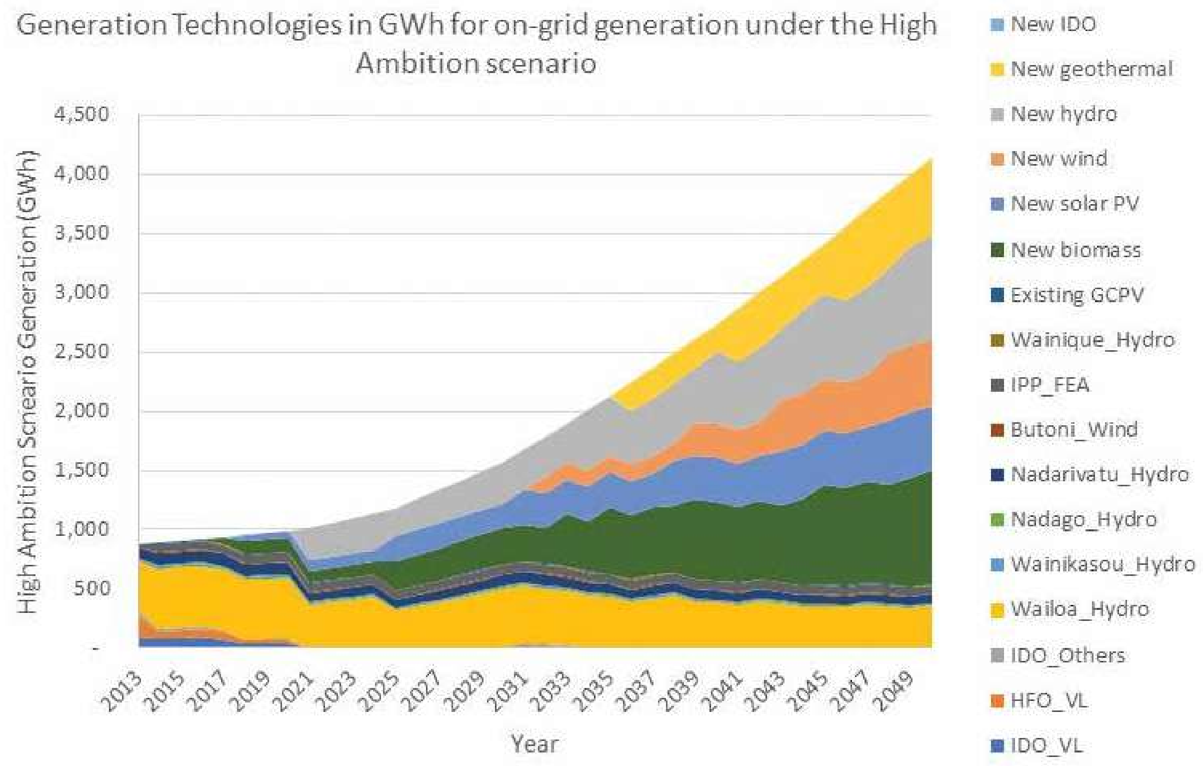


Figure 21. New capacity added in MW in High Ambition scenario.

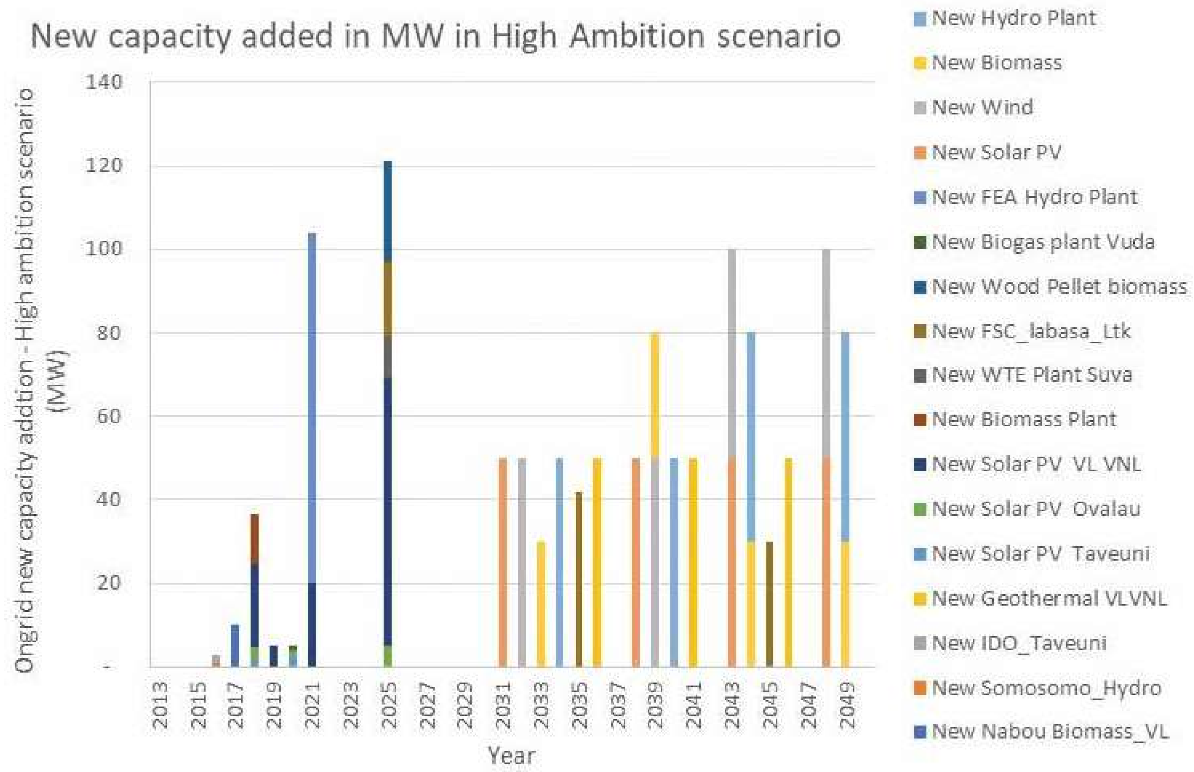


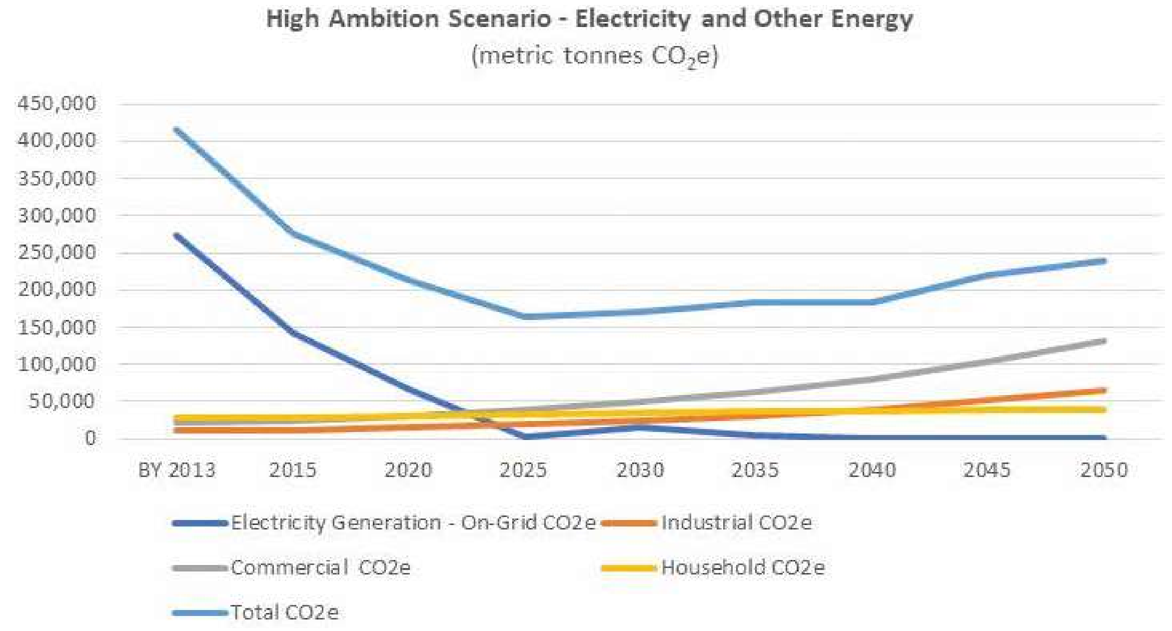
Table 7 shows projected emissions from on-grid and off-grid electricity generation for urban and rural households and other sectors that are connected to the electricity grid. As illustrated, despite significant renewable energy development, Fiji's electricity sector will still generate a significant amount of GHG emissions even in the High Ambition scenario.

Table 7. High Ambition Scenario for Electricity Generation and Other Energy Use.
(all values for all gases in metric tonnes CO_2e)

High Ambition	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
Electricity Generation - On-Grid										
IDO	CO_2	117,445	85,707	40,630	1,816	8,737	2,372	306	300	293
	CH_4	100	73	35	2	7	2	0	0	0
	N_2O	295	215	102	5	22	6	1	1	1
HFO	CO_2	154,822	56,796	25,804	0	5,264	1,034	0	0	0
	CH_4	126	46	21	0	4	1	0	0	0
	N_2O	372	136	62	0	13	2	0	0	0
Biogas	CO_2	0	0	861	539	810	718	649	601	607
	CH_4	0	0	0	0	0	0	0	0	0
	N_2O	0	0	0	0	0	0	0	0	0
WTE power plant	CH_4	0	0	0	93	140	124	112	104	105
	N_2O	0	0	0	184	276	245	221	205	207
Subtotal		273,160	142,974	67,516	2,639	15,275	4,505	1,290	1,211	1,213
Electricity Generation - Off-Grid										
Vatukoula Gold Mine	CO_2	71,900	65,800	67,800	69,800	46,400	48,600	24,900	27,200	3,600
	CH_4	100	100	100	100	0	0	0	0	0
	N_2O	200	200	200	200	100	100	100	100	0
Off-Grid Resorts	CO_2	8,706	1,665	1,559	1,289	489	440	111	88	21
	CH_4	8	1	1	1	0	0	0	0	0
	N_2O	22	4	4	3	1	1	0	0	0
Subtotal		80,936	67,770	69,664	71,393	46,990	49,141	25,111	27,388	3,621
Industrial										
LPG	CO_2	10,667	11,761	15,010	19,157	24,449	31,204	39,826	50,829	64,872
	CH_4	4	4	5	6	8	10	13	17	22
	N_2O	5	6	7	9	12	15	20	25	32
Subtotal		10,676	11,770	15,022	19,173	24,470	31,230	39,858	50,871	64,925
Commercial										
LPG	CO_2	21,546	23,755	30,318	38,694	49,384	63,028	80,442	102,667	131,031
	CH_4	36	40	50	64	82	105	134	171	218
	N_2O	11	12	15	19	24	31	40	50	64
Subtotal		21,593	23,806	30,383	38,777	49,491	63,164	80,615	102,888	131,314

High Ambition	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
Household										
Biogas	CO_2	433	448	490	522	552	580	606	631	653
	CH_4	1	1	1	1	1	1	1	1	1
	N_2O	0	0	0	0	0	0	0	0	0
Kerosene	CO_2	15,034	15,088	15,360	16,543	17,678	18,343	18,945	19,460	19,900
	CH_4	44	44	45	48	52	54	55	57	58
	N_2O	39	39	40	43	46	47	49	50	51
LPG	CO_2	9,239	10,028	12,223	14,293	16,334	16,971	17,551	18,051	18,484
	CH_4	15	17	20	24	27	28	29	30	31
	N_2O	5	5	6	7	8	8	9	9	9
benzene	CO_2	15	11	0	0	0	0	0	0	0
	CH_4	0	0	0	0	0	0	0	0	0
	N_2O	0	0	0	0	0	0	0	0	0
Wood	CH_4	3,281	2,968	2,072	1,050	0	0	0	0	0
	N_2O	646	584	408	207	0	0	0	0	0
Subtotal		28,751	29,233	30,665	32,737	34,697	36,033	37,246	38,289	39,189
Total	CO_2e	**415,116**	**275,553**	**213,250**	**164,719**	**170,922**	**184,073**	**184,121**	**220,646**	**240,262**

Figure 22. High Ambition scenario – Electricity and other Energy.

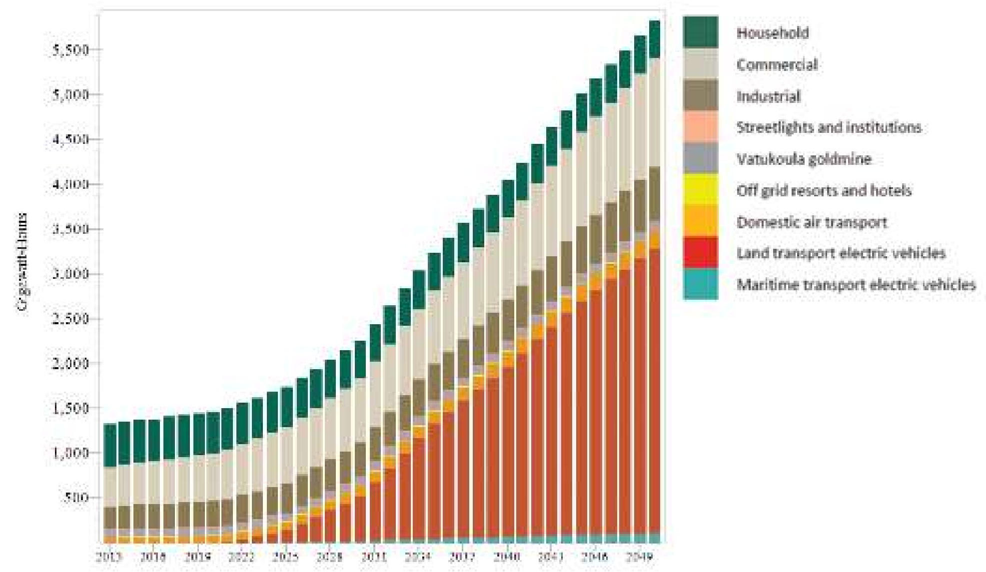


Very High Ambition Scenario

Under the Very High Ambition scenario, Fiji anticipates achieving net zero emissions from the energy sector. For this to happen, the whole cooking fuel sub-sector will need to be electrified, including the industrial and commercial operations currently utilizing LPG. With respect to commercial demand, Fiji assumes an annual growth rate of 2%. This will lead to a 20% reduction in demand by 2050, compared to the BAU Unconditional scenario. This scenario also assumes replacing all LPG technologies with electric technologies.

With respect to industrial demand, annual growth rate for electricity demand is assumed to be 1.5%. This will lead to a further 16% reduction in demand by 2050, compared to BAU Unconditional scenario.

Figure 23. Demand (GWh) under Very High Ambition scenario.
(Note the high electrification of transport sector)



Regarding on-grid generation, the Very High Ambition scenario incorporates grid storage by changing the system load curve. The storage technologies would include a combination of batteries and pumped-hydro systems with a total of an estimated 3.8 MWh per MW of PV installed.[74]

The scenario envisions continued use of existing technologies including: IDO and HFO generators, wind power, hydropower, GCPV, and FSC and Tropik Wood.

New hydropower and biomass will be added consistent with the NDC Implementation Roadmap and the amount of investment in solar PV, wind power, and geothermal will go considerably beyond the NDC Implementation Roadmap (see Table 8). A large number of proposed GCPV systems will be installed on suitable building rooftops and also on water reservoirs using floating systems. Wind turbines will be installed at identified onshore and offshore locations.

[74]A feasibility study will be required to confirm the exact capacity of batteries and pumped hydro systems required.

Figure 24. Generation Technologies in GWh for on-grid generation under Very High Ambition scenario.

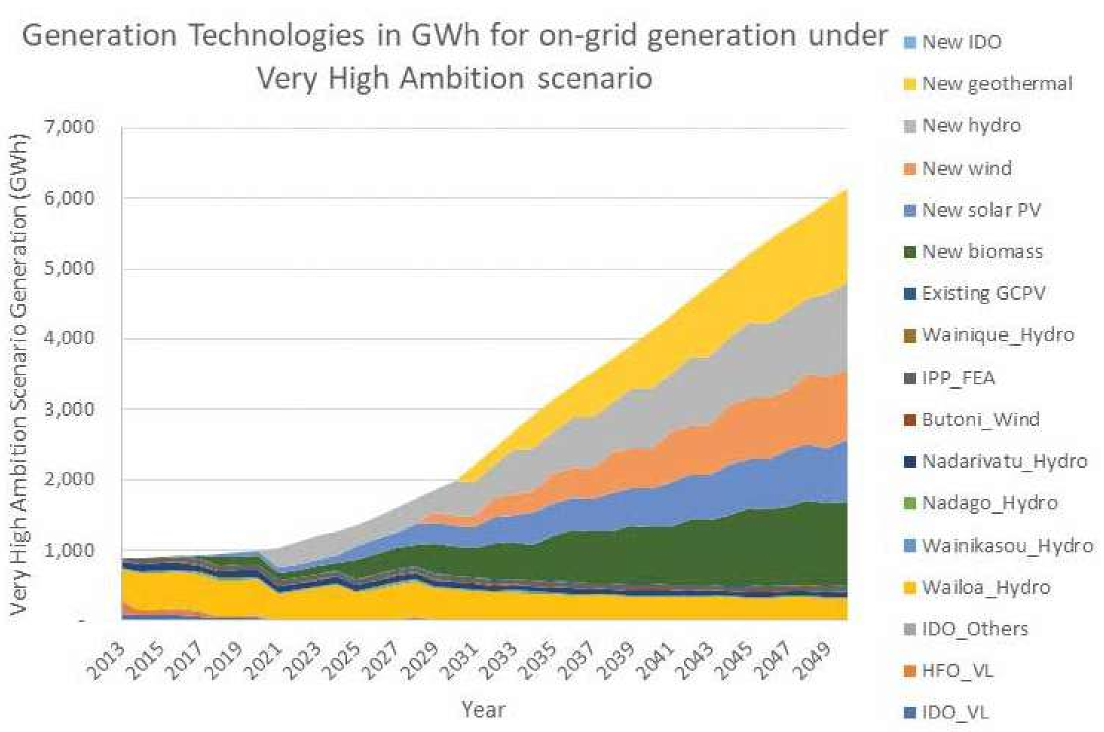
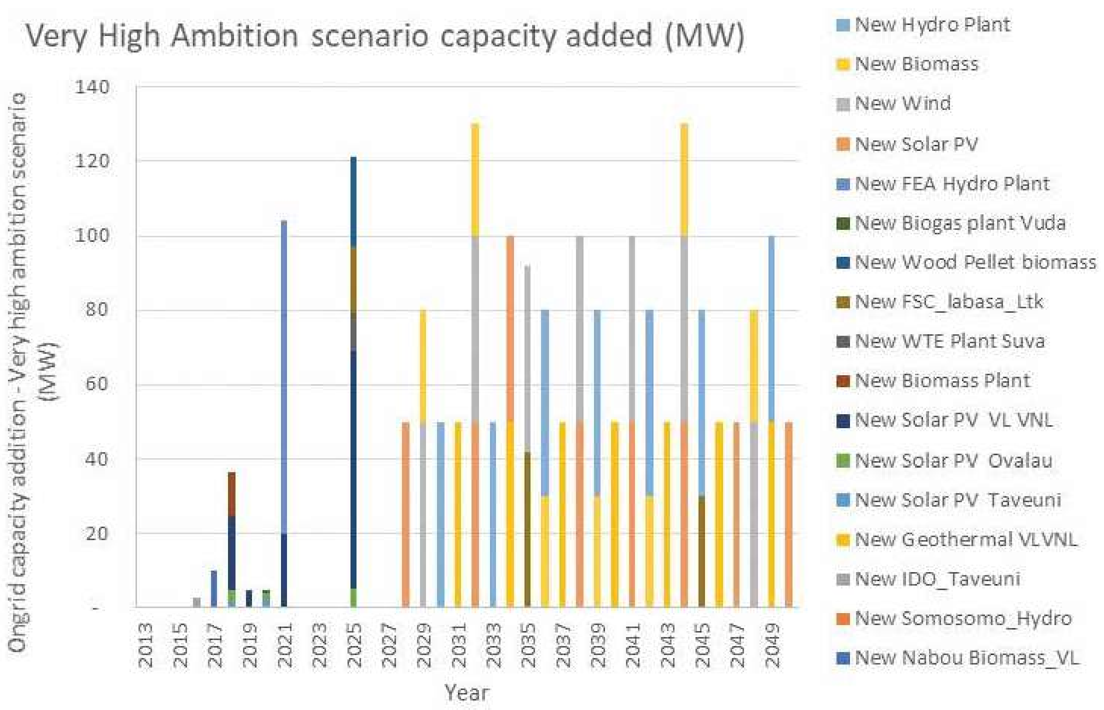


Figure 25. Very High Ambition scenario capacity added (MW).



With respect to off-grid generation, the Very High Ambition scenario for Fiji will expand the use of solar home systems and introduce new solar PV hybrid systems (solar PV, diesel with battery storage), but gradually phase out diesel generators from 5.5 MW in 2013 to 3 MW in 2020, to 1 MW in 2030, and down to 0 MW in 2040. The Vatukoula mine is assumed to adopt new energy efficiency measures. Energy demand is assumed to grow at 0.4% per annum giving rise to almost a 20% reduction in energy demand by 2050 compared with the BAU Unconditional scenario. Generation at the mine is assumed to be from existing diesel generators that will be retired, starting from the 19 MW in capacity in 2013, reduced to 18 MW by 2025, 12 MW by 2030, 9 MW by 2040, and 0 MW by 2050. Capacity will otherwise be replaced with new solar PV, new geothermal, and new wind technologies.

Table 8 below shows the emissions from on-grid and off-grid energy for urban and rural households and other sectors that are connected to the electricity grid. Due to high levels of renewable energy investment, GHG emissions will be almost negligible.

Table 8. Very High Ambition scenario for Electricity Generation and Other Energy Use.
(all values for all gases in metric tonnes CO_2e)

Very High Ambition	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
Electricity Generation - On-Grid										
IDO	CO_2	117,445	85,259	39,267	1,816	2,462	1,027	717	912	1,095
	CH_4	100	73	33	2	2	1	1	1	1
	N_2O	295	214	99	5	6	3	2	2	3
HFO	CO_2	154,822	56,493	24,898	0	1,093	0	0	0	0
	CH_4	126	46	20	0	1	0	0	0	0
	N_2O	372	136	60	0	3	0	0	0	0
Biogas	CO_2	0	0	860	663	726	633	575	547	547
	CH_4	0	0	0	0	0	0	0	0	0
	N_2O	0	0	0	0	0	0	0	0	0
WTE power plant	CH_4	0	0	0	115	126	109	100	95	95
	N_2O	0	0	0	226	247	215	196	186	186
Subtotal		273,160	142,221	65,239	2,827	4,666	1,988	1,591	1,743	1,927
Electricity Generation - Off-Grid										
Vatukoula Gold Mine	CO_2	71,900	65,500	66,800	68,200	39,100	40,500	10,900	12,400	0
	CH_4	100	100	100	100	0	0	0	0	0
	N_2O	200	200	200	200	100	100	0	0	0
Off-Grid Resorts	CO_2	8,706	1,896	1,673	578	152	26	0	0	0
	CH_4	8	2	1	1	0	0	0	0	0
	N_2O	22	5	4	1	0	0	0	0	0
Subtotal		80,936	67,703	68,778	69,080	39,352	40,626	10,900	12,400	0
Industrial										
LPG	CO_2	10,667	11,477	13,501	10,126	6,750	3,375	0	0	0
	CH_4	4	4	4	3	2	1	0	0	0
	N_2O	5	6	7	5	3	2	0	0	0
Subtotal		10,676	11,486	13,512	10,134	6,756	3,378	0	0	0
Commercial										
LPG	CO_2	21,546	24,052	30,318	22,738	15,159	7,579	0	0	0
	CH_4	36	40	50	38	25	13	0	0	0
	N_2O	11	12	15	11	7	4	0	0	0
Subtotal		21,593	24,104	30,383	22,787	15,192	7,596	0	0	0

Very High Ambition	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
Household										
Biogas	CO_2	433	448	490	522	552	609	665	717	766
	CH_4	1	1	1	1	1	1	1	1	1
	N_2O	0	0	0	0	0	0	0	0	0
Kerosene	CO_2	15,034	15,088	15,360	16,543	17,678	13,757	9,472	4,865	0
	CH_4	44	44	45	48	52	40	28	14	0
	N_2O	39	39	40	43	46	36	25	13	0
LPG	CO_2	9,239	10,028	12,223	14,293	16,334	12,728	8,776	4,513	0
	CH_4	15	17	20	24	27	21	15	8	0
	N_2O	5	5	6	7	8	6	4	2	0
Benzene	CO_2	15	11	0	0	0	0	0	0	0
	CH_4	0	0	0	0	0	0	0	0	0
	N_2O	0	0	0	0	0	0	0	0	0
Wood	CH_4	3,281	2,968	2,072	1,050	0	0	0	0	0
	N_2O	646	584	408	207	0	0	0	0	0
Subtotal		28,751	29,233	30,665	32,737	34,697	27,200	18,986	10,133	768
Total	CO_2e	**415,116**	**274,747**	**208,577**	**137,565**	**100,663**	**80,788**	**31,476**	**24,276**	**2,695**

Figure 26. Very High Ambition scenario – Electricity and Other Energy.

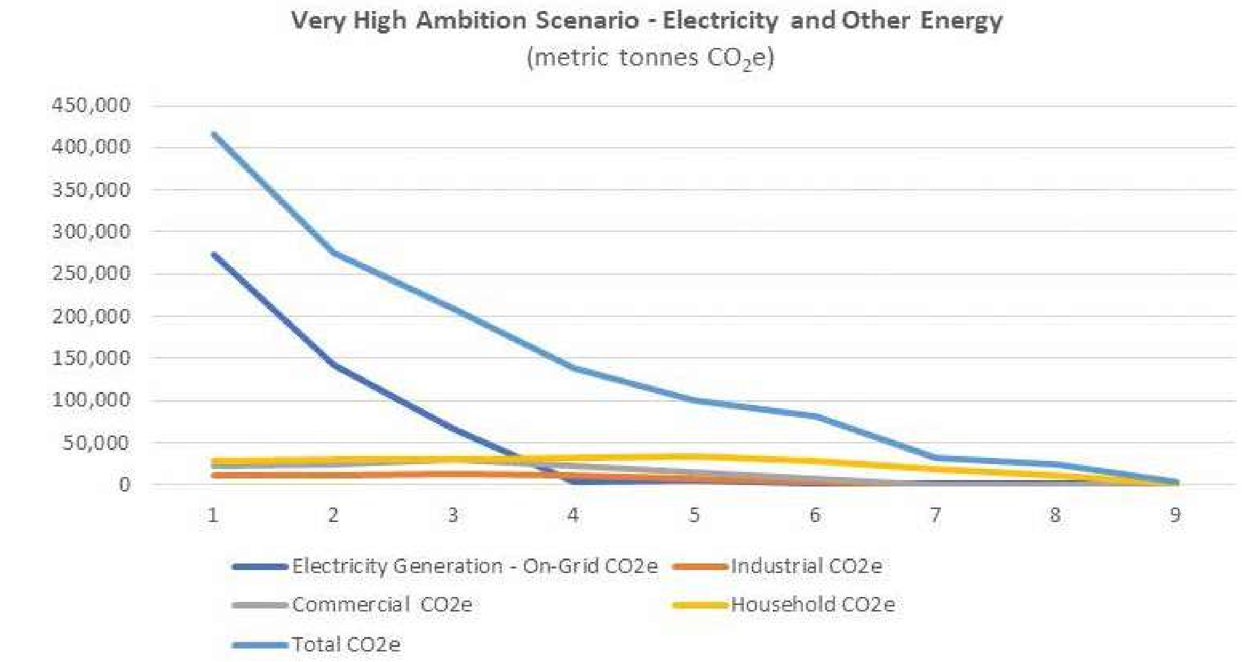


Figure 27. Renewable energy contribution to electricity generation under all four scenarios.

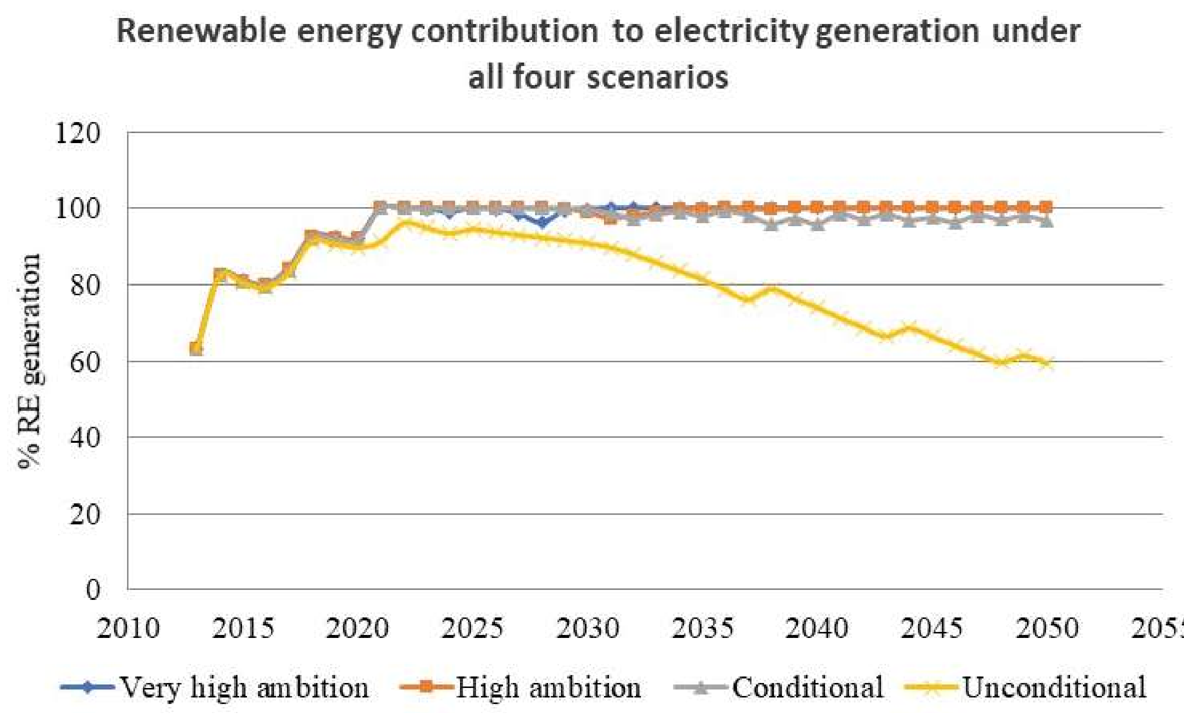
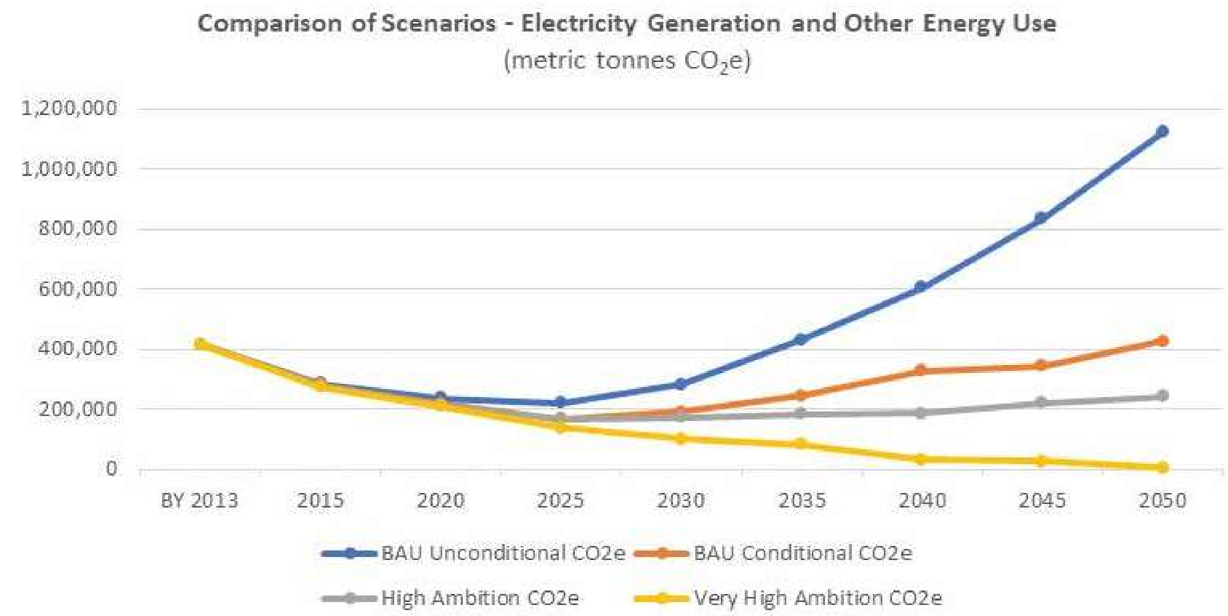


Figure 27 shows the share of renewable energy sources under all four scenarios. It shows that under BAU Unconditional scenario, in the absence of additional financing, the proportion of renewable energy will drop to less than 60% of total generation if the transport sector is electrified.

Comparison of Scenarios

Figure 28 shows total emission reductions under all four scenarios. It shows that the interventions outlined in the Very High Ambition scenario will be required to make Fiji's energy sector fully renewable and reduce emissions to almost zero. Note, all electricity generation (including for transport sector) related emissions are present in Figure 28. For purposes of this LEDS, it is important to note that emissions from the burning of biomass are assumed to be carbon neutral.

Figure 28. Emissions under various scenarios for on-grid electricity generation.



4.1.6 Policy Recommendations, Priority Actions, and High-Level Costing

Table 9 summarizes the necessary installed capacity of various generation technologies under the four scenarios and Figure 29 presents the corresponding approximate investment costs for each. Under the BAU Unconditional scenario, which is based on lower renewable energy capacity, the total cost of investment is estimated at about USD 1.4 billion. This increases to USD 4.193 billion under the BAU Conditional scenario, whereas USD 5.386 billion is required for a High Ambition scenario and USD 9.211 billion for a Very High Ambition scenario. The costs of different technologies are taken directly from the NDC Implementation Roadmap as well as from IRENA.[75] It should be recognized that energy storage costs in the future are uncertain. The costs are currently on a downward curve and, should this continue, then costs for the High Ambition and Very High Ambition scenario could change significantly in the future. The newly added electricity generators are essential for decarbonising the transport sectors and this adds significantly to the investment cost for the electricity sector. All costs are high-level estimates and specific projects will require feasibility studies to define detailed design and costs which may vary from the estimates below, particularly for technologies new to Fiji, for example for pumped hydro.

Table 9. Summary of total installed capacity for different scenarios for on-grid generation.
(in MW)

	Very High Ambition	High Ambition	Conditional	Unconditional
New Biogas plant Vuda	1.0	1.0	1	0.0.
New Biomass Plant	256.0	166.0	136.0	22.0
New WTE plant	10.0	10.0	10.0	0.0
New Solar PV	522.8	322.8	272.8	222.8
New hydro	434.7	284.7	234.7	0.7
New FSC	90.0	90.0	18.0	0.0
New geothermal	350.0	150.0	52.0	0.0
New wind	350.0	200.0	150.0	0.0
New HFO	0.0	0.0	105.0	105.0
New IDO	2.0	2.0	107.0	142.0
Total	**2016.5**	**1226.5**	**1086.5**	**592.5**

Figure 29 provides total estimated cumulative investment costs for all types of generation for each scenario. Between 2016 and 2050, total investment in additional electricity generation capacity will range from USD 1.4 billion and USD 4.2 billion for BAU Unconditional and Conditional scenarios, respectively, to as much as USD 5.4 billion and USD 9.2 billion under High Ambition and Very High Ambition scenarios, respectively.

Table 10 presents the technology capacity and corresponding approximate investment costs for the off-grid sub-sector. The total investment for the off-grid sector, depending on the scenario, varies between USD 29.8 and 91.2 million.

[75]Taylor M, Daniel K, Ilas A, So EY. (2015). *Renewable power generation costs in 2014*. Germany: International Renewable Energy Agency (IRENA).

Figure 29. Cumulative investment costs for on-grid generation capacity addition.

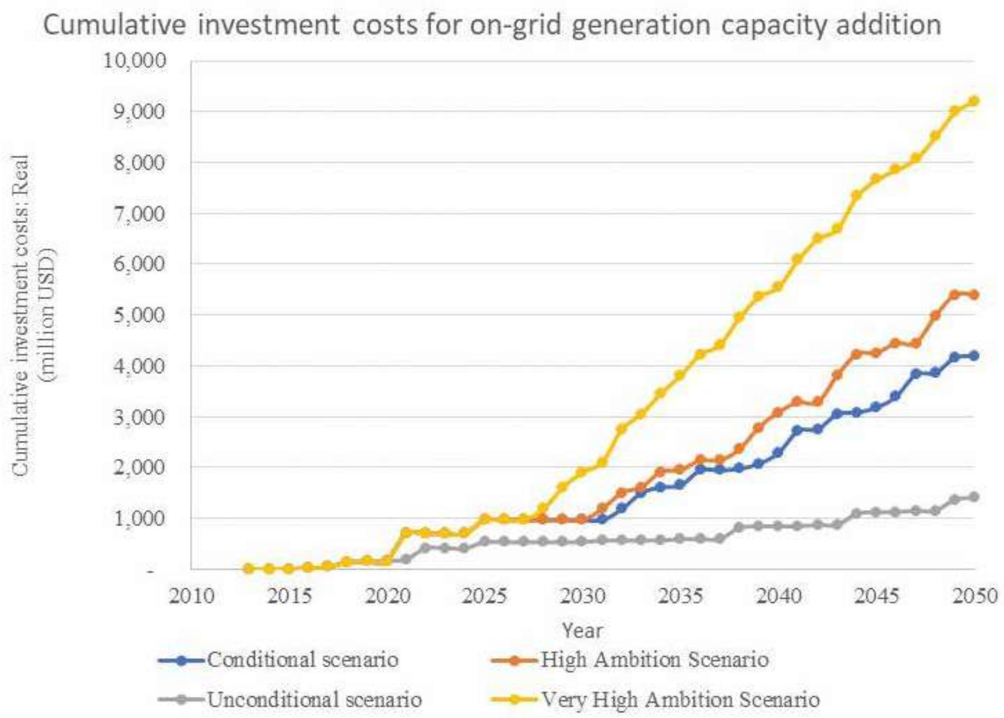


Table 10. Additional capacity and investment required for off-grid rural households under each scenario.

	BAU Unconditional	BAU Conditional	High Ambition	Very High Ambition
New solar home systems (MW)	1.51	1.708	1.708	4.676
Solar PV hybrid (MW)	9.35	10.54	10.54	28.56
Total Investments (USD million)	29.8	33.6	33.6	91.2

Under all scenarios, it is recommended to review, update (as necessary), and endorse the national energy policy, thus strengthening the policy framework which will provide the basis for the actions below.

Under the BAU Unconditional scenario:

- 22 MW of biomass power and 223 MW of solar PV is installed by 2050;
- 0.7 MW of new hydro with 105 MW new HFO and 142 MW IDO are installed to satisfy increased demand; and
- Open fire cooking is completely replaced with LPG, kerosene, and electric stoves by 2030.

The following are considered priority actions in Fiji's energy sector towards achieving low emission development in the next three scenarios.

Under all three scenarios:

- Energy efficiency measures[76] are implemented economy-wide including:
    - Full implementation of Minimum Energy Performance Standards and Labelling;
    - Review, assessment, and revision of the national codes and standards for buildings[77] and industry;
    - Adoption of ISO 50001:2011 – Energy management in the business community; and
    - Review of budgeting processes and procurement in the public sector to promote energy efficiency, adoption of ISO 50001:2011 – Energy management and energy efficiency demonstration projects for public buildings.
- A centralized renewable energy resource database is launched, regularly updated, and made available to investors;
- Grid-connected and off-grid solar PV guidelines and regulations are established and enforced, including FiT or Net metering mechanisms – this includes review of design and installation standards for both on-grid and off-grid solar systems to meet climate resilience needs, amongst other technical considerations; and
- Capacity building needs for renewable energy development and smart grids will be continuously addressed.

Under the BAU Conditional scenario:

- 272 MW solar PV with storage (including rooftop solar), 136 MW biomass generation, 52 MW geothermal capacity, and 150 MW wind power are installed by 2050, including smaller installations for WTE (10 MW – Naboro Landfill and Kinoya wastewater treatment plant) and biogas (1 MW), and initial efforts are undertaken to develop ocean energy namely tidal power, wave energy and ocean thermal energy conversion (OTEC);
- For off-grid locations, use of wood fuel for cooking is eliminated in all households by 2030;
- All diesel generators (5.5 MW at present) in off-grid locations will be replaced with solar PV with storage by 2040, including at off-grid resorts.

Under the High Ambition scenario:

- All grid-connected households use electric stoves by 2050;
- 322 MW solar PV (including extensive rooftop solar) with storage and 200 MW wind power is on the grid by 2050;
- 285 MW new hydropower, 166 MW biomass power, 10 MW W2E and 150 MW geothermal capacity is installed, plus some ocean power at feasible sites; and
- All diesel generators (5.5 MW at present) in off-grid locations will be replaced with solar PV with storage by 2040, including at off-grid resorts.

[76]Success implementation of the energy efficiency measures will require significant data collection (for all energy sectors) in order to monitor the effectiveness of the measures.

[77]In alignment with Fiji's mitigation and adaptation objectives, the new building code needs to make distinctions between and be tailored to suit rural, outer-island, and urban contexts ensuring that implementation and enforcement of the codes is appropriate. Enforcement of Fiji's building codes for public and private sector premises can ensure that disaster risk reduction, energy efficiency, and climate change adaptation benefits are gained.

Under the Very High Ambition scenario:

- All grid-connected households use electric stoves by 2050;
- 522 MW solar PV with storage (including extensive solar rooftop), 435 MW hydropower,
  10 MW WTE and 256 MW biomass power is installed by 2050;
- Vehicle to grid (V2G)[78] technology implemented to support the grid starting from 2040;
- 350 MW geothermal (and ocean energy) and 350 MW wind (on and offshore) is installed from 2028 onwards;
- 100% renewable energy generation provides grid electricity for domestic, commercial, and industrial use as well as electricity for land transport (EVs), some marine transport, and some electric planes;
- All off-grid households use electric stoves by 2050; and
- By 2040, all off-grid resorts are using 10 MW solar PV and 0.5 MW wind power for their electricity requirements.

"Under the Very High Ambition scenario 522 MW solar PV with storage including extensive rooftop solar is installed by 2050"

In order to achieve the high levels of renewable energy capacity envisaged, a concerted effort is needed in the area of resource assessment, especially for geothermal and wind energy. Geothermal exploration is expensive (on average USD 4 million/MW) and Fiji will surely require external financing. Other equally expensive renewable energy resources, like wave energy, tidal energy, and OTEC, will also be investigated. As technologies for harnessing ocean energy become more economical and efficient, ocean energy can play a role in future energy scenarios for Fiji.

Large increases in solar power capacity will require a significant amount of land[79] for installing PV panels. Combining rooftop systems with floating PV systems on reservoirs can reduce the need for land, which can otherwise be dedicated to AFOLU-based mitigation (see section 4.5). However, feasibility studies are needed to define the reservoir area that could be used and the cost. Provision of adequate storage, in the form of batteries and pumped hydro, will be crucial in order to integrate large amounts of intermittent power. With the introduction of electric vehicles, deploying V2G systems can also help ensure grid stability while providing income to vehicle owners.

[78]V2G technology makes use of electric vehicle batteries to stabilize the grid.

[79]Assuming a rule-of-thumb number of 10 m^2/kW, the PV installations will require about 5 km^2 of combined land/water reservoir/rooftop area.

4.2 LAND TRANSPORT

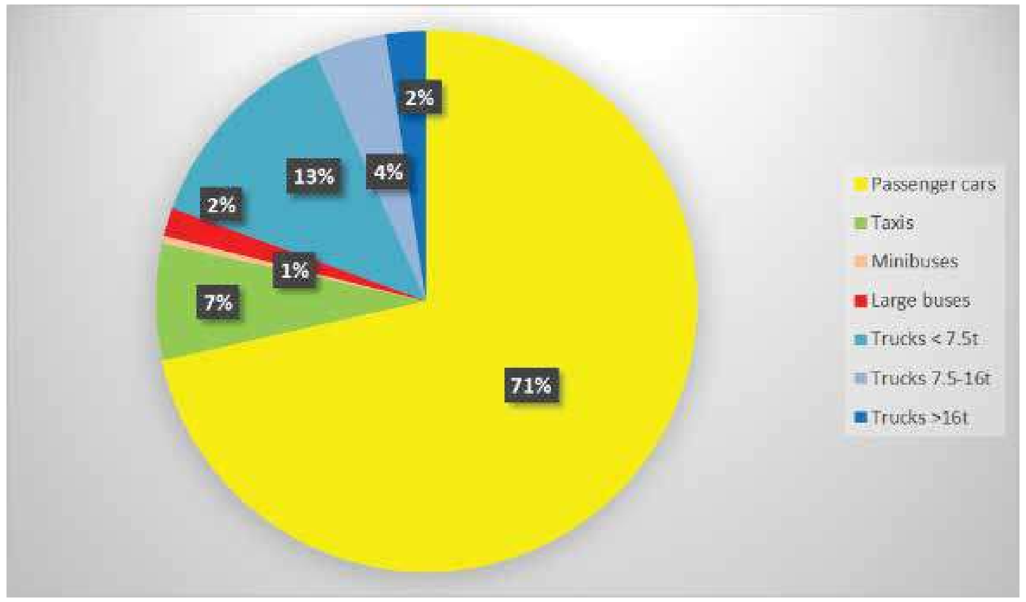
4.2.1 Overview

This section examines the land transport component of Fiji's LEDS. Land transport in Fiji is mainly composed of road vehicles. Passenger and freight rail services do not exist, with the exception of old rail transport of sugarcane from farms to sugar mills used on a limited basis. There are also very few motorbikes.

According to FBoS, the number of vehicles in Fiji is 117,561 in 2017, 84,558 of which are private cars, 6,190 taxis, 2,444 buses (including minibuses as well as larger buses of varying sizes), and 18,397 goods vehicles (including light and heavy goods vehicles such as vans, trucks, pick-ups, and special purpose vehicles). The compound annual growth rate (CAGR) for buses is around 4% and for freight vehicles is 1%.[80] Vehicles typically comply with the Euro 2 vehicle emission standard related to the fuel quality imported (500ppm sulphur for diesel). Figure 30 shows the vehicle distribution in Fiji as of 2017.

"The number of vehicles in Fiji is 117,561 in 2017, 84,558 or 71% of which are private cars"

Figure 30. Vehicle Distribution in Fiji, 2017.

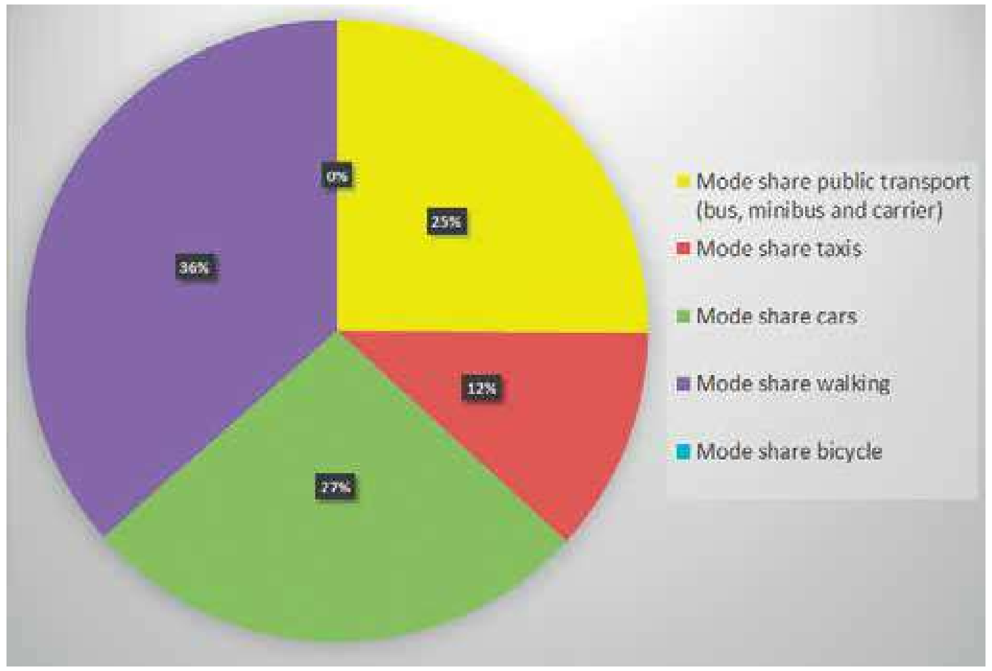


Few 2- and 3-wheelers exist on the roads of Fiji. Among passenger cars, around two thirds run on petrol and the remainder run on diesel. The share of diesel vehicles among taxis is slightly smaller, at around 20% of vehicles. Hybrid cars have surged significantly in the past few years due to tax incentives, mostly as second-hand vehicles imported into Fiji.

[80]Based on registered vehicles period 2001 to 2014; Land Transport Authority.

In the urban context, public transport (PT) buses and passenger cars have a similar mode share of around 40% each of motorized trips, followed by taxis, as can be seen in Figure 31. Bicycle use is rare.

Figure 31. Mode Share of Urban Trips in Fiji, 2015.
(as percentage of trips)[81]



4.2.2 Emission Sources

Summary of Emission Sources

Sources of land transport emissions considered in this LEDS are separated by vehicle type including: passenger cars, taxis, buses, and trucks. Trucks have been further disaggregated into urban or small trucks (less than 7.5 tons) and inter-urban or large trucks (larger than 7.5 tons).

Type of Emissions

This LEDS considers only direct ("tank-to-wheel") GHG emissions, and not indirect emissions ("well-to-tank") or black carbon (BC) emissions. Indirect emissions from electricity generation used to power electric vehicles are considered as part of the energy sector (see section 4.1).

Among the GHGs included under the UNFCCC, only carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are relevant for the transport sector. However, this LEDS primarily considers CO_2 emissions from land transport given that N_2O emissions are generally very marginal (based on IPCC methodologies) and CH_4 is similarly marginal due to limited use of gaseous fuels in Fiji.[82]

Note, indirect emissions from electricity consumption for powering electric vehicles are addressed in section 4.1 on Electricity and Other Energy Generation and Use.

[81]Calculated based on National Household Travel Survey, Fiji 2015.
[82]IPCC. (2006b). *IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 Energy, Chapter 3 Mobile Combustion.* Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T., and Tanabe K. (eds). Japan: IGES.

4.2.3 Existing Policy and Regulatory Framework

Table 11 shows relevant policies identified in existing government strategies and plans along with the specific documents where the policies are mentioned. The policies have been grouped under mitigation actions (MA). These mitigation actions were also considered for the LEDS. Under the section "model and methodology" the different policies are discussed more in detail.

Table 11. Relevant Policies for Land Transport.

Mitigation action	Policy or plan where action is mentioned[83]
Low-carbon vehicles including hybrids, Plug-In Hybrid Electric Vehicles (PHEVs) and Electric Vehicles (EVs)	INDC, GOF, 2018, p.8; GGFF, GOF, 2014, p.74ff; NDP, GOF, 2017; MLTP, GOF, 2015, p.23ff
Public transport expansion	NDP, GOF, 2017; GSTS, FRA, 2014
Vehicle renewal	GGFF, GOF, 2014, p.74ff; MLTP, GOF, 2015, p.23ff
Promote Non-Motorized Transport (NMT)	NDP, GOF, 2017; GSTS, FRA, 2014
Biofuels	INDC, GOF, 2015, p.8; GGFF, GOF, 2014, p. 74ff; NDP, GOF, 2017; MLTP, GOF, 2015, p.23ff
Efficient imported vehicles (including labelling)	GGFF, GOF, 2014, p.74ff; MLTP, GOF, 2015, p.23ff; NDP, GOF, 2017
Liquefied Petroleum Gas (LPG) and Liquefied Natural Gas (LNG) vehicles	NDP, GOF, 2017
Vehicles that comply with Euro IV standard	GGFF, GOF, 2014, p.74ff; NDP, GOF, 2017; MLTP, GOF, 2015, p.23ff

One additional mitigation action modelled in this LEDS analysis, albeit not mentioned in policy documents, is efficiency improvement of existing vehicles. Note, these mitigation actions have different levels of effectiveness in terms of GHG emissions reduction.

4.2.4 Methodology

Model and Methodology Used

Fiji has developed emissions projections for land transport in this LEDS using a bottom-up model. This methodological approach is based on following core elements:

- Use of a bottom-up model based on vehicle-km (vkm) per vehicle technology and fuel type;
- Application of the Tier-2 approach, i.e. vehicle emissions are not related to speed and operating conditions as no data on these factors are available ("hot" and "cold" emissions);
- Core data required to run the model include: the number of vehicles per vehicle category, the emission standard, the vehicle classes per category, fuel types used, annual distance driven, and the total quantity of fuel used;
- Vehicle categories are based on registration data. Petrol and diesel vehicles are separated for each vehicle category. For each category, the main vehicle class is determined based on engine size for passenger cars and based on weight for trucks and buses;
- CO_2 emissions are based on the specific fuel consumption per vehicle category and fuel type used. CO_2 emissions are calculated based on the net calorific value (NCV) and the appropriate CO_2 emission factor for each type of fuel (IPCC 2006 approach); and
- GHG projections are based on GDP projections prepared for the LEDS by the Fiji Ministry of Economy and the elasticity of cargo transported (tonne-km) and passengers transported (passenger-km) to GDP.

[83]The acronyms used in this table include: GOF (Government of Fiji), INDC (Intended Nationally Determined Contribution), GGFF (Green Growth Framework for Fiji), NDP (National Development Plan), MLTP (Maritime and Land Transport Policy), GSTS (Greater Suva Transportation Strategy), and FRA (Fiji Roads Authority).

Data Used, Data Sources, and Assumptions

Land transport scenarios were developed based on the following data parameters and sources.

- **Vehicle numbers per category**. Vehicle numbers are based on the Fiji Land Transport Authority (LTA) database; for goods vehicles three sub-categories are used (trucks ← 7.5t, trucks 7.5-16t, and trucks 16-32t).[84] These truck categories correspond to the European Environment Agency (EEA) Corinair model truck categories. The assignment to each category was made based on the registered gross vehicle weight (GVW); for buses there are two categories: minibuses and large buses (standard 10-12m buses), based on the LTA database.
- **Fuel types used**. Fuel types include petrol and diesel. Some LPG is used for vehicles in Fiji, but this is a very small share and LPG vehicles are also dual-fuel with petrol. Fuel share data is provided by the Fiji LTA.
- **Specific fuel consumption**. Specific fuel consumption values are based on Corinair[85] using a Tier 2 approach; for all vehicle categories the vehicle emission standard Euro 2 was assumed as this corresponds to the median vehicle age registered in the LTA database, the available fuel quality, and the lack of vehicle emission standards except for second-hand imported vehicles since 2013 (requiring Euro 4). The median vehicle year is calculated based on the LTA registration data. The Euro 2 standard is also assumed as this is the vehicle standard in force in major production countries from which Fiji has imported vehicles prior to the year 2000. The average engine size for cars and taxis for petrol vehicles is 1.4-2.0 litres and for diesel vehicles is greater than 2.0 litres, based on the median values provided in the LTA database.
- **Annual average distance driven**. Annual average distance driven for passenger cars is based on calibration with top-down fuel sales for petrol and for diesel, based on the assumption of a 60% higher mileage for diesel units than for petrol cars in accordance with the average mileage difference between diesel or petrol units of other countries. For taxis, average distance is based on 300 working days per year and 200 km driven daily.[86] For trucks. average distance is based on average data of other countries. For sugarcane trucks, the projections assume mileage based on deployment of these trucks for four months per year and average trip distances as reported by the Sugarcane Association. Based on the share of sugarcane trucks, an average mileage was thereafter calculated for all trucks. Average distance for buses is based on data reported by bus operators.
- **Total petrol transport fuel consumed**. Total petrol transport fuel consumed is based on data from Fiji Revenue and Customs Service (FRCS), and a 5% non-road usage for petrol is assumed based on the TNC, 2018.
- **Vehicle turnover rates**. Vehicle turnover rates are required to determine the impacts of new vehicle technologies (i.e., new vehicle stock penetration, based on additional vehicles plus replacement vehicles) based on LTA database per age year and median calculated replacement ages.

This LEDS also makes several basic assumptions in modelling mitigation actions for land transport. The vehicle structure in terms of fuel share (petrol vs. diesel) remains constant per vehicle category (except if replaced by HEVs/EVs under this specific MA), and the relative share of minibuses and bus vs. trucks of different sizes remains constant. In addition, vehicle engine size for fossil-fuel powered passenger cars, vehicle turnover rates (average lifetime age of vehicles), and annual average mileage of vehicles all also remain constant.

Stakeholder Consultation Process

Stakeholders involved in land transport who were invited to participate in stakeholder consultations included: the Ministry of Infrastructure and Transport, the Land Transport Authority, the Fiji Roads Authority, the Fiji Bus Operators Association, the Fiji Taxi Association, the Fiji Minibus Association, several private transport service companies, the International Union for Conservation of Nature (IUCN), the Asian Development Bank (ADB), the World Bank, the Pacific Islands Climate Action Network, and the Pacific Island Development Forum. Individual consultations were also conducted with the Ministry of Infrastructure and Transport and EFL as well as the ADB.

During the First National Stakeholder Consultation Workshop on the 23rd of May, 2018, stakeholders outlined a vision of a "fully fossil-fuel free land transport sector, inclusive of increased PT mode share, with multi-modal transport in urban areas and appropriate hub to provide adequate, affordable, reliable service to all areas of Fiji." The Second National Stakeholder Consultation Workshop focusing on land transport took place on the 6th of July, 2018.

Among stakeholder remarks, a bus company representative commented that a planned increase in taxi licenses in Fiji could lead to changes in mode share from PT. A bus operator also called for stronger government engagement and direction to promote cleaner transport, including creating incentives for cleaner vehicles (including electric scooters and bicycles), and addressing traffic congestion and lack of infrastructure. Stakeholders raised several issues during the Third National Stakeholder Consultation Workshop. One called for broader consideration of cradle-to-grave impacts of developing new low or zero emission vehicles, and stronger consideration of non-motorised transport and ways of addressing traffic congestion.

One observed that reducing the required weight of trucks has led to more trucks on the road. Another noted a correction in the baseline information on the number of vehicles in Fiji. Furthermore, a participant commented that shifting to Euro 4 standards has limited difference in terms of GHG emissions, although there are indeed significant reductions in other pollutant emissions. There was some debate about promoting vehicle scrapping vs. renewal, the latter offering the ability to direct people to buy lower emission vehicles, as well as whether increasing demand for electricity by transitioning to EVs would increase emissions (hence the need for increased renewable generation).

4.2.5 Low Emission Development Scenarios

A description of the base year and the four emission reduction scenarios for land transport follows below. For each of the scenarios, it should be noted that cumulative actions are not necessarily additive. Some might even cancel themselves out, e.g. if 100% of vehicles are converted to EVs, there is no need for biofuels. The estimation approach used in this LEDS is a first step to determine the impact of combined measures and then the mode shift impact based on the new vehicle efficiencies.

The nine mitigation options considered for low emission projections for land transport include:

- Adoption of HEVs and EVs;
- Promotion of PT;
- Promotion of non-motorized transport (NMT) including cycling;
- Promotion of vehicle renewal and scrapping;
- Promotion of biofuels;
- Adoption of efficient new vehicles; and
- Efficiency improvements in operating vehicles.

Other possible options considered for this LEDS include: promotion of LPG and LNG vehicles and compliance with Euro IV standards, but neither is seen as highly relevant in reducing GHG emissions per se, and thus not incorporated into the scenarios.

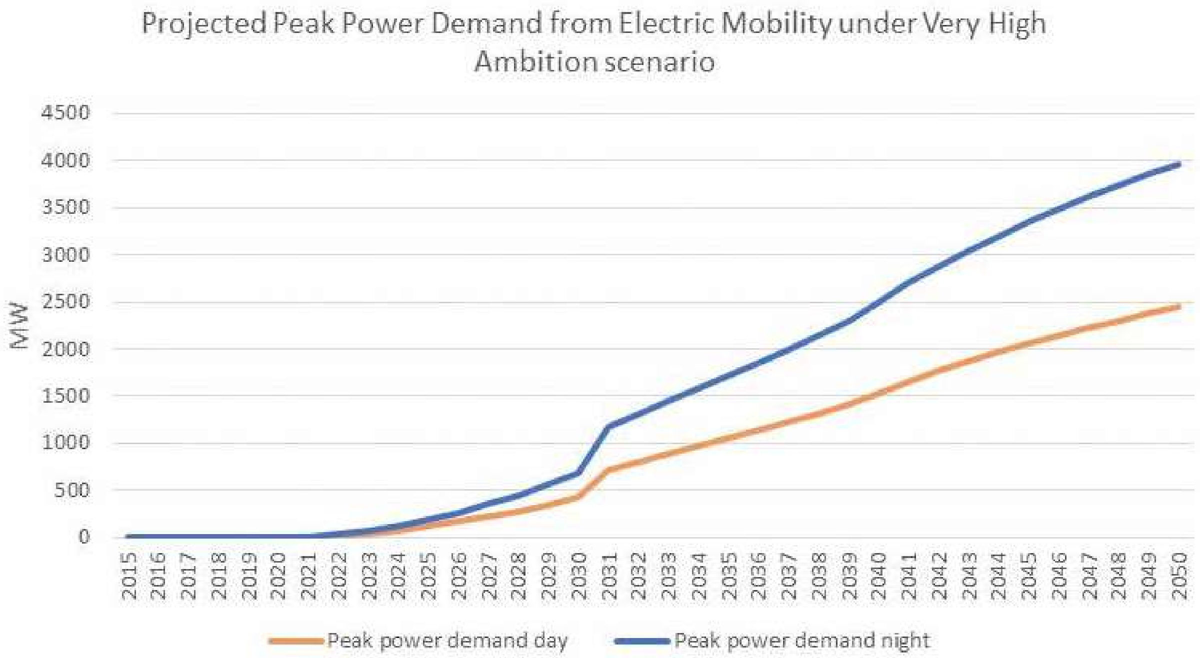
Other key considerations used in developing the low emission scenarios for land transport include the following:

- **Power Supply.** The strategy to run 100% EVs will create significant additional demand on the electric power grid from 2030 or 2035 onwards, especially as high GDP growth rates would result in increased vehicle fleet and mileage. To achieve maximum emission mitigation, all new EVs should be charged using electricity from renewable sources. If this were not the case, GHG emissions in the electricity sector would continue to increase.
- **Peak Power Demand**. Running 100% EVs will not only stress the grid in terms of electricity production, but also in terms of power demand. EV charging can have a sizeable impact on the loads applied to the grid at certain times and locations. Figure 32 shows the projected peak power demand from EVs under the very high ambition scenario and indicates that EVs will pose a considerable demand on the grid in Fiji concerning available power. Solutions to these problems will involve controlled charging and smart charging. For fast charging, managing power demand is also likely to require the deployment of stationary storage at the local level.[87] Promoting Demand Side Management (DSM) is another important option (see policy section below). The figure below shows that EVs will pose a considerable additional power demand on the grid in Fiji.

[84]Trucks → 32t are less than 0.1% of all trucks in Fiji according to the LTA database, 2015.
[85]EEA. (2016). *Air pollutant emission inventory guidebook Version 2016 update December 2016.*
[86]Various data sources from within Fiji.

[87]See IEA. (2017). *Global EV Outlook 2017.*

Figure 32. Projected Peak Power Demand from Electric Mobility under Very High Ambition scenario.



- **Usage of Used Batteries**. Used EV batteries can provide for low-cost storage capacity which is especially important in renewable energy grids. Particularly for small isolated islands, increasing renewable energy penetration requires sufficient energy storage systems due to the unpredictability of renewable energy sources, such as wind and solar. The effectiveness of DSM can be enhanced by bi-directional V2G capabilities where power can flow from the grid to the vehicle and vice-versa.[88] The development of electric mobility and of a renewable electricity system can thus contribute to reducing total costs. EV fleets could play a role as distributed energy storage systems, thereby assisting to increase the participation of renewables.[89]
- **Truck Age**. Trucks are the most complex vehicle category concerning the reduction of GHG emissions, especially long-haul trucks. Their commercial lifetime in Fiji can be very long; given the mileage in Fiji, a lifetime of 30 years could be normal and economically efficient. Reducing the commercial lifespan of long-haul trucks can be a very costly and ineffective policy, except if replaced with long-haul electric trucks (which will probably only be commercially available starting a decade from now).
- **Used Vehicles and Cost**. As of 2018, Fiji primarily imports used vehicles. These have a far lower cost than new vehicles. With its reduced tax on HEVs, Fiji has received a large influx of hybrid vehicles, thus achieving its goal of promoting these vehicles. In the case of EVs, however, there are far fewer second-hand EVs to import. While this is expected to change in the future, used EVs would have at least partially depleted batteries and purchasers may have to make costly investments in new battery sets, while not having the advantages of a vehicle with a state-of-the art battery management system or charging option (i.e., in terms of the charging power the vehicle supports). It will be difficult for second-hand EVs and even harder for new EVs to compete with used conventional cars given the large financial gap that exists between EVs and conventional vehicles. This gap is smaller in countries where new, rather than second-hand, vehicles are sold.

[88]IEA. (2018). *Global EV Outlook 2018.*
[89]For example, Renault is testing a "smart electric island" with EVs, V2G, and energy storage in Porto Santo island, Portugal (see https://electrek.co/2018/02/21/renault-smart-electric-island-electric-vehicles-v2g-energy-storage/).

- **Biofuel Plants**. It should be noted that it may be difficult for Fiji to attract investment in biofuel plants for the production of biodiesel if Fiji runs an aggressive EV strategy at the same time, since demand for biodiesel will gradually decline, resulting in reduced investment recovery periods.
- **Mode Shift.** If most or all vehicles are electric, mode shift will no longer reduce GHG emissions or local pollutants as the direct emissions from land transport will be zero, independent of the mode used. However, higher numbers of EVs would continue to congest the road, result in accidents, and discourage PT and non-motorised transport. Even if they would be carbon neutral at the time, promoting PT and NMT will still be justified to reduce congestion, save time, reduce car accidents, reduce environmental impacts for required road infrastructure, and improve health by encouraging cycling and walking.
- **EVs**. The economic viability of electric vehicles will depend on national price structures and cannot be determined in a general form. This is discussed further in the policy section below.

Base Year Emissions in 2014

GHG emissions from the land transport sector were an estimated 635,972 tCO_2 in 2014. GHG emissions are dominated by goods vehicles which comprised 45% of emissions, followed by passenger cars generating 28% of emissions, buses 14%, and taxis 13%.

Table 12. GHG Emissions 2014 for Land Transport.
(tCO_2)

Source	Amount	Unit	Share
Passenger cars	177,388	tCO_2	28%
Taxis	82,616	tCO_2	13%
Goods vehicles	284,222	tCO_2	45%
Buses	91,747	tCO_2	14%
Total	**635,972**	**tCO_2**	

This LEDS aims to achieve net zero emissions across all sectors by 2050 and does so for the land transport sector specifically under the Very High Ambition Scenario (see below).

BAU Unconditional Scenario

The BAU Unconditional scenario for land transport has been structured around a target of reducing GHG emissions from energy sources by 10% by 2030 on an unconditional basis as, outlined in the NDC Implementation Roadmap. This has been extrapolated to 2040 and 2050 by having targets of -10% for 2030, -20% for 2040 and -30% for 2050, compared to the extrapolated "do-nothing" scenario.

The main mitigation actions for the BAU Unconditional scenario include: promoting hybrid and electric vehicles, PT, cycling, and biofuels.

This scenario envisions gradually increasing the share of new vehicle sales to 10% HEVs for cars and taxis starting in 2020. Starting in 2030, 80% of all cars, 60% of taxis, and 30% of buses will be HEVs. In addition, 20% of cars, 40% of taxis, 70% of buses, and 30% of urban trucks will be EVs. By 2050, 80% of cars, 50% of taxis, and 10% of buses will be HEVs, while 20% of cars, 50% of taxis, 90% of buses, 40% of urban trucks will be EVs. All large trucks will continue to use conventional fuels in this scenario.

The scenario also envisions gradually increasing the share of public transport to 40% in 2020 and 45% from 2030 onwards. The share of cycling will also gradually start to increase from 0% in 2020 to 1% in 2025 and onwards.

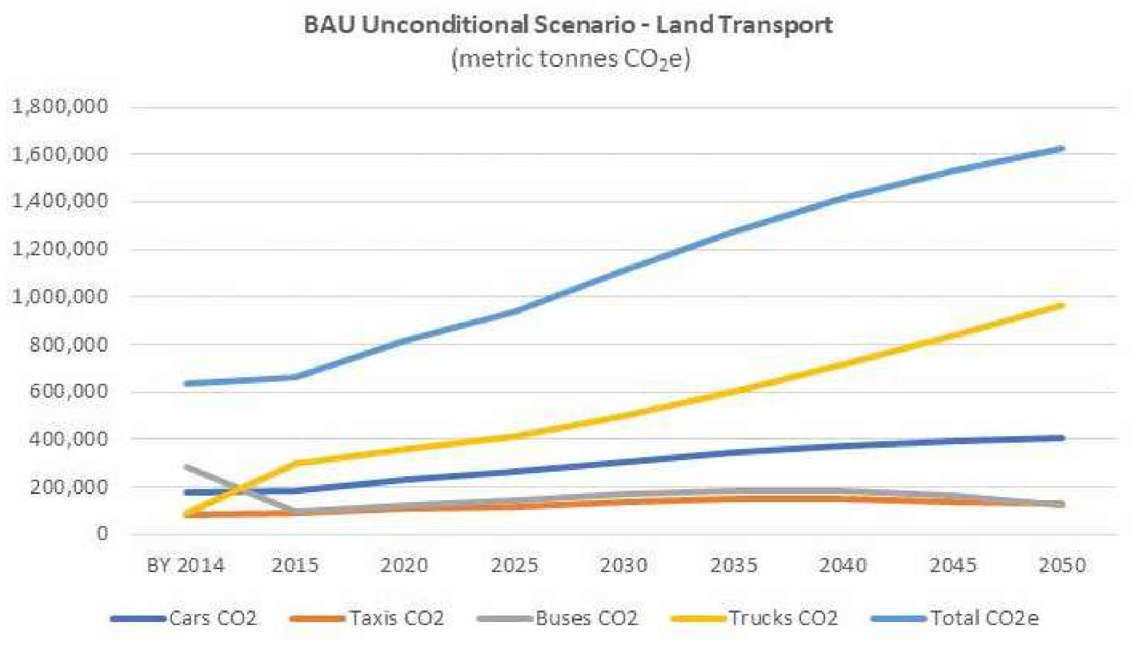
Under the BAU Unconditional scenario, Fiji will also promote biofuels, a bioethanol blend for petrol and biodiesel blend for diesel. By 2020, the scenario would achieve 2% bioethanol in petrol and by 2050 and onwards 10% bioethanol in petrol and 5% biodiesel in diesel.

The emissions resulting from the adoption of mitigation actions under BAU Unconditional are provided in Table 13 below.

Table 13. BAU Unconditional scenario for Land Transport.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2014	2015	2020	2025	2030	2035	2040	2045	2050
Cars	CO_2	177,388	185,778	231,074	261,825	306,956	344,030	372,789	393,514	405,842
Taxis	CO_2	82,616	86,524	107,438	118,387	135,525	147,802	149,202	138,505	129,316
Buses	CO_2	284,222	96,086	120,910	142,754	168,525	183,092	181,227	164,928	123,391
Trucks	CO_2	91,747	295,363	357,974	414,118	501,902	602,260	713,042	834,290	965,297
Total	**CO_2e**	**635,973**	**663,751**	**817,396**	**937,084**	**1,112,908**	**1,277,184**	**1,416,260**	**1,531,237**	**1,623,846**

Figure 33. BAU Unconditional scenario – Land Transport.



BAU Conditional Scenario

The BAU Conditional scenario for land transport has been structured around a target of reducing GHG emissions by 30% by 2030 on a conditional basis as outlined in the NDC Implementation Roadmap. This has been extrapolated to 2040 and 2050 by having targets of -30% for 2030, -40% for 2040 and -50% for 2050 compared to the extrapolated "do-nothing" scenario.

As with the BAU Unconditional scenario, the main mitigation actions for the BAU Conditional scenario include: promoting hybrid and electric vehicles, PT, cycling, and biofuels.

This scenario envisions gradually increasing the share of new vehicle sales of HEVs starting in 2020 to 30% for cars, 40% taxis, and 20% buses. By 2030, 30% of cars will be HEVs and 70% of cars and 100% of taxis, buses, and urban trucks will be EVs, along with 10% of large trucks. By 2050, all HEVs except large trucks will be phased out and 100% of cars, taxis, buses, and urban trucks will be EVs, as well as 40% of large trucks.

The scenario also envisions gradually increasing the share of PT to 40% in 2020 and 45% from 2030 onwards. The share of cycling will also increase from 0% in 2020 to 10% in 2030 and to 20% by 2050.

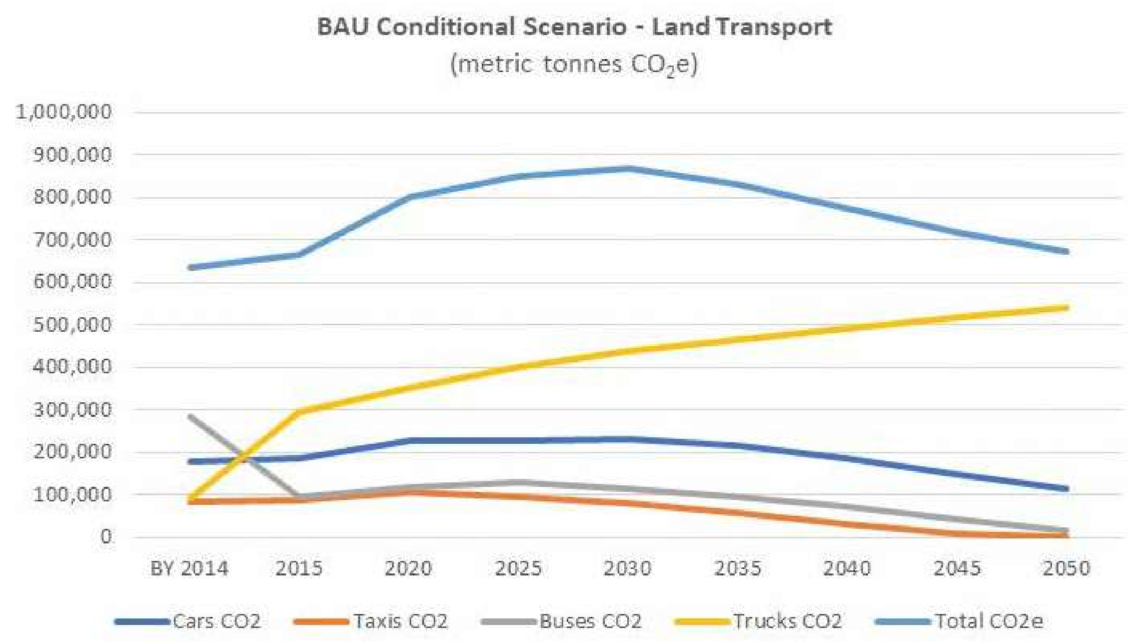
Under the BAU Conditional scenario, Fiji will also achieve 5% bioethanol in petrol and 2% biodiesel in diesel by 2020, and by 2025 onwards 10% bioethanol in petrol and 5% biodiesel in diesel.

The emissions resulting from the adoption of mitigation actions under BAU Conditional are provided in Table 14 below. GHG emissions are projected to peak in 2028 under this scenario and, thereafter, start dropping (even with increasing GDP and freight and passenger movement).

Table 14. BAU Conditional scenario for Land Transport.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2014	2015	2020	2025	2030	2035	2040	2045	2050
Cars	CO_2	177,388	185,778	225,468	226,364	232,381	213,943	184,108	149,722	115,336
Taxis	CO_2	82,616	86,524	106,240	95,840	81,664	58,046	30,377	8,901	0
Buses	CO_2	284,222	96,086	118,316	127,168	115,501	93,308	71,171	43,951	15,481
Trucks	CO_2	91,747	295,363	351,459	400,685	439,423	464,529	489,951	515,719	541,470
Total	**CO_2e**	**635,973**	**663,751**	**801,483**	**850,057**	**868,969**	**829,826**	**775,607**	**718,293**	**672,287**

Figure 34. BAU Conditional scenario – Land Transport.



High Ambition Scenario

The High Ambition scenario for land transport achieves part of the ambition towards full net zero emissions in the Very High Ambition scenario.

As with prior scenarios, the main mitigation actions for the High Ambition scenario include: promoting hybrid and electric vehicles, public transport, cycling, and biofuels, as well as efficiency improvement of operating vehicles.

This scenario envisions gradually increasing the share of new vehicle sales for HEVs and EVs starting in 2020, with 40% HEV cars, 50% HEV taxis, and 30% HEV buses. By 2030, 20% of cars will be HEVs and 80% cars, 100% taxis, 100% buses, 100% urban trucks, and 40% large trucks will be EVs. By 2050 HEVs will be completely phased out and 100% of all cars, taxis, buses, and urban trucks and 70% of large trucks will be EVs.

The scenario also envisions gradually increasing the share of PT to 40% in 2020, 53% by 2030, and 55% by 2050. The share of cycling will increase from 1% in 2020 to 15% in 2030 and to 35% by 2050.

Under the High Ambition scenario (as with the BAU Conditional scenario), Fiji would achieve 5% bioethanol in petrol and 2% biodiesel in diesel by 2020, and by 2025 and onward 10% bioethanol in petrol and 5% biodiesel in diesel.

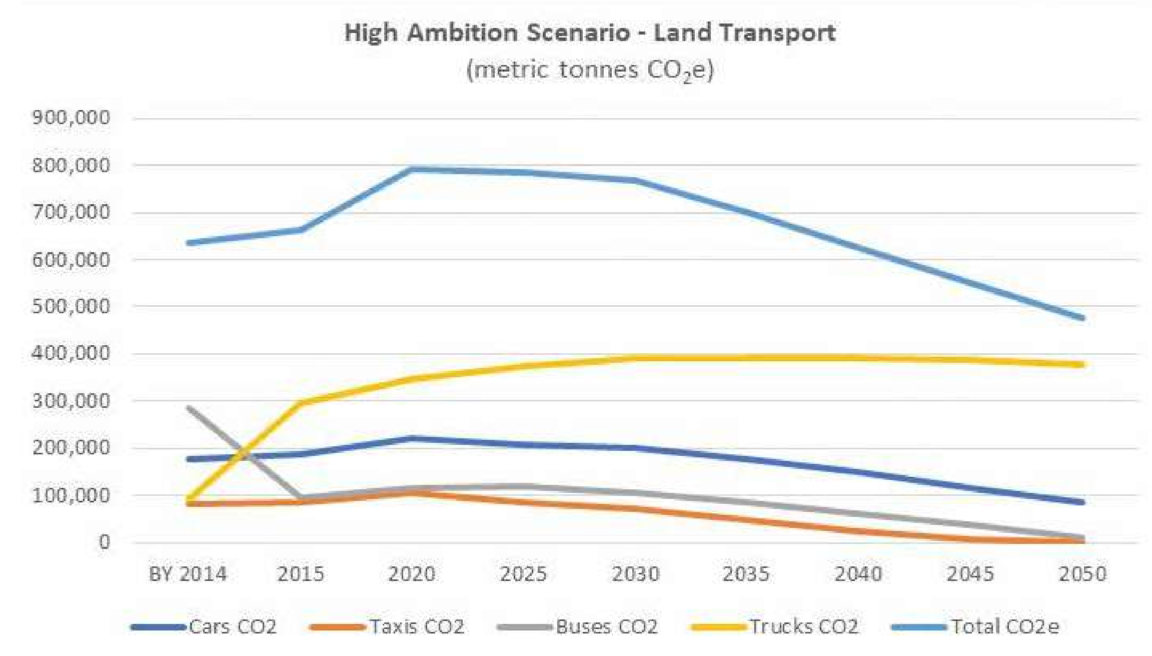
Measures implemented by 2020 under the High Ambition scenario will result in capturing 10% of the total potential, and 50% by 2025 and onwards (not all possible measures are expected to be implemented or may only partially be implemented).

The emissions resulting from the adoption of mitigation actions under the High Ambition scenario are provided in Table 15 below. It is projected that GHG emissions will peak in 2026 and, thereafter, start dropping even with increasing GDP and freight and passenger movement. By 2040, the total GHG emissions will be less than that of the base year of 2014.

Table 15. High Ambition scenario for Land Transport.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2014	2015	2020	2025	2030	2035	2040	2045	2050
Cars	CO_2	177,388	185,778	222,468	206,614	201,826	178,520	148,765	117,050	85,683
Taxis	CO_2	82,616	86,524	104,691	86,685	70,780	48,754	23,456	5,989	0
Buses	CO_2	284,222	96,086	116,887	117,896	105,633	84,413	63,261	37,255	12,253
Trucks	CO_2	91,747	295,363	347,945	373,306	390,171	389,638	391,155	389,355	379,168
Total	CO_2e	**635,973**	**663,751**	**791,991**	**784,501**	**768,410**	**701,325**	**626,637**	**549,649**	**477,104**

Figure 35. High Ambition scenario – Land Transport.



Very High Ambition Scenario

Fiji aims to achieve zero emissions by 2050 from the land transport sector under the Very High Ambition scenario. This requires that, in addition to adopting all mitigation action options, all vehicles from 2030 onwards are scrapped after 20 years of use, thereby ensuring that all vehicles are electric by 2050.

As with prior scenarios, the main mitigation actions for the High Ambition scenario include: promoting hybrid and electric vehicles, public transport, cycling, biofuels, and efficiency improvement of operating vehicles, with the addition of vehicle scrapping and maximum vehicle age.

This scenario envisions gradually increasing the share of new vehicle sales for HEVs and EVs starting in 2020, with 50% HEV cars, 60% HEV taxis, and 50% HEV buses (0% EVs). By 2030, EVs will aggressively replace most vehicles, including HEVs (which will be reduced to 0%), with 100% of all cars, taxis, buses, and urban trucks and 90% of large trucks replaced with EVs. By 2050, 100% of all vehicle types will be EVs. In addition, a maximum vehicle age of 20 years would apply to all vehicle categories from 2030 onwards.

The scenario also envisions gradually increasing the share of PT to 40% in 2020, 60% by 2030, and 80% by 2050. The share of cycling will increase from 1% in 2020 to 25% in 2030 and to 60% by 2050.

Under the Very High Ambition and BAU Conditional scenarios, Fiji would achieve 5% bioethanol in petrol and 2% biodiesel in diesel by 2020 and, by 2025 onwards, 10% bioethanol in petrol and 5% biodiesel in diesel.

Measures implemented by 2020 under the Very High Ambition scenario will result in capturing 10% of the total potential, and 100% by 2025 and onwards (all possible mitigation measures are fully implemented).

The emissions resulting from the adoption of mitigation actions under the Very High Ambition scenario are provided in Table 16 below. GHG emissions are projected to peak in 2020 and thereafter start dropping (even with increasing GDP and freight and passenger movement). The total GHG emissions around 2030 is expected to be at parity with that of the base year of 2014.

Table 16. Very High Ambition scenario for Land Transport.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2014	2015	2020	2025	2030	2035	2040	2045	2050
Cars	CO_2	177,388	185,778	222,040	189,043	169,353	89,156	45,780	13,720	0
Taxis	CO_2	82,616	86,524	104,446	78,165	58,985	40,078	17,292	3,476	0
Buses	CO_2	284,222	96,086	116,498	108,368	94,283	56,040	30,560	9,304	0
Trucks	CO_2	91,747	295,363	347,945	336,897	317,664	183,487	121,767	34,090	0
Total	**CO_2e**	**635,973**	**663,751**	**790,929**	**712,473**	**640,285**	**368,761**	**215,399**	**60,590**	**0**

Figure 36. Very High Ambition scenario – Land Transport.

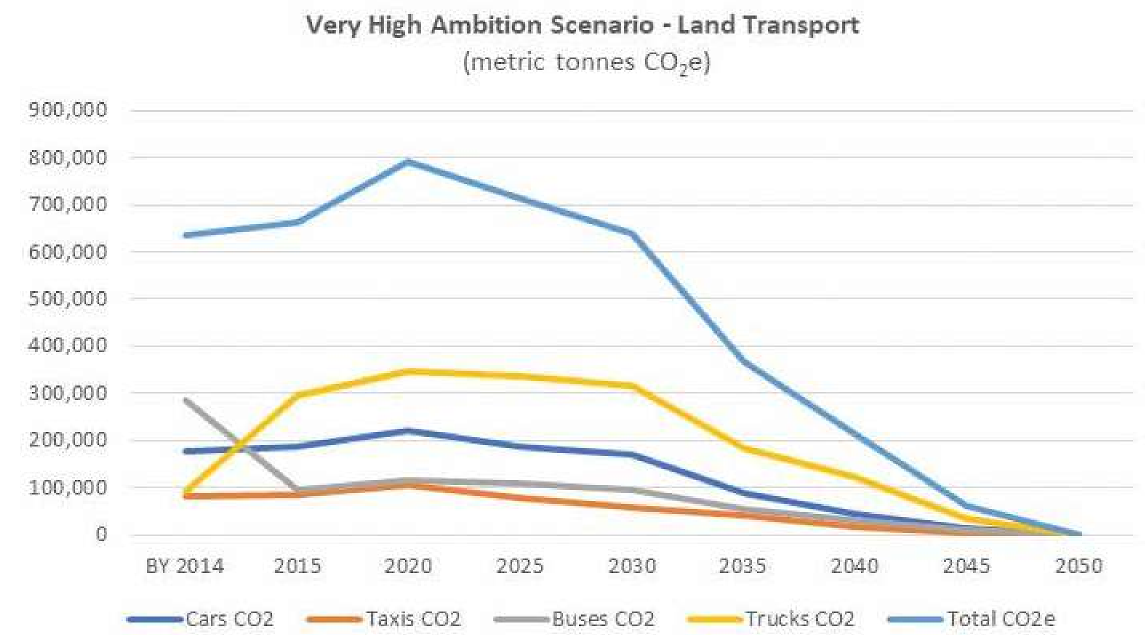
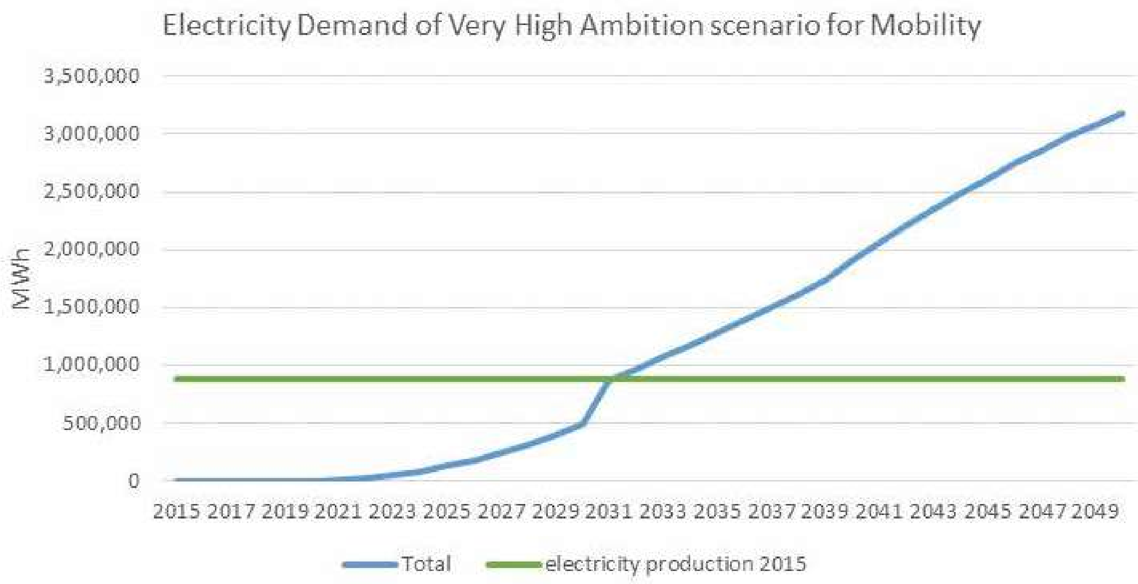


Figure 37 shows the total electricity demand for mobility related to the implementation of the Very High Ambition scenario, compared with Fiji's electricity production in 2015, which highlights the large scale of additional electricity required.

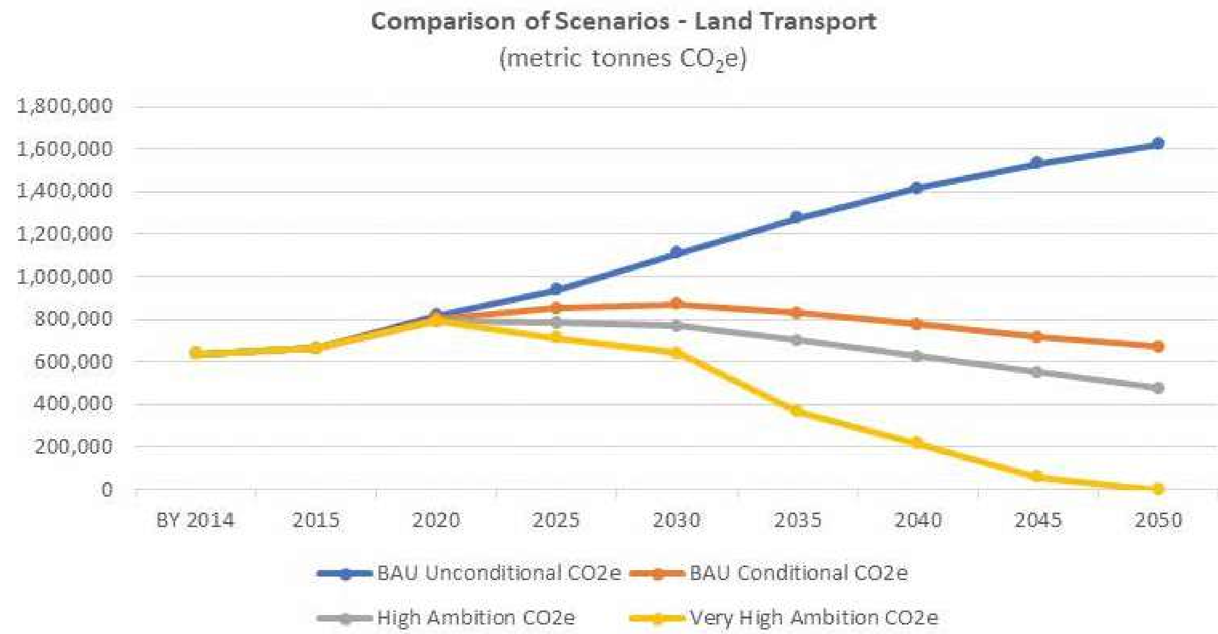
Figure 37. Electricity Demand of Very High Ambition scenario for Mobility.



Comparison of Scenarios

Figure 38 shows projections of GHG emission trajectories of the four scenarios, along with the extrapolation of the current GHG emissions used in the analysis.

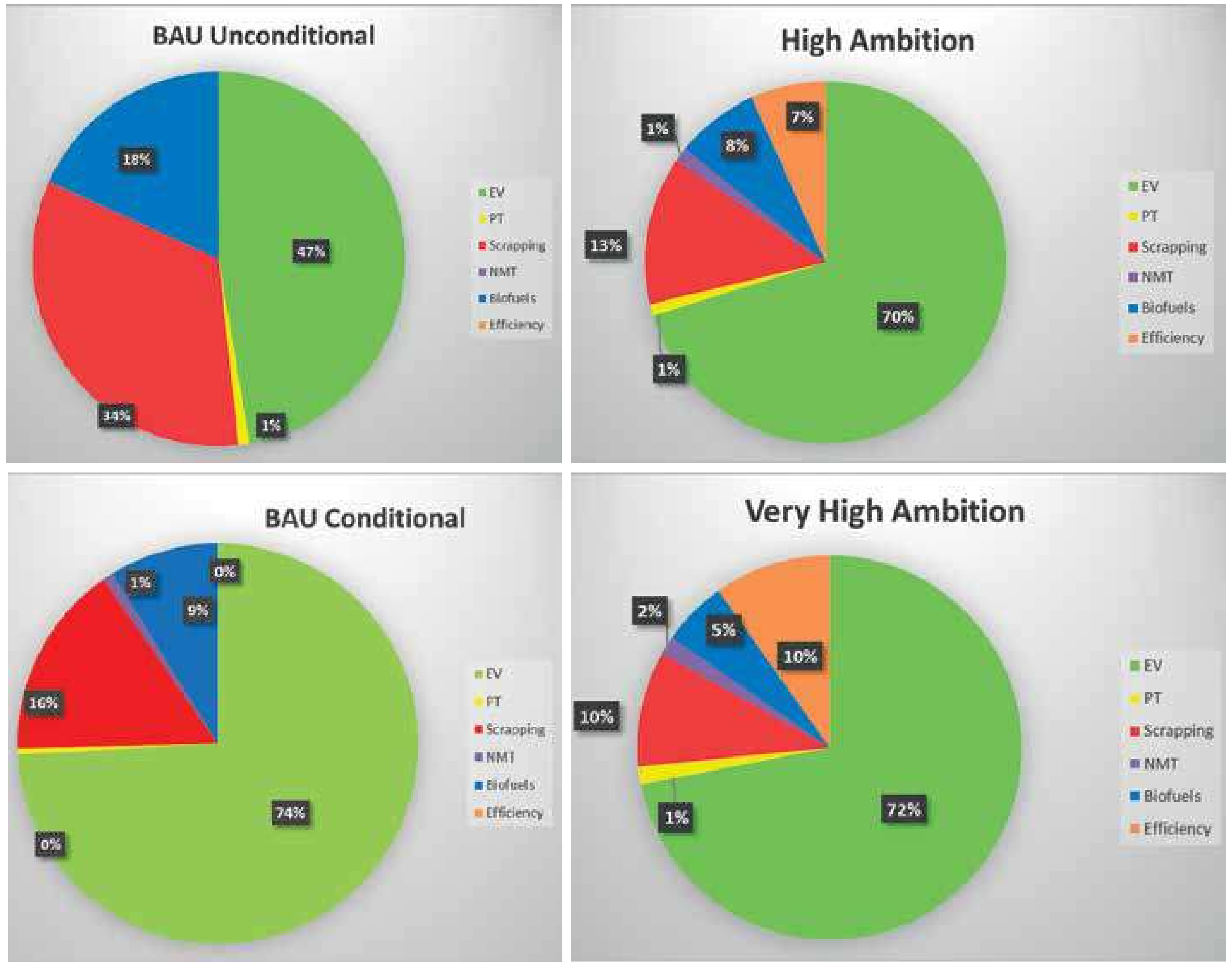
Figure 38. Comparison of scenarios – Land Transport.



4.2.6 Policy Recommendations,Priority Actions, and High Level Costing

All scenarios are technically achievable. The following graphs show the percentages that different mitigation actions contribute to GHG emissions reduction under each scenario.

Figure 39. Contribution of Mitigation Actions to GHG Emissions Reduction in the Land Transport Sector.



As shown in Figure 39, EVs are by far the dominant mitigation action in all LEDS scenarios for the land transport sector. Biofuels and vehicle scrapping (especially in BAU unconditional and BAU conditional), and vehicle efficiency in the High Ambition and Very High Ambition scenarios, can also play an important role in achieving low emission development. All other mitigation actions have much more minor impact in terms of GHG mitigation. However, it should be noted that for the Very High Ambition scenario, EV mitigation also includes establishing a maximum vehicle age of 20 years starting in 2030 which can also be considered as a vehicle scrapping measure.

Several critical points listed below need to be taken into consideration for implementing mitigation options in land transport as part of this LEDS.

Transitioning the land transport sector towards full net zero emissions over the short-, medium-, and long-term will require strategic policies and investments that catalyse and incentivise change without unduly burdening individuals, business, or government resources.

Short-term mitigation actions, which can be implemented in the next one to three years include: vehicle efficiency improvements, biofuels, and NMT.

Vehicle efficiency improvements include eco-driving, efficient tyres, and improved aerodynamics for trucks. Improvements should be financially attractive to vehicle owner as a result of fuel savings, but may not be attractive enough to be implemented, with the exception of aerodynamics. Therefore, it may be necessary to adopt regulations to encourage these practices, such as making eco-driving training compulsory to receive a driver's license or assigning maximum levels of Coefficient of Resistances (CORs) for tyres. Limited finance is required to structure these types of actions, which can be driven by appropriate policies, regulations and standards, alongside public education, awareness and enforcement.

"Medium-term mitigation actions include adopting EVs and fostering public transport"

Biofuels are, in general, more expensive to produce than conventional fuels. However, actual cost differences will depend on national circumstances and, thus, need to be assessed in detail for Fiji. NMT plans have already been drafted in Fiji. Important steps to take in the future will include establishment of safe bike lanes, bike sharing systems including e-bikes, and policies for "putting bikes first." Establishing a large biking infrastructure will not have short-term impacts on trip mode shares, but will create a culture of biking starting with sports and recreation and moving towards usage for daily commuting. Without safe and appropriate infrastructure, this shift cannot happen.

Medium-term mitigation actions include adopting EVs and fostering public transport. These actions can be planned and trialled in the next few years; on-the-ground implementation is not expected in the short-term, but in the period after 2025. Fostering PT will require a detailed project plan about what is required and what systems are most appropriate. For EVs, it is recommended to develop an EV roadmap for Fiji that identifies which vehicle segments and areas to focus on and details the intervention strategies and financial means.

As addressed above, long-term mitigation actions include mandating vehicle scrapping or maximum vehicle age in coordination with the increased adoption of EVs and alternative modes of transport for freight, potentially including rail or coastal shipping. The latter could provide alternatives to scrapping trucks. This will need to be defined prior to 2030 in order for Fiji to achieve zero emissions by 2050 due to the long commercial lifespan of trucks.[90]

Additional policy measures Fiji would need to consider to achieve these low emission scenarios include:

Mode Shift. New policies will be needed to promote transport mode shifts, and simultaneously to promote EVs as well as PT and NMT. From the socio-economic perspective, increased use of PT is seen as economically profitable due to time savings and vehicle operating cost savings. The increase in the mode share of PT can be achieved with demand management measures which have a very low cost, or with supply measures which can entail high investment costs and/or support subsidies, or a combination of supply and demand measures. Actual costs thus depend on specific policies and strategies for promoting PT. Increased use of NMT is seen as economically profitable due to vehicle operating cost savings. The increase in NMT can be achieved with demand management measures (e.g., vehicle-free zones) which have a very low cost and/or with supply measures such as bike lanes and bike sharing facilities. Again, actual costs depend on the specific policies chosen. Some estimations of costs are given in Annex A.

[90]To avoid excessive scrapping costs, a regulation establishing vehicle maximum age should be put into place prior to 2030 as then purchasers of vehicles are aware of their commercial lifespan of the vehicle and cannot claim after 20 years a residual value to be paid by the government.

Power Supply. As referenced in section 4.1, broad measures to increase investment in renewable energy will be essential for effectively transitioning the land transport sector.

Peak Power Demand. As mentioned above, DSM is an instrument that can reduce the need for grid upgrades and additional generation capacity. It consists largely of optimising the charging time to match power supply and demand basically shifting charging to the night or mid-day (depending on the grid).[91] Instruments to achieve this include dynamic tariffs that incentivise customers to charge EVs when optimal, assisted by smart charging applications that can facilitate the choice of customers by allowing them to take advantage of a dynamic tariff. Currently, Fiji only has one fixed tariff, plus a power charge. Price differentiation between times of the day (depending on the structure of the grid, e.g., if wind power plays an important role, night tariffs would need to be reduced) and also between times of the day for power demand will be required to reduce additional power demand and high peaks.

Fiji will also consider new policies to allow for EV owners to support bi-directional V2G capabilities where power can flow from the grid to the vehicle and vice-versa.

Promoting Adoption of HEVs and EVs. Promotion of HEVs and EVs will require overcoming their higher costs to consumers and businesses. In part, HEVs (in the short-term) and EVs (in the longer-term) are expected to recover their incremental investment with lower operating costs. This is especially true for high-mileage vehicles, such as taxis and buses, and at a later stage also for trucks (due to technology not being as far developed as for buses and cars). The significant upfront subsidies given to EVs from countries with high EV numbers is a certain indication that EVs are currently not economically viable.[92] The purchase cost is not the only barrier, but it is still a significant barrier towards purchase of an EV by potential customers.[93] Currently, the incremental cost, based on the total cost of ownership difference between EV and fossil fuel vehicles, is estimated at USD 5,000 per passenger car, zero for taxis (due to higher mileage of the vehicles thus being able to recover the incremental investment), USD 50,000 per bus and truck larger than 7.5t, and USD 10,000 per truck smaller than 7.5t.[94] This would result in a cost of implementing the policy with 100% EVs at around USD 1.1 billion. Given the above, it will be necessary to consider adoption of financial incentive schemes for importers and vehicle purchases to encourage the adoption of HEVs and EVs in order to achieve the ambitions of this LEDS. Appropriate national price structures will also need to be considered to ensure the profitability of electric vehicles.

An important aspect to consider is how subsidies are structured. If they are fiscally neutral and subsidies given to EVs are paid by the same vehicle category as fossil fuel powered vehicles, they tend not to have a negative social impact. If subsidies are, however, paid out of general government revenues (or result in reduced government revenues e.g., due to lower taxation levels on electric cars), then a negative social impact can occur. This is the case if subsidies or tax reductions are given for private passenger cars. This would be difficult to justify based only on the environmental impact. Subsidies or tax exemptions to commercial vehicles, on the other hand, are socially more justified as the major beneficiaries from improved PT are lower income groups.

Other measures can include separating vehicle ownership and vehicle operation (e.g., through leasing contracts with taxi operators and bus operators), reduced taxes on HEVs and EVs (e.g., complemented by increasing taxes on fossil vehicles), and subsidizing the development of public charging infrastructure.

Efficiency Improvements in Vehicles. Efficiency improvements are cost-effective. Public funds would thus be used to set up the structure e.g., regulatory measures for efficient tyres or training facilities for eco-driving combined with making their attendance compulsory to obtain a driving license. Initial funds required to set up such a system and make the adequate policy steps are limited (USD 500,000-1 million for tyres and similar for eco-driving). The incremental CAPEX of tyres is paid by vehicle owners which also profit from lower tyre and fuel usage. Also, in eco-driving the user should pay the full course cost without subsidies whilst initial funds can be used to set up the system. Such funds can be drawn from the national budget, but also international cooperation e.g., from the UN system or bilateral donors (this has been the case in various countries).

PT and NMT. Fiji will consider ways that PT systems can recover investments with user charges and by collecting part of the windfall profit from increased land prices around core routes through taxation e.g., through parking fees and property taxes. Public subsidies, of course, can also support PT financing schemes. Fiji will also aim to develop integrated low carbon mobility plans that include PT, last mile connectivity, and NMT to attract international climate financing. To support the investment case, bus use will be promoted and public investments will be made into pedestrian and public transport infrastructure and traffic control measures to improve bus operations and usage. There will also need to be a commitment to better planning and understanding of bus operations. These measures will strengthen the business case and create an enabling environment for investment, thereby supporting bus operators and other stakeholders in making the transition to a low carbon PT system.

"Fiji will also aim to develop integrated low carbon mobility plans that include PT, last mile connectivity, and NMT"

Promoting More Efficient Trucks. To achieve zero emissions in the transport sector in the Very High Ambition Scenario, this LEDS envisions a maximum lifetime of vehicles of 20 years. All vehicles after 2030 would need to be replaced with electric units after reaching 20 years. This will require considerable financial resources in terms of scrappage fees. Efficiency improvement measures have a (low) investment cost and this is recovered through energy savings i.e., measures are profitable and thus do not result in a total cost increase. The cost for promoting more efficient trucks would be in the range of USD 3 million.

Promoting Biofuels. Similar policies will be needed to encourage short-term investment in biofuel plants to assist in the transition towards EVs and net zero emission scenarios. Based on the incremental cost of biofuels of around USD 0.20 per litre[95] and blending levels of 5% biodiesel and 10% bioethanol, the annual cost would be USD 3 million for this policy (at the specified blending levels).

Access to green financial funds such as the Global Environment Facility (GEF) or the Green Climate Fund (GCF) for electric mobility is also an option. However, each project must clearly demonstrate the impact of the business model used i.e., considering how financing needs will evolve as new mitigation actions are adopted.

[91] High non-demanded power generation from wind generators during the night and solar PV at midday.
[92] As an example, the government of Norway (with the highest share of electric cars) subsidizes 45% of the EV price and the government of China (with the largest absolute number of electric cars) subsidizes 23% of the total price while also providing numerous other benefits (see McKinsey. (2017b). *Dynamics in the global electric-vehicle market*). China has more than 95% of the world market of electric buses in operation and subsidizes them on average with 65% of the purchase cost, making them cheaper than conventional buses (see Grütter Consulting. (2018). *Low Carbon Buses in PR China*).
[93] McKinsey. (2017a). *Electrifying insights: How automakers can drive electrified vehicle sales and profitability.*
[94] Data based on EV policy study prepared by Grütter Consulting for ADB, 2018.

[95] Incremental cost based on price differences in Europe.

4.3 MARITIME TRANSPORT

4.3.1 Overview

This section examines the maritime transport component of Fiji's LEDS. Maritime transport encompasses emissions from all domestic shipping and related port infrastructure within Fiji Port Authority boundaries.

Throughout human history, maritime transport has played a key role in economic development. Today, shipping is the lifeblood of international trade and a highly interlinked global economy. Powered almost exclusively by fossil fuels, shipping is also a major emitter of greenhouse gases, accounting for 2-3% of anthropogenic CO_2 emissions.[96] International shipping was omitted from the Paris Agreement, mainly because of its international nature and the corresponding difficulty of apportioning emissions from the sector to individual parties. However, the International Maritime Organization (IMO), tasked to control and reduce greenhouse gas emissions from international shipping, has since adopted an initial GHG emission reduction strategy, which includes a target of reducing total CO_2 emissions by at least 50% over a 2008 baseline by 2050.[97]

In Fiji, shipping plays a particularly important role, with people relying on sea transport not just for trade and fishing, but also for personal transport and access to crucial services, such as health and education. Maritime transport is a cross-cutting issue for a maritime nation such as Fiji and is interrelated with most domestic economic, social, and environmental drivers. A strategy for the maritime transport sector will therefore be a key element of any successful drive for sustainable development in Fiji and emission reductions must be achieved without compromising safety, access, and affordability of maritime transport services.

Using the Maritime Safety Authority of Fiji (MSAF) ship register, emissions from maritime transport are broken down into the following:

- Government Shipping Service (GSS) vessels;
- Vessels operating on designated "Uneconomic Routes" – subsidised, privately owned shipping that services the "uneconomical routes" as defined by Ministry of Infrastructure and Transport (MoIT);
- Economical vessels – privately owned shipping that services the "economical routes" as defined by MoIT;
- Tourism vessels;
- Fishing vessels (domestic flagged vessels only);
- Small boats – under 15 m in length and predominantly powered by outboard motors; and
- Other vessels – a range of "specialist" vessels such as tugs and dredgers.

> "People rely on sea transport not just for trade and fishing, but also for personal transport and access to crucial services, such as health and education"

[96]Smith et al. (2014). *3rd Greenhouse Gas Emission Study*. London: International Maritime Organization.
[97]International Maritime Organisation. (2018). *Initial GHG Emissions Reduction Strategy*. London: IMO

4.3.2 Emission Sources

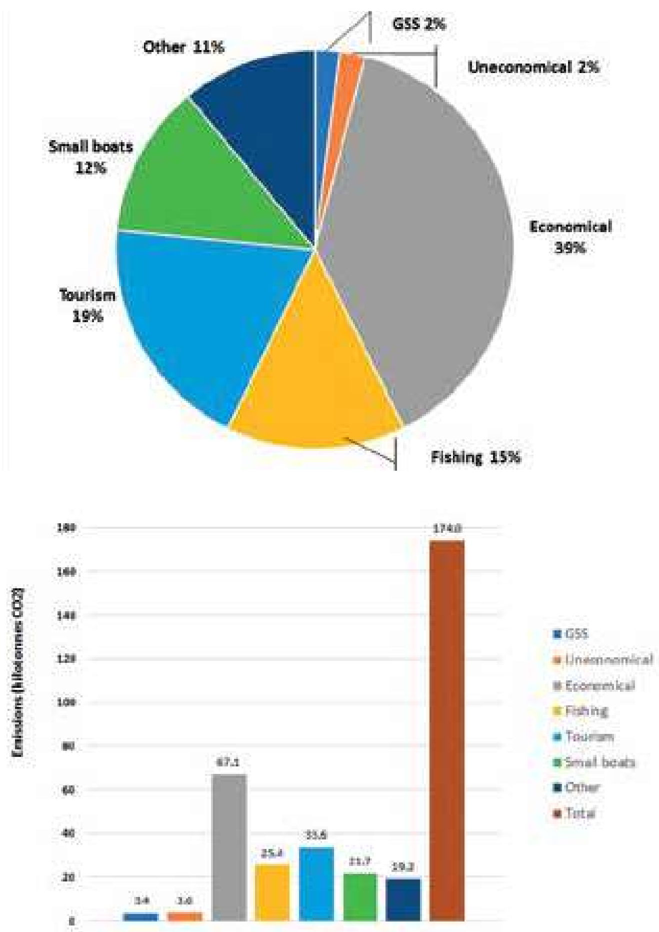
Summary of Emission Sources

Emissions from the sector are primarily from combustion of diesel or petrol aboard vessels of varying size and capacity. These include fuel burnt in propulsion engines and, in larger vessels, auxiliary electricity generation motors.

In addition to vessel emissions, a limited amount of emissions are associated with shoreside buildings and vehicles within the Port Authority's boundaries. Vessels have been classified according to size into small vessels (under 15 m length) and large vessels (over 15 m length). While not a strict delineation, it has been assumed that small vessels are primarily powered by petrol motors and large vessels by diesel engines. Large vessels will also commonly have independent electricity generation capacity, usually also diesel fuel powered. This is not an exact distinction as some small vessels may be diesel powered and some vessels over 15 m may be powered by large petrol outboard motors, but the variance is considered to be too small to make any major statistical difference.

Shoreside emissions are thought to be a small component, comprising emissions from within Port Authority boundaries. However, as no data is available on port energy use, these emissions are not included in this LEDS. Although not considered in this LEDS, shoreside emissions may be considered in future LEDS prepared by Fiji. Shoreside emissions are associated with buildings and infrastructure, electricity generation, and petrol and diesel fuel used in vehicles and equipment.[98] Generally, international estimates of such shoreside emissions are about 1.0-1.5% of total maritime emissions.[99] Given their negligible contribution and lack of data, these emissions have been excluded from the modelling undertaken for this LEDS.

Figure 40. Estimated 2016 Fiji maritime emissions.



[98]Note, savings are potentially available and to be encouraged from changes to building efficiency, installation of electricity saving measures, changes in vehicle operator behaviour, and transition to electric or alternative fuel powered machinery. The primary future impact would come if the use of "cold ironing" (switching off ship electricity generation systems in ports in favour of grid power connections to land-based supply) were to be contemplated. Given the structure and capacity of the electricity generation sector, this is not considered a feasible future option for Fiji. Reefers are also potentially a large source of demand if stored and powered within Port Authority boundaries on grid electricity supply.

[99]Smith, T. et al. (2014). *3rd Greenhouse Gas Emission Study*. London: International Maritime Organisation.

As depicted in Figure 40, total emissions for the Fiji maritime sector are estimated at 174 kilotonnes of CO_2 in 2016. Commercial vessels on "economical" routes are the largest source, followed by tourism vessels.

This LEDS considers all estimated emissions from domestic fishing vessels. However, emissions from international fishing vessels that bunker and operate in Fiji waters are not included. Under IPCC carbon accountancy guidelines of 2006, such emissions are to be accounted for under Agriculture, Forestry, and Fisheries (mobile combustion) and not Transport. However, as no data is available for this sub-sector, it has not been included in the scenario projections for the LEDS.

"Total emissions for the Fiji maritime sector are estimated at 174 kilotonnes of CO_2 in 2016"

Type of Emissions

In terms of Fiji's maritime transport emissions, CO_2 is the main type of emission which is produced through the internal combustion of diesel and petrol (primarily premix).[100] While there are other GHG gases from the sector (such as black carbon, hydrocarbons, methane, and nitrous oxide) these are a minute proportion of the totals and have not been considered in the LEDS. When electric motors become available in this sector, any relevant emissions will be accounted for under the electricity sector (if fossil fuels are used – see also section 4.1 of the LEDS).

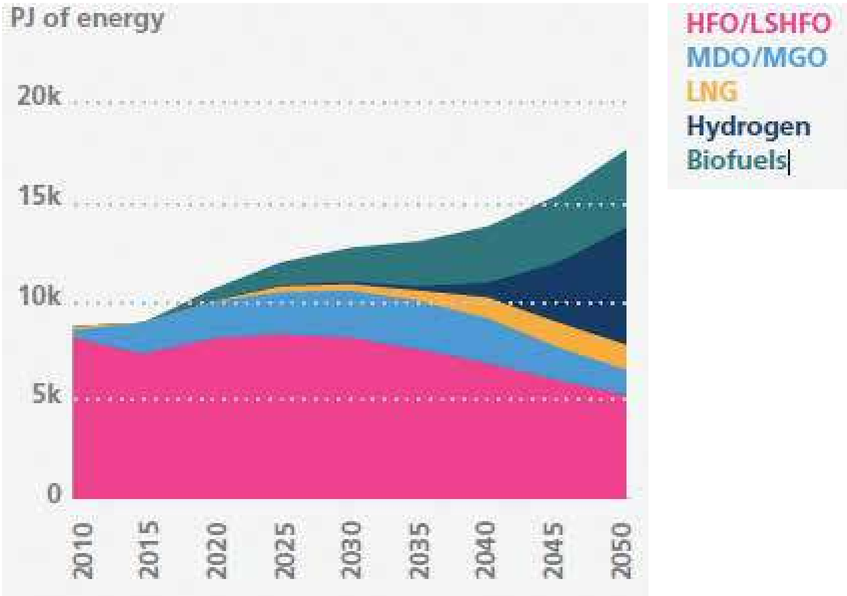
4.3.3 Existing Policy and Regulatory Framework

There are numerous plans, policies, strategies, acts, and regulations relating to maritime transport and emissions from vessels in Fiji, and others are being developed (e.g., NDP, TNC, and the Green Growth Framework for Fiji). These are discussed elsewhere in the LEDS as they have implications for all sectors of Fiji's emissions. A summary of key policies is provided below.

Adopted in April 2018, the International Maritime Organisation Initial Strategy for GHG Emissions Reduction (2018) addresses emissions from international shipping. As an IMO member, the Fiji Government has supported adoption of "high ambition" targets for GHG emissions reduction from international shipping consistent with keeping open the possibility of achieving the 1.5°C temperature goal. A key effect of the IMO strategy will be to catalyse changes in fuels used by the shipping industry as shown in Figure 41.

[100]Premix refers to a 50:1 petrol/2-stroke oil mixture sold in all Fijian service stations. It provides a rough proxy for 2-stroke outboard engine use, see Smith, T. et al. (2016). *CO_2 emissions from international shipping. Possible reduction targets and their associated pathways.* London: UMA.

Figure 41. Potential fuel mix changes in international shipping in line with 50% decarbonisation target.



"The revival of traditional knowledge associated with use of small canoes and *camakau* (traditional watercraft) to reduce the reliance on fossil fuel outboard motors is part of national policy"

As a maritime nation, Fiji has various domestic maritime policies and has engaged in several important regional agreements to promote sustainable maritime transport. Relevant regional policies include the Suva Declaration (2015) which provides for an integrated approach to transitioning Pacific countries to low carbon transport futures, including sea transport; the Pacific Community (SPC)'s Framework for Action on Transport Services (2011), and USP's Regional Research and Education Strategy (2014) which promotes research and education needs to promote a shift to low or zero carbon sea transport in the Pacific.

Among the key national policies is the Maritime and Land Transport Policy (2015), which promotes improved efficiency at ports, the introduction of fuel-efficient transport equipment and engines able to operate on biofuels, operation and maintenance of transport equipment in a manner that minimises consumption and CO_2 emissions, and the development and introduction of low carbon propulsion alternatives and hull designs. The policy aims to reduce the energy and carbon intensity of the domestic fleet through the adoption of operational actions (such as slow steaming and weather routing), retrofitting and replacement to energy/carbon efficient propulsion and hull design, the use of smaller, more efficient craft that are suited to inter-island routes,[101] introduction of renewable energy (biofuel, solar, or sail assisted) vessels and the revival of traditional knowledge associated with use of small canoes and *camakau* (traditional watercraft) to reduce the reliance on fossil fuel outboard motors.

Other relevant policies include the Marine Act (1986) (which addresses vessel registration and safety), the Sea Ports Management Act (2005) and Sea Ports Management Regulations (2008), the Ship Registration Decree (2013), the Maritime Transport Decree (2013), and the Maritime (Fiji Small Craft Code) Regulations (2014). Other more ambitious policies to achieve low or zero emissions in Fiji's maritime sector are also in development, including a proposed GHG Mitigation Plan for the Maritime Transport Sector in Fiji.

[101]Including routes between Suva and the outer islands as well as travel directly between outer islands

4.3.4 Methodology

Model and Methodology Used

The LEDS for maritime transport includes four emissions scenarios modelled against the estimated 2016 domestic maritime emission profile (i.e., base year). The four future scenario pathways have targets of 10% by 2030, 30% by 2030 (in line with the 2017 NDC Implementation Roadmap) and 70% by 2050 and 100% by 2050 (in line with Fiji's position in IMO emissions reduction framework negotiations in 2017-18).

Emission scenarios for the maritime sector in this LEDS are calculated based on the number and type of vessels, annual energy consumption for each vessel, and an emission factor for the amount of CO_2 emitted per unit of energy used. The projections used in this LEDS take into account the replacement rate of vessels as well as measures to improve energy efficiency and reduce energy demand in vessels, and the degree to which new technologies are adopted in the fleet. The LEDS assumes that the value of the emission factor declines over time based on the rate of adoption and penetration of low emission technologies for propulsion power, e.g., alternative fuels.

A range of mitigation options is available for reducing and finally eliminating GHG emissions from the maritime transport sector. The description of the scenarios below sets out the minimum mitigation measures needed to achieve each outcome, and the assumptions made as to the enabling environment that will be needed to effect implementation. Measures are divided into those needed for small vessels under 15 m, and those needed for larger vessels (all those over 15 m).

The literature[102] includes various marginal abatement cost (MAC) curves that model such reductions at various scales of vessels with options divided into operational and technological measures and alternative fuels. Existing vessels can be improved through retrofits of various technologies, but increased emissions savings at real scale will require transition to new generation vessels. Given the long asset life of most maritime vessel types, this requires a staged and planned fleet replacement strategy over time.

Transition to a full decarbonisation pathway presents a significant challenge to Fiji (and other SIDS) and there are few current market leaders. There is a marked increase in both policy development and the availability of technological solutions. For Fiji to achieve deep decarbonisation, it will require the creation of a full enabling environment including policies, regulations, and financial incentives amongst others. This would need to be accompanied by a whole-of-sector approach to consultation and implementation including all key stakeholder groups, in particular the private sector and industry operators.

The search for low carbon transitions in the maritime sector globally has demonstrated a significant lag time behind development of such alternatives in other energy sectors, in particular electricity generation and land transport. The lack of research and development in the maritime sector in comparison to other energy use sectors and the barriers to such transitions have resulted in a lack of 'proof of concept' demonstrations. This lag is particularly significant for the scale and type of vessels typical to Fiji, where vessel types are predominantly smaller and comparatively older.

To effect change, therefore, it is recommended that government shipping assets and services (GSS, Water Police, Navy, Fisheries, and Biosecurity) should be used to pilot and demonstrate the potential for reducing emissions and increasing economic savings to the private sector. Such an enabling environment will also rely on external investment in technology trials and long-term capacity development throughout the sector. It will also require a balanced mixture of financial incentives (e.g., reduced import taxes for agreed measures and subsidized or soft loan packages such as green bonds) and penalties (e.g., import taxes, financial modality packages, and regulation) to drive transition and uptake by the private sector of successfully demonstrated pilots. Market champions should be valorised – for example, leaders in the maritime tourism sector are the obvious group to drive transition in the small vessel market. These strategies are based on a number of assumptions which are set out in the context of each modelled scenario.

[102]For a full overview of low carbon transition for SIDS see https://unctadsftportal.org/sftftoolkit/transitioningtolowcarbonshippingmodule/

Direct measures to reduce emissions can be grouped under the following headings.

- **Reduction** in the number and/or use of vessels – this is not considered a viable option for a maritime nation and vessel number and use is predicted to increase with increasing GDP and population.
- **Increased operational efficiency of vessels** through measures including: increased maintenance, trim and ballasting; slow steaming (travelling at slower speeds); better route and weather planning; just-in-time routing (to arrive in port at the optimal time and reduce use of auxiliary motors in port); improved hull coatings and hull scrubbing to reduce friction resistance; and crew training and capacity development.
- **Technological options** include: use of renewable energy (sails, rotors, solar, and biofuels) either as sole power, or primary power hybrids; improved hull shapes and vessel design; improved efficiency propellers and propeller cowlings; upgrading the power plants of older vessels to newer and more efficient motors; air cavitation; and battery electric hybrid motors.
- Increase the fuel efficiency of the vessel motors through transition from current fuel use to **lower carbon or more efficient carbon fuel alternatives and vessel types**, including: transitioning from 2-stroke to 4-stroke petrol motors, higher efficiency diesel and electric hybrid motors, wing-in-ground (WiG) vessels and high efficiency hull designs. For each of these options there are varying degrees of technology uptake barriers that will need to be addressed, primarily through long-term human capacity development and financing modalities.
- **Alternative fuels**. All of the above, in combination, can play a role in the initial reduction of existing emissions. However, the consensus in the literature is that these options are likely insufficient to achieve deep or full decarbonisation across the fleet. Achieving full decarbonisation will require the use of currently commercially unproven fuel sources. There are a number of such energy sources being developed, with methanol, ammonia, and hydrogen as the most likely alternatives, and there is increasingly rapid progress being made for each of these. The "high ambition" and "very high ambition" scenarios are predicated on such energy sources being proven and available commercially in the future. LNG has been shown to be unlikely to achieve significant emissions reductions globally, and this is particularly true for the Pacific given issues of bunkering and supply.

Mitigation measures also vary according to whether they are targeted at small or large vessel scale, reflecting the current dominant fuel use for each (petrol and diesel respectively).

Small vessels: Vessels under 15 m are powered with petroleum and premix (or 2-stroke) petrol mix. There are two basic types of outboard engines used in Fiji, 2-stroke petrol combustion models and 4-stroke, with 2-stroke engines making up the vast majority. 2-stroke motors are cheaper to purchase initially and less complicated to maintain. However, they are considered to be 40% less fuel efficient than 4-strokes. As small vessels make up 12.5% of the total emissions for this sector, a 40% overall saving (5% of total emissions for the sector) is available simply from full transition to 4-stroke outboards. This would require investment in training and capacity development for 4-stroke outboard maintenance, as well as economic instruments (such as duty concessions) to address the current cost differential and a strong public education campaign. Further savings will require transition to electric motors (e-motors) and, finally, fuel cells (most likely hydrogen).

Additionally, wind assistance or primary propulsion is a readily available, but currently under used. This proven technological fix offers between 5-100% savings. Greater efficiency hull designs (both hydrodynamic and aerodynamic) also offer the potential for significant (3-60%) savings.

Ultimately, to achieve 100% decarbonisation of the sector, all petrol outboards would need to be replaced with sails and small motors powered by renewable energy, such as electric (this would have to be produced from renewable energy sources such as solar to be effective in reducing emissions) or hydrogen fuel cells.

Larger vessels: There are a variety of vessels of between 15 m and 130 m in length, with the vast majority being under 50 m, which burn diesel for propulsion and auxiliary power. As there is a wide range of different types of vessels serving different purposes in this category (e.g., RoRo passenger/cargo ferries, landing craft, fishing boats, tourism related, and specialist vessels such as tugs) there is also a range of mitigation options and their effectiveness will be specific according to vessel type and function. Slow steaming is a well-recognized practice for reducing fuel consumption in shipping and can be applied to some vessels in Fiji. However, this measure is not generic to all vessels, the nature of a harbour pilot vessel for example means slow steaming is not an available option. As discussed previously, emissions reductions are available to existing vessels through operational measures and retrofitted technologies, but such savings will always be lower than what can be achieved with new build vessels. A planned long-term approach to overall fleet replacement with low carbon alternatives is needed over the next 30 years. The introduction of new technologies, at all scales, provides an opportunity to establish Fiji as a regional centre for fitting, servicing, and at least partial construction of such technologies and potentially construction of complete vessels. This will require investment in training, education, development, and skill retention across the sector.

Data Used, Data Sources, and Assumptions

The primary data source was taken from the ADB technical assistance study for the sector[103] and updated against fresh data sets supplied by various government departments, in particular MSAF and FRCS, and data collected in preparation of the TNC.

Limitations and Uncertainties

There is insufficient data to be able to measure, with any accuracy, the historical growth trends of the Fiji domestic maritime sector. Therefore, future growth in the sector and its related emissions have been calculated using government projections of change in GDP as an equivalent proxy.

The lack of data for the maritime sector is a limiting factor in developing the LEDS and an issue that will require ongoing attention. Due to lack of data, totals reflect a margin of error. Improving data capture and analysis is a critical first step in any decarbonisation agenda and will require dedicated internal government capacity to be built and retained. It will be important, for example, to initiate the top-down collection of disaggregated data on fuel imports, combined with improved bottom-up data collection from the private sector and vessel operators on fuel sales, motor sales, and fuel use.

Due to lack of data, error bars are provided in the baseline for each type of vessel with the exception of GSS vessels (for which reliable data is available) and (to a slightly lesser degree) vessels operating under the government franchise scheme on uneconomical routes. Commercial vessels on "economical" routes are the largest emitting sub-sector followed by "tourism." It is also possible there are some overlaps between the sub-sectors. For example, small boats may also engage in fishing or tourism activities, however the emissions are not double-counted.

Stakeholder Consultation Process

The primary stakeholders for domestic maritime transport in Fiji include the Ministry of Infrastructure and Transport (Transport Planning Unit and Government Shipping Services), the Ministry of Rural and Maritime Development, the MSAF, the Fiji Ports Authority, the Fiji Ship Owners and Agents Associations, USP, the Fiji Maritime Academy, Sailing for Sustainability Fiji (an NGO), the Fiji Yachting Association, the Uto ni Yalo Trust, Fiji Ships & Heavy Industries Ltd and other private shipping and ship building companies, the European Union Delegation, SPC, the World Food Programme, and ADB.

During the first stakeholder workshop on the 23rd of May, 2018, stakeholders developed a long-term vision for Fiji to have a decarbonised maritime transport sector by 2050 which is clean, safe, affordable, appropriate, and provides connectivity to its maritime communities. Participants noted that broader buy-in by the private sector, ship operators, and other relevant stakeholders would be needed, as several private sector representatives were not in attendance. Achieving deep decarbonisation would mean net zero emissions in the sector by 2050 as a result of adopting renewable energy (including hybrid solar/sail technology) and traditional sailing. Success would depend on improving planned maintenance programmes for ships, support for community owned and operated small vessels, and the adoption of enabling policies, increased investment, financing, and improved data collection. Stakeholders also noted the importance of engaging the tourism sector. Key challenges for decarbonising the sector discussed during the second stakeholder consultation included: lack of adequate data, insurance, financing, human capacity, enabling policies, and monitoring equipment, as well as obsolete machinery and old infrastructure and buildings. Key opportunities included:

[103] Traut, M., Newell, A. and Smith, T. (2017). *GHG Mitigation Plan for the Maritime Transport Sector in Fiji.* Manila: ADB.

capitalising on international trends and development, access to climate financing, potential financial savings for public and private sector, potential for increased shipping solutions at all levels, increased employment opportunities from greener shipping (local and overseas), increasing Fiji's profile internationally, expanding the maritime sector generally and increasing slipways to accommodate 6,000 tonne vessels, promoting existing low carbon vessels (e.g., Uto ni Yalo), and providing a low carbon maritime hub/model for outer islands. The third stakeholder workshop provided an opportunity for key stakeholders to confirm the four low emission scenarios for the sector. They also suggested that Fiji should lead regional capacity development through research, education, and training. Stakeholders expressed confidence in achieving net zero emissions for maritime transport by ensuring all GSS vessels are low carbon (it was assumed that GSS would be operating at least 10 ships), adopting increasingly stringent targets for deep decarbonisation, and greatly increasing use of coastal maritime freight due to its high energy efficiency.

"Stakeholders expressed confidence in achieving net zero emissions for maritime transport"

4.3.5 Low Emission Development Scenarios

Four Scenarios have been modelled against the estimated 2016 profile as the base year (see Figures 42 and 43).

Base Year (2016)

The year 2016 is the base year used as it has the most recently available data.

BAU Unconditional Scenario

The 2016 Baseline emissions for the domestic maritime sector are shown in Table 17.

Table 17. Baseline Emissions for the Domestic Maritime Sector.

Baseline (2016)	
Sub-sector (based on MSAF categorization)	**Emissions** (kt CO_2)
GSS	3.44
Franchise (uneconomical routes)	3.61
Passenger & cargo (economical routes)	67.12
Fishing (domestic flagged only)	25.37
Tourism	33.59
Small boats (<-15m)	21.67
Other	19.18
TOTAL	173.98

In 2016, total emissions for the maritime sector are estimated at 174 kt of CO_2.

This scenario reflects existing NDC targets that are unconditional and are to be implemented without the need for external/international financing and assumes existing programs, such as the Pacific Maritime Technology Cooperation Centre and the Micronesian Center for Sustainable Transport, would continue to provide support. Under this scenario, domestic maritime emissions will increase from 174 kt CO_2 in 2016 to just over 500 kt CO_2 annually by 2050.

Achieving this is primarily a result of converting small vessels (mainly using petrol) to new motors. This includes converting 50% of these vessels from 2-stroke to 4-stroke outboard motors and 10% from petrol to electric outboard motors. Additionally, 20% of small vessels will adopt sail-assist or sail-powered designs

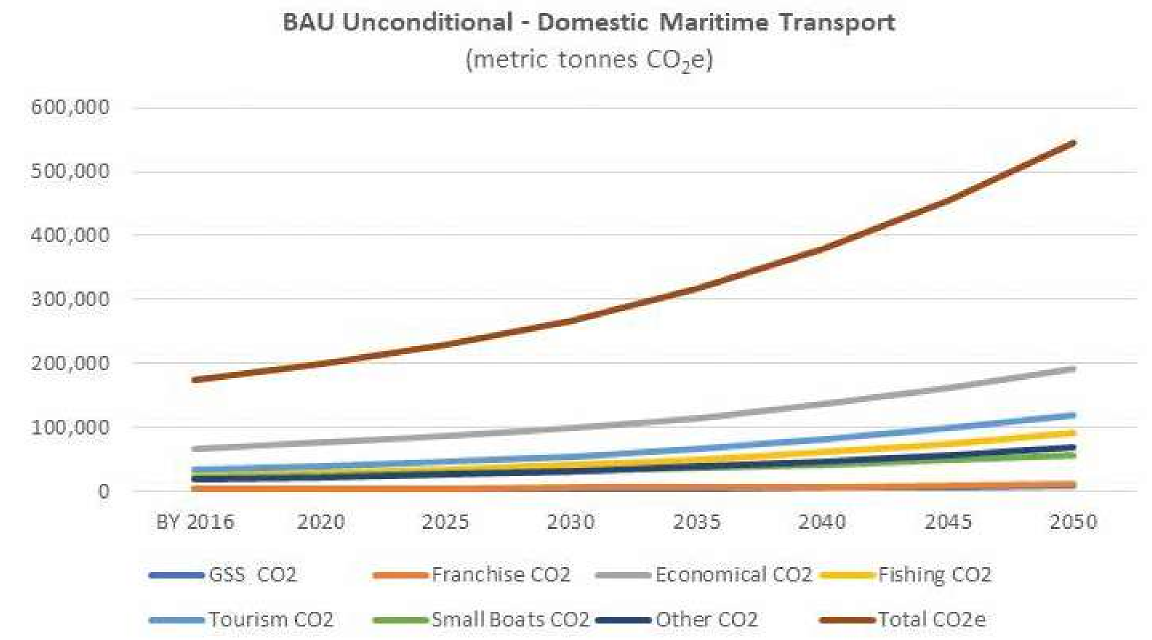
With regard to large vessels running on diesel, improved operational efficiency measures would be adopted in 100% of government vessels and 20% of private sector vessels. The GSS would also purchase and operate at least one low carbon "proof of concept" vessel in this scenario.

Achieving this level of reduction is dependent on several assumptions. For example, the government will work to ensure that existing policies and plans are implemented (e.g., GSS purchase of a low carbon demonstration vessel) and that proposed new policies are enacted. Long-term and ongoing investment will be needed in national education and research in the sector, as well as ongoing stakeholder engagement (especially with private sector support services, boat builders, and tourism operators), and awareness raising and training for conversion to 4-stroke and e-motors at training institutions and private sector maintenance facilities. In line with plans for electricity generation in this LEDS, it will also be essential to ensure all recharging of small vessel electric motors is from renewable sources and is commercially viable.

Table 18. BAU Unconditional scenario for Domestic Maritime Transport.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2016	2020	2025	2030	2035	2040	2045	2050
GSS	**CO_2**	3,400	3,900	4,000	4,200	4,900	5,700	6,700	7,900
Franchise	**CO_2**	3,600	4,100	4,600	5,300	6,200	7,300	8,600	10,300
Economical	**CO_2**	67,100	76,400	86,400	98,200	115,100	135,700	160,800	191,300
Fishing	**CO_2**	25,400	29,000	34,600	41,400	50,300	61,200	74,500	90,600
Tourism	**CO_2**	33,600	38,400	45,800	54,800	66,600	81,100	98,600	120,000
Small Boats	**CO_2**	21,700	24,800	28,400	32,000	36,400	41,800	48,500	56,700
Other	**CO_2**	19,200	21,900	26,100	31,300	38,000	46,300	56,300	68,500
Total	**CO_2e**	**174,000**	**198,500**	**229,900**	**267,200**	**317,500**	**379,100**	**454,000**	**545,300**

Figure 42. BAU Unconditional scenario – Domestic Maritime Transport.



BAU Conditional Scenario

This scenario reflects existing NDC targets that are conditional and dependent on external/international financing being available to implement, and thus have higher ambition than the "unconditional scenario" above. The BAU Conditional scenario projects a 30% decrease in emissions from the sector by 2030 relative to the 2016 baseline. In this scenario, emissions will continue to increase, but only from 174 kt CO_2 in 2016 to 340 kt CO_2 in 2050.

To achieve these emission reductions, among small vessels (running on petrol) 60% of all 2-stroke outboard motors will be converted to 4-stroke, 25% of motors running on petrol will be converted to electric outboard motors. Additionally, 40% of small vessels will adopt sail-assist or sail-powered designs; wind assist can be used by small vessels using outboards (either 4-stroke or electric).

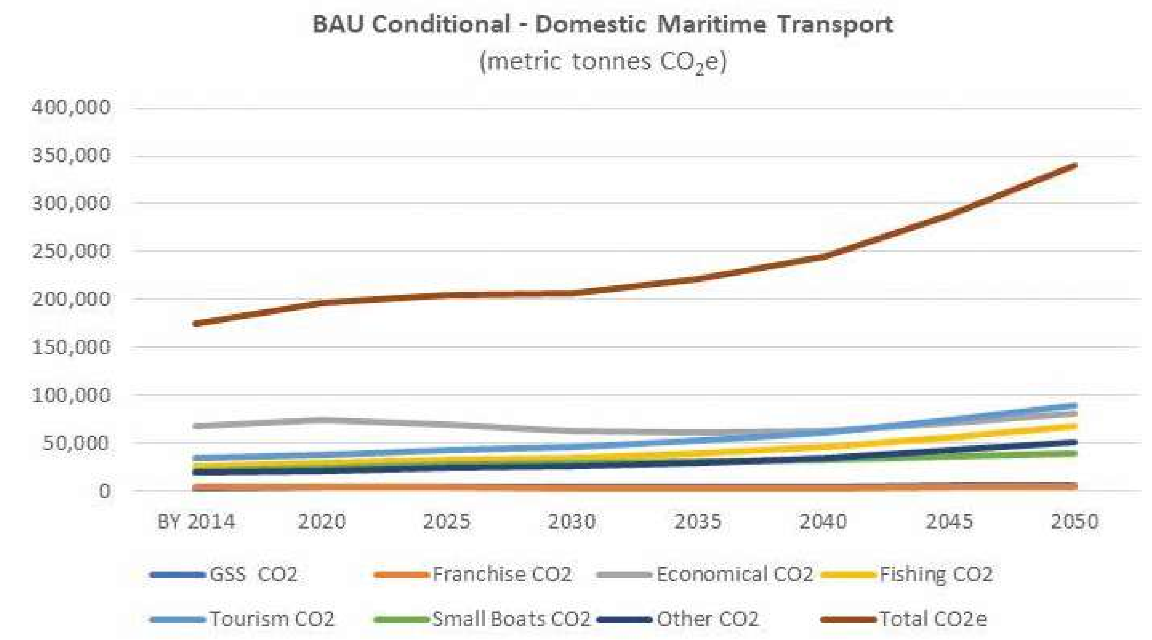
Among large vessels running on diesel, improved operational efficiency measures would be adopted in 100% of government vessels and 50% of private sector vessels. The GSS would also purchase and operate at least two low carbon "proof of concept" vessels in this scenario and prepare and implement a 25-year fleet replacement strategy with an increasing shift towards low carbon designs as mandatory requirements for new vessels purchased. All vessel imports will be subject to increasingly stringent Tier II efficiency requirements. A vessel financing modality program will be designed and implemented to support public and private sector uptake of new technologies and Fiji's franchise scheme will need to be amended to favour use of low carbon vessels and operational efficiencies.

In addition to the assumptions for the BAU Unconditional scenario, the BAU Conditional scenario will involve regular training and outreach to the private sector to promote operational efficiency measures. External funding will be secured for a government fleet replacement strategy, a financing modality for private sector adoption, and research and development (including data collection/analysis, monitoring, and enforcement). The government will also maintain and expand partnerships with leading Centres of Excellence and technology providers with the support of bilateral and donor agencies.

Table 19. BAU Conditional scenario for Domestic Maritime Transport.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2014	2020	2025	2030	2035	2040	2045	2050
GSS	CO_2	3,400	3,800	3,800	3,700	4,100	4,700	5,600	6,700
Franchise	CO_2	3,600	4,000	3,800	3,200	3,200	3,300	3,700	4,200
Economical	CO_2	67,100	74,400	69,800	62,100	61,200	63,300	71,400	81,400
Fishing	CO_2	25,400	28,800	32,200	34,900	39,600	45,900	55,900	68,000
Tourism	CO_2	33,600	38,100	42,600	46,300	52,400	60,800	74,000	90,000
Small Boats	CO_2	21,700	24,800	28,000	29,300	30,600	32,600	35,300	38,800
Other	CO_2	19,200	21,700	24,300	26,400	29,900	34,700	42,200	51,400
Total	CO_2e	**174,000**	**195,600**	**204,500**	**205,900**	**221,000**	**245,300**	**288,100**	**340,500**

Figure 43. BAU Conditional scenario – Domestic Maritime Transport.



High Ambition Scenario

The High Ambition scenario projects a 70% decrease in emissions from the sector by 2050, or earlier, relative to the 2016 baseline. This reflects the lower-bound position advocated by the Fiji Government in IMO GHG emissions reduction negotiations for international shipping. The scenario projects a decline in emissions after 2020 but then slight increases over time, with emissions remaining around 200 kt CO_2.

To achieve these emission reductions, among small vessels (running on petrol), 30% of all 2-stroke outboard motors will be converted to 4-stroke, 40% of petrol motors will be converted to electric outboard motors, and there will be a 30% uptake of hydrogen fuel cells. Moreover, 70% of small vessels will adopt sail-assist or primarily sail-powered designs, in addition to switching to 4-stroke or electric motors.

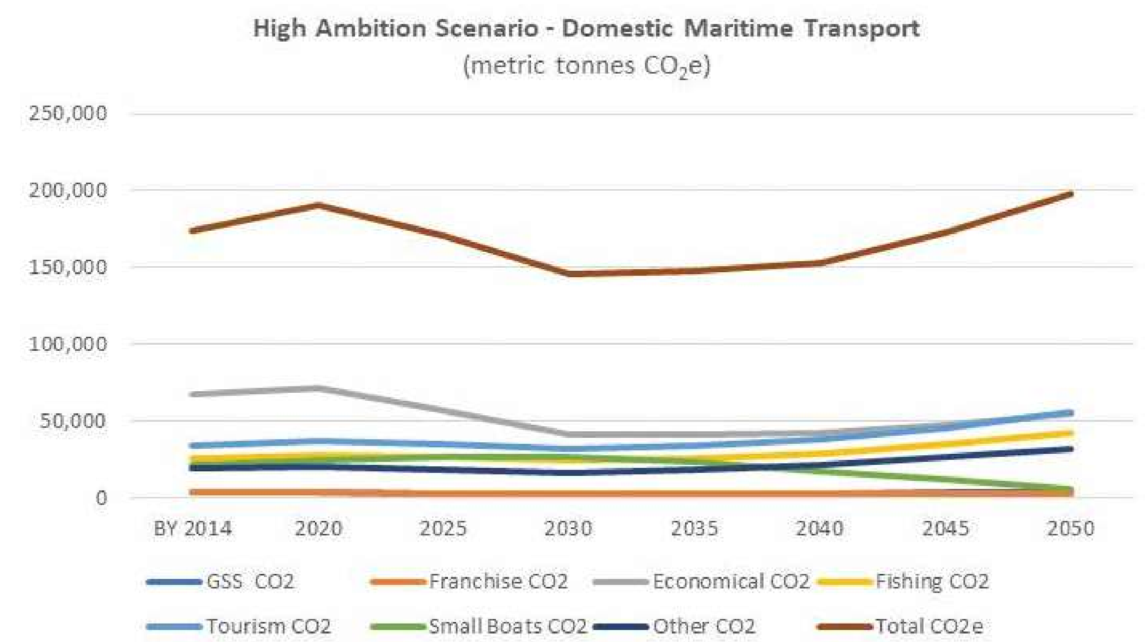
Among large vessels running on diesel, improved operational efficiency measures would be adopted in 100% of government vessels and private sector vessels. The GSS would also purchase and operate at least 10 low carbon "proof of concept" vessels in this scenario and implement a 25-year fleet replacement strategy with an increasing shift towards low carbon designs as a mandatory requirement for new vessels purchased. All vessel imports will be subject to increasingly stringent Tier II efficiency requirements. A vessel financing modality program will be designed and implemented to support public and private sector uptake of new technologies, and Fiji's franchise scheme will need to be amended to favour use of low carbon vessels and operational efficiencies. In addition, Fiji will adopt regulations to impose penalties on the use of fossil fuel-powered vessels, and low carbon requirement provisions will be included in new and renewed sea route licenses for economic routes. Finally, Fiji will establish a low carbon maritime technology industry hub, supported by the government and supplying local and regional markets.

In addition to the assumptions reflected in the BAU Unconditional and BAU Conditional scenarios, the High Ambition Scenario assumes the availability of commercially proven and affordable hydrogen fuel cells for small vessels.

Table 20. High Ambition scenario for Domestic Maritime Transport.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2014	2020	2025	2030	2035	2040	2045	2050
GSS	CO_2	3,400	3,700	3,000	2,400	2,500	2,800	3,300	4,000
Franchise	CO_2	3,600	3,900	3,100	2,200	2,200	2,300	2,600	2,900
Economical	CO_2	67,100	72,100	57,200	41,700	41,100	42,500	48,000	54,600
Fishing	CO_2	25,400	27,900	26,400	24,200	25,800	28,600	34,800	42,300
Tourism	CO_2	33,600	36,900	34,900	32,000	34,200	37,800	46,000	56,000
Small Boats	CO_2	21,700	24,700	27,200	26,500	23,200	17,800	11,800	5,600
Other	CO_2	19,200	20,900	18,700	16,400	18,600	21,600	26,300	32,000
Total	CO_2e	174,000	190,100	170,500	145,400	147,600	153,400	172,800	197,400

Figure 44. High Ambition scenario – Domestic Maritime Transport.



Very High Ambition Scenario

The Very High Ambition scenario projects 100% decrease in emissions from the sector by 2050. This scenario projects ambition well beyond those already specified in policy and envisages achieving net zero emissions by 2050 or earlier. This represents the upper-bound target advocated for by the Fiji Government in the IMO. Achieving 100% decarbonisation in the domestic maritime sector is based on a number of assumptions, including international commercial availability of new technologies (such as new generation fuels), and adequate transitional financing to public and private operators. The measures and assumptions are cumulative as ambition increases.

To achieve these emission reductions, among small vessels (running on petrol), 40% of petrol motors will be converted to electric outboard motors, complemented by adoption of hydrogen fuel cells in the remaining 60% of small vessels. Additionally, 90% of small vessels will adopt sail-assist or sail-powered designs to maximise efficiency.

With regard to large vessels currently running on diesel, improved operational efficiency measures will be adopted in 100% of government vessels and private sector vessels as a first step. The GSS would also purchase and operate at least 10 low carbon "proof of concept" vessels in this scenario and implement a 25-year fleet replacement strategy with an increasing shift towards low carbon designs, as a mandatory requirement for new vessels purchased. All vessel imports will be subject to increasingly stringent Tier II efficiency requirements. A vessel financing modality program will be designed and implemented to support public and private sector uptake of new technologies and Fiji's franchise scheme will need to be amended to favour use of low carbon vessels and operational efficiencies. As in the High Ambition scenario, Fiji will adopt regulations to impose penalties on the use of fossil fuel-powered vessels, promote low carbon provisions for new and renewed sea route licenses for economic routes, and propose to establish a low carbon maritime technology industry hub.

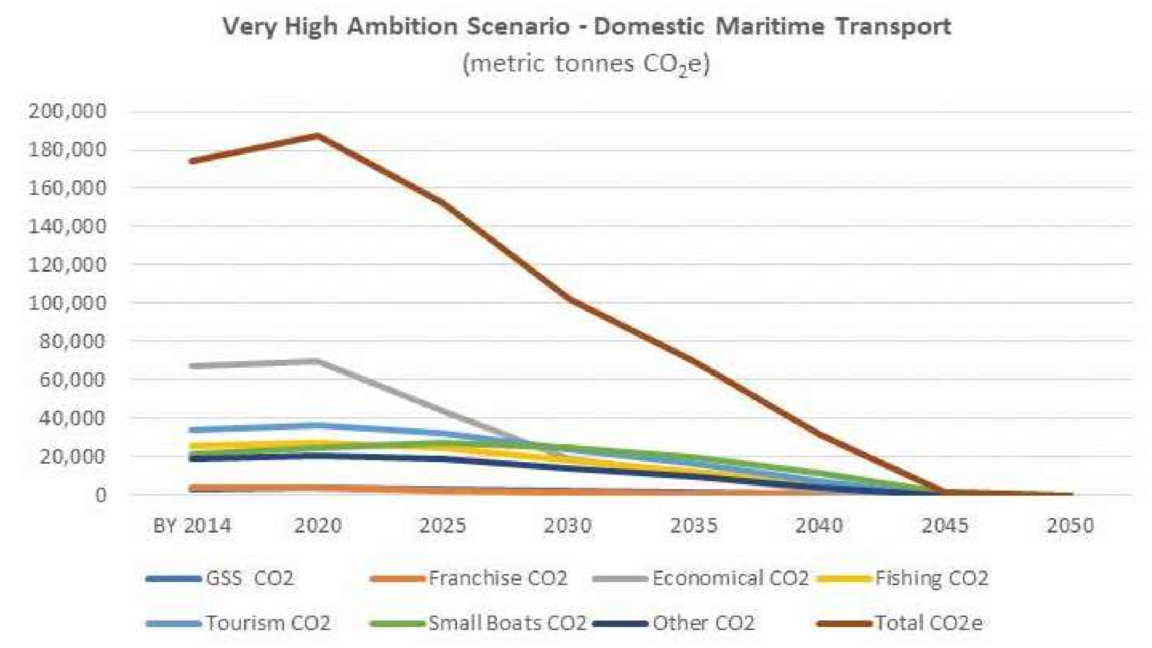
Under this scenario emissions would peak before 2020 and decline thereafter.

In addition to the assumptions for the three scenarios above, this scenario assumes: alternative maritime fuels will be available commercially internationally, all GSS vessels will use zero emissions technology by 2050, and a "hub and spoke" model will be adopted for all outer island connectivity routes.

Table 21. Very High Ambition scenario for Domestic Maritime Transport.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2014	2020	2025	2030	2035	2040	2045	2050
GSS	CO_2	3,400	3,700	3,000	2,000	1,300	500	0	0
Franchise	CO_2	3,600	3,800	2,400	1,000	600	100	0	0
Economical	CO_2	67,100	69,900	44,300	19,200	10,600	2,500	0	0
Fishing	CO_2	25,400	27,600	24,500	18,000	12,400	5,500	0	0
Tourism	CO_2	33,600	36,600	32,400	23,900	16,400	7,300	0	0
Small Boats	CO_2	21,700	24,700	27,200	24,900	19,500	11,500	1,000	0
Other	CO_2	19,200	20,900	18,500	13,600	9,400	4,200	0	0
Total	CO_2e	174,000	187,200	152,300	102,600	70,200	31,600	1,000	0

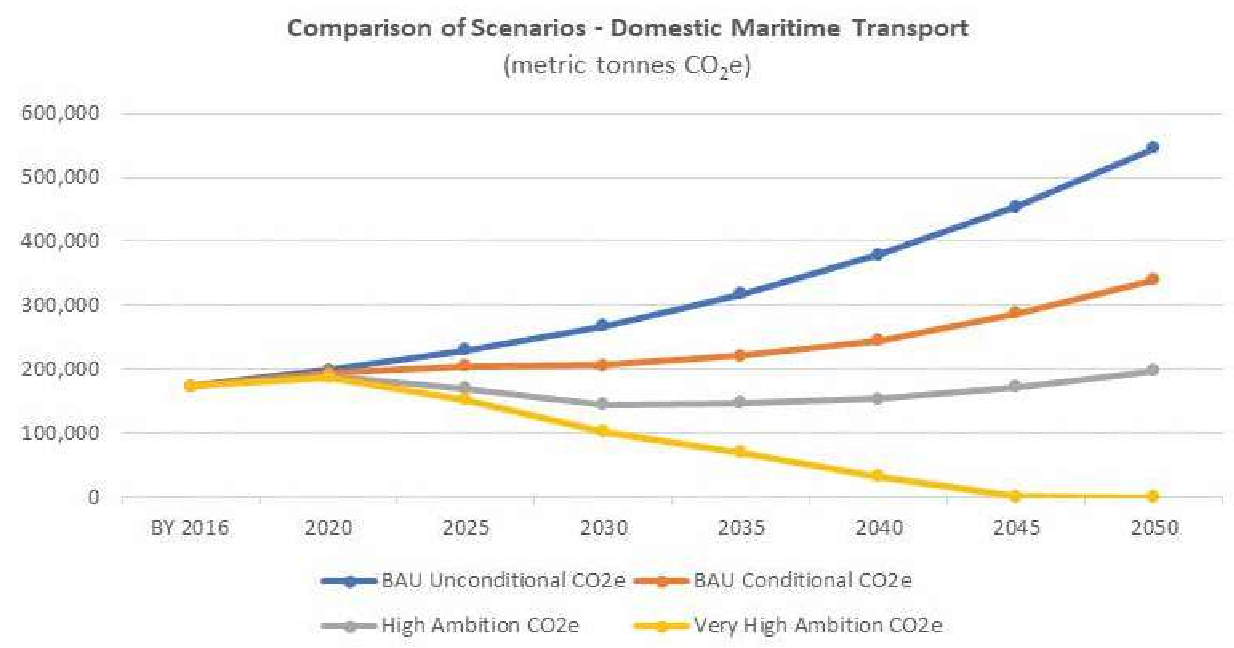
Figure 45. Very High Ambition scenario – Domestic Maritime Transport.



Comparison of Scenarios

The comparative result of all four scenarios is provided in Figure 46.

Figure 46. Comparison of scenarios – Domestic Maritime Transport.



4.3.6 Policy Recommendations, Priority Actions, and High Level Costing

Significant progress is now being made at the international level on the policy drivers for maritime decarbonisation and there is demonstrable progress on development and commercialisation of an increasing range of low carbon maritime technological solutions. This strongly indicates that, globally, this sector is about to undergo long-term and far-reaching technological change from intensive fossil fuel use to low carbon alternatives.

International leadership on climate change and shipping by Fiji and other Pacific SIDS provides a significant opportunity to harness climate awareness and financing to promote external investment into maritime decarbonisation in Fiji. This, in turn, provides the opportunity to completely overhaul the domestic maritime sector to vessels and technologies, that are not only low emission but also more affordable, accessible, and appropriate for Fiji. This will be an ambitious agenda, however, the savings in fuel imports and the potential for Fiji to become the primary low carbon maritime hub for the Pacific region (with the associated economic, commercial, and employment benefits that could accrue), provide strong positive incentives for adopting these measures. It is necessary for Fiji to lead in this area in order to ensure that new low emission measures and technologies are developed which are appropriate for Fiji, other SIDS, and coastal LDCs. It is highly likely that significant carbon penalties (taxes, levies, etc.) will be levelled across the global maritime industry in the next 5-10 years, making all maritime users of fossil fuel subject to increasing costs for not transitioning away from carbon, which will inevitably affect the Fiji domestic industry.

> "International leadership on climate change and shipping by Fiji provides a significant opportunity to harness climate awareness and financing to promote external investment into maritime decarbonisation"

At a national level, an integrated, whole-of-sector approach is required for decarbonisation to be effectively achieved, requiring full stakeholder buy-in across the sector. The government must create a complete enabling environment for this to happen; the judicious use of economic instruments will be a key tool. Actions to initiate preliminary decarbonisation measures for this sector are already contained in numerous existing policies; although, to date, these have been implemented inconsistently. These policies should be reviewed as the basis for preparing a maritime sector action plan. As decarbonisation of this sector must be a long-term process, given the long-life expectancy of the primary assets, the foundation must be set early. As part of this process, Fiji will need to undertake more concerted efforts to improve the accuracy and extent of data collected for the maritime sector.

Actions for initial implementation include: transitioning 2-stroke engines in small vessels to 4-stroke engines (costing USD 0.5-1 million), coupled with a longer-term shift to wind and electric hybrids; use of government vessels as demonstration models, coupled with financing modality packages to prompt private sector uptake of successful trials (costing between USD 10-100 million) and incentivising key market sectors to lead in the transition (such as the maritime tourism sector). The inclusion of shoreside (port) emissions could be possible if one of two policies were considered in the future. The first would be large-scale practice of powering shoreside-stored reefer containers from the grid. A much larger impact would result from requiring large berthed vessels to use shoreside connections to the grid to provide their power needs ("cold ironing"). However, neither of these policies is considered in this LEDS as there would be significant impact on electricity sector generation needs and associated investments.

Initial emission reductions can be readily achieved in this sector using existing technologies and operational practices at low investment costs. At the same time, however, achieving the total reductions required for deep decarbonisation will require successful introduction of new and currently commercially unavailable technologies and fuels. Details of indicative costs are given in Annex A.

> "Domestic airlines play an important role in Fiji's economic development"

4.4 DOMESTIC AIR TRANSPORT

4.4.1 Overview

This section examines the domestic air transport component for Fiji's LEDS. Domestic air transport encompasses emissions from domestic flights only.

The Fijian Government's Department of Civil Aviation (DCA) is responsible for the safe, efficient, and effective regulation of air transport in Fiji. It ensures necessary compliance with International Civil Aviation Organisation (ICAO) standards through its regulatory arm, the Civil Aviation Authority of Fiji (CAAF). Airports Fiji Limited (AFL), renamed Fiji Airports Limited in May 2018, administers the operation of Nadi and Nausori International Airports and the operation of 13 other government airports throughout Fiji. The government continues to develop the infrastructure of the 15 airports operated by Fiji Airports Limited including Nadi, Nausori, and Rotuma.[105]

People rely on domestic airlines to travel within Fiji and to access crucial services. The average load factor in the last three years has increased from 50% before 2013 to 70%. This improvement is mainly due to the introduction of new planes. Domestic airlines play an important role in Fiji's economic development. Fiji Link Airlines continues to be the principal domestic operator. It uses Nadi Airport as its main base but also operates flights out of Suva to Levuka, Savusavu, Taveuni, and Kadavu which are in addition to their existing operations between Suva to Nadi and Suva to Labasa. Fiji Link Airlines also connects Nadi and Suva to Rotuma where the runway has recently been extended allowing larger planes to operate.

Fiji Link has a fleet of two ATR 72-600, one ATR 42-600, and three De Havilland Twin Otters.[106] Another 100% locally-owned domestic airline, Northern Air, uses Nausori Airport as its main base operating a fleet of six aircrafts (one Britten Norman Islander, one Britten Norman Trilander BN2, and four Embraer Banderaintes). It offers flights to Taveuni, Savusavu, Labasa, Levuka, Moala, and Nadi. It also offers a full charter service. [108] Other commercial domestic operators offering non-scheduled services include Pacific Island Air, Turtle Airways, Air Wakaya, and Laucala Air. Pacific Island Air, which mainly operates seaplanes, is based at Nadi Airport and provides charters to island resorts.

4.4.2 Emission Sources

Summary of Emission Sources

Emissions from domestic aviation are largely the result of the combustion of fossil fuel for aircraft operation, such as Jet A1 fuel (kerosene) and Avgas (petrol) fuel. For example, Fiji Link's ATR 72 planes use Jet A1 fuel on flights between Nadi, Suva, and Labasa and the De Havilland twin otters use Avgas fuel on all other domestic flights. In the Fiji TNC[108] to the UNFCCC, total fuel consumption amounted to 1.8 million litres of avgas and 3.7 million litres of Jet A1 fuel per annum. For purposes of this LEDS, and following the TNC data, these numbers are rounded up to 2.5 million litres and 5.0 million litres, respectively, to account for fuel use in other aircraft, delays, and charter flights.

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[105] Department of Civil Aviation. (2018). *Licensing Procedures*. Accessed 30th August 2018. Available at www.civilaviation.gov.fj/licensing-procedures.

[106] Fiji Airways. (2018). *Our Fleet*. Accessed 30th August 2018. Available at https://www.fijiairways.com/about-fiji-airways/our-fleet/.

[107] Northern Air. (2018). Accessed 30th August 2018. Available at https://www.northernair.com.fj/.

[108] Government of Fiji. (2018c). *Fiji Third National Communication (TNC) to the UNFCCC*.

Activity in domestic aviation is measured in passenger kilometre (pkm). The LEDS uses 2013 as the base year for air transport, during which there was a total of 38,950 pkm travelled, according to FBoS.

Type of Emissions

The types of emissions from the above sources are carbon dioxide, nitrous oxide, and methane. IPCC 2006 default emission factors are used (an average of 72.5 kg/TJ for both the fuels JetA1 and Avgas was used, which is within the IPCC limits).[109]

4.4.3 Existing Policy and Regulatory Framework

The primary legislation covering aviation in Fiji includes the Civil Aviation Act (CAA) [CAP 174], Civil Aviation Authority of Fiji Act (CAAFA) [CAP 174A], and the Civil Aviation (Reform) Act (CARA).[110] The Department of Civil Aviation is the custodian of these Acts and is accountable to the Minister for Civil Aviation through the Solicitor General and Permanent Secretary for Civil Aviation in the provision of sound advice that ensures the effective and efficient regulation of air transport within Fiji. Under these regulations, the department is responsible for the following functions:

- Establishing Air Services Agreements with sovereignties wishing to generate trade, tourism links, and diplomatic relations with Fiji through the provisions of air transportation;
- Facilitating requests for non-scheduled international air operators who wish to make a landing or over flight within the Flight Information Region (FIR);
- Facilitating the issuance of air service permits to international operators wishing to provide scheduled air services into and out of Fiji in accordance with the Air Services Agreement;
- Chairing the National Civil Aviation Intelligence Community Committee as well as the National Aviation Security Committee including the Airport Aviation Security Committees for both Nadi International Airport and Nausori International Airport, and representing the Ministry for Civil Aviation in the National Aviation Facilitation Committees and the two International Airports subsidiary Aviation Facilitation Committees; and
- Overseeing the continuous implementation of the air subsidy scheme, to encourage air operators onto routes in Fiji deemed uneconomical via a tender process; domestic airline operators use the government subsidies to facilitate trade, tourism, and public travel needs that are essential especially to Fiji's outer island communities which rely a great deal on aviation services.

CAAFA established the Civil Aviation Authority of Fiji, which is a Statutory Authority tasked to ensure that the highest safety standards are met and services are provided in an efficient manner, meeting both the regulatory requirements and the needs of its customers.[111] The Authority is also responsible for overseeing the National Civil Aviation Management Plans (NCAMP) and policies aligned to support the ICAO regional and global aviation safety, security, efficiency, and environment initiatives and goals. This is to ensure that the national aviation legislation, regulations, and standards are regularly reviewed and harmonised with international best practices and standards to further raise Fiji's safety and security record.

Airports Fiji has a Carbon Management Policy in place, the main aims include:

- Conduct relevant research and data collection to identify and control activities of Fiji Airports that generate carbon;
- Develop plans to monitor carbon emitting activities and develop a baseline;[112]
- Ensure a third party can review and verify data;
- Consider low carbon alternatives;
- Create awareness; and
- Work closely with all stakeholders and airlines.

[109] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf.
[110] *Laws of Fiji*. Accessed 30th August 2018. Available at www.paclii.org/fj/legis/sub_leg/caa1976anr2009491.
[111] *Laws of Fiji*. Accessed 30th August 2018. Available at www.paclii.org/fj/legis/sub_leg/caa1976anr2009491.rtf.
[112] http://airportsfiji.com/includes/AFL-Carbon-Management-Policy-2016.pdf

4.4.4 Methodology

Model and Methodology Used

The four LEDS scenarios for air transport were developed using the LEAP model.

Data Used, Data Sources, and Assumptions

Fuel intensity for domestic flights is assumed to be 5 MJ/pkm[113] and is held constant in future years. For all scenarios, domestic aviation activity is assumed to increase at 4% per annum on average based on past trends in the sector and assumed growth of 4% GDP/capita per annum. GDP/domestic aviation activity elasticity is assumed to be one.

The key data sources for the domestic aviation sector include:

- FRCS: data for liquid fuel and gas imports;
- FBoS: general data; and
- Airports Fiji: passenger activity data.

Limitations and Uncertainties

One major limitation for this component is that fuel consumption data is not available from individual domestic airline companies; hence, TNC data is used for calibrating the model for fuel intensity. The TNC air transport model was constructed using airline schedules for Fiji national flights and emissions were calculated using IPCC values.[114] Also due to the unavailability of official tourist number projections, we have used the past trend to estimate the growth.

Stakeholder Consultation Process

Key stakeholders invited to discuss the domestic air transport components of the LEDS included: the Ministry of Justice and Civil Aviation, the Civil Aviation Authority of Fiji, the Ministry of Industry and Trade, the Department of Tourism, domestic airlines, the Air Transport Licensing Board (ATLB), Air Terminal Services (Fiji), Fiji Airports Limited, the World Bank, the Fiji hotel and tourism associations, private tourist operators, and the Pacific Island Development Forum.

Dialogue with stakeholders began with an initial consultation with the Department of Civil Aviation, and then with a larger group during the second round of national consultations with a workshop held on the 28th of June, 2018 which involved senior officers from the Department of Civil Aviation and from Fiji Airports Limited who contributed to the proposed scenarios. Suggestions included considering the use of biofuels (B5) to offset emissions from domestic aviation, offsetting emissions through the international carbon market, considering commercial and private helicopters in the analysis, the possibility of a certification scheme for low emission airlines, and whether military aircraft should be considered in the LEDS (there are none in the Fijian military). Although no specific stakeholders from the air transport sector attended the third national stakeholder workshop, several relevant comments were raised, most notably about the selection of electric planes as the best zero emission option (and the only currently viable option).

4.4.5 Low Emission Development Scenarios

BAU Unconditional Scenario

The BAU Unconditional scenario assumes no external financial support and that Fiji will continue to rely on its own resources to implement mitigation actions. For demand under this scenario, all domestic air travel is serviced by aircraft in current fleets using fossil fuels (Jet A1 and Avgas).

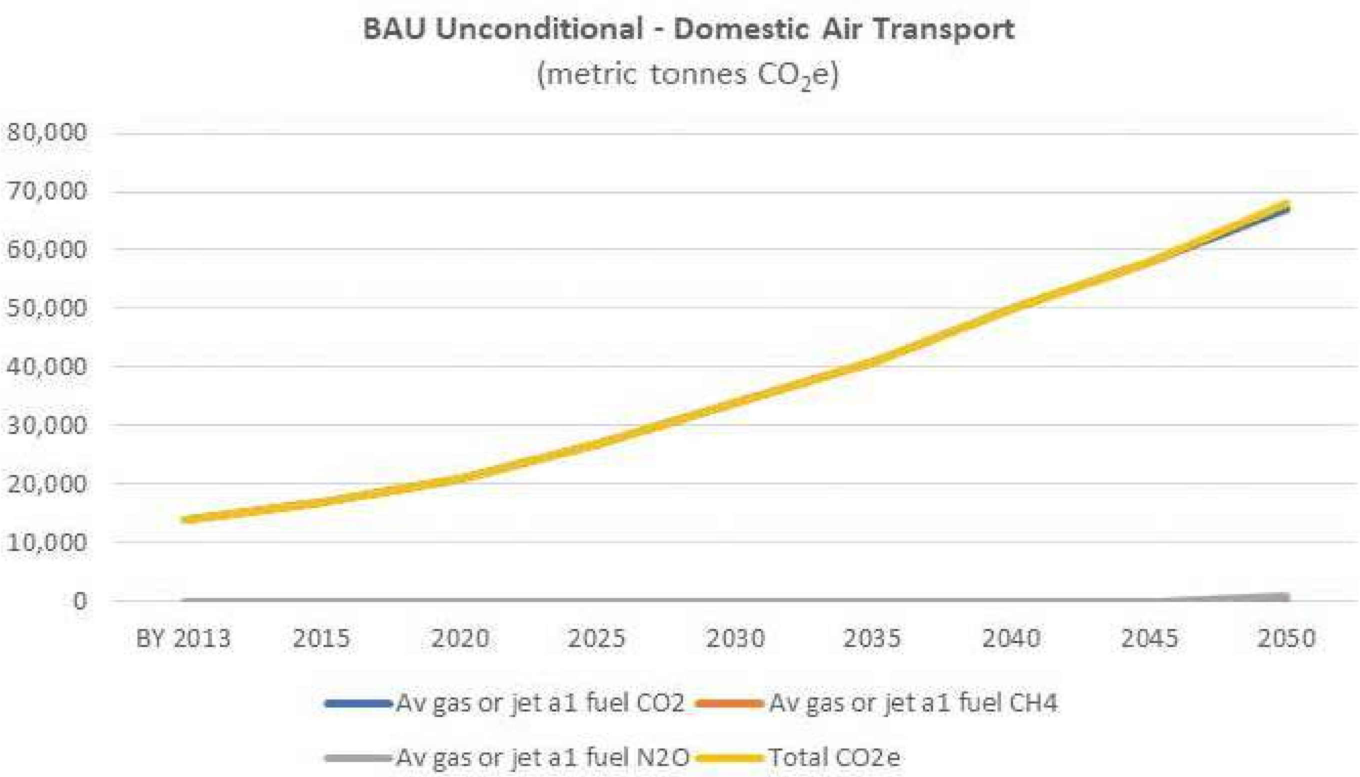
Projected emissions in the BAU Unconditional scenario are provided in Table 22.

[113] Based on data from the TNC.
[114] See for example: https://www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx

Table 22. BAU Unconditional scenario for Domestic Air Transport.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
Av gas or jet a1 fuel	CO_2	14,000	17,000	21,000	27,000	34,000	41,000	50,000	58,000	67,000
	CH_4	0	0	0	0	0	0	0	0	0
	N_2O	0	0	0	0	0	0	0	0	1,000
Total	CO_2e	14,000	17,000	21,000	27,000	34,000	41,000	50,000	58,000	68,000

Figure 47. BAU Unconditional scenario – Domestic Air Transport.



The solar-at-gate is an ICAO initiative which replaces diesel generators at airports with solar PV.[115] This action could be part of BAU scenarios. Establishing solar PV at all the airports will be a sub-set of Fiji's 100% renewable electricity programme.

BAU Conditional Scenario

The BAU Conditional scenario assumes some international financial support is available to implement mitigation actions. For demand under this scenario, all domestic air travel is serviced by aircraft using fossil fuels (Jet A1 and Avgas). In addition, the scenario envisions adoption of energy efficiency measures, such as improving load factor and reducing fuel consumption by changing the types and direction of landing (i.e., improved air traffic management at all airports).[116]

Adopting these efficiency measures is expected to reduce fuel intensity from 5 MJ/pkm to 4 MJ/pkm.

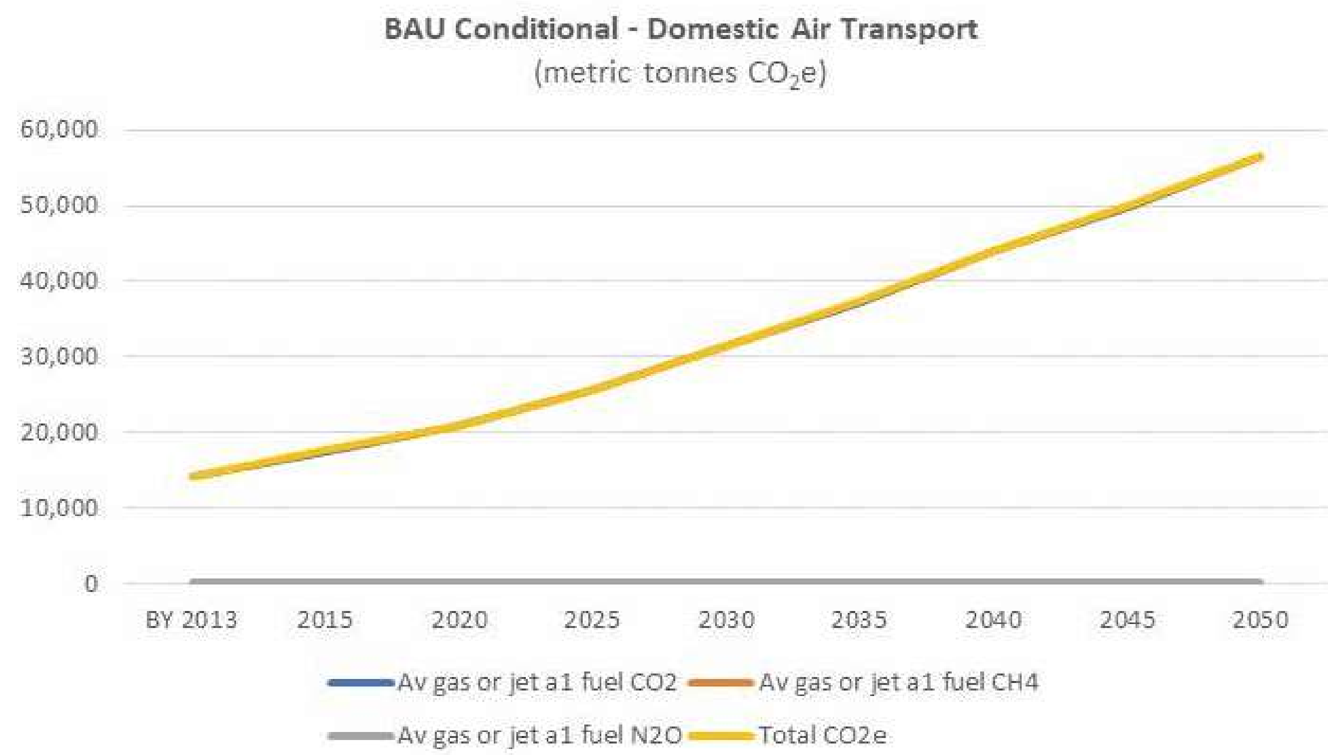
[115]https://www.icao.int/Meetings/greenairports/Documents/2.%20Steve%20Barret.pdf
[116]Energy efficiency measures cannot be adopted unilaterally by airlines and need to be discussed, agreed, and implemented with a number of key stakeholders.

Efficiency measures would be adopted starting in 2020, during which 4% of passenger activity (pkm) would be serviced with efficient (newer) aircrafts, increasing to 40% by 2030 and 80% by 2050. Projected emissions for the BAU Conditional scenario are provided in Table 23.

Table 23. BAU Conditional scenario for Domestic Air Transport.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
Av gas or jet a1 fuel	CO_2	14,129	17,475	20,927	25,641	31,361	37,326	43,977	49,822	56,415
	CH_4	2	2	2	2	2	2	2	2	2
	N_2O	121	121	121	121	121	121	121	121	121
Total	CO_2e	14,252	17,598	21,050	25,763	31,484	37,449	44,099	49,945	56,537

Figure 48. BAU Conditional scenario – Domestic Air Transport.



Biojet fuel will start to be used in 2030, initially for 2% of passenger activity (pkm), and then rising to 20% of passenger activity by 2040 and 40% by 2050. The fuel economy of Biojet fuelled planes is assumed to be the same as for efficient aircraft, i.e. 4 MJ/km. The emission factor used for Biojet fuel is 75% of the emission factor of fossil fuelled planes (based on the assumption that 25% Biojet fuel will be blended with conventional jet fuel).

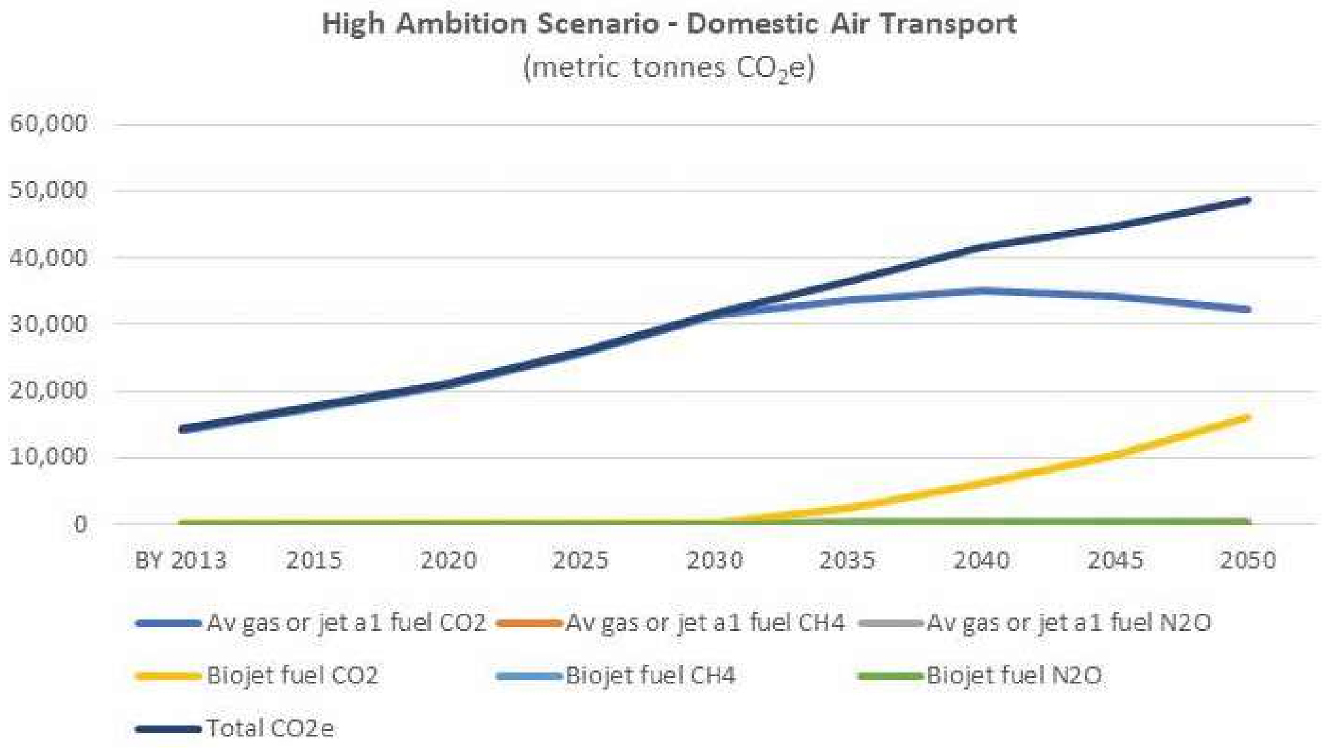
The same energy efficiency measures and assumptions used in the BAU Conditional scenario will be adopted in the High Ambition scenario.

Projected emissions for the High Ambition scenario are provided in Table 24.

Table 24. High Ambition scenario for Domestic Air Transport.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
Av gas or jet a1 fuel	CO_2	14,129	17,475	20,927	25,641	31,361	33,593	35,181	34,065	32,237
	CH_4	2	3	3	4	5	5	5	5	5
	N_2O	121	149	179	219	268	287	301	291	275
Biojet fuel	CO_2	0	0	0	0	0	2,488	5,997	10,428	16,118
	CH_4	0	0	0	0	0	0	1	2	2
	N_2O	0	0	0	0	0	21	51	89	138
Total	CO_2e	14,252	17,627	21,109	25,863	31,634	36,374	41,485	44,790	48,638

Figure 49. High Ambition scenario – Domestic Air Transport.



Very High Ambition Scenario

Under this scenario, short haul electric planes will be introduced starting in 2040 covering 2% of passenger activity (pkm), increasing to 20% of all passenger activity by 2050. The fuel intensity of electric planes is assumed to be 2.8 MJ/pkm.

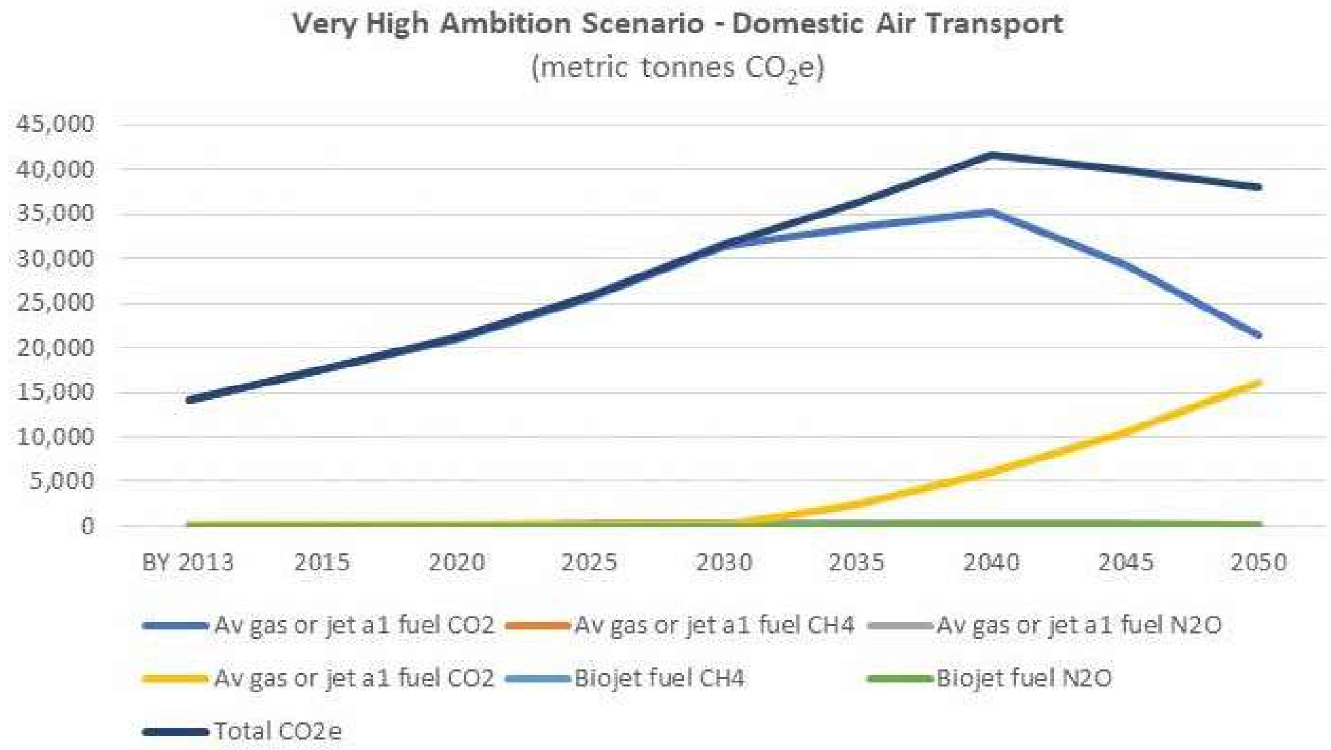
The same assumptions for adopting energy efficiency and biojet fuel measures used in the High Ambition scenario will be adopted in the Very High Ambition scenario.

Projected emissions for the Very High Ambition scenario are provided in Table 25.

Table 25. Very High Ambition scenario for Domestic Air Transport.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
Av gas or jet a1 fuel	CO_2	14,129	17,475	20,927	25,641	31,361	33,593	35,181	29,198	21,491
	CH_4	2	3	3	4	5	5	5	4	3
	N_2O	121	149	179	219	268	287	301	250	184
Biojet fuel	CO_2	0	0	0	0	0	2,488	5,997	10,428	16,118
	CH_4	0	0	0	0	0	0	1	2	2
	N_2O	0	0	0	0	0	21	51	89	138
Total	CO_2e	14,252	17,627	21,109	25,863	31,634	36,395	41,536	39,971	37,937

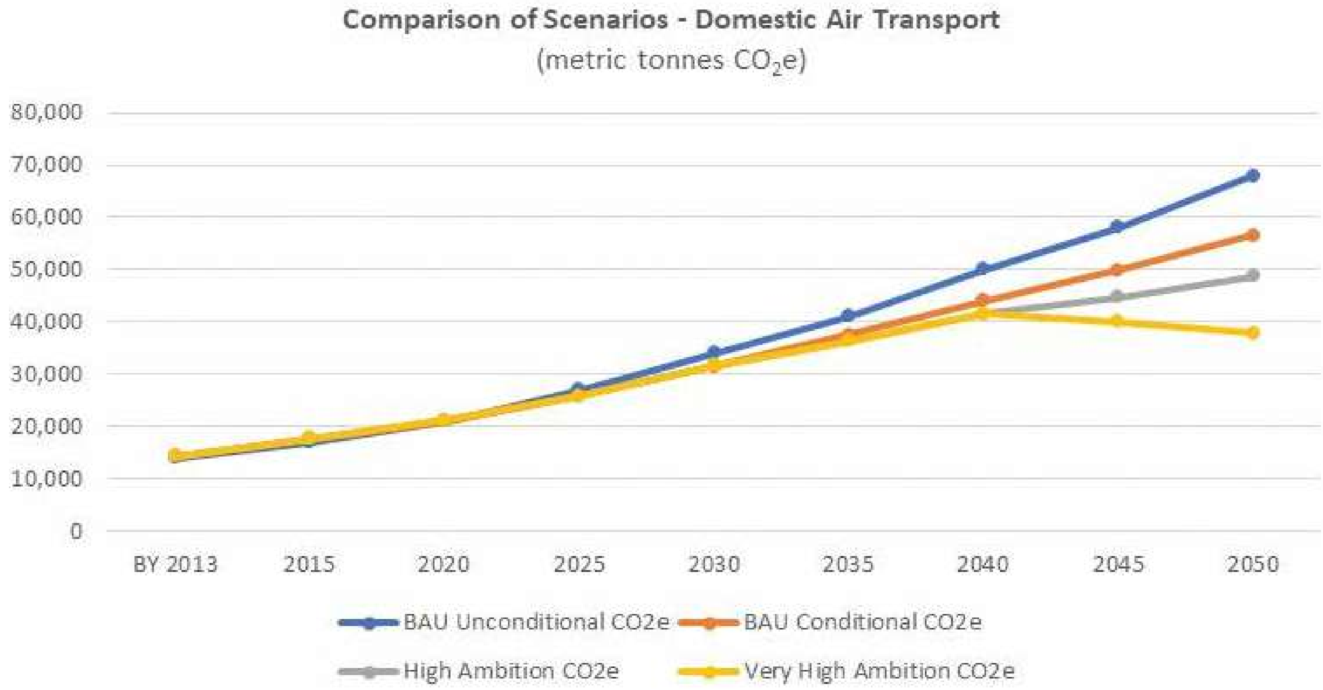
Figure 50. Very High Ambition scenario – Domestic Air Transport.



Comparison of Scenarios

The comparative result of all four scenarios addressing domestic air transport is provided in Figure 51.

Figure 51. Comparison of scenarios – Domestic Air Transport.



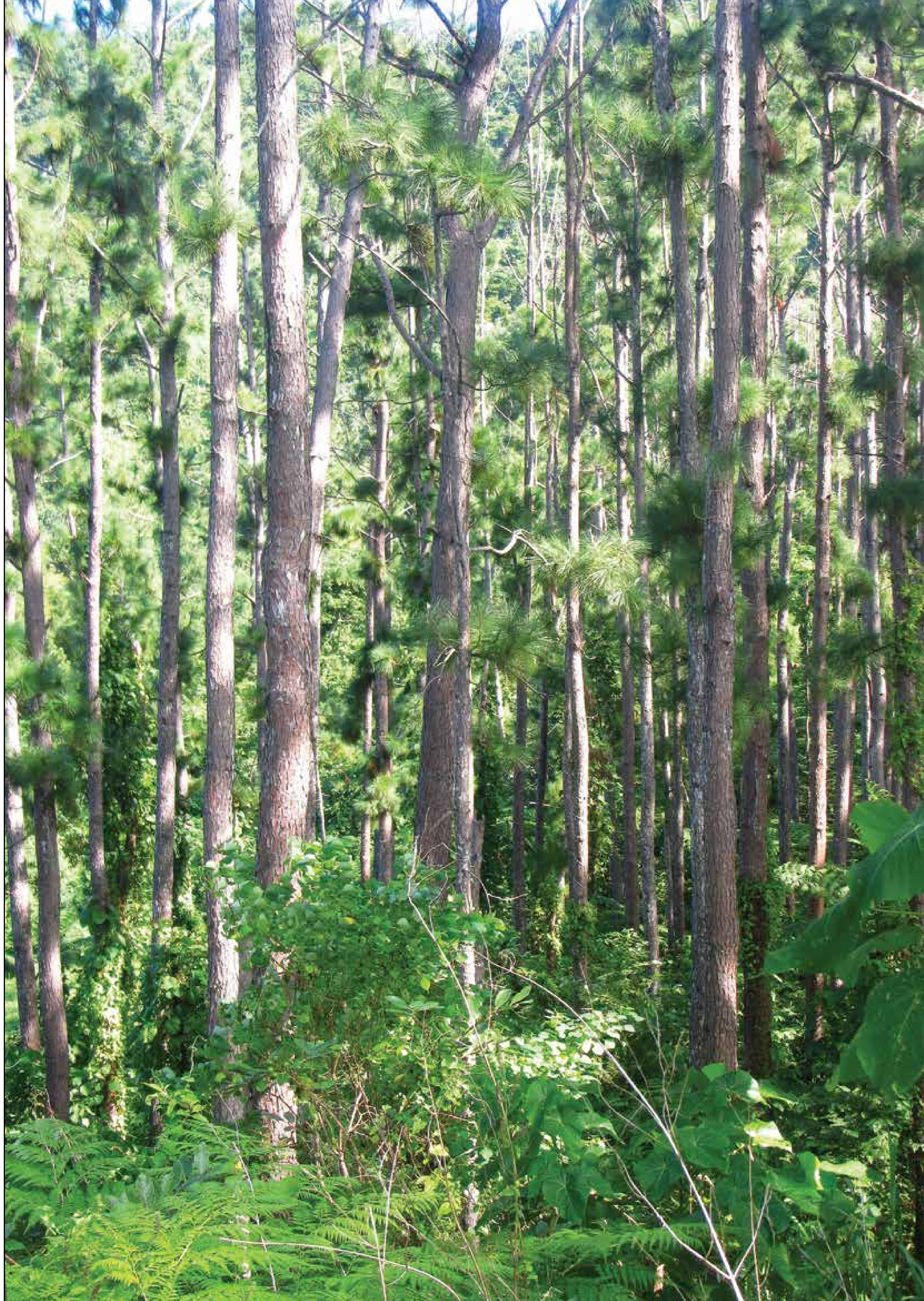
4.4.6 Policy Recommendations, Priority Actions, and High-Level Costing

Implementation of the High Ambition and Very High Ambition scenarios can reduce CO_2 emissions by 20,000 metric tonnes and 30,000 metric tonnes, respectively, by 2050. This would require the introduction of biojet fuel around year 2030, with incremental increase of 20% of passenger activity to be serviced by biojet fuelled planes by 2040 and further increases to 40% by 2050. This to be complemented with energy efficiency measures, such as improving load factor and changing landing type. The Very High Ambition scenario will see introduction of electric planes by 2040 with 20% of all passenger activity to be serviced by electric planes 2050.

Replacing older aircraft with efficient new planes would cost around USD 500-600 million. Introducing biojet fuel is not expected to create financial burden as the cost would be comparable to traditional fuels. Powering all off-grid airports and using solar-at-gate for airplanes at these airports could be part of transforming Fiji's domestic air sector to renewable energy. The cost of these two measures is estimated at approximately USD 20 million. Costs of electric aircraft should be investigated further in the future as these technologies are still in the development stage and should be examined again when commercially mature.

There will be an ongoing need from the BAU Unconditional scenario to the Very High Ambition scenario to continue to improve on energy efficiency, such as introducing energy efficient planes by 2020. Fiji will, therefore, need to formulate national policy and regulatory frameworks on the use of energy efficient planes, with biojet fuel and electric planes technology in the period from 2020 and beyond.

"The Very High Ambition scenario will see introduction of electric planes by 2040 with 20% of all passenger activity to be serviced by electric planes 2050"



“AFOLU combines possibilities for reducing GHG emissions with possibilities for increasing removals of atmospheric CO_2”

4.5 AFOLU

4.5.1 Overview

This section examines the Agriculture, Forestry, and Other Land Use (AFOLU) component for Fiji's LEDS. AFOLU deals with activities in the areas of land use, land use change, forestry, and agriculture. With regard to mitigation potentials, this sector occupies a special position, since it combines possibilities for reducing GHG emissions with possibilities for increasing removals of atmospheric CO_2. The potential for emission reductions results from changed land management and livestock farming and avoided deforestation and forest degradation. The potential for increased removals is mainly through forest management and afforestation. AFOLU contributes about a quarter of global net anthropogenic GHG emissions, mainly from deforestation and forest degradation, as well as agricultural emissions from livestock farming, tillage, and fertiliser use. In addition to its importance for GHG emissions, the sector provides a wide range of co-benefits, including ecosystem services. Land management ensures food security, makes a decisive contribution to safeguarding the quality of life (especially in rural populations), provides renewable raw materials and energy sources, and preserves natural habitats and their biodiversity. Therefore, measures to reduce emissions and increase removals cannot be considered in isolation but must always consider the effects of other demands on the sector.

About 60% of Fiji's land area is covered by forest. The total forest area (1.162 million ha) consists of native forest (87%) and plantation forest (13%).[117] In addition, around 50,000 ha are stocked with mangroves and are treated in the blue carbon section. A forest area change assessment, which was carried out on the basis of satellite data, shows an error-adjusted annual forest loss of around 2500 ha for the period 2006-2016. Approximately 1,800 ha were newly forested every year during the same period.[118]

The main drivers of deforestation are commercial and smallholder agriculture. The traditional practices of shifting cultivation (migratory agriculture) have gradually been replaced by commercial agriculture in order to establishing cash crops such as kava and taro, which are a common cause of deforestation at the forest frontier. Timber harvesting is the main driver of forest degradation. Although commercial harvesting in native forests has been largely replaced by timber extraction from plantations, harvesting for domestic and informal markets continues to drive unregulated forest degradation.

The forest sector accounts on average for 1.2% of GDP and 4.1% of export earnings.[119] In 2016, FJD 31.8 million worth of wood chips or particles and FJD 25.7 million worth of mahogany were exported. Forest management has shifted from timber production to conservation and sustainable management, focusing more on the social functions of forests with the aim to improve the quality of water resources, improving agricultural land, contributing to biodiversity protection and climate change mitigation, and reducing vulnerability to natural disasters, particularly floods.

[117]FAO. (2010). *Global forest resources assessment 2010: Main Report*. Rome: Food and Agriculture Organization of the United Nations; and FAO. (2015). *Global forest resources assessment 2015*. Rome: FAO.
[118]SPC. (2018). *Forest change dectection Fiji*. Suva: SPC.
[119]Republic of Fiji. (2014). *Second national communication to the United Nations Framework Convention on Climate Change*. Suva: Ministry of Foreign Affairs.

Around 285,000 hectares of permanent crops are cultivated in Fiji.[120] According to the 2009 National Agricultural Census,[121] the main crops cultivated are sugarcane (57,200 ha), cassava (15,500 ha), dalo (15,200 ha), coconuts (15,000 ha), yaqona (8,900 ha), and rice (3,600 ha). The other main crops included ginger, eggplant, and tropical fruits. The main livestock raised in Fiji are beef and dairy cattle, poultry, goats, and pigs.

There are three basic types of agriculture in Fiji: (1) subsistence, (2) semi commercial, and (3) commercial. Small farms dominate Fiji's agriculture; about 44% of the farms are less than one hectare in size, while a small number of farms (0.2%) manage areas over 100 ha. As a result, subsistence agriculture continues to play a significant role in the Fijian agriculture system, accounting for up to one third of total production.[122] In terms of income structure, 26% of households earn less than 25% and 58% of households more than 50% of their household income from agricultural activity.

In 2015, the agricultural sector contributed FJD 541.8 million (8.1%) to GDP.[123] Livestock alone (FJD 52.8 million) accounts for about 0.8% of GDP. Total agricultural production in Fiji is 295.536 metric tons, of which 14% (40.085 t) is cattle farming and 86% (255.451 t) is arable farming. In 2015 food and live animals worth FJD 465.5 million were exported, of which sugar contributed FJD 129.4 million, and FJD 803.4 million worth were imported (including FJD 109 million worth of wheat and meslin, FJD 200 million worth of fresh fish, and FJD 42.4 million worth of rice). The sector has actively employed close to two-thirds of the labour force.

4.5.2 Emission Sources

Summary of Emission Sources

Agriculture and forestry are by far the most important contributors of emissions in the AFOLU sector in Fiji. Forests can be sources as well as sinks of greenhouse gases. Trees remove atmospheric CO_2 via photosynthesis and store it as carbon in their woody components. Tree growth increases the carbon storage of forests. Natural forests unaffected by human activity eventually reach a climax stage in which biomass production and biomass degradation balance each other out. These forests can store significant amounts of carbon, but only sequester additional carbon to a limited extent.

Afforestation of non-forested areas is particularly suitable for sequestering additional quantities of CO_2 and thus increasing the sink function of the forestry sector. Particularly fast-growing tree species and corresponding silvicultural management methods offer a high potential for carbon sequestration. Harvesting interventions in forests generally lead to a loss of biomass and therefore reduce carbon stocks. This is especially true for permanent deforestation. When intervening in natural forests, it should be noted that only a small proportion of the wood that is removed from the standing wood volume is actually removed from the forest and utilized. Often considerable quantities of wood remain unused as harvest waste in the forest. Heavy use interventions can overstrain the resilience of forest ecosystems and therefore lead to forest degradation. In contrast, sustainable forest management intervenes gently in forest stands and can lead to an increase in biomass growth and, thus, carbon sequestration (if the rules of good forest practice are observed).

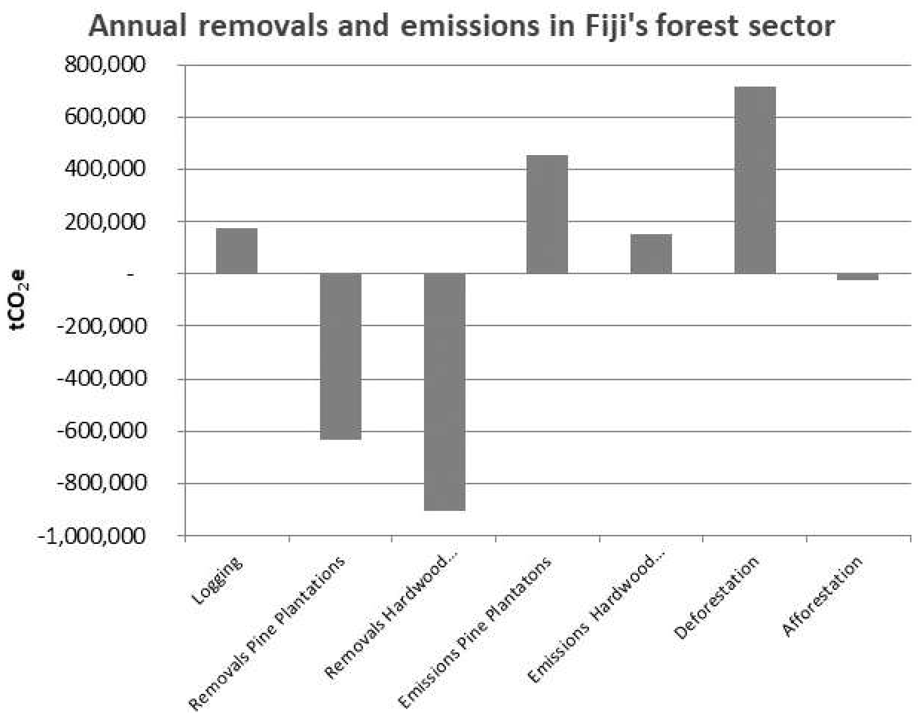
Although harvesting wood reduces the amount of carbon stored in forests, this reduction must not be equated with an immediate release of CO_2. Instead, some of the wood harvested is either converted into durable wood products in which the carbon remains fixed, or the wood harvested is used energetically, thus, avoiding additional emissions from fossil fuels. In addition to energetic substitution, positive carbon effects are also created by wood processing, which generally requires less energy in the production of goods than in the production of alternative, non-renewable materials. The carbon effects of wood use can be quantified by life cycle analyses. For the sake of simplicity and to avoid double counting, emissions from wood utilization are included in the AFOLU sector in this report. This means that there are no calculated emissions from the energetic use of woody biomass.

[120]Ministry of Agriculture. (2014). *Fiji 2020 agricultural sector policy agenda*.
[121]Republic of Fiji. (2009). *National Agricultural Census - 2009 Report*. Suva: FAO, Fiji Department of Agriculture.
[122]Cole, S. (2017). *Fiji crops sector strategy*.
[123]http://www.agriculture.gov.fj/images/Production%20Chart.pnghttp://www.agriculture.gov.fj/images/Production%20Chart.png

"Emissions from agriculture can be roughly separated into emissions from managing croplands, livestock farming and the use of fertilisers"

In Fiji, the current annual emissions and removals for deforestation, logging, and associated forest degradation, as well as current removals and emissions from plantation management, are shown in Figure 52.

Figure 52. Annual removals and emissions in Fiji's forest sector.[124]



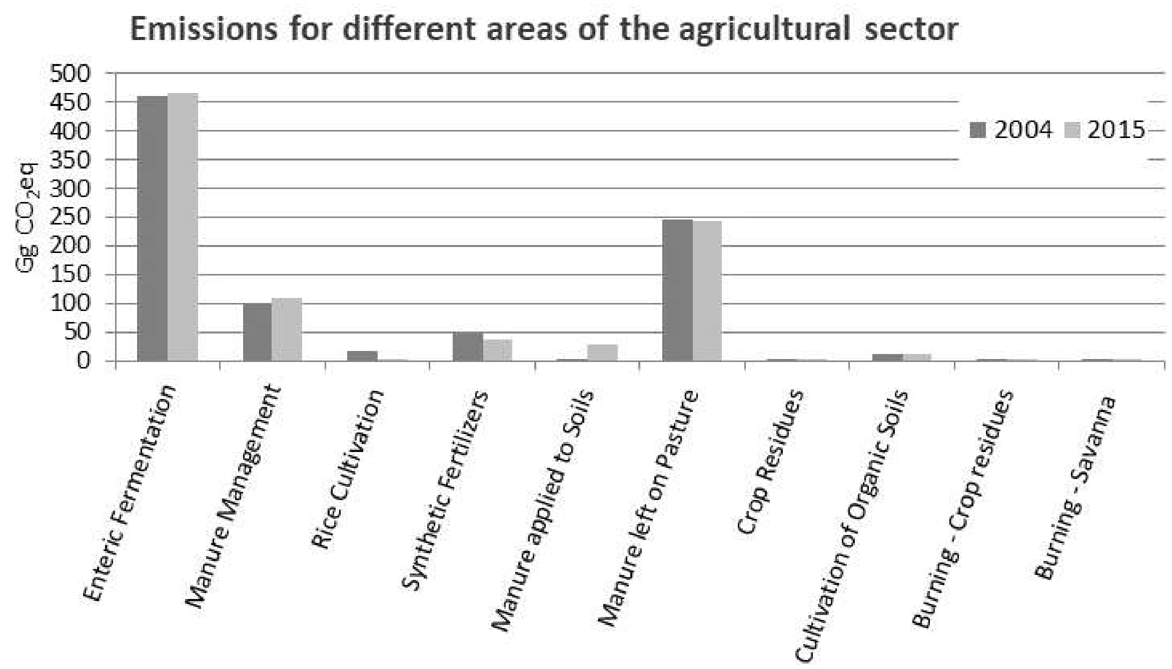
In contrast to forestry, agriculture is strictly a source of GHGs. Emissions from agriculture can be roughly separated into emissions from managing croplands and emissions from livestock farming. In addition, there are emissions from the use of fertilisers, which can mainly be applied to croplands and, to a lesser extent, also to grasslands. By far the largest emissions are caused by livestock farming. Ruminants emit methane (CH_4) during digestion and excrement from all livestock species lead to GHG emissions from manure. The amount of GHG emissions from livestock farming depends on a number of factors, e.g., whether the livestock are kept indoors or outdoors, the feed used, and the treatment of the manure. When quantifying the emissions from agriculture, a distinction is usually made between the following management areas: livestock management, enteric fermentation, manure management, manure left on pasture and manure applied to soils, and from arable farming, rice cultivation, burning of croplands and savannas, crop residues, cultivation of organic soils, and the application of synthetic fertilisers.

[124]For the forestry sector, data from the 2006 national forest inventory and the forest area change assessment 2006-2016 (provided by SPC) are used, as well as plantation data provided by Fiji Pine Ltd and Fiji Hardwood Ltd. For plantation growth, IPCC default values have been applied.

For Fiji, different data sources are available that can be used to assess the composition of sector emissions. Although the data sources indicate different orders of magnitude of the emissions, they offer a relatively consistent picture of the composition of emissions from different management areas. Emissions estimates for the agricultural sector are based on information from Food and Agriculture Organisation Corporate Statistical Database (FAOSTAT),[125] the Agricultural Census 2009,[126] and the Animal Health and Production (AHP) Report 2015.[127]

Figure 53 shows emissions for different areas of the agricultural sector in 2004 and 2015 using data from FAOSTAT. The largest emissions are caused by enteric fermentation, manure left on pasture, and manure management. Emissions from the use of synthetic fertiliser and rice cultivation are significantly lower. Other emissions from crop farming play a negligible role.

Figure 53. Emissions for different areas of the agricultural sector.



The values shown in Figure 53 have been validated using various approaches. A validation with data on synthetic fertiliser application shows that the respective annual emissions in the period from 2010-2014 are well below 25 Gg CO_2e.[128] Research indicates that rice cultivation in 2014 yielded emissions of 2.98 Gg CO_2e.[129] Emissions from livestock farming were verified with data from the Agricultural Census 2009 and the AHP report. IPCC default values for per animal head emissions from enteric fermentation and manure production were utilized to calculate the total emissions from livestock by means of a Tier 1 approach.[130] Low emissions from 2010 onwards are due to the fact that the AHP report only covers livestock in the formal sector (Table 26).

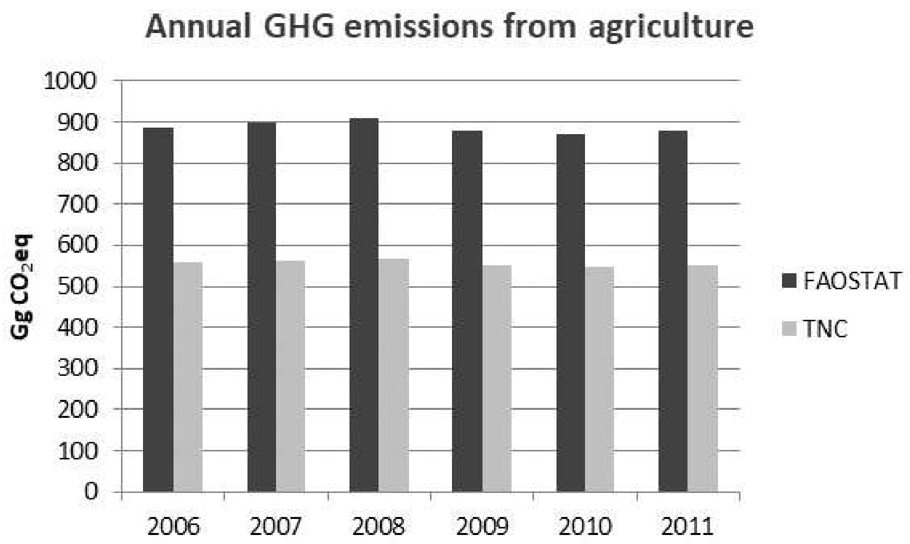
[125]http://www.fao.org/faostat/en/#home
[126]Republic of Fiji. (2009). *National Agricultural Census - 2009 Report.* Suva: FAO, Fiji Department of Agriculture.
[127]Ministry of Agriculture. (2015). *Animal health and production report.*
[128]Chand, D., Mani, F.S., Maata, M., Macanawai, A. (2017). Evaluation of methane emissions from the agricultural sector in Fiji. Suva, Fiji: USP.
[129]IPCC. (2006a). *Agriculture, Forestry and other Land Use.* Eggleston, S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. (Eds.). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4. Japan: IGES.
[130]Republic of Fiji. (2009). *National Agricultural Census - 2009 Report.* Suva: FAO, Fiji Department of Agriculture; and Ministry of Agriculture. (2015). *Animal health and production report.*

Table 26. Emissions from livestock in Gg CO_2e.

Livestock type	2009	2010	2011	2012	2013	2014	2015
Beef	131.4	n.a.	46.7	55.9	66.2	77.4	70.2
Dairy	185.5	26.6	54.9	58.6	59.5	85.7	96.4
Goat	14.8	3.2	3.4	3.6	5.3	5.6	5.9
Sheep	2.0	1.6	1.5	1.8	2.7	2.2	3.1
Pig	28.9	n.a.	9.5	11.5	11.4	11.3	13.8
Horses	15.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Poultry	2.1	n.a.	9.5	7.3	8.6	6.7	5.5
Total	380.0	31.4	125.4	138.8	153.6	188.9	195.0

For the agricultural sector, Fiji's Second National Communication to the UNFCCC reported GHG emissions of 977 Gg CO_2e for 2004. The TNC shows relatively constant annual GHG emissions of 550 Gg CO_2e for the period 2006-2011. This value is considerably lower than the average annual emissions of 887 Gg CO_2e presented by FAOSTAT for the same period as the TNC. For 2015, FAOSTAT reports annual GHG emissions from agriculture at 878 Gg CO_2e. The annual GHG emissions according to Fiji's TNC are about 40% below the emissions reported by FAOSTAT (Figure 54). While FAOSTAT updates historical data for livestock farming, manure management, and fertiliser application to fill in missing data, the TNC refers to reported national data and applies no interpolations to fill gaps in the data. The national data only allow an IPCC Tier 1 approach, which is associated with an error margin of 30% or more.

Figure 54. Annual GHG emissions from agriculture as reported by FAOSTAT and the Fiji TNC.



Type of Emissions

Large amounts of CO_2 move between the atmosphere and plant biomass through plant photosynthesis and respiration. In the woody biomass of trees, atmospheric CO_2 is stored as carbon over long periods of time. Reduction of the carbon stock of forests thus leads to the release of CO_2. In non-forest ecosystems, such as grasslands or croplands, biomass is usually non-woody and the carbon it contains is released annually or within a few years. Non-CO_2 emissions in the AFOLU sector are largely a product of microbial activity. The non-CO_2 gases of primary concern are methane (CH_4) and nitrous oxide (N_2O). Emissions of other nitrogenous gases, including NOx and NH_3, can serve as a source of subsequent N_2O emissions.[131]

[131]Republic of Fiji. (2009). *National Agricultural Census - 2009 Report*. Suva: FAO, Fiji Department of Agriculture; and Ministry of Agriculture. (2015). *Animal health and production report.*

Crop and livestock production for food contribute to emissions from agriculture in a variety of ways. The application of synthetic and organic fertilisers, the growth of nitrogen fixing plants, irrigation practices and the drainage of organic soils can lead to increased availability of nitrogen in the soil, which in turn leads to emissions of N_2O. Livestock, especially ruminants like cattle, produce CH_4 emissions from enteric fermentation in the course of their normal digestion and both CH_4 and N_2O emissions resulting from manure treatment and storage methods. Burning of crop residues also produces CH_4 and N_2O.

Note, the following emissions are not considered in the AFOLU sector scenarios, but rather in energy and transport sectors:

- Emissions from sugar cane residues burned in sugar mills for energy production;
- Emissions caused by the use of machinery in the management of forests and agricultural land;
- Emissions caused by the transport of forestry and agricultural goods;
- Emissions through the use of energy in the operation of stables;
- Emissions resulting from the production of food or the processing of wood;
- Emissions resulting from the production and transport of synthetic fertilisers; and
- Emissions from fuel consumption in fishing vessels.

4.5.3 Existing Policy and Regulatory Framework

Activities in the AFOLU sector depend directly on land ownership conditions and their regulation in the relevant laws and regulations. More than 80% of land in Fiji is native land, which would be governed by the Native Land Trust Board, according to the iTaukei Land Trust Act. These acts form the backbone of Fiji's land tenure system. Traditionally owned land is not for sale. Leases of iTaukei land, under the Land Trust Act, can be issued for up to 99 years. Any expansion of forest and agricultural land can only take place in accordance with the iTaukei Land Trust Act and taking into account the interests of the local population.

The National Forest Policy 2007 specifies the sector's goal: "Sustainable management of Fiji's forests to maintain their natural potential and to achieve greater social, economic and environmental benefits for current and future generations." The Fiji REDD-Plus Policy[132] is embedded in the National Forest Policy and has the overall objective of "enhancing the national forest carbon balance." It will "contribute towards the development of a national carbon trading policy" and "strengthen the capacities to facilitate access to international financing mechanisms." Government commitment for Reducing Emissions from Deforestation and Forest Degradation (REDD+) and for the emissions reduction program is indicated in the National REDD+ Policy, the NCCP, the National Forest Policy, and the recently launched Green Growth Framework for Fiji. The Fiji REDD-Plus Policy has the overall objective of enhancing the national forest-based carbon balance by (1) supporting and strengthening initiatives that address the drivers of forest-based carbon emissions and (2) encouraging the drivers of forest-based carbon sinks.[133] According to the Emission Reduction Program Idea Note (ER-PIN),[134] the Forestry Department – in partnership with private sector players and landowners – is planning to establish about 77,400 ha plantations in Fiji over the next 15 years.

The Fiji Agricultural Strategy 2020[135] prioritises a diversified and economically and environmentally sustainable agriculture economy in Fiji and, thus, complements the National Green Growth Framework. It emphasises renewable energy and the production of feedstock for biofuels (e.g., cassava and sugarcane) in order to reduce the country's petroleum fuel importation bill. The Agricultural Sector Strategy highlights the need to prepare a national land use plan and to introduce "climate change agriculture." Enabling conditions for the agricultural sector have been covered by the Fiji crops sector strategy[136] and the Fiji livestock sector strategy.[137] Both include domestic policy support frameworks, institutional barriers, measures for capacity building and training, and cost estimates for individual activities.

[132]Fiji Forestry Department. (2011). *Fiji REDD-Plus Policy: Reducing emissions from deforesta on and forest degrada on in Fiji*. Secretariat of the Pacific Community.
[133]Fiji Forestry Department. (2011). *Fiji REDD-Plus Policy: Reducing emissions from deforesta on and forest degrada on in Fiji*. Secretariat of the Pacific Community.
[134]FCPF. (2015). *Emission reductions program idea note (ER-PIN) - Republic of Fiji*. Forest Carbon Partnership Facility Carbon Fund.
[135]Ministry of Agriculture. (2014). Fiji 2020 agricultural sector policy agenda.
[136]Cole, S. (2017). *Fiji crops sector strategy.*
[137]Livestock Sector Strategy Working Group, Ministry of Agriculture. (2016). *Fiji livestock sector strategy.*

4.5.4 Methodology

Model and Methodology Used

The FAO Global Livestock Environmental Assessment Model (GLEAM)[138] was used to verify emissions from agricultural livestock farming. GLEAM simulates the bio-physical processes and activities along livestock supply chains under a life cycle assessment approach. GLEAM provides:

- Systematic, global coverage of six livestock species and their edible products: meat and milk from cattle, buffalo, sheep, and goats; meat from pigs; and meat and eggs from chickens;
- Spatially explicit modelling of livestock distribution, climatic data, feed yields, and biophysical processes that allows the capture of local production drivers and/or constraints, environmental impacts, and intervention measures; and
- Estimation of GHG emissions from each stage of production: the model covers emissions of methane (CH4), carbon dioxide (CO2), and nitrous oxide (N2O), using an IPCC Tier 2 methodology, providing more accurate information on how animal feeding, herd, and manure management options can help in mitigation.

GLEAM allows the definition of scenarios in which different aspects of the livestock (e.g., herd size, feed, maturity) are mapped. As the available data in Fiji are not sufficient for a complete parameterization of the model, the GLEAM analysis in part uses default values and information derived from the 2009 Agricultural Census. GLEAM is not used for direct calculation of emissions but to verify the order of magnitude derived according to IPCC TIER1 methods. The use of other models (e.g., AFOLU Carbon Calculator)[139] was not possible due to lack of input data.

Data Used, Data Sources, Assumptions, Limitations, and Uncertainties

Forestry

Table 27 presents the data sources that were used for the forestry sector.

Table 27. Data sources for the forestry sector.

Data Source	Reference period	Description	Provider
Forest area change assessment	2006-2012 2012-2016	Visual interpretation of LANDSAT TM data for forest area; derived classes: deforestation, forest remaining forest, afforestation; does not include areas of forest plantation	SPC Geoscience Division, Suva
National Forest Inventory	2006	Sample-based assessment of more than 1,000 field plots with measurements of tree and site data and derived timber volume, biomass, and C-stock	SPC Geoscience Division, Suva; Ministry of Fisheries and Forests, Management Service Division, Suva; GIZ, Suva
Plantations	2006-2016	Area of forest pine and mahogany plantations, including areas logged and reforested; logged volume	Fiji Hardwood, Inc. Fiji Pine, Inc.
Logging data	2006-2016	Logging volumes of harvesting operations in concessions and harvested area	Ministry of Fisheries and Forests, Management Service Division, Suva
Default values	-	Default values from the IPCC Guidelines for, e.g., forest growth in plantations	IPCC

[138]http://www.fao.org/gleam/en/
[139]http://afolucarbon.org

The different data sources are associated with various errors, some of which are unknown. The forest area assessment for Fiji was subject to an extensive accuracy analysis, carried out according to the guidelines of the IPCC[140] and the methodological framework of the FCPF.[141]

In 2006, a sample-based field survey was carried out (National Forest Inventory). Using plots in the forest, measurement data on trees and descriptions of the forest stand were collected. Data on wood, biomass, and carbon were derived with models. Errors in this survey are composed of sampling errors, model prediction errors, and non-statistical errors (e.g., measurement errors) and are likely to be in the range of 10-20%.

No uncertainty assessment is available for logging data. Local foresters collect data on harvested volumes and areas using state-of-the-art methods (e.g., GPS for area determination) and are therefore within a usual error range of less than 10%.

No accuracy data are available for plantation data. However, there are discernible data gaps in the information on areas harvested and afforested. IPCC default values were used for timber volume growth. These have an error range of 30-50%.

Agriculture

More limited data was available for the agricultural sector than for the forestry sector, as there are no current representative surveys covering the entire sector (livestock and arable farming). The latest representative survey, which provides reliable data for the whole sector, dates from 2009. The Ministry of Agriculture publishes the Animal Health and Production Report annually, and this LEDS uses the 2015 edition. Due to significant disease infestation at the beginning of the 2010s, Fiji livestock was drastically reduced and gradually recovered in the following years. No information is available on the recovery of livestock in the subsistence sector. Data on agricultural land-use and temporary crops should be less volatile than in the livestock sector. Therefore, the data from the 2009 Agricultural Survey were used for the base year 2015.

Livestock data were taken from the 2009 Agricultural Census and the 2015 Animal Health and Production Report. Only for 2009 do these figures reflect cattle stocks for both the subsistence and commercial sector. For the following years, only stocks for the commercial sector are available.

Data for rice cultivation were taken from a review of the development of the rice industry,[142] as provided by MOA and are shown in Table 28.

[140]IPCC. (2003). *Good practice guidance for land use, land-use change and forestry.* Japan: IGES.
[141]FCPF. (2016). *Carbon fund methodological framework.* Forest Carbon Partnership Facility.
[142]Bong, B.B. (2017). *Review of the development of the rice industry in Fiji.*

Table 28. Rice area, production, and yield during 2010-2015.

Year	2010	2011	2012	2013	2014	2015
Area (ha)	2 507	3 355	1 803	2 156	3 156	3 200
Production (tonnes)	7 663	7 914	4 653	6 873	6 843	6 329
Yield (tonnes/ha)	3.01	2.36	2.58	3.19	2.20	2.00

No specific emission data have been collected for the agricultural sector for this strategy. The LEDS therefore derives emissions on the basis of IPCC default values.[143] This corresponds to an IPCC Tier 1 approach associated with an error of 30-50%. In addition, the analysis uses data from FAOSTAT on emissions from the agricultural sector in Fiji. These data are based on national reports and adjustments made by FAO. FAOSTAT covers the areas of rice cultivation, synthetic fertilisers, enteric fermentation, manure applied to soils, manure left on pasture, manure management, burning – crop residuals, burning – savanna, crop residues, and cultivation of organic soils. These data are also subject to an error frame of 30-50%.

According to IPCC,[144] the increase in biomass stocks of annual crops in a single year is assumed equal to biomass losses from harvest and mortality in that same year, thus, there is no net accumulation of biomass carbon stocks.

Other data

For population estimates and projections, data from FBoS has been used (this is supplemented with World Bank data to 2050 following discussions with FBoS).[145] Data on the use of nitrogen fertilisers and urea application were taken from the FAO database.[146]

Assumptions

The technical mitigation potential of various measures in the AFOLU sector is based on a compilation presented in IPCC's AR5.[147] The technical mitigation potential ranges from less than 1% for, e.g., plant or animal management on grazing lands, and more than 15% for manure management.

As methane emissions from rice cultivation is not a significant source and country-specific emission factors were also not available, Fiji has applied the Tier 1 approach. Equations 5.1. and 5.3 in chapter 5.5, volume 4 of IPCC[148] were applied to determine the methane emissions from rice production.[149] Area and production data were taken over from a review of rice production. It is assumed that 50% of the total area planted is irrigated and the other 50% is rain fed. A total of 90 days cultivation was taken into consideration. Based on the production data, a rice-straw ratio of 1:2 is assumed to calculate the amount of straw produced. The amount of straw absorbed into the soil is determined on the basis of an equal mass basis equal to the dry weight of the straw.

Direct N_2O emissions from urine and dung inputs to grazed soil are calculated for cattle, pigs, and poultry by applying an emission factor of 0.02 Kg N_2O-N/kg N and for sheep and others the emission factor is 0.01 Kg N_2O-N/kg N (taken from the TNC). Volume 4, Chapter 10 of IPCC[150] (Equation 10.25 and Tables 10.A4 -10.A8) is used to estimate emissions from manure management following a Tier 1 approach. Again Tier 1 methodology is used as the default emission factor of 0.01 Kg N_2O-N/kg N input was applied for the total amount of N-synthetic fertiliser addition.

[144]IPCC. (2006a). *Agriculture, Forestry and other Land Use*. Eggleston, S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. (Eds.). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4. Japan: IGES.
[145]World Bank. (2011). *Population estimates and projections.*
[146]http://ref.data.fao.org/
[147]Smith, P., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Elsiddig, E.A., Haberl, H., Harper, R., House, J.I., Jafari, M., Masera, O., Mbow, C., Ravindranath, N.H., Rice, C.W., Robledo Abad, C., Romanovskaya, A., Sperling, F., Tubiello, F. (2014), Agriculture, Forestry and Other Land Use (AFOLU). In: Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, J., Schlömer, S., von Stechow, C., Zwickel, T., Minx, J.C. (Eds.). *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.*
[148]IPCC. (2006a). *Agriculture, Forestry and other Land Use*. Eggleston, S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. (Eds.). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4. Japan: IGES.
[149]Bong, B.B. (2017). *Review of the development of the rice industry in Fiji.*
[150]IPCC. (2006a). *Agriculture, Forestry and other Land Use*. Eggleston, S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. (Eds.). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4. Japan: IGES.

Equation 11.9 from the IPCC's AFOLU Guidelines is used to estimate the emissions from the use of synthetic fertilisers. Default values (Table 11.3 from the IPCC Guidelines) are used for the emission factors and the volatilization from synthetic fertilisers. The annual amount of synthetic fertilisers applied to soil is taken from FAOSTAT. Since FAOSTAT only provides values until 2013, the average consumption of the years 2006 to 2013 is used to estimate the consumption in the years 2014 and 2015 (Table 29).

Table 29. N-fertiliser and urea application.[151]

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
N- fertiliser application (tonnes)	4,220	4,025	6,758	2,747	2,435	4,101	4,020	3,662	3,996*	3,996*
Urea (tonnes)	453	458	632	948	453	151	605	432	516*	516*

*estimate

Since the available stock densities for cattle for the years from 2010 onwards only include the stocks of the commercial sector, the data for beef and dairy cattle have been adjusted by adopting the subsistence sector stocks of the 2009 Agricultural Census for the 2015 informal sector (Table 30).

Table 30. Number of livestock by species.

Livestock type		2009	2010	2011	2012	2013	2014	2015
Beef	commercial	20,355		26,888	32,203	38,117	44,568	40,452
	subsistence	55,327						55,000*
	total	75,682		26,888	32,203	38,117	44,568	95,452*
Dairy	commercial	22,551	8,469	17,500	18,699	18,958	27,341	30,742
	subsistence	36,599						36,000*
	total	**59,150**	**8,469**	**17,500**	**18,699**	**18,958**	**27,341**	**66,742***

*estimate

Stakeholder Consultation Process

Key stakeholders invited to engage in consultations on AFOLU-related issues included: the Ministry of Agriculture, the Ministry of Fisheries and Forest, the Fiji Crops and Livestock's Council, the iTaukei Land Trust Board, several private agricultural producers and non-governmental organisations, the Sustainable Energy Industry Association of the Pacific Islands, Conservation International, the Food and Agriculture Organization of the United Nations (FAO), GIZ, SPC, and Pacific Island Development Forum. It should be noted that only a limited number of representatives from the agricultural sector took part in the stakeholder workshops, mostly with regard to plant breeding, livestock farming, and livestock feeding; there were no representatives from the informal sector. Stakeholders focused on forestry represented a comparably broad coverage of interests, although local communities were not present.

Overall, in the agricultural sector, the mitigation options of plant management of croplands, set aside land use change (LUC) croplands, degraded soils restoration, biosolid application, and agroforestry were considered to

[151]http://ref.data.fao.org/dataset-data-filter?entryId=d1a87a6c-37a8-43be-bfdc-c5cb398a1956&tab=data

“Stakeholders recommended opportunities to improve forest harvesting through low impact logging methods and addressing degradation, which have mutually reinforcing benefits and can promote timber recovery and green jobs”

have high technical feasibility. Fire management on grazing land, improved tillage in croplands, revegetation, restoration of organic soils, and cropland plant management were considered to have the lowest costs. High priority was assigned to improved plant management in croplands and in grazing lands, livestock feeding, livestock breeding, set aside LUC croplands, degraded soils restoration, biosolid application, and integration of biomass production. With regard to forestry, afforestation, reforestation, and forest management were all equally considered to have high technical feasibility, and reducing deforestation was considered to have the highest financial feasibility. Forest management was given the highest priority and reducing deforestation the lowest.

During the first national stakeholder consultation, participating stakeholders developed three visions for AFOLU: to reduce the amount of CO_2 (and other emissions) from the agriculture sector by supporting awareness and advocacy with farmers on organic farming, GHG emissions mitigation measures, sustainable land management, traditional farming, fuel-efficient machinery use, and a 60% reduction in the use of synthetic fertilisers; to promote the sustainable conservation of forest habitats for resilience and long-term prosperity with informed voluntary landowner participation; and to restore degraded forest resources with national planting/restoration exceeding logging/harvesting. During the second national stakeholder consultation on the 26th of June, 2018, questions mainly related to data sources and gaps (such as for the number of chickens and consideration of the information sector, which is not captured in FAOSTAT or in the IPCC 2009 and 2015 livestock numbers), and the need for certain assumptions in forming emissions projections. Other stakeholders recommended opportunities to improve forest harvesting through low impact logging methods and addressing degradation, which have mutually reinforcing benefits and can promote timber recovery and green jobs.

During the third stakeholder workshop on the 27th of August, 2018, participants raised questions about the differences between levels of emissions by different animal species, whether cyclones would impact on future emissions projections (it would be limited), and the potential for sustainable biofuel use for electricity generation domestically (rather than exporting wood chips to China).

4.5.5 Low Emission Development Scenarios

Base Year (BY)

A forest area change assessment is available for the forestry sector for the period 2006-2016. For the agricultural sector, the latest reliable figures are available for 2015. Therefore, the years 2015 for the agricultural sector and 2016 for the forestry sector are defined as the base year (BY) for the simulations. Since the development of forest areas and forest carbon stocks are not subject to short-term fluctuations, no inconsistencies in the simulations result from this small time difference. Table 31 shows the emissions of the various areas of the agricultural and forestry sectors.

Table 31. Emissions and removals of the AFOLU sector.

Source	Gas	BY (2015/2016) [Gg]	Gg CO2e
Forestry			
Logging[1)]	CO_2	174.29	174
Removals Plantations	CO_2	-1,539.27	-1,539
Emissions Plantations	CO_2	610.45	610
Deforestation	CO_2	717.75	718
Afforestation	CO_2	-21.50	-22
Agriculture			
Livestock: enteric fermentation	CH_4	22.61	633
Livestock: manure	CH_4	5.19	145
	N_2O	0.46	123
Rice management	CH_4	0.38	11
Synthetic fertiliser	N_2O	0.06	17
Urea fertilisation	CO_2	0.38	0
Total [CO2e]*	**CO_2e***		**871**

*GWP NH_4: 28; N_2O: 265[152]; 1) net emissions = emissions from logging removals from improved growth

BAU Unconditional Scenario

In the forestry sector, BAU behaviour and the lack of external financing will leave emissions from afforestation, deforestation, and logging relatively unchanged to the year 2050. Under this scenario, the spread in plantation areas of African Tulip, an invasive tree species, will reduce the growth of commercial species. It is assumed that measures to contain the spread of African Tulip will limit losses in growth (and, thus, in removals) to 5%. Similarly, emissions from plantation use will decrease due to the decline in growth.

The BAU Unconditional scenario assumes that emissions in the agricultural sector will remain almost unchanged, and that only existing policy measures would be implemented. This will mainly affect livestock farming, as breeding programs are expected to improve production from dairy cows and, thus, reduce emissions from enteric fermentation. However, as these improvements relate primarily to the commercial sector, the effect on total emissions remains small. The decline in rural households will reduce the number of livestock in the subsistence sector, accordingly, while at the same time increasing livestock in the commercial sector in order to secure food supplies. Thus, this strategy assumes an overall reduction of emissions from enteric fermentation in commercial livestock of 1%.

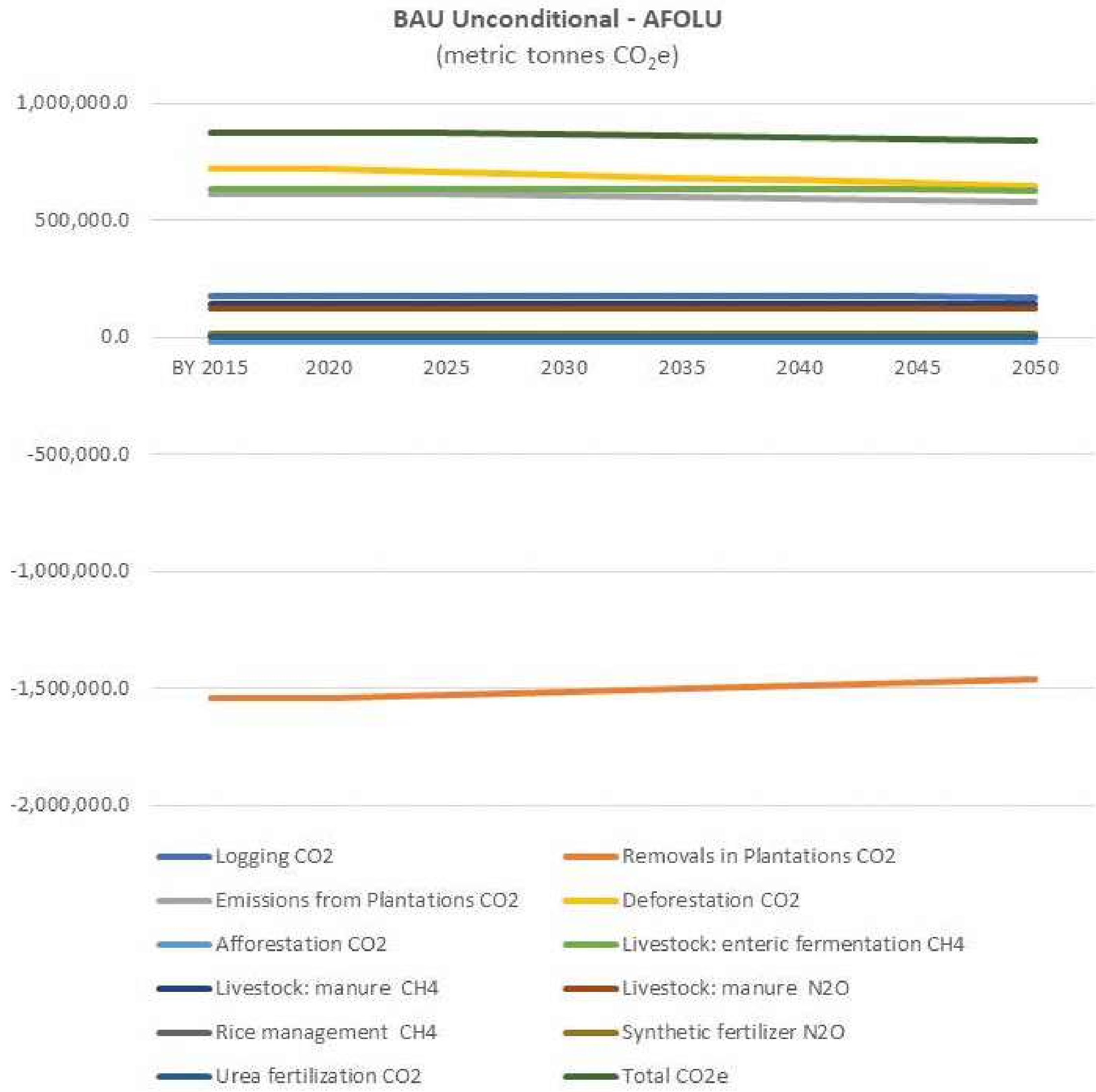
If current practices are largely maintained, emissions from the AFOLU sector will decrease by around 4% to 840 Gg CO_2e by 2050 (Table 32).

[152]http://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

Table 32. BAU Unconditional scenario for AFOLU.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2015	2020	2025	2030	2035	2040	2045	2050
Logging	CO_2	174,290	174,290	174,000	173,709	173,419	173,128	172,838	172,547
Removals in Plantations	CO_2	-1,539,274	-1,539,274	-1,526,447	-1,513,619	-1,500,792	-1,487,965	-1,475,138	-1,462,310
Emissions from Plantations	CO_2	610,452	610,452	610,452	604,347	598,243	592,138	586,034	579,929
Deforestation	CO_2	717,750	717,750	705,788	693,825	681,863	669,900	657,938	645,975
Afforestation	CO_2	-21,503	-21,503	-21,503	-21,503	-21,503	-21,503	-21,503	-21,503
Livestock: enteric fermentation	CH_4	633,055	633,055	632,528	632,000	631,473	630,945	630,418	629,890
Livestock: manure	CH_4	145,296	145,296	145,296	145,296	145,296	145,296	145,296	145,296
	N_2O	123,028	123,028	123,028	123,028	123,028	123,028	123,028	123,028
Rice management	CH_4	10,568	10,568	10,568	10,568	10,568	10,568	10,568	10,568
Synthetic fertiliser	N_2O	16,640	16,640	16,640	16,640	16,640	16,640	16,640	16,640
Urea fertilisation	CO_2	379	379	379	379	379	379	379	379
Total	CO_2e	870,681	870,681	870,727	864,670	858,612	852,554	846,496	840,439

Figure 55. BAU Unconditional scenario – AFOLU.



BAU Conditional Scenario

Under this scenario, Fiji assumes there will be access to limited international financing that can be used to improve its BAU scenario through increased plantation productivity, reduced emissions from logging of natural forests, and reduced of emissions from enteric fermentation. This scenario takes into account measures that were classified as a priority in the stakeholder workshops.

In the forestry sector, an improved BAU scenario involves promoting sustainable forest management, which can be implemented, on the one hand, to avoid emissions in connection with timber harvesting measures and, on the other hand, to increase biomass production and thus carbon sequestration. At present, the mean annual increment (MAI) in mahogany plantations is 6.3 m^3 per ha per year (5.43 tCO_2e per ha per year, gravity=0.5 kgm-3), and in pine plantations is 10 m^3 per ha per year (8.44 tCO_2 per ha per year, gravity=0.49 kgm-3). An additional 20% increase in MAI would be achieved through improved plantation management (higher number of plants planted, weeding, introduction of thinning regimes). Although emissions from timber harvesting in plantations would also increase from increased yield, net CO_2 removals from improved plantation management would increase to 1,114 Gg CO_2e by 2050. Consistent application of reduced impact logging in timber harvesting operations in

> "Promoting sustainable forest management can avoid emissions in connection with timber harvesting measures and increase biomass and thus carbon sequestration"

natural forests will further reduce the corresponding emissions by at least 10%, or 17 Gg CO_2e, by 2050. By 2050 the total contribution of the forestry sector to the reduction of emissions would, thus, amount to 261 Gg CO_2e.

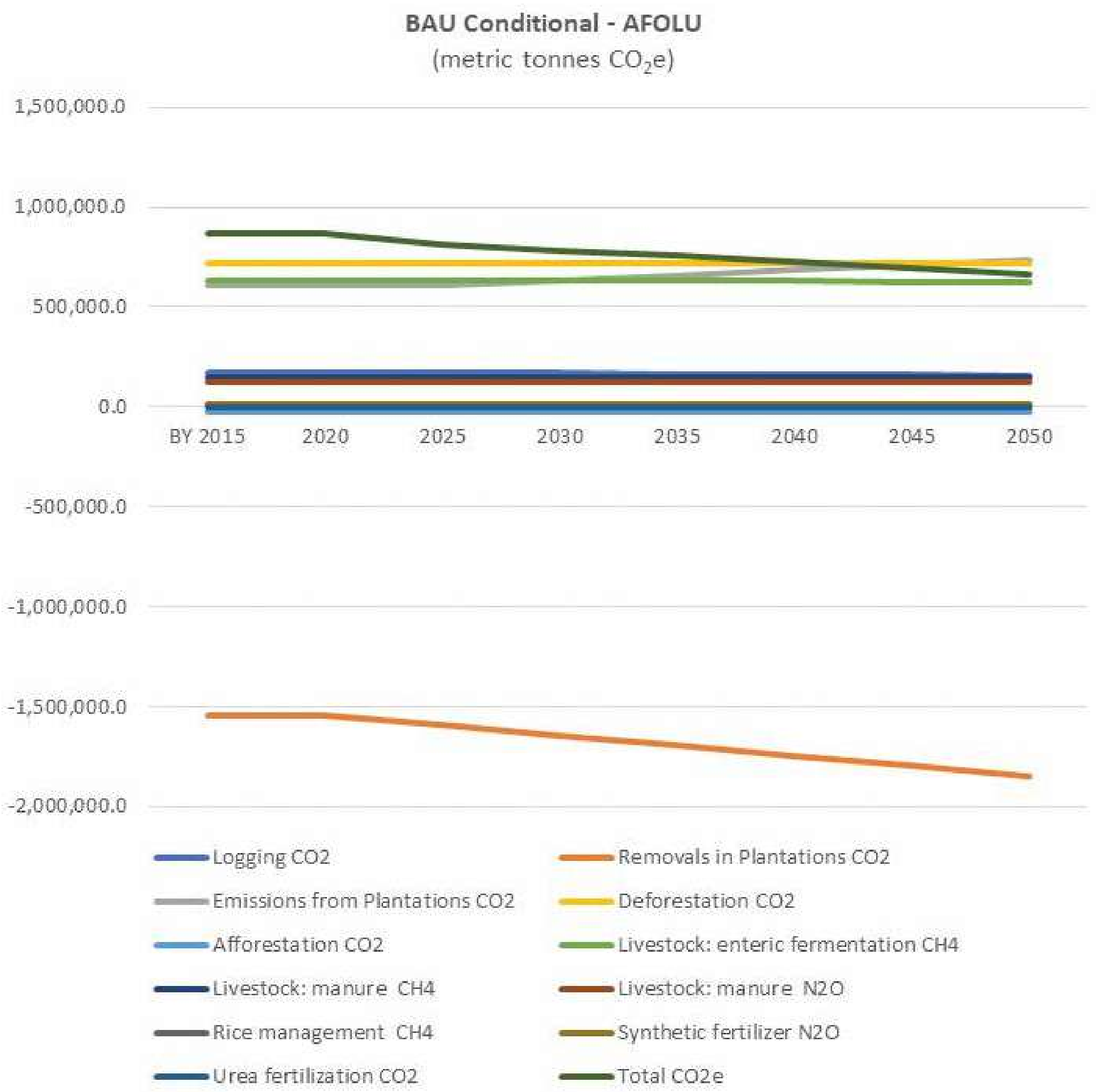
In the agricultural sector, the technical mitigation potential of livestock farming is being further expanded. Assuming external financial support, emissions from enteric fermentation in commercial livestock will be reduced by 2%, or 6 Gg CO_2e, by 2050.

Compared to the base year, these assumptions suggest an emission reduction by 210 Gg CO_2e to approximately 660 Gg CO_2e in 2050 (Table 33).

Table 33. BAU Conditional scenario for AFOLU.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2015	2020	2025	2030	2035	2040	2045	2050
Logging	CO_2	174,290	174,290	171,385	168,480	165,576	162,671	159,766	156,861
Removals in Plantations	CO_2	-1,539,274	-1,539,274	-1,590,583	-1,641,892	-1,693,201	-1,744,511	-1,795,820	-1,847,129
Emissions from Plantations	CO_2	610,452	610,452	610,452	634,870	659,288	683,706	708,124	732,542
Deforestation	CO_2	717,750	717,750	717,750	717,750	717,750	717,750	717,750	717,750
Afforestation	CO_2	-21,503	-21,503	-21,503	-21,503	-21,503	-21,503	-21,503	-21,503
Livestock: enteric fermentation	CH_4	633,055	633,055	632,000	630,945	629,890	628,835	627,780	626,725
Livestock: manure	CH_4	145,296	145,296	145,296	145,296	145,296	145,296	145,296	145,296
	N_2O	123,028	123,028	123,028	123,028	123,028	123,028	123,028	123,028
Rice management	CH_4	10,568	10,568	10,568	10,568	10,568	10,568	10,568	10,568
Synthetic fertiliser	N_2O	16,640	16,640	16,640	16,640	16,640	16,640	16,640	16,640
Urea fertilisation	CO_2	379	379	379	379	379	379	379	379
Total	CO_2e	**870,681**	**870,681**	**815,412**	**784,561**	**753,710**	**722,859**	**692,008**	**661,157**

Figure 56. BAU Conditional scenario – AFOLU.



High Ambition Scenario

In addition to the measures included in the BAU-conditional scenario, Fiji's high ambition scenario includes additional activities to reduce emissions. In the forestry sector, an area of 10,000 ha will be reforested with mahogany or equivalent hardwoods by 2050, the MAI of plantations will be increase by 30%, and deforestation will be decreased by 20%. Compared to the BY emissions in the forestry sector, this will result in an additional 587 Gg CO_2e being removed annually at the end of the observation period. When afforested stands are harvested at the end of their rotation period, the total emission reductions will be decreased by roughly 2%.

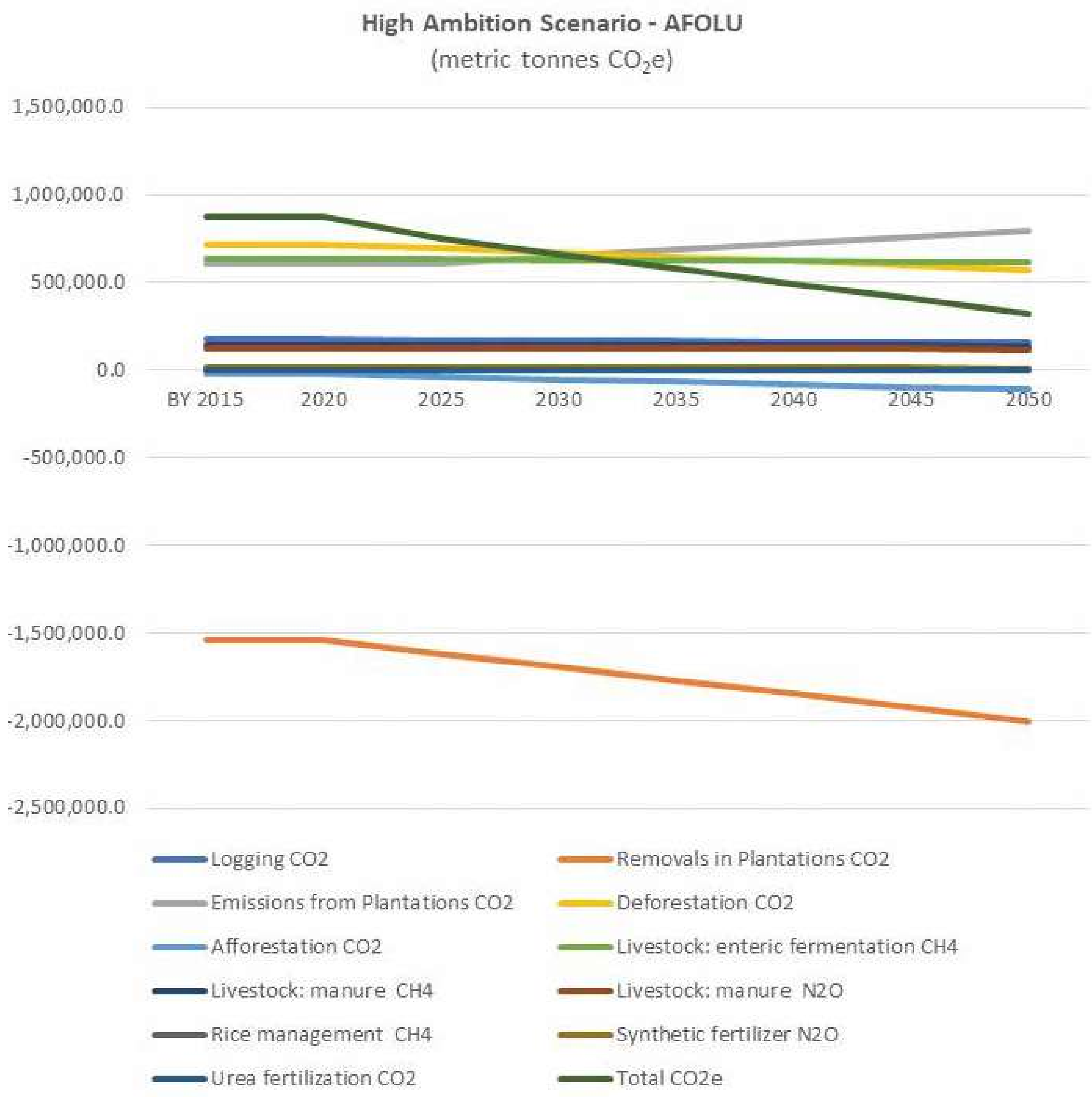
In the agricultural sector, emissions from the use of synthetic fertilisers will be reduced by 1% by changing fertiliser rates and types, adjusting the time of application, increasing the precision of application, and using inhibitors. In the commercial livestock sector, emissions from enteric fermentation will be reduced by 5% and emissions from manure by 2%.

These measures result in a reduction of the AFOLU sector's emissions by almost 70% to 323 Gg (Table 34).

Table 34. High Ambition scenario for AFOLU.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2015	2020	2025	2030	2035	2040	2045	2050
Logging	CO_2	174,290	174,290	171,385	168,480	165,576	162,671	159,766	156,861
Removals in Plantations	CO_2	-1,539,274	-1,539,274	-1,616,238	-1,693,201	-1,770,165	-1,847,129	-1,924,093	-2,001,056
Emissions from Plantations	CO_2	610,452	610,452	610,452	647,079	683,706	720,333	756,960	793,588
Deforestation	CO_2	717,750	717,750	693,825	669,900	645,975	622,050	598,125	574,200
Afforestation	CO_2	-21,503	-21,503	-36,325	-51,146	-65,967	-80,788	-95,609	-110,430
Livestock: enteric fermentation	CH_4	633,055	633,055	630,418	627,780	625,142	622,504	619,867	617,229
Livestock: manure	CH_4	145,296	145,296	145,054	144,811	144,569	144,327	144,085	143,843
	N_2O	123,028	123,028	122,823	122,617	122,412	122,207	122,002	121,797
Rice management	CH_4	10,568	10,568	10,568	10,568	10,568	10,568	10,568	10,568
Synthetic fertiliser	N_2O	16,640	16,640	16,613	16,585	16,557	16,530	16,502	16,474
Urea fertilisation	CO_2	379	379	379	379	379	379	379	379
Total	CO_2e	870,681	870,681	748,953	663,853	578,753	493,653	408,552	323,452

Figure 57. High Ambition scenario – AFOLU.



Very High Ambition Scenario

Based on the recommendations of the ER-PIN,[153] the very high ambition scenario assumes the afforestation of an area of 77,400 ha and the reduction of deforestation by 80%. Through intensive forest management measures and tree improvement, the MAI of plantations is increased by 40%, compared to today's values, which seems feasible in view of the growth in comparable regions. In the agricultural sector, emission from enteric fermentation and from manure in commercial livestock will be reduced by 10% each and emissions from the application of synthetic fertilisers by 1%.

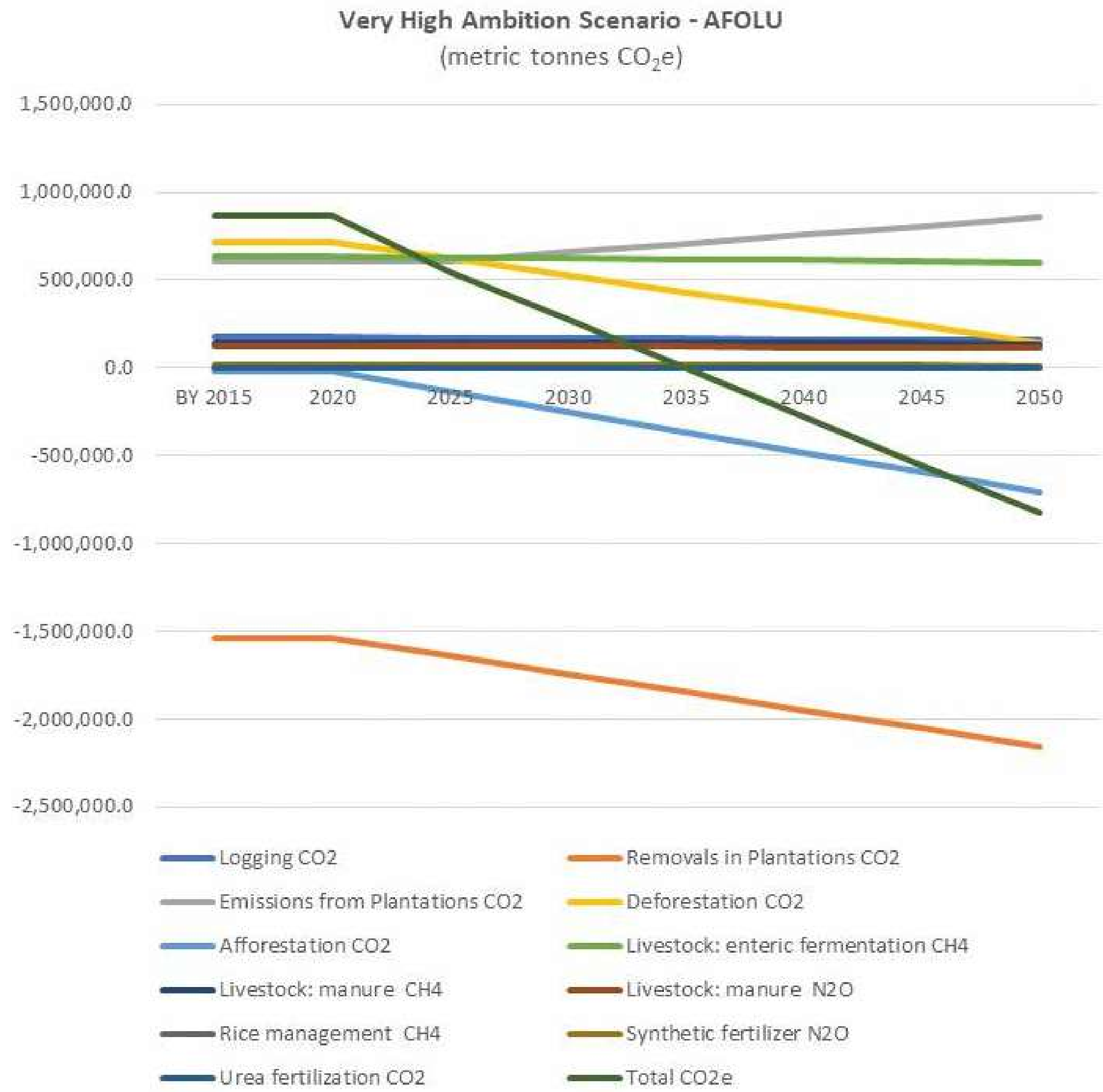
[153]FCPF. (2015). *Emission reductions program idea note (ER-PIN) - Republic of Fiji.* Forest Carbon Partnership Facility Carbon Fund .

Under these assumptions, clear removals can be seen in the AFOLU sector from 2035 onwards. In 2050, net removals of around 826 Gg CO_2e will be achieved. The forestry sector, thus, compensates for all emissions from the agricultural sector and makes a significant contribution that can be credited to other sectors (Table 35). At a later stage, the afforested areas may be harvested. This would result in calculated emissions of about 3-5% of removals.

Table 35. Very High Ambition scenario for AFOLU.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2015	2020	2025	2030	2035	2040	2045	2050
Logging	CO_2	174,290	174,290	171,385	168,480	165,576	162,671	159,766	156,861
Removals in Plantations	CO_2	-1,539,274	-1,539,274	-1,641,892	-1,744,511	-1,847,129	-1,949,747	-2,052,365	-2,154,984
Emissions from Plantations	CO_2	610,452	610,452	610,452	659,288	708,124	756,960	805,797	854,633
Deforestation	CO_2	717,750	717,750	622,050	526,350	430,650	334,950	239,250	143,550
Afforestation	CO_2	-21,503	-21,503	-136,219	-250,935	-365,651	-480,366	-595,082	-709,798
Livestock: enteric fermentation	CH_4	633,055	633,055	627,780	622,504	617,229	611,953	606,678	601,403
Livestock: manure	CH_4	145,296	145,296	144,085	142,874	141,663	140,453	139,242	138,031
	N_2O	123,028	123,028	122,002	120,977	119,952	118,927	117,901	116,876
Rice management	CH_4	10,568	10,568	10,568	10,568	10,568	10,568	10,568	10,568
Synthetic fertiliser	N_2O	16,640	16,640	16,613	16,585	16,557	16,530	16,502	16,474
Urea fertilisation	CO_2	0,379	0,379	0,379	0,379	0,379	0,379	0,379	0,379
Total	CO_2e	870,302	870,302	546,824	272,180	-2,461	-277,101	-551,743	-826,386

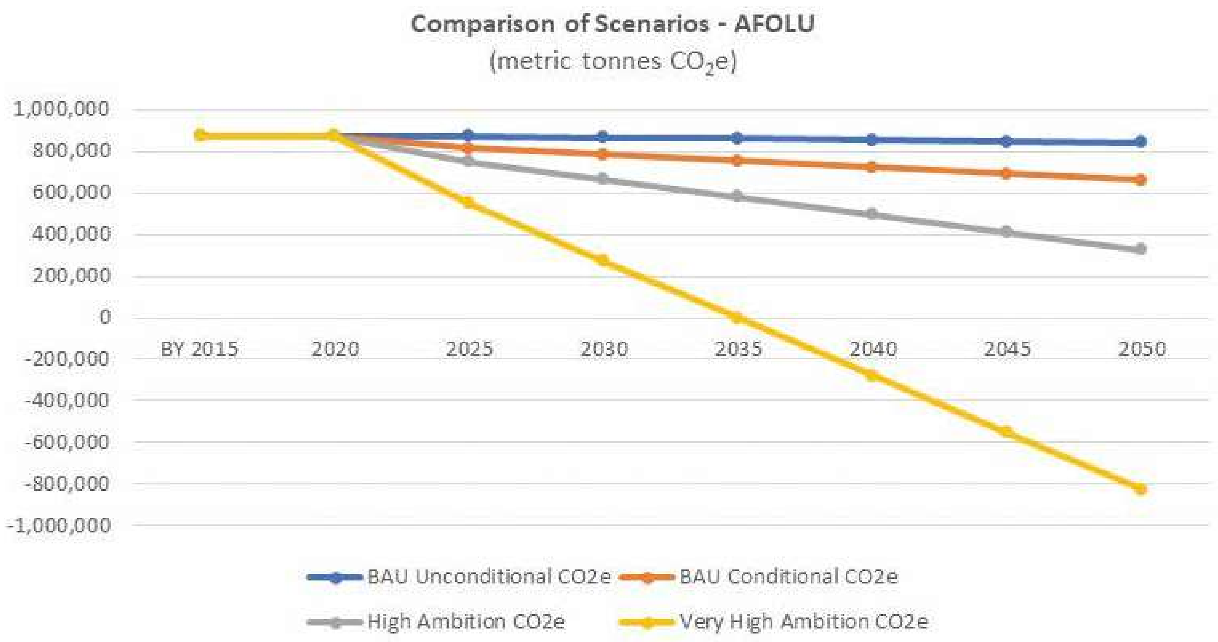
Figure 58. Very High Ambition scenario – AFOLU.



Comparison of Scenarios

The comparative results of all four scenarios for AFOLU is provided in Figure 59.

Figure 59. Comparison of scenarios – AFOLU.



4.5.6 Policy Recommendations, Priority Actions, and High-Level Costing

Climate change mitigation activities in the AFOLU sector are embedded in the complex interrelations between environmental and socioeconomic factors that simultaneously affect patterns, processes, and dynamics of land systems.[154] Therefore, the creation of an enabling environment and the removal of barriers remain major challenges for implementing AFOLU activities.[155]

An essential prerequisite for the successful implementation of emission reductions in the AFOLU sector is the provision of additional land for forestry and agricultural use. For the cultivation of energy crops, the NDC Implementation Roadmap[156] sees an additional need for 30,000 ha of agricultural land. In order to increase forest carbon storage, an additional 77,400 ha are recommended for afforestation as part of the introduction of REDD+.[157]

The expansion of agricultural and forestry production areas can only take place in accordance with traditional land use rights in Fiji. In addition to official institutions, local landowners in particular should be involved in the programs and compensated accordingly for the use of their land where necessary. In addition to participatory approaches, the creation of employment and income for the local population, as well as sufficient and fair participation in the profits achieved through land use, are indispensable.

[154]Turner, B.L., Lambin, E.F., Reenberg, A. (2007). *The emergence of land change science for global environmental change and sustainability. Proceedings of the National Academy of Sciences* 104.
[155]FCPF. (2015). *Emission reductions program idea note (ER-PIN) - Republic of Fiji.* Forest Carbon Partnership Facility .
[156]Government of Fiji. (2017b). *NDC Implementation Roadmap 2017-2030.*
[157]FCPF. (2015). *Emission reductions program idea note (ER-PIN) - Republic of Fiji.* Forest Carbon Partnership Facility.

It should also be noted that the expansion of forestry production could include other benefits if measures are put in place to include in afforestation the three hardwood species customarily used for the construction of seafaring canoes: *Intsia bijuga – Vesi*, *Agathis macrophylla – Dakua*, and *Calophyllum inophyllum – Damanu*. From these species, combined with a few others to provide the necessary organic pitch and fibres, sustainable sea transport materials can be sourced alongside carbon sequestration in the agroforestry sector over the coming decades.

"By including in afforestation the hardwood species used for seafaring canoes, Vesi, Dakua, and Damanu, sustainable sea transport materials can be sourced alongside carbon sequestration"

While the development and implementation of Measurement, Reporting, and Verification (MRV) systems has already been initiated in the context of REDD+, corresponding systems are not yet available in the agricultural sector. In particular, there is a lack of basic information on the reliable derivation of emissions from livestock farming, which accounts for a large proportion of Fiji's national emissions. The implementation of an agricultural census, as well as the training of employees to calculate the corresponding emissions, is an outstanding necessity.

In the forestry sector, measures that increase productivity and, thus, carbon sequestration in forest plantations are mandatory. Deforestation must also be reduced to a minimum. In the agricultural sector, measures to reduce emissions from livestock farming are mandatory. On the one hand, the existing programs to improve productivity in the dairy industry and to safeguard animal health should be extended. On the other hand, Fiji will also need to undertake initiatives to improve feed quality, with the aim of reducing emissions from enteric fermentation, and to introduce innovative manure management techniques.

Human resources and capacity building are needed for the implementation of sustainable forest management including: the improvement of plantation productivity, afforestation and reforestation activities, climate-smart agriculture, animal health, animal breeding, and use of manure for bioenergy.

Actions in the forestry sector for the very high ambition scenario are costed at over USD 150 million. Actions in the Agricultural sector for the very high ambition scenario are costed at just under USD 25 million. More details on indicative costs can be found in Annex A.

4.6 COASTAL WETLANDS

> "Mangrove carbon stocks, by area, exceed that of seagrass, tidal marshes, and even rainforests. The global average carbon stock of mangroves is estimated at 1,000 tonnes/ha"

4.6.1 Overview

This section examines the coastal wetlands – or blue carbon – component for Fiji's LEDS, and the mitigation potential this important sector offers. It should be noted, however, that due to insufficient data all estimated emissions from and sequestration by coastal wetlands (i.e., mangroves) are not included in the total net emissions for the LEDS.

The term "blue carbon" refers to carbon that has been captured and stored by living organisms in oceanic and coastal ecosystems, particularly in mangroves, seagrass beds, and tidal marshes. The absence of tidal marshes in Fiji means that the focus of national coastal carbon and GHG inventories is on mangroves and seagrass beds. Of the two ecosystems that are present, mangroves receive greater attention due to development pressure leading to large-scale conversions, higher data availability due to greater research interest, and in recognition of the ecosystem's role in climate change mitigation and adaptation.

The Global Forest Resource Assessment Country Report - Fiji (2015) defines a mangrove forest as a "forest occurring below the high tide water mark with a high occurrence of mangrove species." There are eight mangrove plant species in Fiji and one hybrid,[158] as well as five species and one subspecies of seagrass.[159]

Seagrass meadows have high biological productivity, recycle nutrients, and play an important role in maintaining coastal water quality. They are important foraging areas for green turtles and provide nursery habitat for fish, molluscs, and crustaceans that support the livelihoods of Fiji's coastal communities. While the importance of seagrass meadows for fisheries is well known, no carbon sequestration studies have been carried out, so far, on the seagrass meadows in Fiji. The only data available for carbon capture and storage by seagrass areas are based on studies, under comparable conditions, in the Indo-Pacific region. Therefore, seagrasses have not been considered in this LEDS due to lack of data specific to Fiji. It is recommended that efforts are made in the future to collect relevant data on seagrasses in Fiji.

Similarly, the rich variety of ecosystem goods and services offered by mangroves are well documented. These include provisioning, regulating, supporting, and cultural services. The climate regulation service results from the capacity of mangrove soils to sequester carbon and act as a carbon sink. Mangrove carbon stocks, by area, exceed that of seagrass, tidal marshes, and even rainforests. The global average carbon stock of mangroves is estimated at 1,000 tonnes/ha with some 83-99% of it stored in the soil,[160] compared with the global average carbon stock of the other three ecosystems estimated at 100, 400, and 500 tonnes/ha, respectively.[161] Logically, then, the GHG emissions from mangrove deforestation and degradation are among the highest of all land use practices in the tropics.

[158] Tuiwawa, S. H., Skelton, P. A., and Tuiwawa, M. V. (2014). *A field guide to the management of mangroves and seagrass species of Fiji.* Suva: University of the South Pacific Press.
[159] Brodie, G. and N'Yeurt, D. R. A. (2018). Impacts of Climate Change on Seagrasses and Seagrass Habitats Relevant to the Pacific Islands. Pacific Marine Climate Change Report Card. *Science Review:* 112-131.
[160] UNEP. (2014). *The Importance of Mangroves to People: A Call to Action.* Van Bochove, J., Sullivan, E., Nakamura, T. (Eds). Cambridge: United Nations Environment Programme World Conservation Monitoring Centre.
[161] UNEP. (2014). *The Importance of Mangroves to People: A Call to Action.* Van Bochove, J., Sullivan, E., Nakamura, T. (Eds). Cambridge: United Nations Environment Programme World Conservation Monitoring Centre.

Studies that have quantified GHG emissions from mangrove conversion to shrimp ponds in the Dominican Republic[162] and cattle pastures in the Pantanos de Centla in Mexico,[163] showed a potential loss of 661-1135 Mg C/ha and 786-2,173 Mg CO_2 e/ha, respectively. Mangrove removal in the Rewa Delta in Fiji was estimated to result in emissions of 1,513 Mg CO_2e/ha.[164]

With the deforestation rate of mangroves and their inordinate ability to sequester carbon, mangroves need to be part of mitigation strategies to reduce GHG emissions from anthropogenic sources. In addition to promoting mangrove rehabilitation, which itself presents challenges, there needs to be a concerted national effort to significantly reduce the loss of mangroves.

Unlike the mangrove resources, there is currently no baseline data available for seagrass meadows in Fiji. There has been no mapping and no biomass data collection meaning the estimation of 16.5 km^2 seagrass area cover for Fiji, which is frequently quoted figure in the literature, is likely grossly underestimated.[165] Some ad hoc monitoring of seven sites in Fiji has been done by Seagrass Watch in 2007-2008; this measured seagrass cover, species composition, algae cover, and epiphyte cover. The volume of data collected, however, is insufficient to detect any trends. There has been no further analysis on emissions from seagrass meadows, but the potential for such analysis should be investigated.

The economic valuation of the carbon sequestration function of Fiji's mangroves has been valued at USD 1,920 ha/year while that of seagrass is USD 758 ha/year.[166]

4.6.2 Emission Sources

Summary of Emission Sources

GHG emissions from seagrasses and mangroves in Fiji results from large-scale mangrove conversion for tourism facilities, industrial estates, agriculture, municipal rubbish dumps, and housing. Tourism development in Nadi Bay resulted in the removal of more than 200 ha of mangroves from 1986-2005, which constituted 22% of the mangrove cover in the area.[167] One of the last pockets of mangroves on Denarau (200 ha) was removed for tourism development with a lease issued in 2009. The Suva-Navua corridor and Denarau have recorded the largest mangrove losses due to developmental pressures in the five years since 2013.

Mangrove degradation from the haphazard dumping of dredge spoil and from the impact of severe cyclones is another source of emissions.

GHG emissions from the blue carbon sector are not currently reflected in Fiji's national GHG inventory reported in the TNC but are nevertheless considered in this LEDS.

Type of Emissions

Due to the huge reservoir of carbon accumulated in mangrove soil over millennia, the main gas emitted from mangroves is CO_2. Methane emissions are relatively low due to the saline conditions of the ecosystem. Nitrous oxide is emitted when mangroves are converted for aquaculture uses. Seagrasses are also known to emit CO_2 and CH_4.

[162]Kauffman, J. B., Heider, C., Norfolk, J., Payton, F. (2014). Carbon stocks of intact mangroves and carbon emissions arising from their conversion in the Dominican Republic. *Ecological Applications* 24(3): 518-527.
[163]Kauffman, J. B., Trejo, H. H., del Carmen, M., Heider, C., Contreras, W. M. (2015). Carbon stocks of mangroves and losses arising from their conversion to cattle pastures in the Pantanos de Centla, Mexico. *Wetlands Ecological Management* 23(3).
[164]Watershed Professionals Network. (2013). *MESCAL Carbon Assessment: Rewa Delta Mangrove Reference Levels & Emissions Due to Mangrove Conversion.*
[165]Brodie, pers. comm.
[166]Gonzalez, R., Ram-Bidesi, V., Leport, G., Pascal, N., Brander, L., Fernandes, L., Salcone, J., Seidl, A. (2015). *National marine ecosystem service valuation: Fiji.* Suva, Fiji: MACBIO (GIZ/IUCN/SPREP).
[167]Environment Consultants Fiji (ECF). (2006). In literature.

4.6.3 Existing Policy and Regulatory Framework

"The Environment Management Act (2005) is the umbrella legislation for environmental governance and covers all ecosystems including mangroves and seagrasses"

The Environment Management Act (2005) is the umbrella legislation for environmental governance and covers all ecosystems including mangroves and seagrasses. Part 3 of the Act deals with environment reports and plans and requires a National Environment Strategy to be developed. The Strategy must contain a Natural Resource Inventory and a Natural Resource Management Plan. Mangroves and seagrasses are important coastal wetlands which constitute a part of the Inventory. Part 4 of the Act explains the requirements and processes involved in Environmental Impact Assessments (EIA) that developers are required to submit.

The Environment Management Regulations (2007) detail the steps required in the submission of a proposal to develop wetlands areas, the EIA process and additional requirements that may need to be submitted, like an environment management plan and the payment of environmental bonds.

A development proposal that impacts mangroves is forwarded to the Mangrove Management Committee (MMC) for their review. Should a developer propose the removal of 30% of a mangrove forest then a mangrove management plan needs to be submitted with the proposal.[168] A Mangrove Management Plan outlines landscaping options, the selection of areas for landscaping, and conservation and steps in restoring deforested mangrove areas.[169] There is no requirement to state the extent and impact of GHG emissions of such proposals, although it is possible for these to be introduced in the future as part of the Terms of Reference for future EIAs.

The Ministry of Environment and Waterways charges developers an environmental bond as a surety so that the bond can be used to compensate for any damage done to adjacent ecosystems, including the removal of mangroves.

The Mangrove Management Plan (2013) begins with a review of the previous Mangrove Management Plans (MMP), Phases 1 and 2, that were developed in 1985-1986. It provides the background to how the original MMP was developed, the basis of the zonation maps that were part of the plan, the strengths and shortcomings, and issues that need to be addressed in the revised plan.

The MMP 2013 states that an MMP should be based on a national policy specifically on mangrove use and management, although no such policy currently exists, and that an effective MMC needs to be established. Mangrove use and management have nevertheless been integrated into various legislation and policies such as the State Lands Act (Cap 132), the Environment Management Act (2005), the Forest Decree (1992), and the Town Planning Act (Cap 139).

The MMP 2013 has yet to be endorsed by Cabinet, one of the major reservations is the lack of zoned maps. The author of the MMP 2013 stresses that significant resources are required for the inclusion of spatial maps with zones demarcated for various uses, and there would need to be extensive consultations with traditional fishing rights owners to develop consensus. Rather than spatial maps, the MMP 2013 recommends that large scale conversions be dealt with on a case-by-case basis within the legislative framework provided by the Environment Management Act and a rigorous EIA process.

[168]Singh, pers. comm.
[169]Mangrove Management Committee. (2013). *Mangrove Management Plan for Fiji 2013*; and, Sykes, H. (2007). *Mangrove Management Plan for resorts in the Fiji Islands.* Marine Ecology Consulting Report.

The MMP 2013 further recommends that any significant conversion of mangroves should require an offset, the offset being an equal or larger area of equivalent mangrove being acquired as a mangrove reserve. This has been done by developers on Naisoso, Nadi who removed seven hectares of mangroves but conserved 100 ha (more than 14 times the area). Such a requirement is currently being implemented by the Ministry of Waterways and Environment, which has stipulated that an offset must be six times the area removed.[170] The scientific basis of the required offset is unclear, except that it is twice the area recommended in the only mangrove carbon emission study done to date in Fiji.[171] Despite its apparent benefits, the ecological practicality of the stipulated offset of 1:6 hectares is unclear as mangroves generally will only thrive in the same locations where they have grown previously. Finding sites on the scale that the proposed offset requires is challenging, especially with respect to appropriate substrate type, hydrology, and shelter from wind and wave action. Effective approaches for expanding mangroves requires further investigation.

The State of Environment Report (2013) for Fiji states that between 1991-2007 there was a 5% loss in mangrove cover with much of the loss recorded in peri-urban and urban areas. Analysis of satellite imagery shows a 40% reduction in cover in the Suva Peninsula and Lami areas and a 19% reduction in the Coral Coast area between 1991-2007. These tracts of mangroves were removed for housing, industrial and tourism facilities. The lack of rigour in some EIA processes has seen many areas lying desolate bereft of vegetation and without further development. Although there is acknowledgment of the importance of mangroves in mitigating GHG emissions, no data has been collected on the emissions resulting from the large-scale destruction that occurred during the 16-year period.

As part of the National Biodiversity Strategy and Action Plan (2017-2024), under the strategic area of Protected Areas, the occurrence and status of all existing wetlands is to be analysed, mapped, and documented led by the national Protected Areas Committee.

The Fisheries Department, in conducting fisheries impact assessments, does not support any removal of mangroves. Cooperation between government departments at middle management level may be more effective at enforcing a moratorium on mangrove removal and initiating mangrove rehabilitation than at senior levels. NGOs, academic institutions, and development partners play a critical role in supporting the government's efforts to reduce GHG emissions through projects implemented.

The Pacific Blue Carbon Initiative is an example of one such initiative that will assist by mapping seagrass and mangrove areas and documenting potential threats and trends. The ecosystems will be assessed for carbon storage, which should hopefully generate much needed data for modelling blue carbon ecosystems in Fiji. Conservation International has initiated the development of a Blue Carbon Roadmap for Fiji and is currently engaged in assessing community perceptions of blue carbon in the Rewa Delta. The Mangrove Ecosystems for Climate Change Adaptation and Livelihoods (MESCAL) project implemented by IUCN from 2010-2013 was the flagship mangrove project in the country, and the wider Oceania region, that generated the first mangrove biomass and carbon emissions data and resulted in the revised MMP and contributed to the revival of the MMC.

Seagrass meadows are not mentioned in national policies or regional frameworks despite their importance in emissions mitigation.

[170] Singh, pers. comm.
[171] Watershed Professionals Network. (2013). *MESCAL Carbon Assessment: Rewa Delta Mangrove Reference Levels & Emissions Due to Mangrove Conversion.*

4.6.4 Methodology

Model and Methodology Used

The approach used to develop estimated emissions and sequestration scenarios for coastal wetlands is a simple extrapolation of the only data available in-country for Rewa delta mangrove carbon stocks and estimated emissions and replanting rates. Consideration of mangroves and other coastal wetlands in future national inventories, NDCs, and LEDS will allow gradual movement towards adoption of Tier 1 estimation for carbon stock changes for the BAU unconditional scenario and the Stock Gain-Loss method using the guidance provided in section "2.3.1.2 Land Converted to Another Land-Use Category" and chapters 4 and 7 of volume 4 of the 2006 IPCC Guidelines and chapter 4 of the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands.

Efforts to improve emission and sequestration estimates that utilize the IPCC Tier 1 methodology will require significant improvements in activity data. This may include:

- Obtaining high-resolution satellite imagery and mapping mangrove cover and land use changes;
- Establishing a database for all management activities in mangroves and seagrass beds;
- Determining country-specific allometric equations;
- Replication of above-ground and below-ground biomass studies and soil carbon content at all major locales nationally; and
- Recording activity data for seagrass beds, which are currently reported anecdotally.

Data Used, Data Sources, and Assumptions

Data sources and gaps are summarised in Table 36.

Table 36. Data sources and gaps for Wetlands.

Data used	Data sources	Data gaps
Mangrove area	Lands Dept, SPC and reports	Mangrove losses and areas revegetated.
Carbon stock/biomass	MESCAL reports	Data from Rewa Delta mangroves only. Physiology of mangroves in western and northern part of the group, with different climatic conditions, will yield lower biomass values.
Carbon emissions	MESCAL reports	Only one study with limited sites sampled. Paucity in activity data.

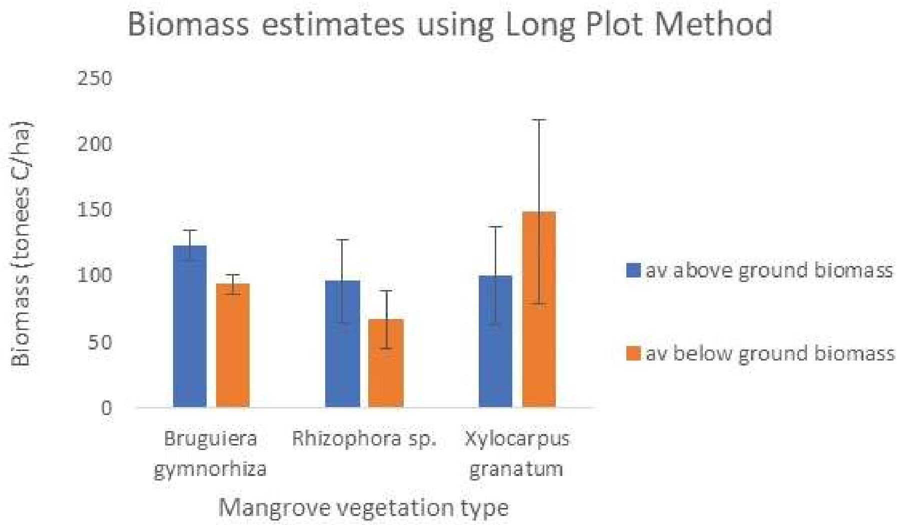
Using the carbon stock assessment figures from Rewa delta rests on the assumption that the mangrove stands in the Western Division will have the same biomass. Factors such as the hydrology, salinity, and frequency of tropical cyclones affect the ability of mangroves to store carbon. Those areas that have lower soil salinity, higher rainfall, and infrequent cyclones promote larger carbon stocks, thus, the marked difference in physical stature of the mangroves in Rewa delta and the more stunted mangroves of the Western Division.

"Factors such as the hydrology, salinity, and frequency of tropical cyclones affect the ability of mangroves to store carbon"

> "Three dominant mangrove species are found in the Rewa delta: *Bruguiera gymnorhiza*, *Rhizophora sp.*, and *Xylocarpus granatum*"

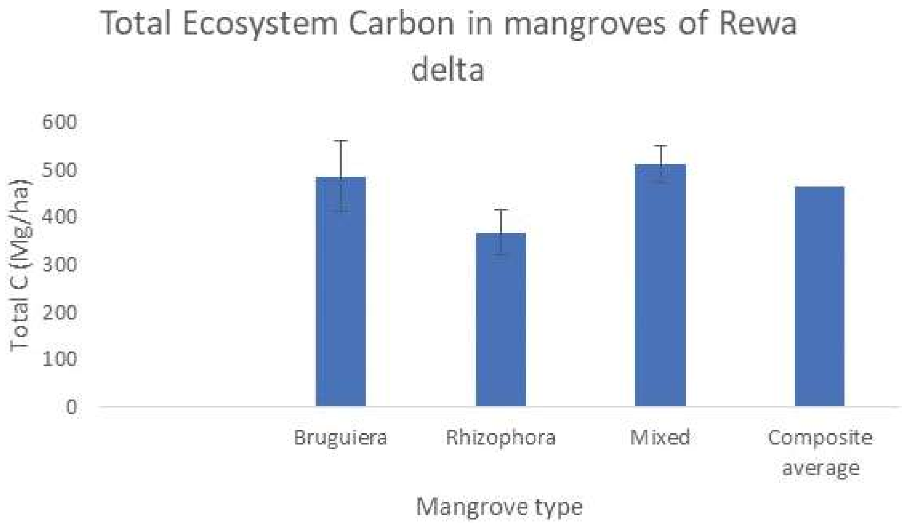
There were two studies done[172] using different methodologies to determine the total carbon stock of mangroves in the Rewa delta. One study calculated above-ground and below-ground biomass of three dominant mangrove species found in the Rewa delta: *Bruguiera gymnorhiza, Rhizophora sp.*, and *Xylocarpus granatum*. The results from 43 long plots are shown in Figure 60.

Figure 60. Above-ground and below-ground biomass of three dominant mangrove species in Rewa Delta.



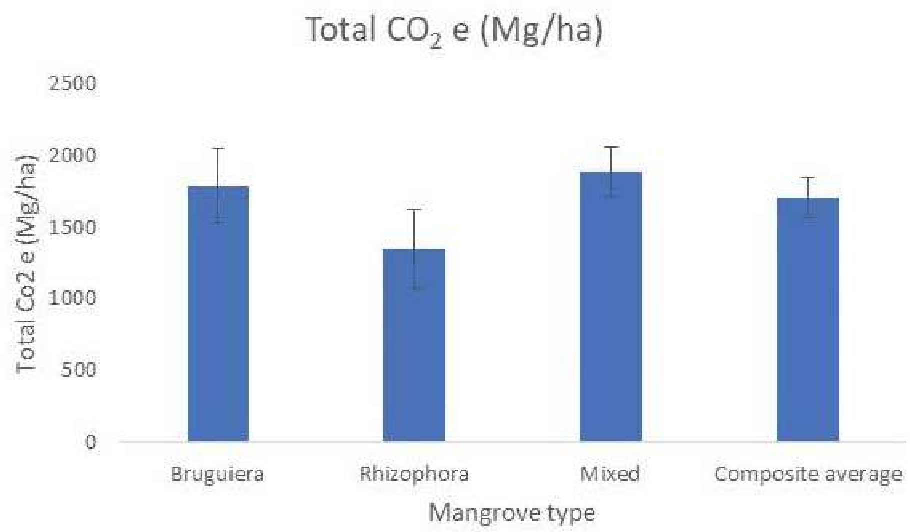
Figures 61 and 62 show the Total Ecosystem Carbon stock and Total CO_2e calculated by Watershed Professionals Network (2013) for *Bruguiera* mangrove sites, *Rhizophora* mangroves, and sites that had a mix of both species in the Rewa delta. The method used two metre radius and seven metre radius plots.[173] The main difference between the two methods was that the former looked at a set number of trees (30-50) within each plot, while the latter looked at all trees within a given radius.

Figure 61. Results of eleven plots with fixed radius where data on standing tree biomass (live and dead), downed wood (dead wood on the forest floor), and soils at five depth profiles were collected.



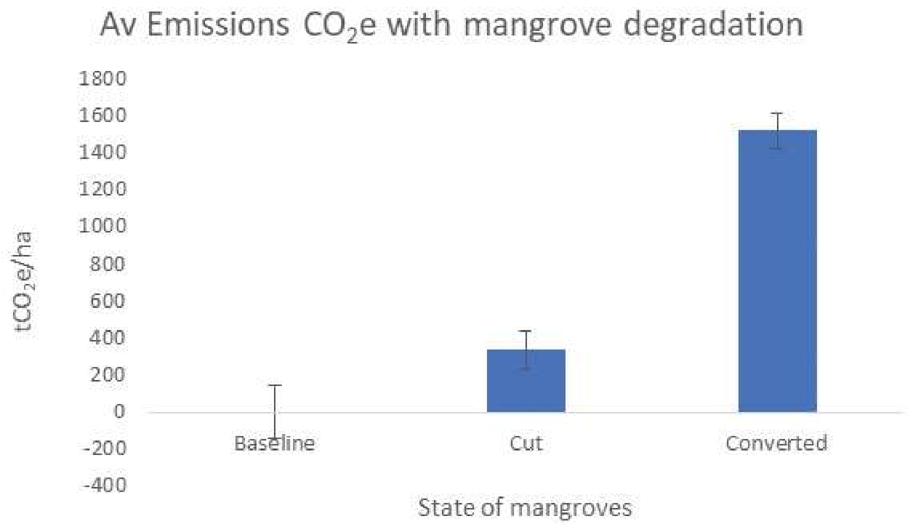
[172]Duke, N. C., MacKenzie, J., and Wood, A. (2013). *An assessment of biomass and carbon content of mangroves in Solomon Islands, Vanuatu, Fiji, Tonga & Samoa*. TropWATER Report No. 13/24. James Cook University Australia.
[173]Kauffman and Donato. (2012). *Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests.* Working Paper 86. Bogor, Indonesia: CIFOR.

Figure 62. Total Ecosystem Carbon pools expressed in CO_2 equivalent for the main mangrove types in Rewa delta.



A rapid assessment of six additional sites was also done, sampling only soil, to determine carbon emissions due to conversion.[174] This was the first such study done in Fiji's mangroves and Figure 63 shows carbon emissions from the different stages of conversion. This study determined that mangroves in Fiji sequester approximately 1,700 tonnes CO_2e/ha.

Figure 63. The emissions associated with a gradient of mangrove conversion in Rewa delta.



[174]Watershed Professionals Network. (2013). *MESCAL Carbon Assessment: Rewa Delta Mangrove Reference Levels & Emissions Due to Mangrove Conversion.*

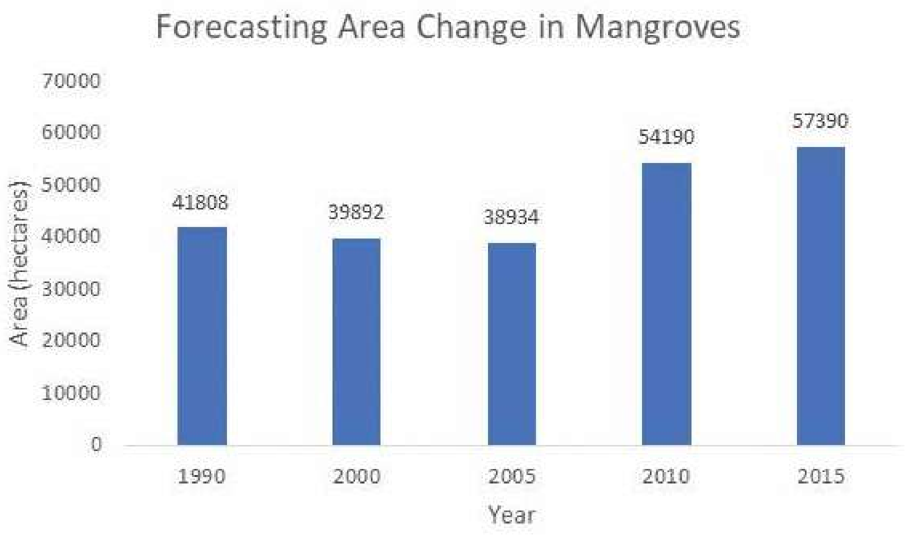
"Mangrove areas experienced a loss of 0.5% per year during 1991-2007"

Limitations and Uncertainties

Figures for the area of mangroves in Fiji vary, but include estimates of: 38,500 ha,[175] 42,460 ha,[176] 48,317 ha,[177] 49,500 ha,[178] and 52,000 ha.[179] This 25% difference is significant and will require considerable additional data collection and analysis to resolve. Mangrove areas experienced a loss of 0.5% per year during 1991-2007.[180] For purposes of this LEDS, the baseline value of the total area of mangroves is taken from the MESCAL report, which took the most comprehensive carbon stock assessment of mangroves in Fiji to date, focusing on the Rewa delta. This remains the only baseline data available for carbon stocks of Fiji's mangroves.

Figure 64 shows the forecasted mangrove area change in the Fiji country report submitted to FAO for the Global Forest Resources Assessment (2015). Once again, the difference in figures is significant. The Forestry forecast has mangrove area increasing during the same period (2005-2010) when other government documents report a loss of mangroves. Carbon stock estimates and, consequently, carbon emission estimates are influenced by such variable values of mangrove area. Accurate coverage figures are essential in order to manage the mangrove resource. A potential source of error in the extent of mangrove cover is the spectral quality of satellite images making the distinction between mangroves and pine forests particularly difficult near human settlements. A case in point are LandSat images from 2006 and 2016 showing the mangrove areas in the Ba delta. Higher resolution satellite imagery is required if more accurate high ambition and very high ambition scenarios are to be developed.

Figure 64. Forecasted mangrove area change submitted for Fiji for Global Forest Resources Assessment.



[175]Gonzalez, R., Ram-Bidesi, V., Leport, G., Pascal, N., Brander, L., Fernandes, L., Salcone, J., Seidl, A. (2015). *National marine ecosystem service valuation: Fiji Suva*, Fiji: MACBIO (GIZ/IUCN/SPREP).
[176]Mangubhai S, Sykes H, Lovell E, Brodie G, Jupiter S, Lal R, Lee S, Loganimoce EM, Morris C, Nand Y, Qauqau I, Rashni B. (2018). *Fiji: Coastal and marine ecosystems.* In C. Sheppard (ed.) World Seas: An Environmental Evaluation Volume II: The Indian Ocean to the Pacific. Elsevier. pp. 765-792.
[177]Mangrove Management Committee. (2013). *Mangrove Management Plan for Fiji 2013.*
[178]Ministry of Lands. (2018). *The Management of Mangrove Areas in Fiji.* Lands Department presentation at the LEDS 1st national stakeholder workshop.
[179]SPC. (2018). *Forest change detection Fiji.* Suva: SPC.
[180]Mangrove Management Committee. (2013). *Mangrove Management Plan for Fiji 2013.*

This LEDS envisions a maximum expansion of mangrove areas to about 54,700 and 65,000 ha in the High Ambition and Very High Ambition scenarios, respectively, following adoption of full moratoriums and significant replanting and restoration efforts. Notably, this would signify an increase in mangrove areas by 13% and 34% by 2050 relative to the 48,317 ha in 2008 presented in the MESCAL report. Further research will be needed to confirm the full extent possible for rehabilitating and expanding Fiji's mangroves.

"This LEDS envisions a maximum expansion of mangrove areas to about 54,700 and 65,000 ha in the High Ambition and Very High Ambition scenarios, respectively"

Stakeholder Consultation Process

Key stakeholders focusing on blue carbon and wetlands in Fiji include: the Ministry of Fisheries and Forest (MFF), the Ministry of Lands and Mineral Resources, the Ministry of Industry and Trade and Public Enterprise, the Ministry of Itaukei Affairs, the Ministry of Environment, Fiji Tuna Association, Pacific Islands Tuna Industry Association, private fishing enterprises, Conservation International, WWF, Nature Fiji, the University of the South Pacific, GIZ, Ramsar Convention on Wetlands, IUCN, and the Pacific Islands Development Forum.

During the first national stakeholder workshop, stakeholders developed a vision that blue carbon and wetland ecosystems of Fiji are sustainably managed and protected, maintaining their ecosystem goods and services for future generations. The second set of stakeholder consultations involved a series of face-to-face meetings with government ministries on the 14th, 22nd, and 24th of August, 2018 to receive input on the policy options and priorities for low emission development of the sector. Participants in the third national consultation workshop indicated that a national mangrove policy governing the use and management of the resource and the effective enforcement of existing legislation were equally high priorities. Also important were the need for accurate mangrove maps that are zoned, similar to the detailed maps produced in the MMP (1985), and the identification of national priority areas for conservation. The LEDS stakeholders proposed that by the year 2023 there would be improved coverage data, representative carbon stock measurements, and economic valuations and established restoration targets. By the year 2050, a central repository for blue carbon and wetlands data would be established, sustainable financing mechanisms to sustain projects would be functioning, and EIA policies and practices would be revised.

4.6.5 Low Emission Development Scenarios

Base Year (BY)

The base year selected for coastal wetlands in this LEDS is 2013.

BAU Unconditional Scenario

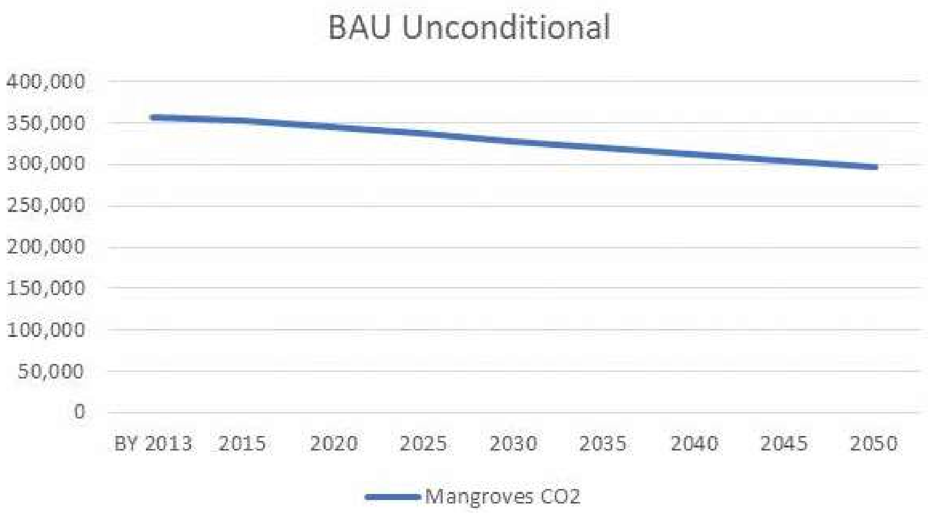
The BAU Unconditional scenario envisions implementation of policies currently in place. The scenario assumes that the total mangroves area in 2008 was 48,317 ha, as stated above, and that mangrove removal will take place at a rate of 0.5% per year thereafter, resulting in approximately 39,144 ha in 2050. Between the 2013 Base Year and 2050, mangrove conversion will release an estimated 1,518 tCO_2e per hectare. As the total area of mangroves is projected to decline, total emissions are also projected to decline from an estimated 357,649 tCO_2e in 2013 to 297,106 tCO_2e in 2050.

Table 37 and Figure 65 present total emissions from mangroves in the BAU Unconditional scenario.

Table 37. BAU Unconditional scenario for Coastal Wetlands.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY (2013)	2015	2020	2025	2030	2035	2040	2045	2050
Mangroves	CO2e	357,649	354,082	345,318	336,771	328,435	320,306	312,378	304,646	297,106

Figure 65. BAU Unconditional scenario for Coastal Wetlands.
(all values for all gases in metric tonnes CO2e).



The BAU Conditional scenario assumes that the total mangroves area in 2008 was 48,317 ha, as stated above, and that mangrove removal will take place at a rate of 0.5% per year thereafter, resulting in approximately 39,144 ha in 2050. The scenario reflects no significant deviations from current policy, except for the initiation of investment in a new replanting program starting in the year 2025, replacing 25% of the area of mangroves lost in the prior year. Emissions resulting from removals are assumed to be 1,518 tCO_2e per hectare. Restored mangroves are assumed to have the potential to sequester the same amount of CO_2 emitted, but require 30 years to do so; thus, the rate of sequestration is estimated to be roughly one thirtieth of the total area being restored. Sequestration is assumed to take place the year after replanting.

Between the 2013 Base Year and 2050, as the total area of mangroves is expected to decline, despite some replanting, total emissions are estimated to decline from 357,649 tCO_2e in 2013 to 231,189 tCO_2e in 2050.

The efforts to protect mangroves under the BAU Conditional scenario will be supported through international and other external financing and resources. It would entail creating mangrove maps that are zoned for different purposes (e.g., housing, research, tourism, agriculture, and reserves), costing approximately USD 250,000 to produce (CI, 2018), based on extensive consultations with traditional fishing rights owners to ensure they consent to the zonation scheme. The maps would serve as a decision support tool for the MMC.

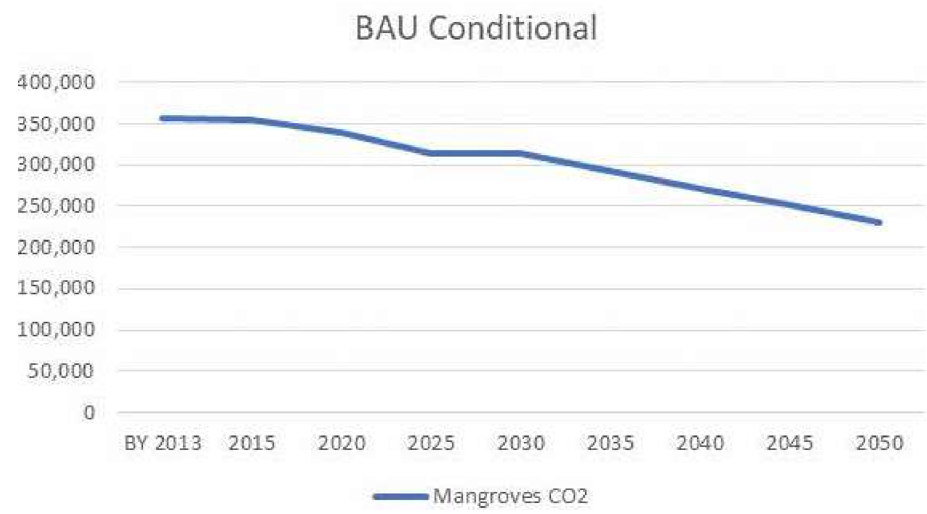
This scenario will also depend on establishing nurseries for the rehabilitation of degraded sites with external funding as well as private sector resources. Mangrove replanting is a popular activity of corporate bodies and reflected in the Suva Mangroves Master Plan, developed in response to this corporate social responsibility. Given that only 6-7% of seedlings survive 12 months after planting through earlier efforts,[181] additional measures will need to be taken to ensure higher success rates. For purposes of this LEDS, this scenario assumes that the mortality of replanted mangroves will be reduced to zero.

Table 38 and Figure 66 present total emissions from mangroves in the BAU Unconditional scenario.

Table 38. BAU Conditional scenario for Coastal Wetlands.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY (2013)	2015	2020	2025	2030	2035	2040	2045	2050
Mangroves	CO2e	357,649	354,082	339,016	314,930	314,852	293,344	272,235	251,520	231,189

Figure 66. BAU Conditional scenario for Coastal Wetlands.
(all values for all gases in metric tonnes CO_2e).



High Ambition Scenario

The High Ambition scenario assumes that the total mangroves area in 2008 was 48,317 ha, as stated above, and that mangrove removal will take place at a rate of 0.5% per year until the year 2029, after which a fully enforced moratorium is assumed to take effect. This scenario incorporates the addition of financing to support the development of mangrove maps and nurseries for replanting, with additional measures to improve success rates. Again, for purposes of this LEDS, this scenario assumes that the mortality of replanted mangroves will be reduced to zero.[182]

Following the recommendation of the MESCAL study, the scenario envisions replanting of two hectares of mangroves for every hectare converted, in this case those hectares converted 12 years previously (i.e., the scale of replanting of 483 ha in 2020 is based on an estimated total of 242 ha converted in 2008).

Again, emissions resulting from removals are assumed to be 1,518 tCO_2e per hectare, whereas restored mangroves are assumed to have the potential to sequester the same amount of CO_2 emitted, but require 30 years to do so; thus, the rate of sequestration is estimated to be roughly one thirtieth of the total area being restored. Sequestration is assumed to take place the year after replanting.

By 2050, as the total area of mangroves is expected to increase by about 13% of 2008 levels, to a maximum level of 54,762 ha. Total emissions of an estimated 357,649 tCO_2e in 2013 will transition to net sequestration starting in 2030 with a maximum sequestration rate of -531,204 tCO_2e in 2050. Annual rates of sequestration are expected to plateau, as the scenario assumes a limit to the area available for mangrove replanting (see above).

Table 39 and Figure 67 present total emissions from mangroves in the High Ambition scenario.

[181]Batibasaga, pers. Comm.
[182]Conversely, success could be assumed if promoting a much larger replanting area and, thus, offsetting unsuccessful replanting efforts in some locations.

Table 39. High Ambition scenario for Coastal Wetlands.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY (2013)	2015	2020	2025	2030	2035	2040	2045	2050
Mangroves	CO_2e	366,726	363,068	354,082	242,264	-242,051	-360,813	-481,918	-531,204	-531,204

Figure 67. High Ambition scenario for Coastal Wetlands.
(all values for all gases in metric tonnes CO_2e)

Very High Ambition Scenario

Using the same total area of mangroves in 2008 as above, the Very High Ambition scenario assumes that mangrove removal will take place at a rate of 0.5% per year until 2020, after which a fully enforced moratorium would take effect. This scenario incorporates the addition of financing to support development of mangrove maps and nurseries for replanting, with additional measures to improve success rates. Again, for purposes of this LEDS, this scenario assumes that the mortality of replanted mangroves will be reduced to zero.[183]

This scenario envisions replanting of six hectares of mangroves for every hectare removed, following a proposal of the Ministry of Waterways and Environment for introducing such offsets.[184] The size of replanting areas would be six times that of areas converted 12 years prior (i.e., the scale of replanting of 1,450 ha in 2020 is based on an estimated total of 242 ha converted in 2008).

Again, emissions resulting from removals are assumed to be 1,518 tCO_2e per hectare, whereas restored mangroves are assumed to have the potential to sequester the same amount of CO_2 emitted, but require 30 years to do so; thus, the rate of sequestration is estimated to be roughly one thirtieth of the total area being restored. Sequestration is assumed to take place the year after replanting.

By 2050, as the total area of mangroves is expected to increase by about 13% of 2008 levels (to a maximum level of 54,762 ha) total emissions (of an estimated 357,649 tCO_2e in 2013) will transition to net sequestration starting in 2021, with a maximum sequestration rate of -939,672.42 tCO_2e in 2050. Annual rates of sequestration are expected to plateau, as the scenario assumes a limit to the area available for mangrove replanting (see above).

Table 40 and Figure 68 present total emissions from mangroves in the Very High Ambition scenario.

Table 40. Very High Ambition scenario for Coastal Wetlands.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY (2013)	2015	2020	2025	2030	2035	2040	2045	2050
Mangroves	CO_2e	366,726	363,068	354,082	-363,077	-726,154	-939,672	-939,672	-939,672	-939,672

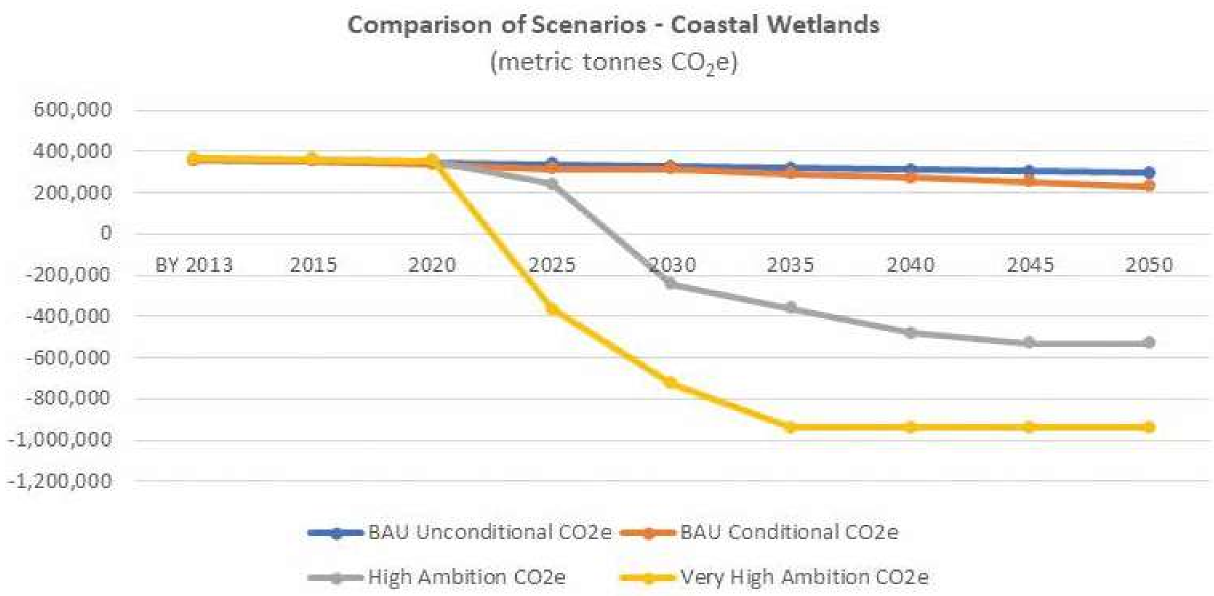
Figure 68. Very High Ambition scenario for Coastal Wetlands.
(all values for all gases in metric tonnes CO_2e)

Comparison of Scenarios

Figure 69 below provides a comparison of the four scenarios developed for Coastal Wetlands. The analysis shows that it appears possible to begin to achieve net negative emissions before 2030 under the High Ambition scenario and before 2025 under the Very High Ambition scenario, as a result of aggressive replanting and restoration. Again, although these projections are highly preliminary and based on a rather simple methodology, they at least present a general idea of the significant carbon sequestration potential that mangroves can offer.

[183]Conversely, success could be assumed if promoting a much larger replanting area and, thus, offsetting unsuccessful replanting efforts in some locations.
[184]Singh, pers. comm.

Figure 69. Comparison of scenarios for Coastal Wetlands.
(all values for all gases in metric tonnes CO_2e).



4.6.6 Policy Recommendations, Priority Actions, and High-Level Costing

One of the recommendations of the 2013 MMP includes the formulation of a national mangrove policy and the revival of a functional MMC. Under this provision, applications for the conversion of mangroves must be vetted and strict adherence to the EIA process is strongly recommended. Such a national policy is being given serious consideration because of the importance of the ecosystem to climate change mitigation and adaptation, as well as disaster risk reduction. Although the Ministry of Lands is the State custodian of mangroves, the Ministry of Environment and Waterways, the Ministry of Forestry, and the Ministry of Fisheries all play a role in determining its use. A national policy that is robust, easy to interpret, and implementable is advocated in the MMP 2013 and will allow the multiple stakeholders to make sound decisions regarding the use of the resource. The MMP 2013 will need formal endorsement by Cabinet to re-establish a fully functional mangrove management mechanism in the country. There is currently a functional MMC chaired by the PS Lands and co-chaired by the Conservator of Forests, but no plan on which to base their decisions.

Accurately zoned mangrove maps, similar to maps produced in 1985-1986, would assist the MMC in making informed decisions on development proposals. Of course, effective enforcement of existing legislation will ensure that mangrove conversion and recovery is carefully managed. Conducting a cost-benefit analysis can help take into account the carbon sequestration value of mangroves as part of any proposals requesting conversion of significant tracts of mangroves. Realistic and effective rehabilitation schemes would also benefit from involving local communities.

To achieve higher ambitions, Fiji's approach to promoting significant restoration of its mangroves will require new ambitious policies, such as to impose a full national moratorium on mangrove removal, and an increasingly large replanting program.

In order to consider mitigation and conservation opportunities for seagrasses, Fiji can consider improved mapping to determine species assemblages and the extent of cover and losses. This can be complemented by measuring biomass to calculate carbon stocks, as well as identifying threats to seagrass meadows.

4.7 WASTE SECTOR

4.7.1 Overview

This section looks at the waste component for Fiji's LEDS. The waste sector contributes approximately 3% of total global GHG[185] and, according to Fiji's recent national GHG inventory in the TNC, the waste sector in Fiji represents 4% of the country's total emissions.[186] With increasing population and more waste generation projected, these emissions are expected to grow under BAU conditions, particularly if emissions from the energy sector are mitigated, as stipulated in Fiji's NDC Implementation Roadmap. The relative percentage of emissions from the waste sector is bound to increase beyond the current 4% if no mitigating actions are implemented.

This section considers methane emissions from the anaerobic decomposition of organic matter, either from solid waste disposal sites (SWDSs) or from wastewater treatment plants (WWTPs). As highlighted in the TNC, methane emissions from the SWDSs are almost double those of WWTPs. In many developed countries, methane emissions from landfills or wastewater treatment plants are trapped and utilized to generate electricity; waste to energy (WTE) projects have been explored, such as incineration of waste to generate electricity. Such recovery and utilization technology is expensive and requires specialized technical expertise and, thus, may face barriers for implementation in SIDS.

Emision reductions from the waste sector provide an opportunity to achieve net zero emissions by capturing methane emissions and utilizing it to generate electricity that would offset CO_2 emissions from the diesel generators. The low emission scenarios developed for the waste sector in this LEDS incorporate Integrated Solid Waste Management (ISWM), which combines different processes and technologies to provide a more holistic approach aimed at diverting waste from landfill and reducing emissions from the waste sector. It has been documented that countries which adopt ISWM strategies have successfully reduced their carbon footprints.[187] Adopting ISWM not only reduces GHG emissions but also offers many economic, environmental, and social co-benefits. These co-benefits include: extension of landfill life, reduction of leachate production, an increase in green jobs, reduced dependence on fossil fuel for electricity generation, production of compost to increase soil fertility, and reduction of plastic pollution, particularly if plastic waste is considered a resource with value.

4.7.2 Emission Sources

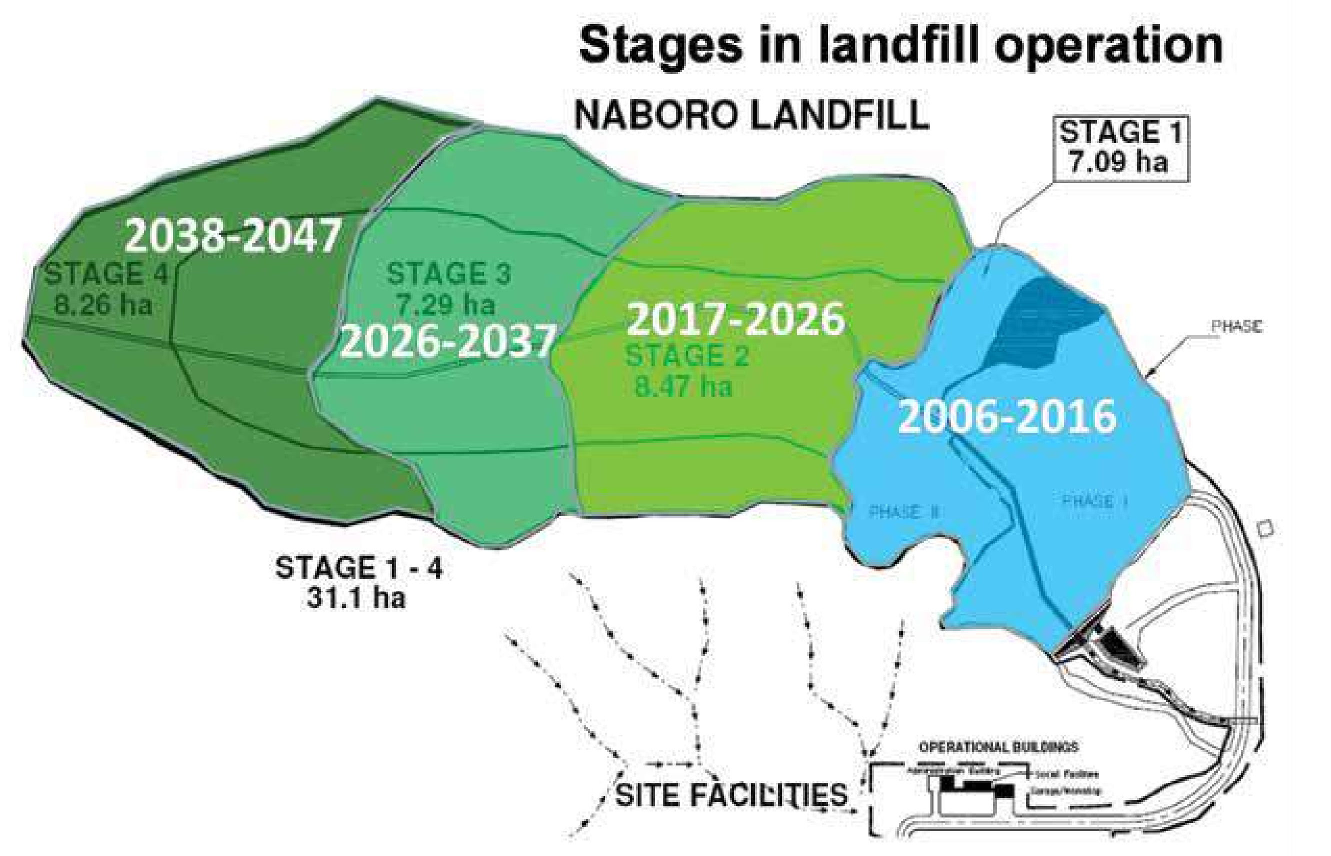
Summary of Emission Sources

For purposes of this LEDS, two major emission source categories in Fiji from the waste sector are considered.[188] Although incineration of waste also emits CO_2, it is not included in this assessment as it is not a significant emissions source category. The only major incineration source identified in Fiji is the incineration of medical waste in hospitals in Suva, Lautoka, and Labasa. The analysis shows that the emissions is in the order of 10 tonnes of CO_2e per year, which is well within the uncertainty range of the calculations shown in this report and, therefore, not included in the emission reduction scenarios. It is noteworthy that rubbish dumped in the backyards of homes and by the roadside, or dumped in the sea or rivers, does not contribute to GHG emissions and is not included in the GHG inventory, according to the 2006 IPCC guidelines.

The major SWD site is Naboro Landfill, which is an anaerobic landfill that receives household waste, green (plant matter) waste, and industrial waste from Nausori, Nasinu, Suva, Lami, and the neighboring Pacific Harbour municipal areas.[189] In 2017, the landfill received around 83,000 tonnes of waste and the amount of waste received is increasing at a rate of 3,000 tonnes per year. The landfill has been in operation since 2005 and is administered by Government of Fiji and operated by a private contractor, HG Leach Company of New Zealand. The landfill at Naboro is planned to be expanded in four stages and stage one was filled in January 2016. Figure 70 shows the layout of the different stages of the landfill. With current practices and increasing volumes of waste generated, the planned filling of the landfill is per schedule and, in the future, it is anticipated that if all the relevant measures are implemented, more diversion of waste from the landfill will not lead to any problem of landfilling before the projections.

[185]Bogner et al. (2008). Mitigation of global greenhouse gas emissions from waste: conclusions and strategies from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. Working Group III (Mitigation). *Waste Management & Research* 26: 11–32.
[186]Government of Fiji. (2018c). *Fiji Third National Communication (TNC) to the UNFCCC.*
[187]Maloof & El-Fadel. (2018). Carbon footprint of integrated waste management systems with implications of food waste diversion into the wastewater stream. *Resources, Conservation & Recycling* 133: 263-277.
[188]For reference purposes, it is estimated that Suva City Council provides residential and commercial solid waste collection services three and six times a week respectively. In Labasa, waste collection services are provided to the entire city three times a week. This data is taken from the recent PRIF study detailing Pacific Country Profiles for the solid waste management sector.
[189]Waste can be classified into two types: organic and inorganic. Organic waste is defined as waste that includes any organic matter which can scientifically be broken down into organic molecules such as carbon dioxide, water, methane through a process of anaerobic digestion, composting or any other similar processes. Inorganic waste is any type of waste that cannot be broken down by micro-organisms.

Figure 70. A plan showing the duration of different stages of landfill operation and hectares of area required for each stage.[190]



Another sanitary semi-aerobic landfill, at Namara, Labasa, has been included in GHG emission calculations. The other major SWD site is the Vunato Rubbish Dump in Lautoka which receives waste from Lautoka and Nadi areas. The dump has been in operation for approximately 50 years and is now coming to the end of its useful life. A new landfill will be needed in the near future and it is preferable that a semi-aerobic landfill, with a leachate collection system, will be developed. The other smaller SWDs included in the LEDS are the rubbish dumps in Savusavu, Sigatoka, Ba, Tavua, and Levuka.

There are 11 major WWTPs around the country and are listed in Table 41. However, only Kinoya and Nadi were considered in the calculation as they both employ anaerobic treatment systems and emissions from the other efficiently-run aerobic plants are negligible. The ADB has recently funded a CDM project to flare methane produced at Kinoya, which recently received Certified Emission Reductions (CERs).[191]

[190]Mani et al. (2016). *Pre-feasibility study for methane recovery at Naboro Landfill, Suva, Fiji Islands.*
[191]https://www.pacificclimatechange.net/node/24774

Table 41. Waste water treatment plants in Fiji and its treatment type.

Sewage Treatment Plant (STP)	STP Capacity (equivalent inhabitants)	Population connected	Treatment Type
Kinoya	180,000	151,000	High Rate Trickling Filter. Sequence Batch Reactor Plant
ACS	2,000	800	IMHOFF tank with 2 low rate filter and secondary sediment process
WailadaLami	500	200	Activated package plant system
Nausori Airport	8,000	2,500	Activated sludge and tertiary pond
Pacific Harbour	10,000	2,500	High rate trickling filter
Sigatoka	10,000	1,200	Oxidation pond system
Naboro	6,000	1,500	Activated Sludge treatment
Nadi	35,000	30,000	Activated Sludge treatment
Lautoka	40,000	45,000	Oxidation pond system
Ba	8,000	5,000	Oxidation pond system
Labasa	5,000	7,000	Oxidation pond system

Type of Emissions

This LEDS considers low emission scenarios for methane (CH_4) emitted from the waste sector.

When organic matter (food waste, garden waste, paper, wood, textiles, and diapers) decomposes in the absence of oxygen, CH_4 and CO_2 are produced. The CO_2 emissions from this biomass are considered carbon neutral and, thus, not accounted for in the GHG inventory or the LEDS.

In WWTPs, when organic matter or sludge undergoes anaerobic digestion it produces CH_4 and CO_2 as well and, again, only CH_4 emissions are accounted for in GHG calculation according to the 2006 IPCC guidelines. Although methane is the primary gas emitted, some N_2O is also produced during the treatment but it is very negligible and is not a key category listed in the national GHG inventory, nor is it included in this LEDS.

4.7.3 Existing Policy and Regulatory Framework

A number of existing policies and regulatory frameworks provide the foundation for low emission development in the waste sector in Fiji. These include: the Solid Waste Management Strategy 2011-2014; the Environment Management Regulations 2007; the National Liquid Waste Management Strategy 2006; the National Integrated Waste Management Strategy 2016-2025; the National Liquid Trade Waste Policy 2013; and the Litter Promulgation Act 2008.

The National Integrated Waste Management Strategy (NIWMS) is the most relevant policy and has provided the guiding principles for developing low emission scenarios for the waste sector. The NIWMS covers the period from 2016 to 2026 and has mid-term (2021) and end-term (2026) strategic goals. Its five strategic goals for the waste sector include:

- Preventing the generation of waste;
- Recovering resources from waste;
- Improving management of residuals;
- Improving protection and monitoring of the receiving environment; and
- Implementing and monitoring the NIWMS.

4.7.4 Methodology

Model and Methodology Used

The IPCC 2006 First Order Decay (FOD) Model is used to calculate methane emissions from the SWDSs. This is the standard tool used to estimate methane emissions from the waste sector. The model, and further explanation of the parameters used in the model, are explained in chapter 3 of volume 5 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The default values used in the calculation are shown in Table 42.

The FOD model assumes the time dependent emissions as the degradable organic content (DOC) in waste matter may take several years to degrade. Thus, within a few years of waste placement in the landfill, the emissions may peak and then slowly decay as the DOC of waste depletes.

Table 42 . List of default values used in the IPCC FOD Waste Model.

Parameters	Default values
DOC [192]	0.14
DOCf	0.5
Methane generation rate constant	0.17
Climate	Moist and wet tropical
Delay Time	6 months
Fraction of methane in landfill gas	0.5
Conversion factor C to CH_4	1.33
DOC for garden waste	0.2
DOC for paper and cardboard	0.4
DOC for wood and straw	0.43
Methane Correction factor	1.0 for Naboro landfill; 0.5 for Namara landfill and 0.6 for all the other uncategorized SWDs
Waste generation rate per capita	690 kg/cap/year
% of waste deposited to SWDs	100% for Naboro landfill and 85% default value for the others.
Waste Composition	Default values for Oceania region
Food 68%	
Paper 6%	
Wood 3%	
Plastics 24%	
Methane recovered	0 (IPCC default value)
Methane oxidized	0 (IPCC default value)

Methane emissions from the two anaerobic wastewater treatment plants are estimated according to the procedure outlined in chapter 6 of volume 5 IPCC 2006 guidelines. The method for estimating CH_4 from wastewater handling requires three basic steps and the three worksheets provided by IPCC were used to calculate each of the following steps:

- Step 1: Estimation of Organically Degradable Material in Domestic Wastewater;
- Step2: Estimation of CH_4 emission factor for Domestic Wastewater; and
- Step 3: Estimation of CH_4 emissions from Domestic Wastewater.

Data Used, Data Sources, and Assumptions

For the FOD model, the main activity data is the amount of waste deposited at the landfill site. Accurate data was obtained for Naboro landfill as there is a weighbridge installed at the site to weigh the tonnage of waste landfilled. The Naboro landfill data was obtained from HG Leach Company and was later verified by the Department of Environment. A linear regression line fitted to data from 2005-2017 was extrapolated to project the amount of waste to be deposited at Naboro landfill until 2050. The approach adopted is current best practice, but there could be a deviation in the total amount of waste from the projection due to an increase in the generation rate, due to an increase in GDP, or more green waste generated due to frequent

[192]Degradable Organic Carbon in a year. This refers to the process in calculating methane emissions where the first order of decay method is used, which takes into account the related time taken for organic carbon content in waste to decay to half its initial mass.

high intensity cyclones in the future. The other SWDSs do not have a weighbridge and, therefore, waste generation rates (kg/cap/day) and population projection for different urban areas (FBoS population projection data supplemented by World Bank projections after consultation with FBoS) have been considered to calculate the amount of waste generated per year. The generation rate of 0.8 kg/cap/day was used and this value was taken from the NIWMS 2016-2028 document that specifically stated that waste generation will be maintained at this rate in future.[193] One uncertainty is estimating the population of informal communities and how the dynamics of such communities will change in future. The Suva City Council makes concerted efforts to collect waste from informal communities by placing large skip bins in the vicinity which are cleared by private companies. The waste generated by such informal communities around the Greater Suva Area is included in the LEDS.

For wastewater treatment emissions, IPCC 2006 worksheets are used and the main input parameters for the model are population, Biological Oxygen Demand (BOD) data, type of system, and amount of methane flared. The data required for calculations is provided by Water Authority of Fiji (WAF) and is highly reliable. The BOD data obtained from WAF for Kinoya WWTP is in close agreement to the default value. A high-resolution BOD measurement exists for Kinoya. For the Navakai (Nadi) WWTP the BOD measurements are limited and, as a result, the IPCC default BOD value is used for the Nadi WWTP as well. The future development plans for Kinoya WWTP have provided the basis for developing low emission scenarios, considering how the plant would expand and how this will affect the amount of methane generated.

Limitations and Uncertainties

Uncertainties for waste are difficult to assess and are quite variable. According to the IPCC 2006 Guidelines, uncertainties can range from 10-30% depending on the quality of the activity data. Given the uncertainties surrounding the trend in future generation of waste in Fiji, and taking a more conservative approach, the LEDS assumes a total uncertainty level of 30% to methane calculations.

The uncertainties are based on assumptions that include:

- Waste generation rates (0.4-1.8 kg/cap/d);[194]
- Population projections;
- Waste characterization – default values were used; and
- Percentage recovery of methane gas at WWTP for electricity generation.

Installing weighbridges at all SWDSs and carrying out detailed waste characterization studies will strengthen data in the solid waste sector.

"Installing weighbridges at all SWDSs and carrying out detailed waste characterization studies will strengthen data in the solid waste sector"

[193]Department of Environment. (2018). *National Integrated Waste Management Strategies 2016-2028*. It is important to note that this assumption is based on the fact that as populations rise, there will be interventions in place to manage the increasing amount of waste generated. Although the NIWMS mentions that the rate of generation will remain stable, if these interventions do not come into practice, this number will change in the future.
[194]www.pacific.undp.org/content/dam/fiji/docs/OtherDocs/.../Fj_FR_Quantification.pdf

Stakeholder Consultation Process

Key stakeholders focusing on waste and wastewater in Fiji include: the Ministry of Local Government, Housing, and Environment; the Water Authority of Fiji; the Ministry of Health; city and town councils of Suva, Nadi, Nasinu, Nausori, Lautoka, Savusavu, and Labasa; several waste management and recycling firms; USP; Pacific Islands Development Forum; SPC; the European Union Delegation; and ADB. In addition to the three stakeholder consultation workshops, individual consultations were also held between May and August 2018 with the CDM project manager (WAF), the Ministry of Health, the Department of Town and Country Planning, the Department of Housing, IUCN, and the Suva and Nasinu Town Councils.

During the first national stakeholder workshop, stakeholders identified a vision for the waste sector: Reduction of GHG emissions from the waste sector through the implementation of integrated solid waste management strategies which are environmentally friendly, economical, and sustainable. The waste session of the second national stakeholder consultation was held on the 6th of July, 2018 to present initial emission scenarios and discuss priorities. Stakeholders raised questions about emissions related to transporting waste, waste collection from informal settlements, management of hazardous waste (including that from disposing of EV batteries), resource recovery (e.g., methane capture for waste-to-energy uses), export of compost, and the idea of creating a recycling hub for the Pacific region in Suva. In response to seeing the emission scenarios, and proposed actions for each, during the third national stakeholder workshop, stakeholders identified the top priority as a national reduction, reuse, recycling and recovery (3R+R) policy to minimise waste going to landfill, combined with composting household kitchen and green waste. They also prioritised an extended producer responsibility policy to promote recycling and methane capture from anaerobic digesters at Kinoya Sewage Treatment Plant (KSTP) for co-generation of electricity.

4.7.5 Low Emission Development Scenarios

Base Year (BY)

The agreed base year used for the waste sector is 2013, the year immediately before the flaring of methane began as part of the CDM project.

BAU Unconditional Scenario

The IPCC waste model result for both the SWD and WWT is shown in the Figure 71 below. The BAU Unconditional scenario assumes that the current practices in waste management are sustained through 2050. In comparison to the base year value, the emissions will increase three-fold in the waste sector overall (combining approximately a four-fold and two-fold increase in emissions from the SWD and WWT subsectors respectively).

Solid Waste Disposal

The growth rate in emissions from SWDs is expected to increase steadily and reflects the urban population growth rate as the amount of waste generated was approximated using the population growth rate. Table 42 below shows that there is an increase of 255% in emissions from SWD subsector by 2050, as compared to the base year value. This scenario only calculates methane emissions from the waste collected and disposed at SWDs. A closer inspection of the different individual sources for the SWDs shows that Naboro landfill generates approximately 80% of emissions. Figure 71 below shows that the greatest opportunity for emission reductions in the future will come from adopting ISWM strategies at Naboro landfill. Vunato rubbish dump, the second largest SWD site, is nearing the end of its useful life. Planning for a new landfill for the Western Division is currently in process and is reflected in this scenario. The LEDS assumes that it will be a semi-aerobic landfill which will reduce emissions by 50%, as compared to an anaerobic landfill.

Waste Water Treatment

There is a 50% increase in CH_4 emissions in the wastewater subsector, as compared to the base year value. It should be noted that the irregularities (the decreased efficiency in Figure 72) observed in the trend for WWT emissions are due to the variances in the efficiency of flaring activity and the planned upgrade work at KSTP. The certified emission reductions stated in the CDM project proposal document are 22,500 tonnes of CO_2 but, due to a malfunction in one of the digesters and problems associated with reporting and verification, emission reductions have been below the target. The current ADB and GCF funding allocated to WAF for upgrade work at Kinoya is expected to result in the increase in the population connected to sewer lines by 2020[195] and, hopefully, would achieve the CERs target for the remaining period of reporting to the CDM in 2022. In the worst-case scenario, there will be no flaring as there will be no more funding or income generated to support calibration and reporting of gas flared.

[195]https://cop23.com.fj/fiji-welcome-new-water-supply-wastewater-management-project-first-ever-adb-gcf-funding-initiative/

Figure 71. Percentage contribution from different SWDs to total methane emissions from solid waste.

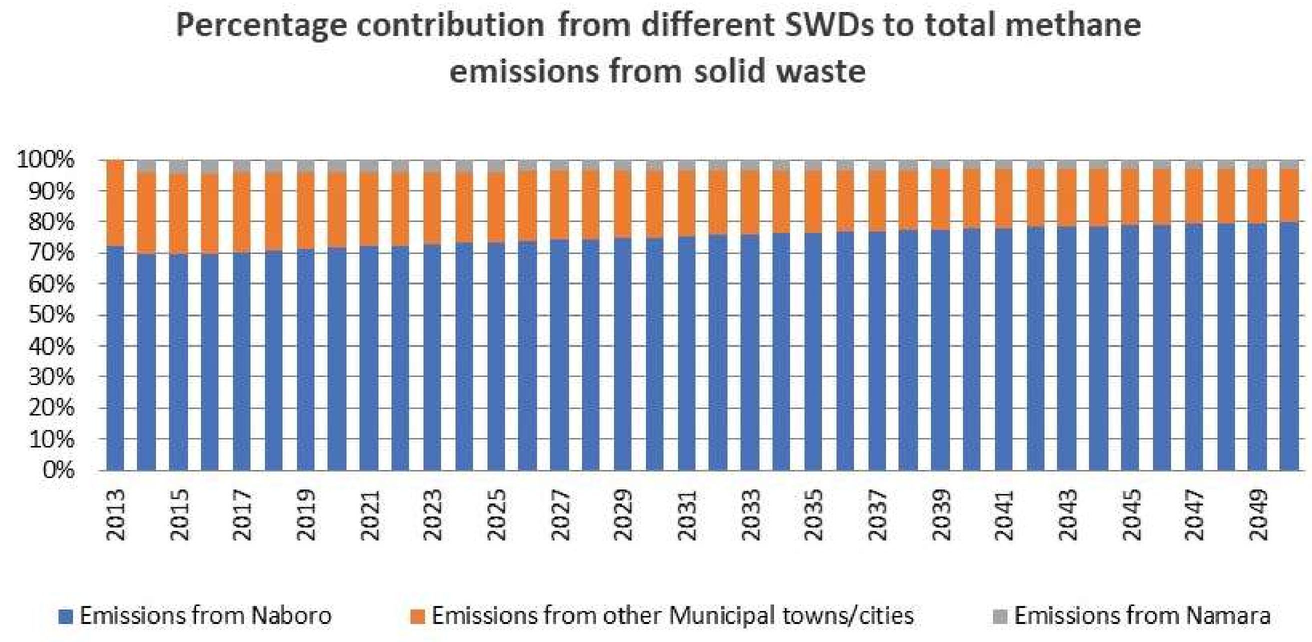
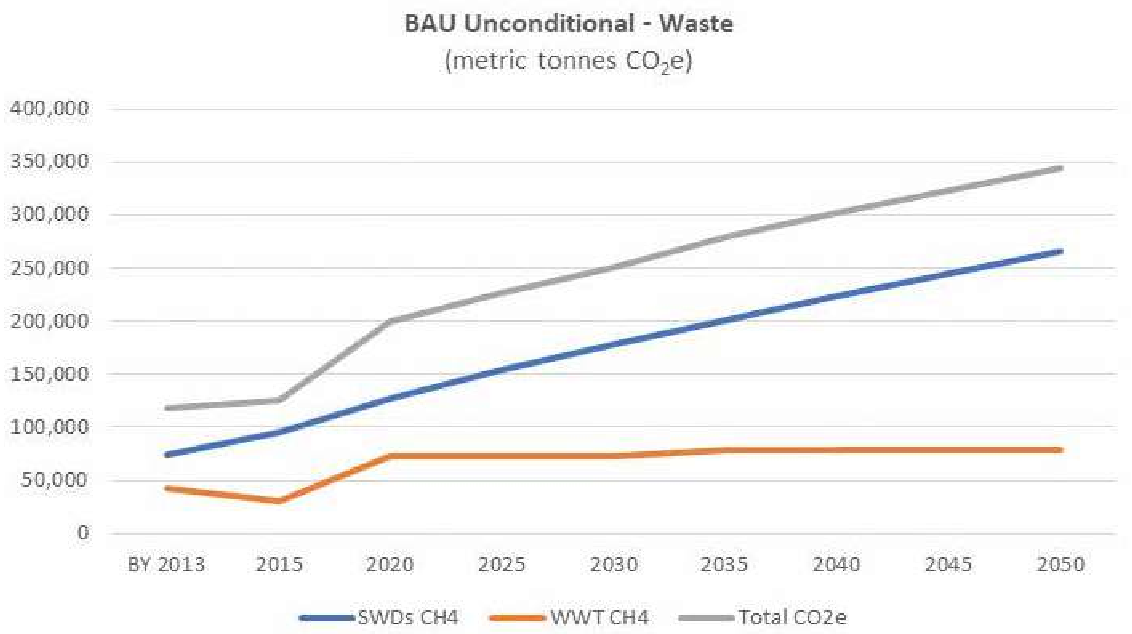


Table 43. BAU Unconditional scenario for Waste.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
SWDs	CH_4	74,991	94,927	127,367	154,148	178,261	201,104	223,203	244,893	266,282
WWT	CH_4	42,280	30,520	72,800	72,800	72,800	78,400	78,400	78,400	78,400
Total	**CO_2e**	**117,271**	**125,447**	**200,167**	**226,948**	**251,061**	**279,504**	**301,603**	**323,293**	**344,682**

Figure 72. The BAU scenario for SWDs and WWTPs and the total emissions in Tonnes of CO_2e for the waste sector.



"With a concerted nationwide effort, and with proper planning and implementation, a 40% reduction in organic waste is feasible"

BAU Conditional Scenario

Solid Waste Disposal

The BAU Conditional scenario envisions diversion of waste from the landfills and rubbish dumps to an increased amount of composting. Starting in 2025, 40% of organic waste generated, such as kitchen waste, garden waste and paper, will be diverted from the landfill. This will almost immediately reduce CH_4 emissions by 40%. Nationwide household composting will be encouraged, and the collection of general household waste is expected to decrease from three to five trips per week to one to two trips only. Each municipality will need to set up a composting facility, whereby all market waste and green waste from maintaining parks and roads should be diverted to the composting facility. Currently, Suva City Council (SCC) diverts market waste either for composting or animal feed. In 2016, market waste (consisting of primarily organic waste), which constitutes 10% of the total waste collected by SCC, was diverted from Naboro landfill. This intervention, not only reduced emissions by 10%, but also saved SCC a total of FJD 5,568 cartage tariffs annually.[196]

This scenario also envisions establishing a waste transfer station. The waste transfer station will not only reduce the emissions associated with the cartage of waste but will also provide an opportunity for recovery of resources, such as recyclables, and diversion of organic waste to a composting facility. The fuel data for transportation of waste to the SWDs for 2016 was obtained from various city and town councils and private contractors (such as Waste Clear). The data was used to calculate emissions of CO_2 as per the 2006 IPCC Energy Tier 1 guidelines. It was calculated that approximately 2,000 tonnes of CO_2 emissions were from transporting waste, and this represents approximately 2% of the total emissions from the SWDSs. With the development of a transfer station for the Greater Suva area, the number of trips to Naboro landfill may decline, although the CO_2 emissions reduction is very small and well within the uncertainty range. Thus, the emissions from the transportation of waste are not specifically accounted for in the development of emission reduction scenarios.

With a concerted nationwide effort, and with proper planning and implementation, a 40% reduction in organic waste is feasible. It will require changing the mindset of the general public, that not everything should be landfilled, through extensive awareness and education. The co-benefit of this action is that it is likely to generate employment in the waste sector, particularly at different municipalities and government ministries responsible for advocating 3R policies in waste management. This can further be encouraged by subsidizing the cost of compost bins or providing incentives for reducing waste at the household level, such as by reducing garbage fee collection or city rates. In addition, separation at source is also encouraged at the household and market level, in addition to separation at landfills, to support composting efforts. In the present 2018-2019 budget, FJD 500,000 is allocated to purchase compost bins for Nasinu town area.[197] If composting waste at a composting facility will be a major driver for waste diversion, then a well-developed market for selling compost as a product needs to be established.

[196]The data was provided by Suva City Council.
[197]http://www.economy.gov.fj/images/phocadownload/1.4%20Infrastructure%20Sector%20Flyer.pdf

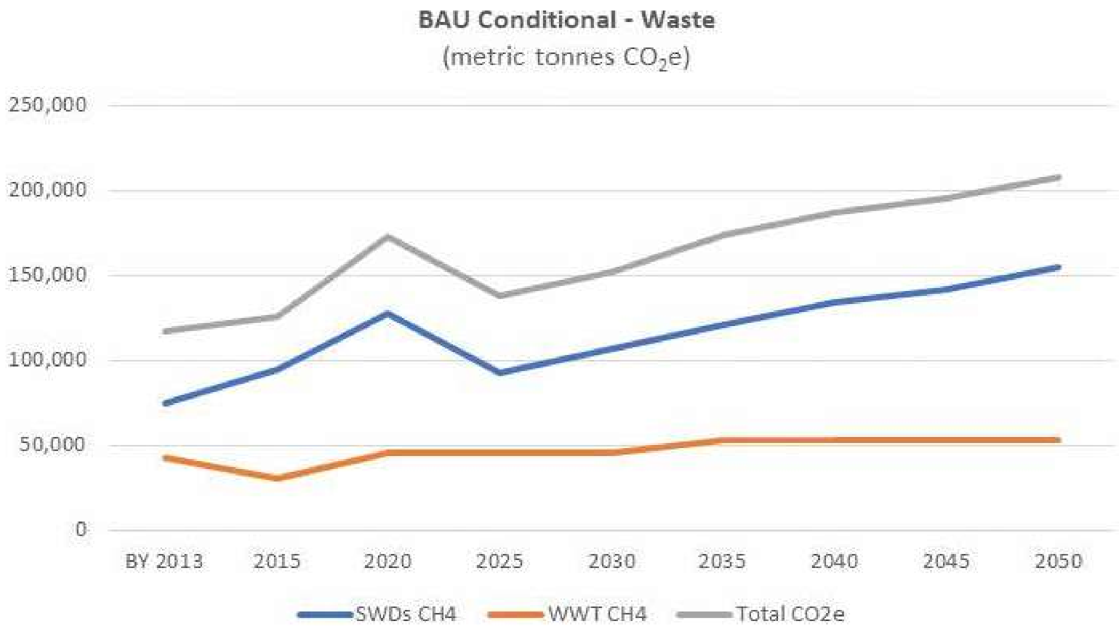
Waste Water Treatment

For waste water treatment the BAU Conditional scenario is aligned to the planned upgrading work at KSTP. Recently, the Fijian Government received funding of USD 405 million dollars from ADB and GCF to expand the capacity at KSTP from the current capacity of 155,000 people to 277,000 people by 2020, and further increased to 330,000 people by 2033. It is also anticipated in this scenario that both digesters will be operational and flaring of methane will be done in accordance with the target specified in the Project Design Document of the CDM project, which will result in a reduction of 22,500 tonnes CO_2/yr. The amount of gas flared will be monitored, although there will be no credits given for the reduction. As illustrated in Table 44, the CH_4 emission reduction from the WWT will decrease by 37% from 2020 onwards, as compared to the BAU Unconditional scenario.

Table 44. BAU Conditional scenario for Waste.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
SWDs	CH_4	74,991	94,927	127,367	92,489	106,957	120,663	133,922	141,767	154,421
WWT	CH_4	42,280	30,520	45,080	45,080	45,080	53,200	53,200	53,200	53,200
Total	CO_2e	117,271	125,447	172,447	137,569	152,037	173,863	187,122	194,967	207,621

Figure 73. BAU Conditional scenario – Waste.



High Ambition Scenario

To achieve even greater ambition than the BAU Conditional scenario, the High Ambition Scenario envisions more rigorous mitigating actions to further reduce methane emissions. In this scenario, Fiji proposes to adopt nationwide recycling of paper and plastics starting in 2030 and exploring WTE options for waste water treatment from 2033 onwards.

Solid Waste Disposal

Ambitious recycling of 30% of paper and 40% of plastic will reduce methane emission for the SWD subsector to 47% above the base value in 2050. This mitigating strategy in the SWD subsector will reduce the emissions further by 28% by the year 2050 (refer to Table 45). To achieve such levels of recycling in Fiji, related policies need to be implemented and actions prioritised, which are further discussed below.

Waste Water Treatment

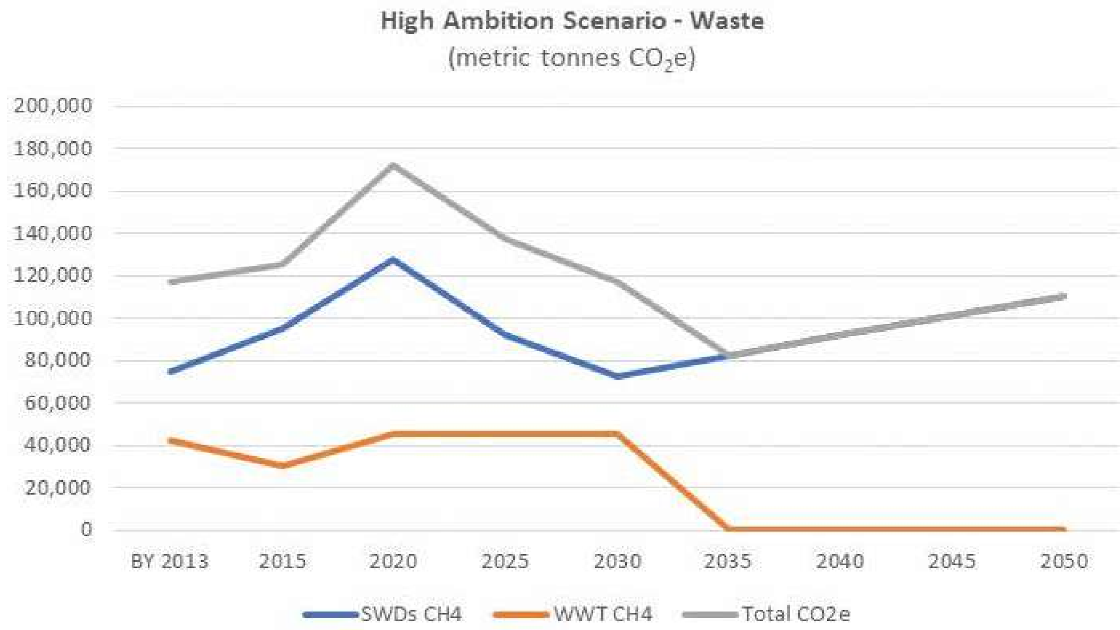
For waste water, Fiji will work to complete the second phase of the upgrade work at KSTP by 2033, and factor in a waste to energy component. It is assumed that approximately 50% of the methane produced will be captured and utilized for co-generation of combined heat and power. After taking into account the avoided emission from electricity generation from diesel and CO_2 emissions from WTE, under this approach total emissions will decline to 1,578 tonnes of CO_2e starting in 2033. The average grid emission factor of 0.24 tonnes of CO_2/MWh obtained from the LEAP model for the years 2033-2050 was used to calculate the avoided emission from diesel generators. The current grid emission factor is 0.5095 tonnes of CO_2/MWh.[198] The grid emission factor used in this scenario is lower than the current value as it incorporates more renewable energy to generate electricity, as stipulated in the NDC Implementation Roadmap.

Significant emissions will still result from SWDs in this scenario, resulting in an overall increase of 35,614 CO_2e (or 48%) from 2013-2050.

Table 45. High Ambition scenario for Waste.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
SWDs	CH_4	74,991	94,927	127,367	92,489	72,367	82,340	91,942	101,341	110,605
WWT	CH_4	42,280	30,520	45,080	45,080	45,080	1,578	1,578	1,578	1,578
Total	CO_2e	117,271	125,447	172,447	137,569	117,447	83,918	93,520	102,919	112,183

Figure 74. High Ambition scenario – Waste.



Very High Ambition Scenario

In the high ambition scenario, it is possible to achieve significantly reduced emissions from WWT by 2035 and, therefore, no mitigating actions are proposed for the WWT sector in this scenario development. To attain these emission levels in the very high ambition scenario, the methane generated from 60% of organic waste ending in the Naboro landfill will be captured and utilized for electricity generation to support the operation of the landfill from 2045. For the SWD sub-sector, even when considering a conservative result of recovering only 30% of the methane and an electricity generation efficiency rate of 40%[199] and CO_2 emissions from WTE, emissions will be reduced by 98% in 2050, as compared to the 2013

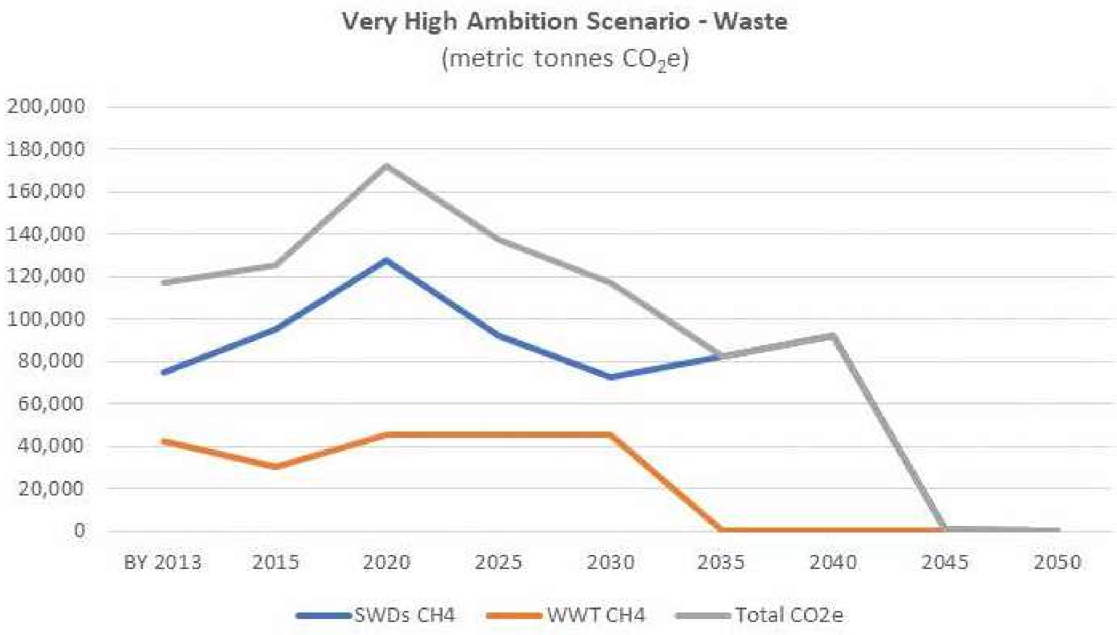
[198]UNEP. (2013). *Fiji Emission Reduction Profile.*
[199]Tercan et al. (2015). Analysis of a landfill gas to energy system at the municipal solid waste landfill in Gaziantep, Turkey. *Journal of the Air & Waste Management Association* 65(5): 912-918.

baseline value. In this very high ambition scenario, near zero emission values of 2,200 to 1,409 tonnes of CO_2e can be achieved in 2045 and 2050, respectively (refer to Table 46 below).

Table 46. Very High Ambition scenario for Waste.
(all values for all gases in metric tonnes CO_2e)

Source	Gas	BY 2013	2015	2020	2025	2030	2035	2040	2045	2050
SWDs	CH_4	74,991	94,927	127,367	92,489	72,367	82,340	91,942	2,200	1,409
WWT	CH_4	42,280	30,520	45,080	45,080	45,080	1,578	1,578	1,578	1,578
Total	CO_2e	117,271	125,447	172,447	137,569	117,447	83,918	93,520	3,778	2,987

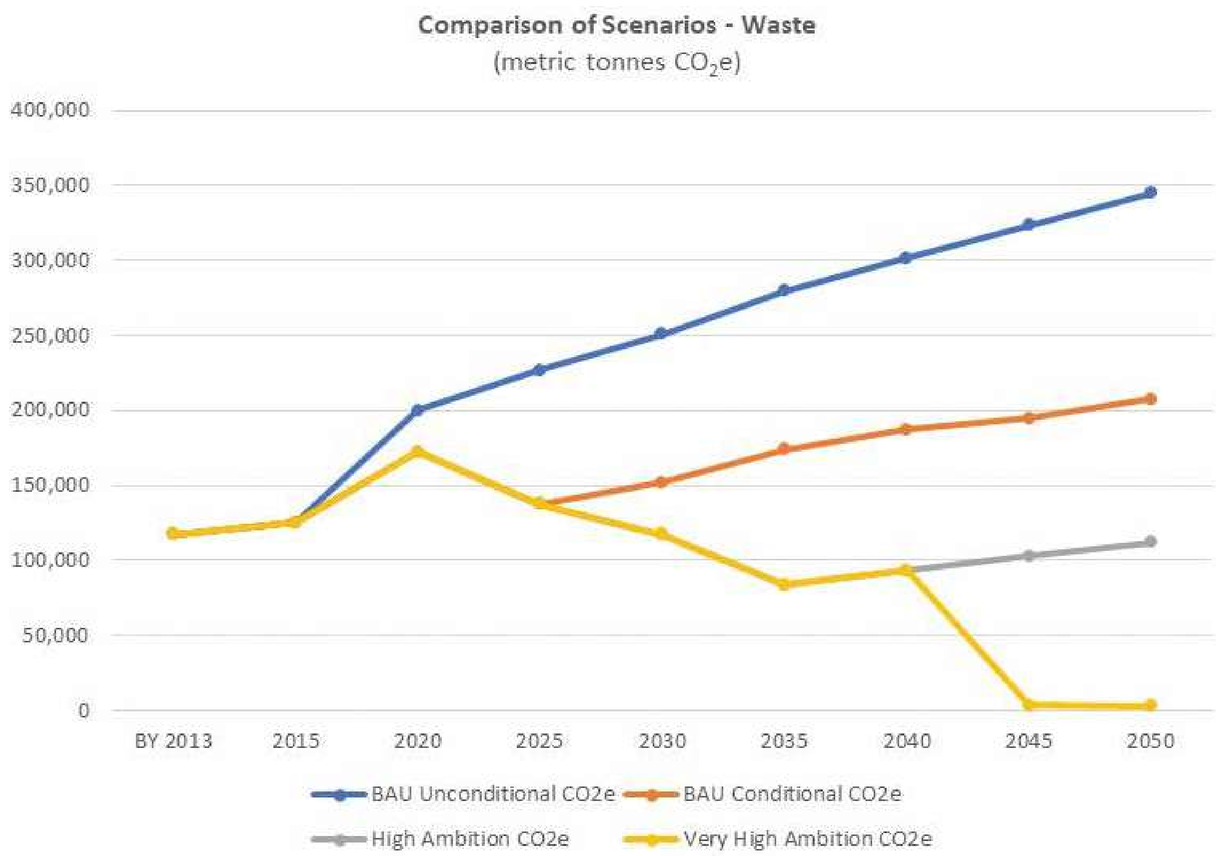
Figure 75. Very High Ambition scenario – Waste.



Comparison of Scenarios

Figure 76 below shows a comparison of the four scenarios developed for the waste sector. The analysis shows that it is only possible to achieve near zero emissions by 2045 with the implementation of methane recovery and utilization to generate electricity using a gas turbine. To reach near zero emissions before 2045 may be possible if there is substantial amount of landfill gas produced for efficient recovery.

Figure 76. Comparison of scenarios – Waste.



4.7.6 Policy Recommendations, Priority Actions, and High-Level Costing

The following policy recommendations and priority actions are proposed for each long-term low emission scenario:

BAU Conditional (40% waste diversion from SWDs and flaring methane at Kinoya WWT):

- A national 3R policy will be adopted and implemented to minimise waste going to landfills and to promote composting of household kitchen and green waste. The NIWMS indicates that the 3R policy is still in draft form and should be finalised soon. The policy should clearly outline the incentives for practicing 3R and should also include the polluter pays principle. Policymakers will also need to address the tariff structure for collection and disposal of waste to promote an integrated solid waste management strategy.
- Currently, local households usually opt for the simplest option of waste disposal – which is to put everything into a bin and let the municipal and town councils dispose of it in a landfill. There is a need for greater national consultations to increase social awareness and to promote behavioural change in order to successfully implement the 3R policy.
- In the Fiji National Budget 2018-2019, funding is allocated for development of a waste transfer station in Nasinu. The waste transfer station will not only reduce the emissions from transporting waste,[200] but it also provides an opportunity for separating organic waste for resource recovery, such as recyclables, and for promoting green jobs.
- Fiji will pursue a program to develop composting facilities so that organic waste can be composted on a large scale. The compost produced could be sold in local markets as fertilisers or soil conditioner. Many stakeholders suggested that the best place to develop a composting facility is at Naboro Landfill itself. Studies have shown that using compost as a soil cover enhances methane oxidation and thereby reduces methane emissions from the landfill.[201]

[200]As calculated, the total emissions from the transportation of waste was approximately 2% of the total emissions from the solid waste disposal sector.
[201]https://www.sciencedirect.com/science/article/pii/S0956053X06002364

High Ambition (30% Paper and 40% plastic recycling and WTE for Kinoya WWTP):

In addition to the actions proposed for the BAU Conditional scenario, the following actions are included in the High Ambition scenario:

- Adoption of a source separation policy, i.e., for separating recyclable and organic waste from general household waste.
- Implementation will begin of the Extended Producer Responsibility (EPR) Policy to promote recycling and put the responsibility on the producer to ensure their products are returned to them and are disposed of properly or recycled or re-used. The EPR policy will also need to be in place for hazardous materials like car batteries, electronic waste, white goods, cars, and plastics. Shifting the responsibility to the producers will force them to make products that can be easily recycled or reused and with the return policy it will enhance the life of the local landfill.
- Adoption of a mechanism for collecting paper and plastics from households. Currently there is limited awareness about recycling paper and plastic bottles. Collection points will need to be established where these recyclables can be dropped off, or recycling companies will be able to pick up these resources from each household on designated days of the month.
- Introduction of Container Deposit Legislation (CDL) to require the collection of a monetary deposit on beverage containers (refillable or non-refillable) at the point of sale. The CDL was passed in the cabinet in September 2011 but it has not yet been enacted.[202] For the high ambition scenario to increase recycling of plastic, effective implementation of CDL is of paramount importance.
- Introduction of subsidies for recycling companies to counteract the fact that recycled materials are sometimes subject to significant taxes (first when they are sold back to the industry as raw materials and again when they are sold as new products). which reduces the demand for recycled material, compared to virgin material.[203] Fiji intends to introduce tax exemptions to make recycling a lucrative business model in Fiji.
- A final action will involve methane capture from anaerobic digesters at KSTP for co-generation of electricity.

Very High Ambition Scenario

In addition to the actions proposed for the BAU Conditional and High Ambition scenarios, Fiji will pursue the following in the Very High Ambition scenario:

- Naboro Landfill Gas Recovery and electricity generation will begin by 2045 to achieve net zero emissions from the waste sector.

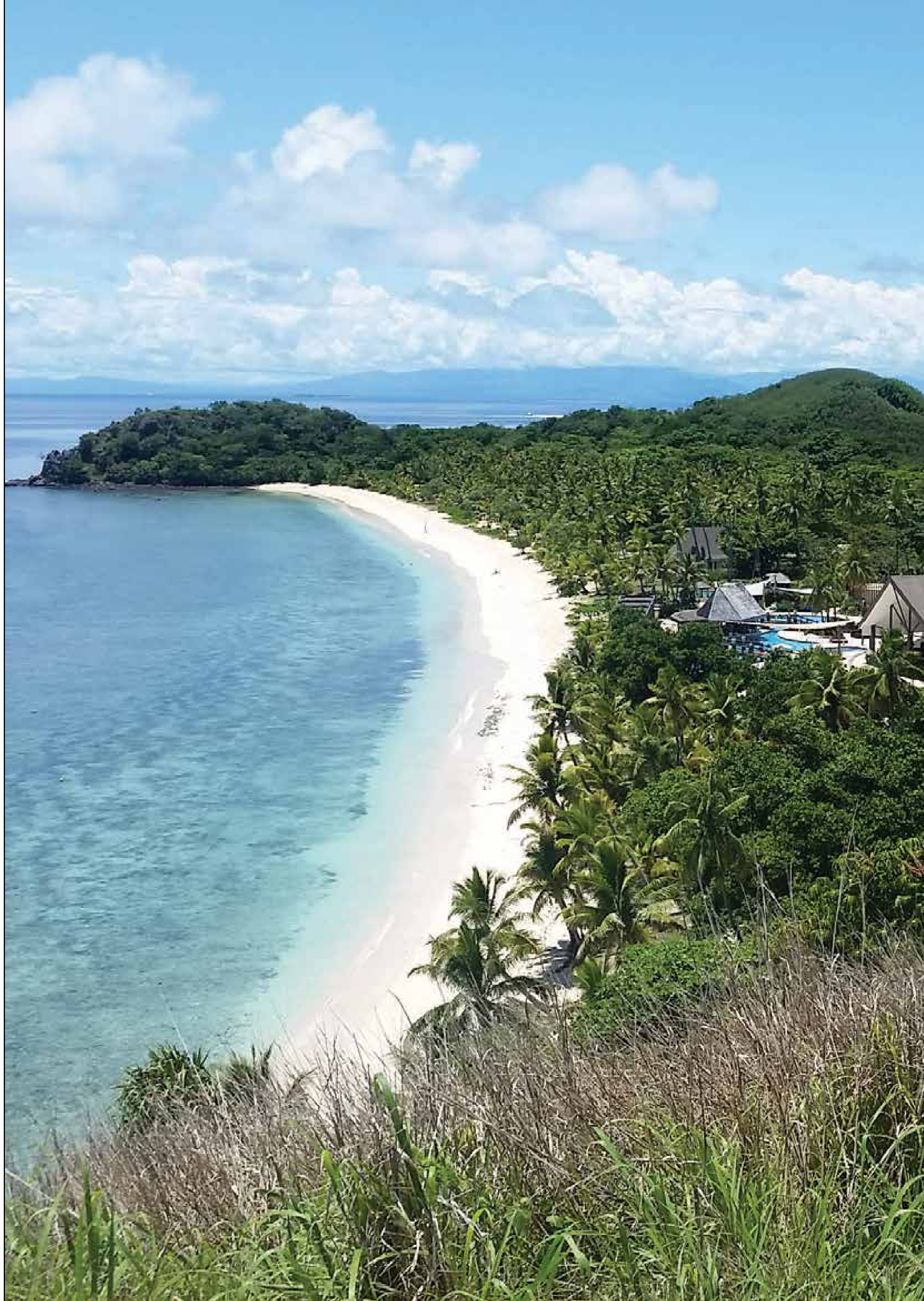
High-Level Costing

This section provides an initial high-level estimation of the cost of some projects identified within the scenarios.

Table 47. High-level costing – Waste.

Projects	Estimated Cost
Composting Facility [204]	FJD 1.5 million consultation with SCC based on replication and upscaling of an existing facility) [205]
Naboro landfill methane recovery and utilization	FJD 4 million (Feasibility Study)
WTE (Kinoya)	FJD 8 million [206]
Implementation of 3R, other legislative policies and creating awareness	FJD 0.6 million per year

[202]http://www.bottlebill.org/legislation/world/fiji.htm
[203]http://ccap.org/assets/CCAP_Net-Zero-August2014.pdf
[204]The composting facility would be one about 10 times bigger than the current capacity, as discussed with Suva City Council.
[205]Personal Communication: Mr. Naresh Narayan, Senior Health Inspector (Operations), Suva City Council, 24th of August 2018.
[206]A proposal was made to WAF by EVO Energy Technologies for power cogeneration for Kinoya. Based on the current capacity of inflow rates, a total investment of FJD 2.65 million was estimated. Due to the ADB investment and current extension plans at Kinyoa, the capacity will almost increase by three-fold and, therefore, the costing is upscaled by a factor of three as well and is estimated to be approximately FJD 8 million.



4.8 CROSS-CUTTING SECTORS: TOURISM, COMMERCIAL, AND INDUSTRIAL AND MANUFACTURING SECTORS

This section provides an overview of low emission pathways for cross-cutting sectors, such as the tourism, commercial, and industrial and manufacturing sectors, and explores how these sectors interact with the electricity, transport, AFOLU, and waste sectors. All sources and emissions described in this section are already reported in the totals provided in sections 4.1 to 4.7 of Chapter 4. This section is intended to provide an illustrative indication of trends and priorities for action, and thus is not to be counted in addition to those emissions described above.

Industrial process emissions are not separately considered in this LEDS due to a shortage of relevant data and the assumption, as shown in Fiji's TNC, that total emissions from this sector are minimal.

4.8.1 Stakeholder Consultation Process

As with other sectors, the LEDS development process included consultations and workshops with stakeholders from the tourism, commercial, industrial and manufacturing sectors. Stakeholders with which the LEDS development process engaged included: Ministry of Sugar, Fiji Sugar Corporation, Fiji Sugar Cane Growers Council, Ministry of Industry and Trade and Tourism, Ministry of Public Enterprise, Vatukoula Gold Mining Limited, Mining and Quarrying Council of Fiji, Newcrest Fiji Limited, Fiji Manufacturers Association, Fiji Export Council, Fiji Hotel and Tourism Association, Duavata Sustainable Tourism Collective of Fiji , Fiji Independent Travelers and Backpackers Association, Talonoa Treks, and Leleuvia Resort, among others.

"The LEDS development process included consultations and workshops with stakeholders from the tourism, commercial, industrial and manufacturing sectors"

During the first national stakeholder workshop, participating stakeholders developed a vision of "A sustainable, responsible, and greener tourism industry by 2050" for the tourism industry, and "A greener and economically viable industry by 2050" for the commercial, industrial, and manufacturing sector. During a half-day second consultation workshop in June 2018, stakeholders from the tourism industry raised the importance of access to improved air, maritime, and land transport for enhancing tourism's potential – underscoring points made elsewhere in the LEDS about the co-benefits of low emission transport.

4.8.2 Tourism Sector

Overview

This section describes the role of electricity generation, transport, AFOLU, and waste to the cross-cutting issue of emissions from tourism in Fiji's economy. Tourism has become increasingly important to the Fijian economy in recent decades with tourism earnings growing from a level of around USD 150 million in 2007 to over USD 800 million in 2016,[207] and contributing significantly to foreign exchange earnings, GDP, and employment.[208] In 2017, a total of 842,884 visitors arrived in Fiji, compared to 792,320 in 2016.[209] The NDP aims to grow the contribution of tourism to GDP from 15% in 2015 to 20% by 2021. The World Travel and Tourism Council expects an overall contribution (indirect, direct, and induced) of 41.4% of GDP by 2027.[210] To illustrate this point, projected tourist arrivals in Fiji through the year 2027 are shown in Figure 77 below.

[207]Fiji Bureau of Statistics. (2018b). *Tourism and Migration Statistics*. Accessed 30th September 2018. Available at https://www.statsfiji.gov.fj/latest-releases/tourism-and-migration/earnings-from-tourism
[208]Government of Fiji. (2014a). *A Green Growth Framework for Fiji*.
[209]Fiji Bureau of Statistics. (2018c). *Visitor Arrivals Statistics*. Accessed 30th September 2018. Available at https://www.statsfiji.gov.fj/index.php/statistics/tourism-and-migration-statistics/visitor-arrivals-statistics.
[210]World Tourism Council. (2017). *Travel & Tourism Economic Impact 2017 Fiji*.

Figure 77. Tourist arrival growth rate for Fiji.

Emissions

Worldwide, the tourism sector is responsible for an estimated 8% of GHG emissions (3.5-4.9 Gt CO_2e).[211] An estimated total of 75% of these emissions are from air, car, and other transport, followed by 21% for accommodation and 4% for other activities (see Table 48).[212]

Table 48. Contribution of various components to tourism sector emissions globally.[213]

Sub Sectors	
Air Transport	40%
Car Transport	32%
Other Transport	3%
Accommodation	21%
[Other] Activities	4%
Total travel and tourism	100%

[211]Lenzen et al. (2018). The Carbon Footprint of Global Tourism. *Nature*.
[212]World Tourism Organization and UNEP. (2008). *Climate Change and Tourism: Responding to Global Challenges, eCLAT.*
[213]World Tourism Organization and UNEP. (2008). *Climate Change and Tourism: Responding to Global Challenges, eCLAT.*

At a national level, the most common sources of energy supply and their usage in hotels are:

- Electricity;
- Thermal energy (LPG) and other forms of fuel for thermal applications (cooking, laundry, water heating, etc.); and
- Petrol and diesel fuel for transport. In Fiji, many hotels also use backup generators that use diesel fuel.[214]

Electricity consumption in Fijian hotels is typically dominated by air conditioning, followed by lighting. Other major consumers of energy are kitchens (cooking), refrigeration, water heating, water pumping, laundry drying, and transport.[215] A feasibility study carried out in 2011 estimated that in Fiji, air conditioning and lighting, accounting for an estimated 70% of electricity use.[216]

A recent survey of hotels found that many are taking actions which will reduce their emissions as shown in Table 49 below. From the total of 42 resorts sampled, 19 responses were received.[217]

Table 49. Percentage of Resorts with Green Initiatives and Green Facilities.[218]

Green Initiatives and Green Facilities	Percentage of Resorts (%)
Directly employed fish wardens, conservation officers or similar.	68%
Formal or informal conservation agreements.	Formal – 39% Informal – 39% Informal – 39% No agreement – 26%
Solar energy supply for the resort.	21%
Practicing organic gardening; for example, through composting.	68%
Water supply and water recycling in the resort; for example, through desalination plants and rainwater harvesting.	95%
Proportion practicing waste management and waste recycling practices.	58%

Existing Policy Framework

The NDP includes the tourism sector as an area for "transformational strategic thrust" and also lists ecotourism as an important part of Fiji's tourism sector. The NDP commits to enhancing domestic air services to support growth in the tourism industry, while mandating sustainable energy use, enforcement of building codes related to energy efficiency, and enhanced waste management.[219] These policies are important to counter emissions growth from the planned increase in number of tourists.

> "Electricity consumption in Fijian hotels is typically dominated by air conditioning, followed by lighting"

The Draft Fijian Tourism 2021 plan aims to grow the tourism industry into a "FJD 2.2 billion industry, increasing arrivals to Fiji to 930,000, deepening the amount spent by tourists, and spreading benefits from tourism throughout the country, while developing a sector that is increasingly sustainable and inclusive in the future."[220] Strategy 21 of the Draft plan directly addresses the carbon emissions from Fiji's tourism sector, which is to "promote climate resilient infrastructure and energy efficiency."[221]

The Green Growth Framework also identifies the need for widespread adoption of CO_2 recovery techniques in tourism, in addition to: increased composting of biodegradable waste, separation of waste materials according to type, and strengthened monitoring of waste disposal by the tourism sector.[222] On greening tourism, the Green Growth Framework identifies the promotion of energy efficiency and waste management as key areas for intervention that impact GHG emissions. The Green Growth Framework encourages widespread use of renewable energy powered transportation in the tourism industry by 2019.[223]

The NCCP also refers to the tourism sector as both a sector that will need to adapt to climate change, but also a major emitter of GHGs in Fiji. The policy emphasises the need to involve the private sector in solutions for low carbon, resilient energy and transport infrastructure, the use of local produce, and investments that demonstrate adaptation co-benefits.[224]

Electricity for Tourism

Future emissions from the tourism sector are included in the emissions described in section 4.1 of the LEDS with respect to the electricity demand projections for the electricity grid. Resorts and hotels on the major islands of Viti Levu, Vanua Levu, Ovalau, and Taveuni are nearly all grid-connected and have been considered in the grid electricity sector in section 4.1 where achieving 100% renewable energy electricity generation will also mean that all grid-connected hotels are running on 100% renewable electricity. This section discusses electricity use for off-grid hotels only.

In 2013, all off-grid resorts and hotels were using diesel generators to meet their electricity demand with an average generator efficiency of 30%, or a total of 4.2 MW in diesel generation capacity. Solar PV and wind use were negligible. Since 2013, a number of off-grid resorts have introduced solar and battery systems to cover all or part of their electricity demand. Wind energy continues to play a very small role in electricity generation.

Low Emission Development Scenarios for Electricity Use in Off-Grid Hotels

It has been assumed that 15% of off-grid hotels are large hotels with an average daily electricity demand of 2,000 kWh and 85% are small hotels with a daily electricity demand of 90 kWh. Furthermore, an AAGR of 0.2% in the number of off-grid hotels is assumed for all scenarios. Therefore, electricity demand is assumed to grow from 10 GWh in 2013 to over 20 GWh by 2050 at an annual rate of 1.5% if no energy efficiency measures are implemented. To mitigate emissions from this increasing energy demand from the tourism sector, this LEDS proposes the adoption of varying capacities of new solar PV, new wind, and energy storage. In the BAU Unconditional and Conditional scenarios new IDO gensets are included. In the High Ambition and Very High Ambition scenarios, all future demand is met by renewables. Based on the above framework, four scenarios were developed with assumptions as described below.

Unconditional Scenario

For demand:

- There are no energy efficiency measures; and
- Energy usage is expected to grow at 1.5% per annum.

For generation:

- Existing technologies are Diesel generators; and
- In the future, new solar PV and new diesel generators are introduced, as solar is already being used by a number of off-grid tourism resort and is therefore expected to continue expansion even under the BAU unconditional scenario.

[214]SPC and GIZ. (2011). *Introduction to Energy Efficiency and Renewable Energy for Hotels in Fiji with applications to other Pacific Island Countries.*
[215]SPC and GIZ. (2011). *Introduction to Energy Efficiency and Renewable Energy for Hotels in Fiji with applications to other Pacific Island Countries.*
[216]WWF. (2011). *PowerPoint Presentation: Hotels Energy Efficiency Project.*
[217]GGGI. (2018b). *Green Jobs Survey.*
[218]GGGI. (2018b). *Green Jobs Survey.*
[219]Government of Fiji. (2017a). *5-Year & 20-Year National Development Plan.*
[220]Government of Fiji. (2017d). *Draft Fijian Tourism 2021.*
[221]Government of Fiji. (2017d). *Draft Fijian Tourism 2021.*
[222]Government of Fiji. (2014a). *A Green Growth Framework for Fiji.*
[223]Government of Fiji. (2014a). *A Green Growth Framework for Fiji.*
[224]Government of Fiji. (2018b). *National Climate Change Policy.*

Conditional Scenario

For demand:

- Energy efficiency measure are implemented; and
- Energy demand is assumed to grow at 1.2% per annum giving rise to almost 10% reduction in energy demand by 2050, compared to unconditional scenario and reducing investment costs.

For generation:

- Existing technologies are diesel generators; and
- In the future, new solar PV, new diesel generators and new wind technologies are introduced.

High Ambition Scenario

For demand:

- There is a greater implementation of energy efficiency measures than in the conditional scenario; and
- The energy demand is assumed to grow at 0.9% per annum giving rise to almost 20% reduction in energy demand by 2050 compared to unconditional scenario.

For generation:

- Existing technologies are diesel generators. This capacity is assumed to be almost completely retired by 2050. By 2030, there will be 3 MW left compared to 4.2 MW in 2013, 2 MW left by 2040 and 1 MW left by 2050; and
- In the future, only new solar PV and new wind technologies are introduced to meet demand.

Very High Ambition Scenario

For demand:

- There is a greater implementation of energy efficiency measures than in the high ambition scenario; and
- The energy demand is assumed to grow at 0.5% per annum giving rise to almost 30% reduction in energy demand by 2050 compared to unconditional scenario and reducing costs of investment in this scenario compared to the high ambition scenario.

For generation:

- Existing technologies are diesel generators. This capacity is assumed to be completely retired by 2050; and
- In the future, only new solar PV, and new wind technologies are introduced to meet demand.

The new capacity and investment required for this are outlined in Table 50. As net zero emissions (through utilization of renewable electricity) can be reached in the High Ambition scenario, the High Ambition and Very High Ambition are similar.

"In the future, only new solar PV, wind and energy storage technologies are introduced to meet demand in off-grid hotels"

Table 50. Generation capacity and investment requirements for the tourism sector until 2050.

		2015	2020	2025	2030	2035	2040	2045	2050
Unconditional									
Cumulative capacity addition (MW)	New IDO	0.44	0.56	0.68	0.84	1.00	1.16	1.80	2.12
	New Solar PV	3.30	4.20	5.40	6.30	7.50	9.00	13.50	16.20
Cumulative investment cost (USD million)		5.97	7.59	9.72	11.39	13.56	16.23	24.41	29.25
Conditional									
Cumulative capacity addition (MW)	New IDO	0.24	0.28	0.36	0.44	0.48	0.56	0.88	1.04
	New Solar PV	1.80	2.40	2.70	3.30	3.90	4.50	6.90	7.80
	New Wind	1.20	1.40	1.80	2.00	2.40	2.80	4.40	5.20
Cumulative investment cost (USD million)		6.42	8.00	9.63	11.25	13.35	15.49	24.05	27.83
High Ambition									
Cumulative capacity addition (MW)	New Solar PV	2.40	2.70	3.30	5.40	5.70	7.80	10.50	12.90
	New Wind	1.60	1.80	2.20	3.40	3.80	5.00	7.00	8.40
Cumulative investment cost (USD million)		8.26	9.29	11.35	18.05	19.61	26.30	36.12	43.85
Very High Ambition									
Cumulative capacity addition (MW)	New Solar PV	2.40	2.70	4.50	6.00	7.50	9.30	11.70	12.30
	New Wind	1.40	1.60	2.80	4.00	5.00	6.00	7.80	8.20
Cumulative investment cost (USD million)		7.73	8.76	14.95	20.64	25.80	31.46	40.25	42.31

These new technology investments are projected to result in the following electricity generation mix for tourism from 2013-2050, as shown for the different scenarios in Figures 78 through 81 below.

Figure 78. Unconditional scenario electricity generation for off-grid hotels.

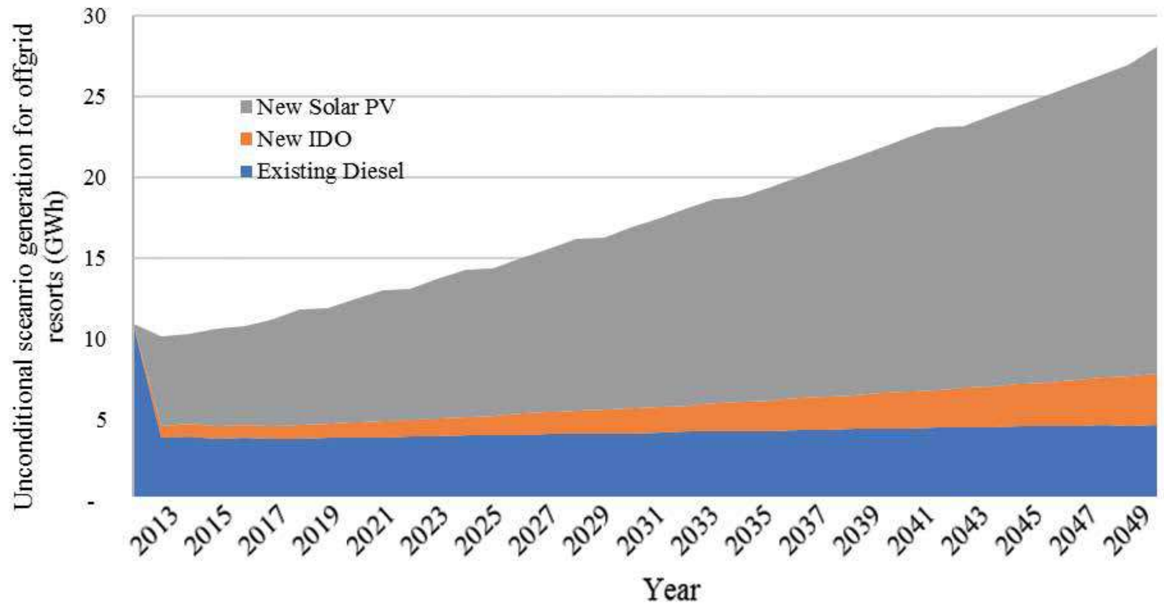


Figure 79. Conditional scenario electricity generation for off-grid hotels.

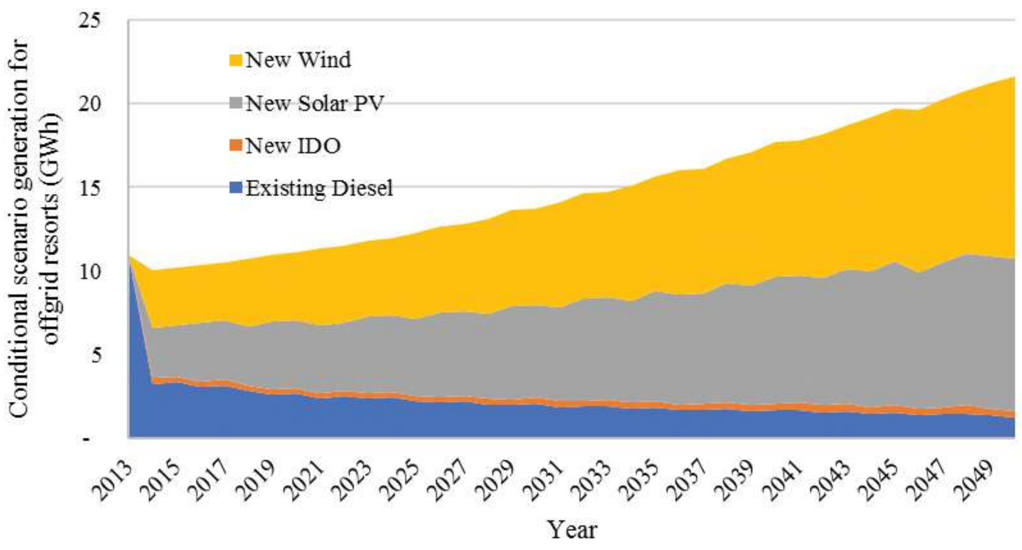
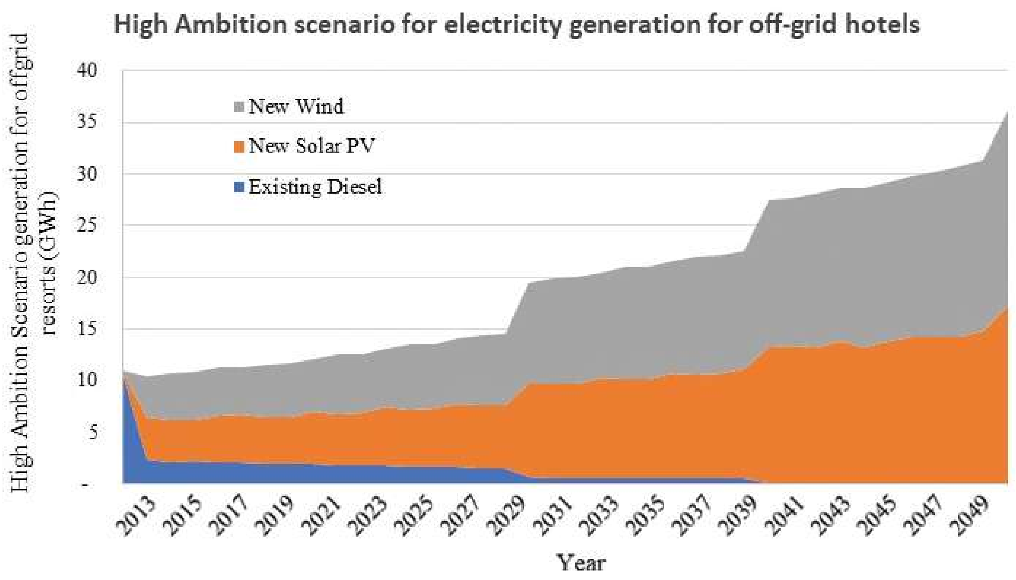
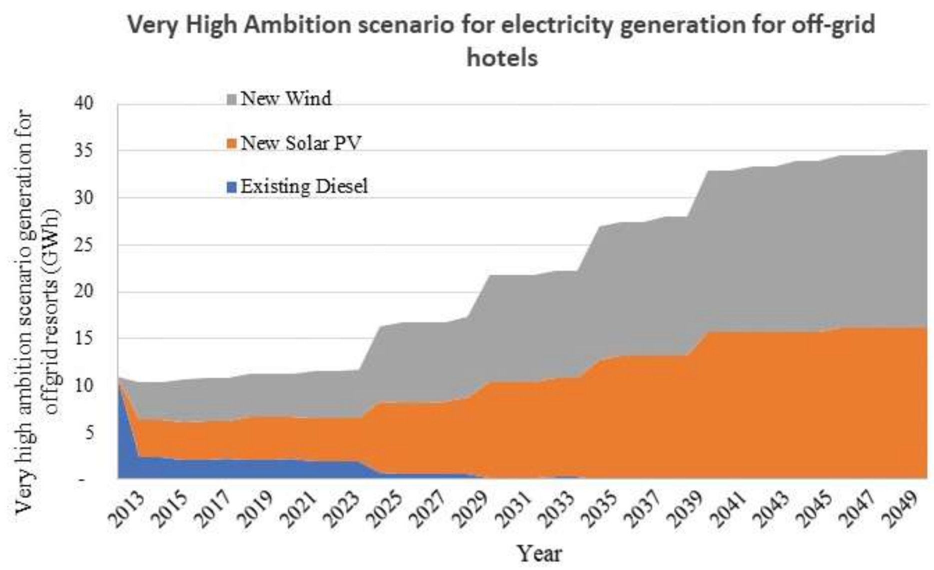


Figure 80. High Ambition scenario for electricity generation for off-grid hotels.[225]



[225]Under the High Ambition and Very High Ambition scenarios, existing diesel generators are retired much earlier (in 2030), compared to the BAU scenarios. This means that new solar PV and new wind would be added to meet the demand. In the modelling, the dispatch rule used for solar and wind technologies is "full capacity." This means that if wind and solar PV are online, then they will be generating based on their available full capacity and are not curtailed to just meet the demand. Therefore, although energy efficiency measures are applied for the HA and VHA scenarios, this is not reflected in Figure 80 and 81. In reality, the excess electricity generated would be sent to a suitable storage system.

Figure 81. Very High Ambition scenario for electricity generation for off-grid hotels.



"Energy efficiency can play a large role in reducing emissions and investments costs for the tourism sector"

The total renewable energy contributions to electricity generation are outlined in Table 51 below. Energy efficiency savings would also be expected of 10% under conditional, 20% under high ambition and almost 30% under very high ambition, which would also play a large role in reducing emissions and investments costs for the tourism sector.

Table 51. Renewable energy contributions to meeting off-grid hotel electricity demand in 2030 and 2050.

% contribution	Unconditional	Conditional	High Ambition	Very High Ambition
2030	65	82	97	99
2050	72	92	100	100

Transport for Tourism

Of course, domestic air, land, and maritime transport are also crucial components of the tourism sector. This LEDS already includes mitigation actions aimed at promoting the decarbonisation of Fiji's domestic air sector in section 4.4, including extensive use of solar energy to power Fiji's airports as well as other measures. Solarisation of the airports would be a very visible action for the domestic air sector. In the land transport sector (section 4.2) major emissions reductions will be achieved through the adoption of HEVs and EVs. It is envisioned that the tourism sector's land transport vehicles will participate in this transition on the same timeline as the rest of the economy. There is, however, an opportunity for the tourism industry to be a first-mover in adoption of hybrid and electric vehicles, which can immediately contribute to increasing Fiji's image as a green tourist destination and allow tourism-oriented businesses to increasingly market Fiji as a green tourism destination.

Similarly, marine transport services are an important part of the tourism sector. The domestic tourism maritime fleet is among the largest for emission sources for maritime transport contributing 19.3% to overall emissions for that sub-sector in 2016 (see section 4.3). While maritime transport emissions are presumed to be low for hotels on Viti Levu, fuel usage for transport to and from the many island resorts in the Yasawas, Mamanucas, and elsewhere is estimated to result in both high costs for hotels and in high emissions.[226] While many of Fiji's coastal tourism operators value and promote "green" attributes and have taken steps to introduce energy efficiency and renewable electricity, to date there has been limited consideration given to greening maritime transport. Responsible tourism operators have a strong track record as market innovators in terms of maritime transport, and there are significant opportunities to leverage greening of the domestic shipping fleet. Section 4.3 covers many of the options which are also available for the tourism fleet. Further, there is an opportunity to reduce fuel use through transition from 2-stroke to 4-stroke outboard motors in the tourism maritime transport sub-sector. A saving of 30-40% in fuel use is possible, with corresponding savings in emissions. There are also a small number of tourist attractions which feature low or zero carbon vessels (solar and wind power being the predominant technologies used). It will soon also be possible to use electric outboard motors, which could be powered through solar energy as well as, to deploy zero-carbon vessels operating predominantly using solar and wind power technologies.

Agriculture, Forestry, and Mangroves for Tourism

Agriculture, forestry, and related land use is an integral component of tourism in Fiji. Ecotourism often takes place in regions where the land cover is largely natural, particularly natural forests. However, the economic importance of ecotourism in Fijian forests is relatively low as most tourism is coastal, and mangroves play a more important role in these areas. Tourism can play a role in promoting the economic as well as low carbon benefits of forest and mangrove conservation, as these ecosystems provide the "product" being sold to tourists.

Tourism also has a strong influence on the agriculture sector. As guests need to be supplied with food, the number of visitors and the length of their stay have a direct impact on local agriculture. A substitution of imports with food produced in country could lead to a substantial increase in agricultural production. Therefore, to cater for the tourism industry, increasing local agricultural production would result in an increase in emissions, especially in livestock farming and meat production.

Tourism is an energy intensive industry with several of its activities contributing to the increasing the carbon footprint of Fiji and, if not managed well, decreasing carbon sinks, such as forests and mangroves. On the other hand, the tourism industry can also be aligned to the measures proposed by the LEDS for agriculture, forestry, and mangroves, thereby promoting low carbon growth in the industries that support its food, furniture, and other supply chains.

Waste and Tourism

Tourism in Fiji also contributes significantly to solid waste generation, particularly food, plastic, and general waste. All the waste emissions from the tourism sector on the main islands of Fiji are included in section 4.7.

Currently, most waste in Fiji's tourism sector is landfilled or dumped at solid waste disposal sites with very limited recycling and diversion of organic waste. There are many off-shore island resorts that recycle solid waste and waste water in recognition of the scarce resources available on the smaller islands and the high transport cost of both bringing commodities and shipping waste, off the islands. New, more rigorous and more widespread waste management plans are needed to reduce the waste generated in the tourism sector, and to provide greater opportunity for recycling paper and plastics and composting food waste.

The actions needed are highlighted in section 4.7 for the economy as a whole and the same actions largely hold true for the tourism sector, including greater implementation of recycling, reuse, and reduction of waste. The High Ambition Scenario for the waste sector envisions 40% of plastics and 30% of paper be recycled to reduce emissions and includes measures to place recycling bins in all hotels and resorts accompanied by fines for failing to do so. The introduction of minimum waste management standards in the tourism sector are an additional measure, accompanied by enforcement measures. Food waste generated in hotels can be composted at little additional cost to the hotel and used in in-situ organic gardens, reducing transport costs. Another option is to use food waste in anaerobic digestors to produce biogas for cooking. Both options are win-wins for the tourism industry and the environment as the tourism industry will avoid the costs of transporting waste to SWDS. From an environmental viewpoint, diverting organic waste from the landfill reduces GHG emissions, thereby achieving the emission reduction targets in the waste sector.

[226]For example, one Fijian resort on a small island currently uses approximately 80,000 L of fuel for its maritime transport, in comparison to 36,000 L for electricity and water desalination annually.

4.8.3 Commercial, Industrial, and Manufacturing Sectors

Overview

Fiji's commercial sector, excluding farming, manufacturing, transport, and tourism, consists of service-providing facilities and businesses and consumes high levels of energy and resources, largely through energy use in buildings and in transport. Commercial buildings are those that are used for commercial purposes and include: office buildings, warehouses, and retail buildings (e.g., convenience stores, large stores, and shopping malls). The commercial sector contributes significantly to GDP, with wholesale and retail, ICT services, real estate, and finance and insurance alone contributing a combined 32% of GDP.[227] With respect to energy, the primary sources of emissions in the commercial sector are emissions from grid and off-grid electricity use, including from diesel and HFO generators, LPG used for cooking, and other fuel use for thermal applications, as well as emissions from fuel used for transport.

> "The industrial and manufacturing sector generates around 16% of total CO_2 emissions, the second largest source of emissions after transport"

The industrial and manufacturing sector in Fiji is closely associated with the use of natural resources as well as energy for operating production plants and equipment which process raw materials into finished goods. Manufacturing contributes approximately 14% of GDP, while construction and mining contribute approximately 3% and 2%, respectively.[228] When considering its contribution to emissions across all sectors, it is estimated that the cross-cutting manufacturing sector – including manufacturing of textiles, garments, footwear, sugar, tobacco, food processing, beverages (including mineral water), wood-based industries, cement, and construction activities – generates around 16% of total CO_2 emissions, the second largest source of emissions after transport.[229] While emissions from primary agricultural production are allocated to the AFOLU sector, emissions from food processing are allocated to the industry and manufacturing sector. The cement and mining industry are highly energy intensive industries.

Electricity Use

In this LEDS, commercial demand for grid electricity is expected to grow by 2.6% per year in the BAU Unconditional scenario and LPG demand grows by 5% per year in BAU Conditional, High Ambition, and Very High Ambition scenarios. The actions for mitigating emissions from electricity in the commercial sector are covered by sector 4.1 on electricity.

Another consideration is electricity generation and consumption by industries and manufacturing plants to process raw materials and to produce marketable products, such as in mining. Emissions from this sector have been covered within section 4.1 on electricity. As noted in section 4.1, significant off-grid emissions also exist in the case of Vatukoula Gold Mines PLC (VGM) which is fully dependent on diesel generators. Figure 82 below displays the emissions from VGM for the four scenarios, and Figure 83 displays the total investments required to achieve long-term deep decarbonisation for the scenarios. Measures to shift the mine to grid-based electricity can mitigated significant emissions as the grid moves to 100% renewable generation.

[227]Fiji Bureau of Statistics. (2017). *Key Statistics – National Income, GDP by Industry, December 2017.*
[228]Fiji Bureau of Statistics. (2017). *Key Statistics – National Income, GDP by Industry, December 2017.*
[229]Government of Fiji. (2014a). *A Green Growth Framework for Fiji.*

Figure 82. Emissions from Vatukoula Gold Mine generation.

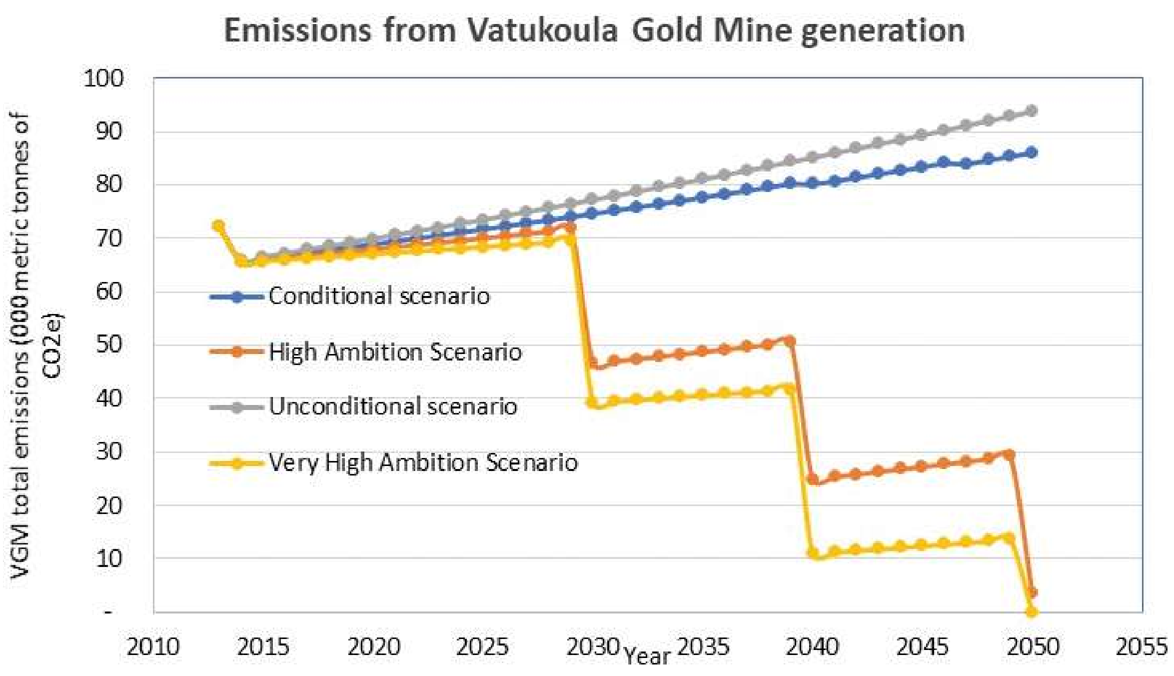
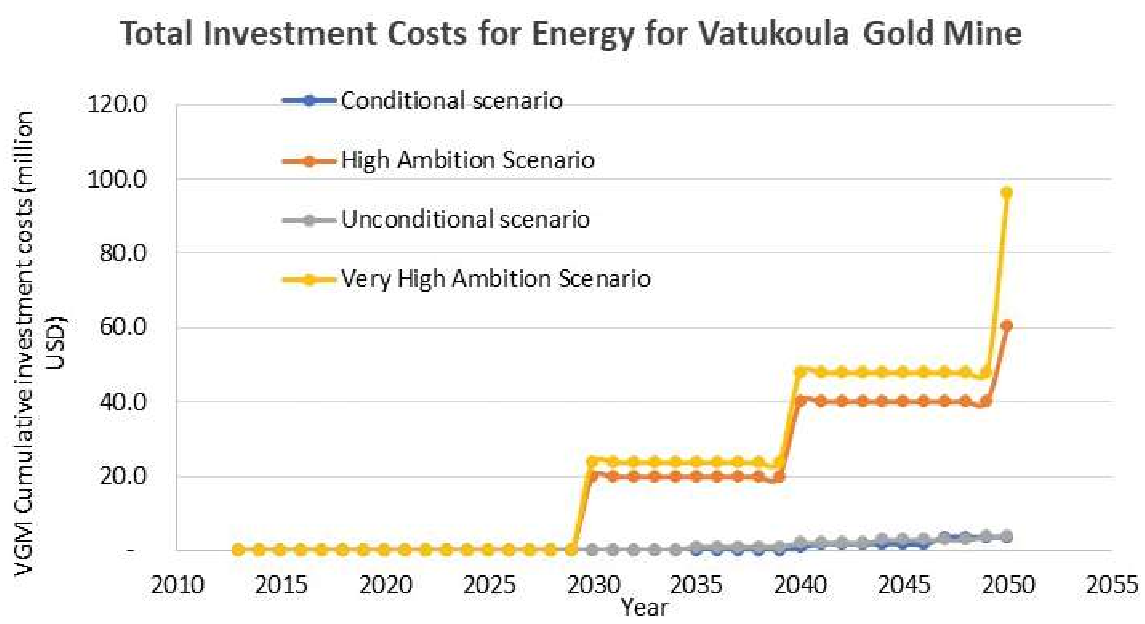


Figure 83. Total Investment Costs for Energy for Vatukoula Gold Mine.



Transport

The commercial, industrial, and manufacturing sectors are heavy users of transport services. As seen in section 4.2 on land transport, trucks and heavy goods vehicles largely used in the commercial, industrial, and manufacturing sectors emit 45% of GHG emissions in the land transport sector, even though they only make up only about 19% of vehicles on the road.

The costs of implementing mitigation actions in land transport are predicted to be especially high for the commercial, industrial, and manufacturing sectors due to increasing costs for transitioning larger freight transport vehicles towards hybrid and electric. These vehicles are expected to be more expensive than those currently used, especially since many commercial vehicles on the road today are either old or second-hand.

Another action that will add cost but cut emissions is the scrapping of freight vehicles after they reach 15 years of age as mentioned in the High Ambition Scenario of section 4.2 above. As trucks would be used over a shorter period, this again would increase transport costs and affect primarily the commercial sector and the agricultural industry, such as Fiji's sugarcane industry which relies heavily on old and very old trucks. It is worth noting that there are around 1,500 sugarcane trucks, representing about 7% of the truck fleet, operating during a four-month harvesting season, i.e., their annual mileage is only a fraction of the mileage of conventional trucks. Hence, sugarcane trucks only represent around 1% of total and 2% of truck emissions of Fiji. The small annual mileage driven by these units will also make replacement with new trucks costly as investments will need to be recovered very slowly.[230] These investments will, nevertheless, be necessary to successfully decarbonise Fiji's sugar, and more broadly, agricultural industry.

Fossil fuels currently comprise between 40-60% of most shipping operational expenditures. While decarbonisation of the maritime transport sector through improved energy efficiency, renewable energy, and biofuels poses real and significant challenges to Fiji, it is also an opportunity for the commercial sector to renew its fleet and save operational costs. The prime opportunity for Fiji's commercial sector is to utilize a decarbonisation plan to deliver alternative shipping services that are carbon friendly and cut recurring fuel costs, enabling more stable prices and efficient operation of routes. Upfront capital costs will be high, but if these can be overcome through subsidy shifts from recurring costs to capital costs, there will be savings in operational expenditures in the short-term and the structural changes to the maritime freight sector will be economically beneficial in the long-term through environmental co-benefits of less local pollution.

Transitioning to a decarbonised domestic shipping sector will require significant investment by both the government and the private sector, initially to retrofit existing ships and ultimately to build new ships and change operational practices (please see Maritime transport chapter for options available). As noted in section 4.3 above, future scenarios are envisioned where larger fleets of smaller vessels operating on a hub-and-spoke model are expected to replace Fiji's current reliance on a smaller number of larger ships. This offers the potential to revitalise Fiji's ship building industry. While this may include construction of larger vessels, there are numerous opportunities for smaller industrial expansion into the niche markets of manufacturing, fitting, maintaining, and adapting individual technological components such as Flettner rotor[231] housings, improved electric hybrid componentry, including maritime battery technologies, sales and service of small boat improved hull designs, e-motors, hybrid and auxiliary sail systems, and other green technologies.

Agriculture, Forestry and Other Land Use

For the AFOLU sector, commercial and smallholder agriculture are the main drivers of deforestation. Commercial agriculture has established increasing amounts of cash crops, such as kava and taro given the favourable market conditions, both of which have been a common cause of deforestation. Although commercial harvesting of native forests has been significantly replaced by timber extraction from plantations, this timber harvesting to supply commercial markets is the main contributor to unregulated forest degradation. Introduction of more sustainable practices for commercial agriculture will be important in enabling Fiji to reach net zero and net negative emissions in the AFOLU sector as outlined in section 4.6.

Commercial forestry and agriculture also play an important role in avoiding emissions in the electricity sector. Emissions from fossil energy sources are avoided through the use of bagasse, wood, and woody biomass

[230]GGGI. (2017). *Emission control strategy for trucks and buses in Fiji.*
[231]A Flettner rotor is a smooth cylinder with disc end plates which is spun along its long axis and, as air passes at right angles across it, the Magnus effect causes an aerodynamic force to be generated in the third dimension.

for electricity production.[232] For Fiji's net zero electricity sector, many commercial plantations, specifically for biomass production for the electricity sector, will have to be planted, creating jobs and income in a new and growing industry for Fiji. The use of wood for energy is carbon neutral, whereas the material use of wood in manufacturing generally produces significantly lower emissions than when manufacturing comparable products made of non-renewable materials. For example, manufacturing a wooden window frame typically results in one twentieth of the emissions of manufacturing an aluminium window frame. (For this LEDS, the energetic use of wood and resulting emissions are considered part of electricity use in commerce, industry, and manufacturing. Nevertheless, emissions are assumed to be net zero; additional analysis would be required to quantify any emissions from the burning of biomass).

Policy Recommendations and Priority Actions

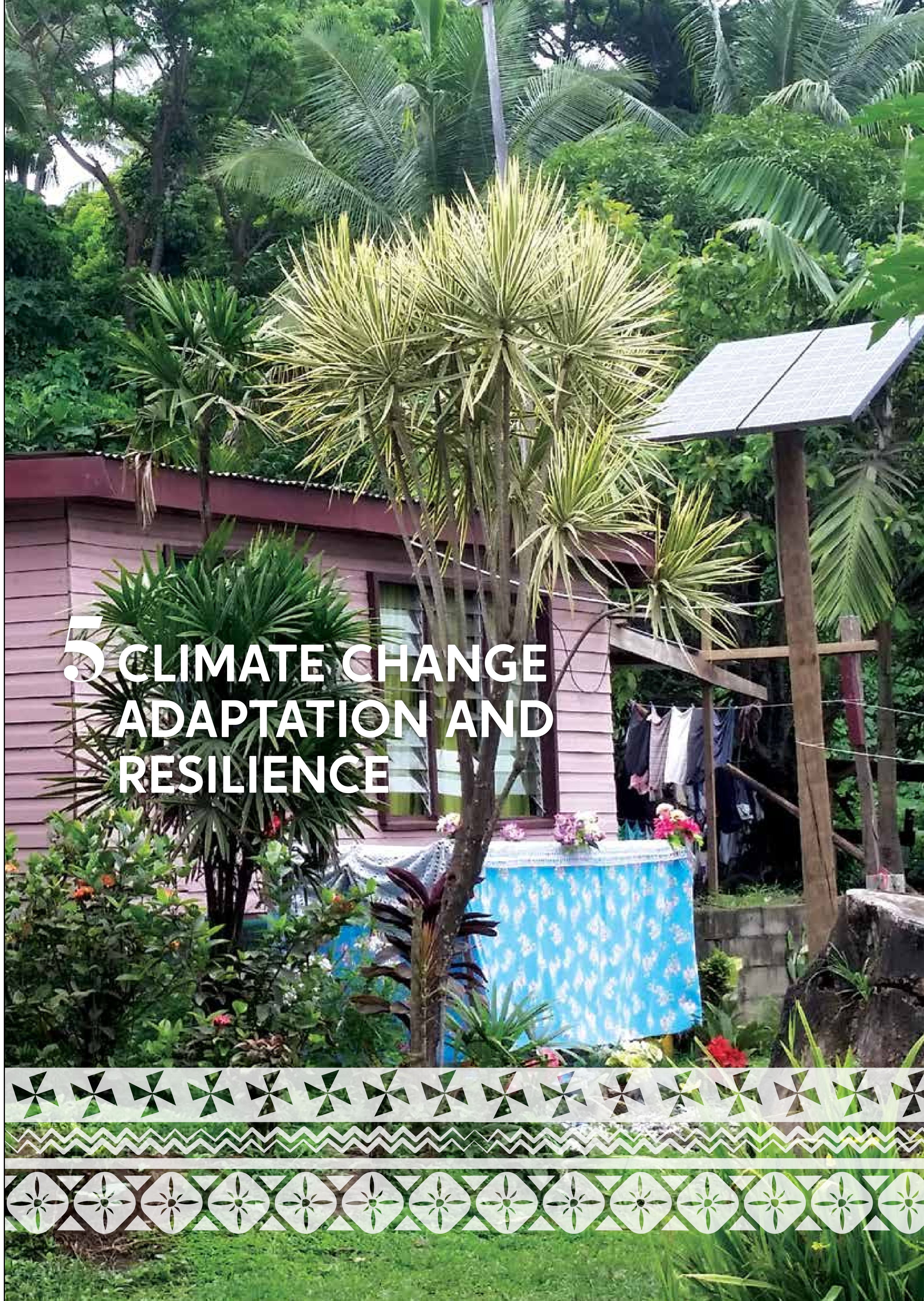
Many policy recommendations and priority actions from other chapters will also have a significant impact on the tourism, commercial, manufacturing, and industrial sectors. Some of the short-term measures which will result in sustained emission reductions include:

- Mainstreaming low carbon development into all tourism-, commercial-, and manufacturing-related plans, frameworks, and legislation;
- Promoting energy efficiency and renewable energy use in these sectors through appropriate incentives and regulations;
- Benchmarking of energy consumption and introducing minimum energy performance standards for hotels and resorts, as well as for commercial buildings;
- Adoption of the ISO 50001:2011 standard in the tourism and commercial sectors;
- Incentives introduced for switching from 2-stroke to 4-stroke outboard motors, for electric motors, and for solar charging for tourism vessels;
- Connection to the grid of major off-grid industrial and manufacturing energy users, such as mines, where possible so that their electricity is sourced from renewable energy rather than diesel or HFO gensets (e.g., specifically, the completion of the Vatukoula Gold Mines Grid Extension, including the connection of other industry in the area);[233] and
- Promoting use of wood in commercial, industrial, and manufacturing sectors and the production of wood and biomass-based products.

Many of these actions need to be taken alongside actions for climate-resilient tourism and commercial development, such as resilient energy and transport infrastructure for tourism and commerce, use of materials and building techniques which consider climate change affects to improve durability and lifetime of developments, and other measures. Climate change will similarly affect forestry and agricultural sectors and may impact their ability to contribute to mitigation actions. Thus, building resilience in agriculture and forestry to climate change can also contribute to meeting mitigation targets.

For additional information on the linkages between low emission development and climate change adaption, please see Chapter 5.

[232]The energetic use of wood also leads to the release of CO_2. However, it is important to note that only the amount of CO_2 that was previously sequestered from the atmosphere by biomass growth is emitted into the atmosphere.
[233]Government of Fiji. (2017b). *NDC Implementation Roadmap 2017-2030.*



5 CLIMATE CHANGE ADAPTATION AND RESILIENCE

5.1 NATIONAL CONTEXT – CLIMATE RISK IN FIJI

Fiji is one of the most vulnerable countries in the world to climate change due to its geographic location, status as a SIDS, and the importance of natural resources to its main economic sectors (such as agriculture and tourism). Fiji is particularly vulnerable to floods and tropical cyclones (TCs), which already have significant impacts on the economy and society.[234] Fiji is located among the most vulnerable sub-regions in the Pacific in terms of the intensity and frequency of severe natural disasters. The impact of climate change on Fiji will depend on regional factors, such as the South Pacific Convergence Zone.

While there is limited data on climate change in Fiji, according to the National Meteorological Service, by 2016 the mean average air temperature in Fiji increased by 0.9°C over the past 50 years due to climate change. The average sea temperature also increased by 0.3°C every 10 years over recent decades.[235] While long-term precipitation patterns have not changed and the number of TCs affecting Fiji has slightly decreased, there has been a statistically significant increase in the intensity of those cyclones. An average of 28 cyclones per decade developed within or crossed Fiji's EEZ between 1969/70 and 2010/11 seasons. 25 out of 78 (32%) TCs between the 1981/82 and 2010/11 seasons became severe events (Category 3 or stronger) in Fiji's EEZ.[236] The average number of TCs for all the 49 seasons (November – April) 1969/70 to 2017/18 is 7.1 TCs.[237] The estimated average annual asset losses due to TCs and floods is approximately USD 234.16 million, or FJD 500 million. In 2016, tropical cyclone Winston alone resulted in a loss of 20% of Fiji's total GDP, or FJD 2 billion.[238] TCs and floods also have severe impact on poverty, causing an estimated 25,700 people, or 3.7% of Fiji's total population, to fall into poverty in 2017.[239]

The predicted annual rainfall for Fiji under different emission scenarios varies and shows insignificant changes over time. However, the models show that Fiji's average temperature is likely to increase with high and medium confidence. Although the frequency of climate hazards is not expected to change significantly in the future, all models predict increasing intensity of TCs resulting in more severe damage.[240]

Infrastructure in Fiji – including water, energy, and transportation systems – are concentrated along the coast and, therefore, particularly exposed to climate change risks, such as sea-level rise and exposure to storm surges. Since basic infrastructure provides critical services to other sectors, any risks to infrastructure can negatively impact all economic activities. Although it is too early to predict the exact impacts of climate change, increasing temperatures in coastal areas and coral reef bleaching events are already visible impacts of climate change in Fiji.

To address the risks posed by climate change challenges in the near- and long-term, Fiji prepared a national Climate Vulnerability Assessment[241] and a National Adaptation Plan Framework[242] in 2017 and adopted the National Adaptation Plan (NAP) in 2018. Under its NAP, Fiji's vision is "to anticipate, reduce, and manage environmental and climate risks caused by climate variability and change to support a vibrant society and prosperous economy."[243] The long-term mitigation actions envisioned in this LEDS are intended to align directly with, and complement, the adaptation actions prioritised in the NAP. While the specific sub-sectors addressed in this LEDS do not match those in the Climate Vulnerability Assessment, the two plans are comprehensive and should be seen as directly complementary.

[234]Government of Fiji. (2018a). *National Adaptation Plan.*
[235]Government of Fiji. (2018b). *National Climate Change Policy.*
[236]BOM. (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. In *Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report.* Melbourne: Australian Bureau of Meteorology (BOM) and Commonwealth Scientific and Industrial Research Organisation (CSIRO).
[237]Fiji Meteorological Service. (2018). *Tropical Cyclone Outlook 2018-19.* Accessed 5th November 2018. Available at http://www.met.gov.fj/aifs_prods/TC_SeasonalOutlook_2018_19.pdf.
[238]Government of Fiji. (2017c). *Climate Vulnerability Assessment.*
[239]Government of Fiji. (2017c). *Climate Vulnerability Assessment.*
[240]Government of Fiji. (2018a). *National Adaptation Plan.*
[241]Government of Fiji. (2017c). *Climate Vulnerability Assessment.*
[242]Government of Fiji. (2017e). *National Adaptation Plan Framework.*
[243]Government of Fiji. (2018a). *National Adaptation Plan.*

While mitigation strategies, such as those included in Fiji's NDC and this LEDS, do not directly influence climate resilience, they are expected to have synergistic benefits in climate adaptation and overall climate resilience. Building climate resilience into mitigation actions can help avoid or reduce the impacts of climate change in those actions. Fiji's proactive adaptation planning can be amplified through the enhanced mitigation measures contained in this LEDS when the implementation of these measures is undertaken jointly with climate adaptation actions.

5.2 CLIMATE VULNERABILITY FRAMEWORK

Fiji's 2017 Climate Vulnerability Assessment covers all sectors and has prioritised five key intervention areas to address climate change impacts more effectively over the next decade, these are: increasing urban resilience; improving infrastructure services (resilient power systems, transport, infrastructure); supporting climate smart agriculture and fisheries; conserving ecosystems; and building socioeconomic resilience.

Critically, Fiji's Climate Vulnerability Assessment serves as the policy basis for actions to build Fiji's climate resilience over the next decade in five intervention areas: ensuring serviced land and housing in safe areas; strengthening infrastructure to meet the needs of the economy and population; supporting agriculture and fisheries development that is smart for the climate, the environment, and the economy; enacting conservation policies that protect assets and reduce adaptation costs; and building socioeconomic resilience, taking care of the poor, and keeping economic growth inclusive.

Because the Climate Vulnerability Assessment, and its identified interventions, are oriented towards climate resilient infrastructure, urban areas, agricultural systems, asset protection, and inclusive economic growth, it is essential that such systems are designed with in-built climate resilience as they are decarbonised. Climate resilience and mitigation actions are in many ways synergistic; the more mitigation is undertaken, the less adaptation that may be necessary in the long-term.

5.3 NAP FRAMEWORK AND NAP

The Government of Fiji adopted its NAP Framework in October 2017 and submitted it to the UNFCCC Secretariat in June 2018. The NAP Framework provides Fiji's approach to enhance capacity to undertake climate change adaptation under the UNFCCC process. The NAP Framework builds on guiding principles, such as participatory and inclusiveness, pro-poor, robust decision-making, and managing trade-offs.[244] These principles apply to the main policy guidance for mitigation and adaptation that stem from the revised NCCP, the Green Growth Framework and the adaptation component of the Government of Fiji's NDC. These important policies inform the NAP, which serves as the vehicle for translating the short-, medium-, and long-term goals into action.

The NAP process aims to incorporate climate change adaptation planning into sustainable development strategies, while minimizing the irreversible impacts of climate change during the development process. The NAP also specifically identifies the linkages and synergies with this LEDS. The focus of the NAP is climate adaptation planning, and while it does not directly address mitigation actions, it does consider mitigation co-benefits by prioritising "low-regret options," such as those developed in this LEDS.[245]

The Government of Fiji used an ecosystem-based adaptation (EBA) approach for its NAP Framework to complement efforts to build local- and community-level climate resilience. The NAP mainstreams climate resilient planning across the economy and will achieve social, economic, and environmental benefits, while actively integrating adaptation and mitigation strategies. The EBA approach has already been used in Fiji's Integrated Coastal Management Framework (2011), the National Biodiversity Strategy and Action Plan (2005), and the National State of Environment Report (2013).

The Government of Fiji has raised awareness of its NDP, and of climate resilient development in general, but effectively implementing the Plan at the sub-national level has been challenging. The NAP Framework enhances the interlinkages between national- and

[244]Government of Fiji. (2017e). *National Adaptation Plan Framework.*
[245]Government of Fiji. (2018a). *National Adaptation Plan.*

sub-national-level government agencies, while facilitating cross-sectoral collaboration, to effectively address climate adaptation. The same network can be utilized to implement other government policies and strategies, including those related to climate change mitigation and poverty reduction.

The NAP describes adaptation measures for five "sectors," including: food security, which encompasses agriculture and fisheries health; human settlements; infrastructure, which includes water and sanitation, energy, transport, and hazard management; and biodiversity and the natural environment, which includes mangroves and natural forests.[246]

The NAP calls for short-term and long-term adaptation measures consistent with this LEDS for reducing climate and environmental risk in each sector. With regard to infrastructure (including energy, transport, and waste), this includes working to ensure infrastructure functions for its full intended lifespan as well as promoting infrastructure that is resilient to climate risks and can meet all future needs while operating under future conditions. Regarding agriculture and fisheries, the NAP aims to improve capacity to anticipate climate events and to transform and reorient the agricultural system to produce food sustainably without degrading soils. The NAP also calls for supporting biodiversity (including mangroves) and the natural environment and the services it provides.

5.4 MAINSTREAMING CLIMATE RESILIENCE INTO CLIMATE MITIGATION ACTIONS

One of the main challenges to mainstreaming climate resilience in Fiji across all sectors is closing the data gap and conducting a comprehensive assessment of climate change impacts and actions to adapt to and mitigate climate change. Climate change models can also be improved with comprehensive and complete observations and real-time data. The NAP calls for a comprehensive climate assessment, to be repeated as part of a regular process, which would contribute to more complete data collection on climate actions and risks in Fiji. This would include observations of climate risks and impacts on individual sectors (including those covered in the LEDS) as a key initial step for developing long-term climate resilience strategies.

While a number of mitigation strategies proposed in this LEDS contribute to efforts to improve climate resilience, long-term climate vulnerabilities and risks will require regular attention and response measures, particularly as they may undermine mitigation efforts. The Climate Vulnerability Assessment, NAP Framework, and NAP combined serve as the foundation for promoting adaptation and resilience for Fiji, and these should be implemented in close coordination with the mitigation strategies outlined in Fiji's LEDS, over the long-term, and NDC, in the near-term (as well as future updates to Fiji's NDC and LEDS).

Key questions that Fiji will need to address and periodically review in considering climate resilience in mitigation measures include the following:

1. Will the mitigation action or project be affected by predicted climate change risks?
2. How will the mitigation action be affected and how can those risks be reduced or eliminated?
3. Will the climate change adaptation measure or project increase carbon emissions?
4. Is there a low or no-carbon alternative to the adaptation measure or project?
5. Are there adaptation actions that will increase the mitigation potential of the activity or project, or vice versa?

5.5 SYNERGIES BETWEEN ADAPTATION AND MITIGATION ACTIONS IN THIS LEDS

While the broad linkages and synergies between adaptation and mitigation planning processes are outlined above, there are also sector-specific synergies. Each section below briefly explores sector-specific climate risks, linkages and synergies for the sectors included in the LEDS.

[246]Government of Fiji. (2018a). *National Adaptation Plan.*

5.5.1 Infrastructure: Electricity and Other Energy Generation and Use

As with other infrastructure, on-grid and off-grid electricity generation is at increased risk from sea-level rise (in coastal areas), floods, and cyclones and other extreme weather events (particularly hydropower facilities and electricity transmission lines). Certain feedstocks used in biofuel and biojet production could also be adversely affected by severe weather and, thus, measures will need to be taken to consider these risks. It is also worth noting that extreme weather events, including natural disasters, could also create pressures to "fall back" on more conventional off-grid fossil fuel-based energy systems – e.g., gensets, when existing generation systems are off-line – hence, there is a need to make preparations that avoid those options where possible.

With regard to energy, the NAP outlines several short-term and long-term strategies, all of which are consistent with and highly complementary to proposed mitigation actions for electricity and other energy use in the LEDS. Design, installation, and construction standards involved in implementing LEDS scenarios will need to be reviewed to meet climate resilience requirements. Mitigation plans considered in the LEDS were developed with recognition that wind farms, solar PVs on rooftops and reservoirs, and solar home systems (SHSs) may be at risk from damage from extreme events, such as TCs, extreme rainfalls, floods, storm surges, and droughts. Similarly, there will be a need to assess operation of hydropower and other renewable energy sources to maximise output under new climate conditions.

In the near-term, the NAP proposes to endorse the National Energy Policy and to create a long-term resilience strategy for the energy sector that addresses the most vulnerable power system and network components and works to use international and domestic financing for priority investments. Consistent with the LEDS, the NAP proposes to investigate options for increasing energy resilience through demand-side management and to expand solar generation, including additional generation in Northwest Viti Levu (5.5 MW solar plants with storage) and distributed generation in Vanua Levu (5 MW). The NAP also proposes to enhance insurance coverage of key energy assets as part of the national Disaster Risk Financing Strategy and to expand underground distribution lines. Long-term strategies include: diversifying renewable energy generation to improve resilience (directly consistent with proposed High Ambition and Very high Ambition scenarios in the LEDS); increasing investments in rural mini-grids and solar home systems (simultaneously investing and improving design and installation standards to ensure their resilience) and diversifying distributed generation options (including mini-grids); working to optimise hydropower operations under new climate conditions; and reviewing design and construction standards for energy facilities and solar home systems for climate resilience.

The NAP emphasis on the national development pathway towards climate-resilient development in the long-term should ensure that mitigation actions are risk-proofed during installation to reduce their vulnerability to future climate change impacts, while insurance of assets should also be enhanced. The NAP, thus, recommends an assessment of the costs and benefits of key measures for improving the resilience of the power system and sourcing of concessional funds to meet the financial viability gap. This action will also strengthen the financial viability and sustainability of the LEDS mitigation actions. It is also worth noting that if the global community fails to halt further increase in temperatures, it may increase demand for energy use and projections from mitigation actions may fall short of the targets. Again, taking a national development pathway towards climate-resilient development will be an ongoing process.

"The strategies outlined in the NAP are consistent with and highly complementary to the mitigation actions for the electricity sector in the LEDS"

5.5.2 Infrastructure: Land, Maritime, and Air Transport

This LEDS recognizes the numerous vulnerabilities of transport infrastructure during the next three decades including: increased risk of rising sea levels to seaports, roads, and airports in coastal areas; and risks from extreme weather and floods in virtually all locations. The Climate Vulnerability Assessment places much focus on the need for future infrastructure investment to ensure resilience to climate change and natural hazards, including transport infrastructure. The assessment indicates that almost FJD 9 billion will be needed to climate-proof infrastructure over the next 10 years.[247]

Whereas the LEDS considers land, domestic maritime, and domestic air transport as individual sectors, all transport is considered collectively in Fiji's NAP, which proposes a series of short-term measures all complementary to proposed actions in the LEDS. Such measures will yield direct or indirect benefits with regard to emissions mitigation. Regarding all transport infrastructure, the NAP proposes to develop certification standards for climate proofing transport infrastructure and establishing measures to ensure compliance, and to promote institution strengthening and capacity building for integrated transport planning.

With regard to land transport, the NAP proposes to: conduct road inspections, renew and upgrade road infrastructure to address current and future risks, address the impacts of overloaded trucks on sealed road pavement and bridges and to enforce load restrictions, and work to renew and upgrade priority water crossings to withstand climate impacts.

Maritime transport has been described as the lifeline of Pacific SIDS, such as Fiji. It is essential to all agendas for climate change resilience, adaptation, economic and sustainable development (including fulfilling most SDGs), government service delivery, and natural disaster preparedness and response. With regard to climate change adaptation, which is inherently linked to enhanced community resilience and sustainability, the maritime transport sector is particularly vulnerable and of high strategic importance. By definition, all maritime infrastructure (which includes: ports, jetties, access roads, navigational markers and beacons, warehousing etc.) sit at or very close to sea level, and will be the first and most affected by rising seas, king tides, and storm surges. Vessels themselves are also highly exposed to increasingly strong storm events and changing weather patterns. In part, to address these issues the NAP calls for new or upgraded climate resilient jetties and landings and repairs and upgrades to lighthouses, beacons, and other navigation aids.[248] Smaller vessels and technology, such as WiG craft and dirigibles, also have potential to allow more direct access to communities and reduce reliance on vulnerable shoreside infrastructure.

The NAP does not directly address adaptation for domestic air transport, but this too is an important consideration for the LEDS. Mitigation actions identified for the domestic air transport sector are aligned with the Government of Fiji's national climate change adaptation and resilience objectives. However, the materials and equipment, like solar PV systems and aircrafts, may be more vulnerable to climate risks than conventional systems and aircraft.

5.5.3 Infrastructure: Waste (including Water and Sanitation)

The implementation of integrated solid waste management strategies in the LEDS will not only reduce emissions from the waste sector but will have a positive impact for climate change adaptation and resilience. The recent Climate Vulnerability Assessment (2017) highlighted the need to improve waste management and processing to reduce pressure on the environment and ecosystems. Some issues at the interface between waste and climate vulnerability include: the risks that are exacerbated by poorly managed waste, such as plastic, and plastic bottles blocking drainage systems. Reducing waste generation and implementing 3R policies would indirectly reduce the impacts of flooding in cities. For Fiji, sea-level rise is among the most serious consequences of climate change. However, most of Fiji's waste disposal sites have been developed near the sea and are vulnerable to coastal flooding, which could also result in marine pollution. The mitigation potential in the waste sector could also be hindered by future extreme climate events, such as flooding, rainfall, and generation, and extreme rainfall could collapse landfills and the excess leachate produced could contaminate groundwater and freshwater resources.

Among the short-term measures in the NAP, Fiji proposes to develop and implement a comprehensive waste management plan (also proposed as part of this LEDS) which minimises waste through both actions to prevent and reduce the creation of waste as well as reuse and recycle waste when created. It also calls for a comprehensive assessment of all of Fiji's water and sanitation infrastructure, in order to meet current and future needs, in light of climate change projections. Over the long-term, the NAP proposes: to require national and sub-national government to prepare and publish climate disaster management plans detailing how water and sanitation resources will be managed and protected; to upgrade and develop new appropriate water and sanitation infrastructure; to develop and implement new appropriate building codes, zoning, and construction codes for water and sanitation infrastructure; and to improve overall planning for water and sanitation.[249]

5.5.4 Food Security: Agriculture

Several key considerations for the agricultural sector relate to LEDS scenarios. For example, extreme events, such as high rainfall, floods, and droughts, can affect livestock production and management. Land arability could be reduced due to salt water intrusion, coastal and riverbank erosion, exposure to salt water spray, and heat stress on soils. Further, floods, droughts, and cyclones may physically damage crops, farm equipment, and infrastructure. In addition, high temperatures and changing rainfall patterns may impact on yields of traditional food crop varieties and may lead to an increase in pests and diseases.

Important measures proposed in the NAP, which could enhance the effectiveness of the LEDS, include a number of long-term measures, such as: undertaking regular climate change assessments; GIS mapping and crop modelling with view to the effects on infrastructure and supply chains; production, distribution, and processing; improving measures to protect against invasive species, pests, and diseases which can affect plant and livestock production; strengthening Fiji's disaster preparedness efforts in the agriculture sector by encouraging the protection, breeding, and cultivation of indigenous species as well as improved seed and food storage; strengthening research collaboration with farmers, communities, and national research institutions; promoting inclusive access to hazard maps and climate information; promoting climate-smart agriculture (CSA); increasing the adoption of sustainable soil and land management techniques; improving water management systems and supporting integrated watershed management planning; and strengthening resilience by diversification of agricultural produce.[250]

5.5.5 Biodiversity: Forestry (including Plantation Forests) and Coastal Wetlands

The NAP's focus on Biodiversity and the Natural Environment correlates closely with LEDS coverage of forests and coastal wetlands (mangroves). Forests and mangroves are both threatened by climate change impacts, but also play important roles in reducing climate risks.

Mangroves and seagrass beds possess extensive root systems that prevent coastal erosion and help in absorbing wave impact and creating calmer conditions inland. Depending on the width of mangrove belts, storm surges are dampened by the aerial and prop roots of mangroves, thus contributing to disaster risk reduction.

Climate change will put mangrove forests at risk. Deterioration in the ability of mangrove forests to survive over the medium- and long-term is threatened by sea-level rise and other related hazards. Any gradual decline of mangroves will have subsequent implications for coastal management, disaster management, and food security. The topic of fisheries is of special interest to the NAP due to the magnitude of threat posed by climate change to inshore and offshore fisheries. The viability of inshore fisheries is inextricably tied to the future of coral reefs, seagrasses, and mangroves over a medium- to long-term timeframe.[251]

Inland forests are also vulnerable. Higher temperatures make forests more vulnerable to fires. Higher temperatures and changes in rainfall patterns may lead to increased occurrence of invasive species and pests. Forest health could be undermined due to salt water intrusion, coastal and river-bank erosion, and exposure to salt water sprays and heat stress on soils. Floods, droughts, and cyclones may physically damage forest plantations, natural forest, and associated infrastructure. Changing temperature and rainfall patterns may cause shifts in habitats and boundaries of certain tree species, pollinators, and seed dispersers which can affect the flowering behaviour of certain tree species. Beyond these concerns, loss of arable land due to climate change would place added pressure on forest areas.

The LEDS aims to support adaptation benefits which align with NAP objectives for the restoration, enhancement, and conservation of coastal ecosystems, such as mangroves and seagrasses, in order to safeguard inshore fisheries resources amongst other

[247] Government of Fiji. (2017c). *Climate Vulnerability Assessment.*
[248] Government of Fiji. (2018a). *National Adaptation Plan.*
[249] Government of Fiji. (2018a). *National Adaptation Plan.*
[250] Government of Fiji. (2018a). *National Adaptation Plan.*
[251] Government of Fiji. (2018a). *National Adaptation Plan.*

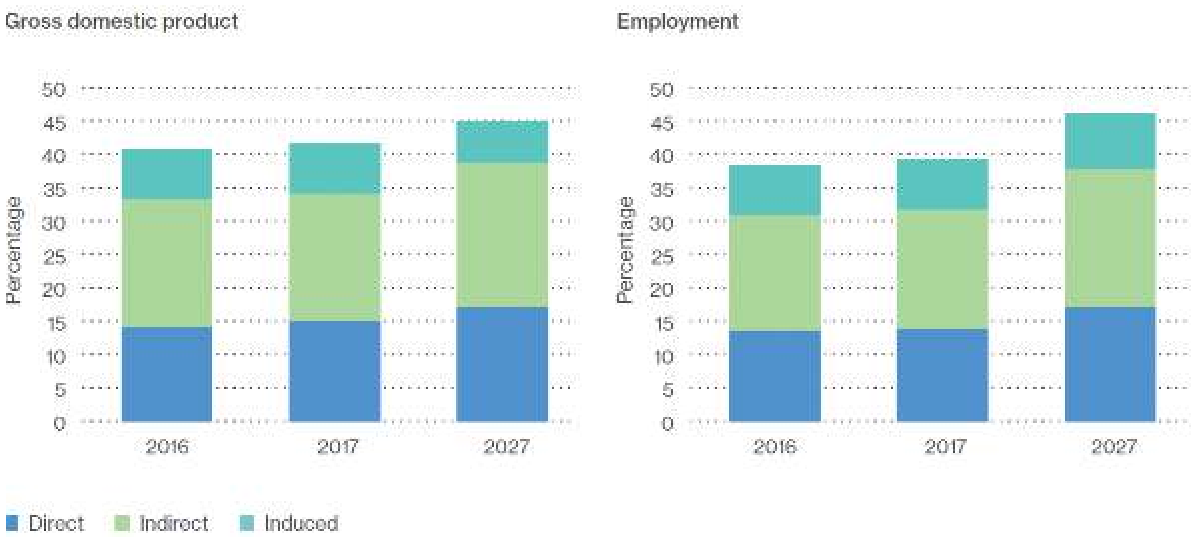
benefits. The NAP also supports efforts to protect, maintain, and restore degraded habitats, particularly the restoration of critical riparian and coastal zones, as a measure to protect coastlines from extreme weather impacts. The NAP proposes enhanced assessment of coastline health. More broadly affecting coastal and inland forests alike, the NAP also calls for identifying and mapping "climate vulnerable" species of flora and fauna, creating a national plan and monitoring system to support climate vulnerable species, and integrated natural and environmental capital in national accounting.

The Ministry of Lands and Natural Resources is working to incorporate a coastal vulnerability layer to overlay the mangroves layer of its GIS to assist in identifying locations for mangrove replanting, when applications are received from corporate bodies as part of their corporate social responsibility initiatives. This is a good example of public-private partnerships in the context of climate change adaptation.

5.5.6 Cross-Cutting Sectors: Tourism

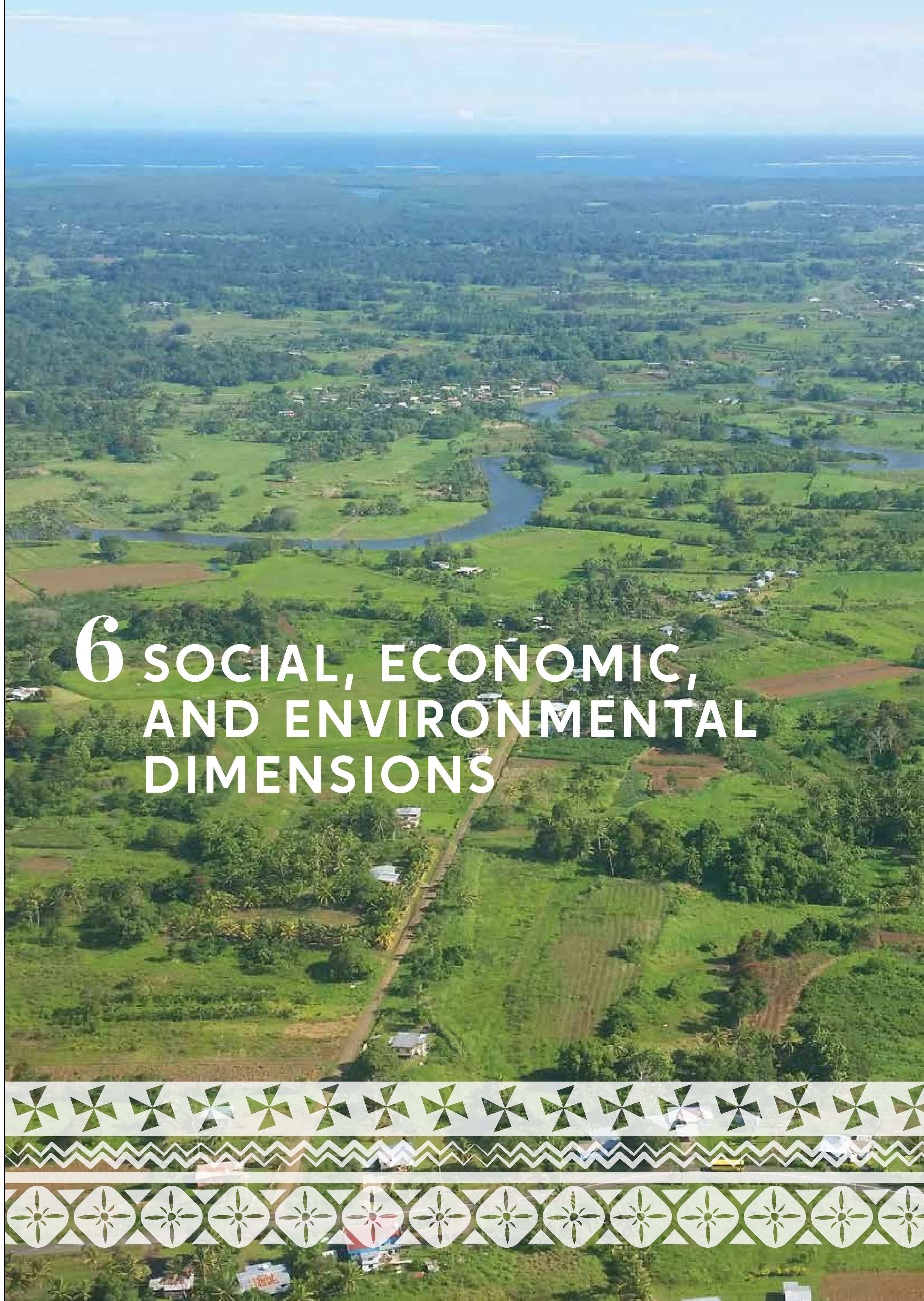
While this LEDS addresses tourism as an important cross-cutting issue (separate from IPCC-defined sectors), the NAP considers tourism indirectly. Tourism is of particular concern as one of the most significant sectors of the economy, estimated to comprise approximately 40% of Fiji's GDP and employment when measured directly and indirectly.

Figure 84. Percentage share of tourism in Fiji's economy, in terms of GDP (left) and employment (right).[252]



Tourism supports and provides livelihoods as well as having a vital role in supporting the national balance of payments. It is estimated that climate change impacts could decrease Fiji's tourism revenues by 18% by the year 2030.[253] Mitigation measures considered in this LEDS for tourism will need to align with efforts identified in the NAP Framework and the NAP to minimise or eliminate climate risks. For example, strengthening conservation measures (such as mangroves) in tourist areas can promote sustainable tourism and more climate resilient coastlines.

[252]Government of Fiji. (2017c). *Climate Vulnerability Assessment;* and World Tourism Council. (2017). *Travel & Tourism Economic Impact 2017 Fiji.*
[253]Government of Fiji. (2018a). *National Adaptation Plan.*



6 SOCIAL, ECONOMIC, AND ENVIRONMENTAL DIMENSIONS

6 SOCIAL, ECONOMIC, AND ENVIRONMENTAL DIMENSIONS

This chapter provides an overview of priority cross-cutting social development and environmental issues associated with the LEDS. Each subsection will address how proposed actions in each of the LEDS sectors and subsectors may have economic, social, and environmental co-benefits, and any additional safeguards that may be needed to ensure social and environmental goals are well maintained.

6.1 GREEN JOBS AND EMPLOYMENT

6.1.1 Introduction

The International Labour Organisation describes green jobs as:

decent jobs that produce goods, provide services or make production processes more energy and resource efficient and less polluting. Green jobs exist and can be created in traditional sectors, such as manufacturing and construction or in new sectors, such as renewable energy and energy efficiency. Green jobs help to: i) improve energy and material efficiency; ii) limit greenhouse gas emissions iii) minimise waste and pollution; iv) protect and restore ecosystems; and v) enable enterprises and communities to adapt to the effects of climate change. [They are] more environmentally sustainable than the conventional alternative and also offer working conditions that meet expected standards of decent work.[254]

This chapter estimates core green jobs in Fiji meeting ILO criteria, plus those in sectors with current green employment and future potential consistent with LEDS priorities, with a focus on energy, tourism (a major and growing employer), forestry, water supply, and waste management and recycling. There are additional opportunities throughout the economy for green jobs creation including: agriculture, transport, the knowledge industry (ICT), and construction, relocation, and related activities for adaptation to increased natural disasters (such as flooding) related to climate change. However, not all opportunities in these areas were assessed due to limited data.

This chapter summarises a baseline green jobs assessment, indicative of future green jobs for a deep decarbonisation scenario, and policy recommendations for green jobs that contribute to development and mitigation of, and adaptation to, environmental degradation and climate change.

6.1.2 Methodology

To the extent that data allow, the analysis conducted follows the methodology of Assessing Green Jobs Potential in Developing Countries: A Practitioner's Guide.[255] Current green employment in selected sectors was estimated through survey questionnaires. The survey was supplemented by information from reports and websites, and interviews with about 100 individuals and sector-specific organisations such as the Sustainable Energy Industry Association of the Pacific Islands (SEIAPI), several Fiji-based renewable energy companies, the Sustainable Tourism Programme of the South Pacific Tourism Organisation (SPTO), the Fiji Hotel and Tourism Association (FHTA), the Fiji Commerce and Employers Federation (FCEF), the Fiji National Training and Productivity Centre (FNTPC), regional and international organisations, public servants, and others. The present summary should be considered as a first step which can be improved as more data become available, providing an indicative baseline of green jobs at present and a first projection of future green employment aligned with the LEDS for a low carbon, resilient future for Fiji.

> "There are opportunities for more green jobs across Fiji's economy, including in energy, transport, tourism, forestry, water supply, and waste management"

6.1.3 Green Jobs Baseline for Fiji

Sectors and activities in Fiji with strong links to the environment include those which: make direct use of natural resources (e.g., farming, fishing, forestry, renewable energy, water supply); support improved environmental management (e.g., pollution reduction, better management of wastes, recycling, more efficient use of energy or natural resources); have a significantly lower environmental impact than other options (e.g., mass transit, electric vehicles, sailing boats); help mitigate the effects of natural environmental risks (e.g., cyclones and floods) or help adapt to climate change (e.g., relocation of facilities to safer areas, more resilient buildings, and infrastructure); and are highly dependent on good environmental quality (e.g., eco-tourism).

There are nearly 72,000 people in Fiji (Table 52 below), about a third of total current formal employment base, who work in environmentally important-sectors in the formal economy within organisations that provide green jobs or services. Many of these cannot be classified as green jobs, such as energy sector jobs in petroleum fuel consumption. The percentage in environmentally important sectors would also be much higher if self-employed and subsistence workers were included. Of 92,187 people so classified in 2017, more than 80,000 (87%) were employed in agriculture, fisheries, or forestry, of whom nearly 57,000 were crop farmers.

Table 52 provides the baseline estimate of current green jobs for a limited range of sectors and core environmental work, consistent with this LEDS. About 20% of the jobs are cross-cutting environment or climate change focussed positions. The table suggests that about 4.5% of formal sector (salary and wage) jobs in Fiji are green in 2018, with nearly a quarter each in tourism and the water sector, and about 10% each in sustainable energy and core cross-sectoral environmental work. These green job totals are probably underestimated, and there was insufficient information to estimate gender division of these jobs.

Table 52. Preliminary Baseline Estimate of Green Formal Jobs in Fiji in Key Sectors (2018).

Industry or Sector	Jobs	Percent	Comment
Agriculture and agro-based products	1,068	12%	May be considerably underestimated
Forestry (Government staff only)	183	2%	Underestimate; no private sector data yet
Fisheries (Government staff only)	282	3%	Commercial fisheries generally not green
Energy	884	10%	Mostly sustainable electricity
Water Supply & Treatment	2,114	24%	State-owned enterprises only
Waste and Recycling	118	1%	Mostly private companies
Tourism (excluding food services)	2,140	24%	Resorts/hotels and tour services
Non-profits, regional & international	817	9%	Includes universities
Other Core government staff	90	1%	Climate Change Division & Dept of Environment
Misc. sustainability training, consulting	71	1%	Green consultants
Unallocated	1,030	12%	Not clearly attributable to one sector
Total	**8,797**	100%	

Total formal sector paid employment	196,800
Green jobs as percentage of total	**4.5%**

Note: Covers only paid employment (full-time equivalent), informal wage or salaried jobs. Rounded off to nearest percent.

[254] ILO. (2011). *Assessing Green Jobs Potential in Developing Countries: A Practitioner's Guide.*
[255] The accuracy of current estimates has been affected by data timeliness, limited sectoral disaggregation of employment data, incomplete knowledge of the informal sector, and, for many jobs, insufficient data to determine compliance with ILO criteria for decent work.

"In the long-term, green employment will be considerably higher than petroleum-fuelled investment"

6.1.4 Future Green Jobs in Fiji under LEDS Deep Decarbonisation Pathways

This section discusses future green employment in Fiji in 2030 and beyond.

Considering that about 60% of Fiji's GHG emissions are from the energy sector, building a greener economy will create more net new jobs than continuing Fiji's current petroleum-intensive development for electricity (nearly 50% petroleum-fuelled) and transport (virtually 100%), as well as in construction, tourism, and commercial agriculture. For Fiji, green investment is expected to create more overall employment than a BAU scenario in the electricity sector, transport, tourism, water supply and waste management, forestry, and construction. This anticipates a decline in petroleum services, and possibly a decline in agriculture.

Electricity. The Very High Ambition scenario in section 4.1 calls for an unprecedented scale-up of investment in renewable energy. Local employment creation will peak during periods of construction, with several hundred new temporary jobs. During the many years of operation, nearly 1,000 permanent new green jobs are likely to be created by 2030, increasing to several thousand by 2050 (excluding employment for growing fuel feedstocks for biomass power). In the long-term, green employment will be considerably higher than petroleum-fuelled investment. Changes in the structure of the energy sector – through investments in electricity generation, efficiency of energy use, transport, and construction – will affect other sectors, such as transport, and create new green employment, both direct and indirect (e.g., in design, construction, and refitting).

Transport. Very little employment in Fiji's transport sector is green today. Converting much of Fiji's land transport to electricity, and sea transport to electricity with some wind, would create considerable green employment (to the extent that the electricity is renewable, and that motor vehicles, marine vessels, and aircraft use low and zero emission technologies). There will also be new green employment in maintenance, but much of this job growth will be offset by losses of maintenance jobs for petroleum-fuelled vehicles.

Tourism. Tourism is a key driver of the economy contributing 59,000 direct jobs in 2017 with growth expected to average 2.8% through 2027[256] and beyond. Green tourism is expected to grow more rapidly than conventional tourism with a concomitant growth in greener employment. This is likely to be a considerable number. Tourism also provides an important market for woman-owned micro and small enterprises, such as those producing flowers, crafts, artisanal food products, jewellery, and cosmetics.

Water and waste management. This sector accounted for about 3,000 jobs in 2017, of which well over half are green jobs, mostly at the Water Authority of Fiji. Green employment in waste management and recycling will increase under a Very High Ambition LEDS scenario, but the absolute numbers are expected to be small.

Construction. Construction accounted for 19,000 jobs in 2017. With roughly 59,000 homes in flood-prone coastal areas requiring relocation or climate resilient reconstruction, there is considerable scope for new employment for homes which are more resistant to natural disasters and more energy efficient. As energy standards (to be incorporated into a new building code) are implemented, there will be a growing demand for employment in efficient design (architects) and energy use (energy auditing, energy systems).

[256]World Tourism Council. (2017). *Travel & Tourism Economic Impact 2017 Fiji.*

Commercial agriculture. With a greener approach, net commercial agricultural employment (excluding sugar cane) could either increase or decrease depending whether the green emphasis is on conservation agriculture (less employment for same output) or organic (more employment).[257] Commercial agriculture, if largely organic,[258] could probably produce more than 10% higher employment for the same yield, at lower overall costs. Sugar employment[259] is likely to continue to decline, even as production increases.

Forestry. Paid employment in forestry is expected to increase due to afforestation and reforestation efforts under the LEDS, as well as substantial employment for wood plantations for electricity generation. Under the VHA scenario, close to 3,000 new jobs (potentially green jobs) will be created by 2030 for growing and processing wood for electric power generation, increasing to over 8,000 by 2050.

6.1.5 Measures and Policies for Green Jobs

A number of measures and policies to assist in monitoring, promoting, and creating green jobs are proposed with this LEDS. These include:

- Develop a detailed Fiji Green Jobs study. When completed, this should be considered a preliminary effort to be updated and revised by 2020, with more inputs from economic models and new data.
- To improve the accuracy of estimates and more standard green job classifications, the FBoS to provide more disaggregation of employment and GDP by sector and gender in forthcoming reports, if practical consistent with the UN guidelines of Systems of Environmental and Economic Accounts (SEEA) 2012.[260]
- The Fijian Government will update its most recent Input-Output Table with multipliers (particularly employment) disaggregated into BAU and green components (the latter, at least, for sectors with significant environment-related employment) to allow more accurate projections of job creation for BAU versus green investment.
- To foster green employment the Fijian Government will support mechanisms for building skills and accessing information, markets, and finance. This includes development of ICT services for all sectors which has potential, in itself, to reduce emissions, and also include sustainable resource management and use and adaption to climate change (such as choice of climate-resilient crops).
- Data on informal work within various ministries (e.g., iTaukei Affairs, Ministry of Women, Ministry of Agriculture, and Ministry of Rural and Maritime Development) will be gathered and assessed to better understand the informal economy and the constraints to, and opportunities for, green informal jobs.
- The Fijian Government will work with the FCEF and other employee associations and unions to: survey its members to determine their understanding of and attitudes to green employment; assess risks to members if they fail to green their businesses; and assess opportunities for green employment and the benefits for members. This will assist the private sector, including employers as well as employees, to prepare for the transition to a low carbon economy, while supporting an inclusive, consultative approach to the transition.

6.2 GENDER AND EQUITY

The first decisions related to gender, equality, and participation of women under the UNFCCC were taken in 2001. Since then there have been gradual discussions on gender, equity, and climate change under the UNFCCC, culminating with the adoption of the Gender Action Plan under the Guidance of the Fijian Presidency of COP during COP23 in 2017. The Gender Action Plan for the Paris Agreement highlights how climate change impacts women and women's roles in bringing about change. It aims to increase the participation of women in all UNFCCC processes and to increase awareness of and support for the development and effective

[257]Conservation agriculture uses minimum mechanical soil disturbance (low tillage), permanent soil cover and diversification of crops (in sequence or in association) reducing farm employment. Organic agriculture avoids genetically modified organisms, synthetic pesticides, veterinary drugs, additives and mineral fertilisers, improving soil quality and biodiversity, reducing nutrient leaching, requiring less energy (reducing GHG emissions) and usually raising market prices. It may require more land and is labour-intensive, increasing employment.
[258]For the potential of organic agriculture, the most conservative data from *Green Jobs for a Revitalized Food and Agriculture Sector* (FAO, 2011) suggesting 8-12% job increase by 2050 for same yield but better quality food.
[259]ILO data show Fiji agricultural employment declined steadily from 53% of total employment in 1991 to 39% in 2016.
[260]UN. (2014). *System of Environmental-Economic Accounting 2012 Central Framework*. United Nations New York. Available at: https://unstats.un.org/unsd/envaccounting/seearev/seea_cf_final_en.pdf

implementation of gender-responsive climate policy at the regional, national, and local levels. The Gender Action Plan specifies five priority areas with detailed goals to deliver by 2019:

- Capacity building, knowledge sharing, and communication;
- Gender balance, participation, and women's leadership;
- Coherence to strengthen the integration of gender considerations within the work of UNFCCC bodies, the secretariat, and other United Nation entities and stakeholders towards the consistent implementation of gender-related mandates and activities;
- Gender responsive implementation of the convention and the Paris Agreement; and
- Monitoring and reporting.

At the national level, Fiji has been making its own efforts to fully integrate gender and equity issue into climate action. The NDP of Fiji (2017) indicates that achieving gender equality in decision-making and income levels and eliminating violence against women, in accordance with international conventions, is crucial for sustainable development.[261] The NCCP (2017) also highlights gender and equality as one of the fundamental approaches to addressing climate change and adaptation planning. As an initial step, Fiji plans to assess gender-related climate impacts with disaggregated data and adequate parameters. Ensuring that a gender- and human rights-based approach is being implemented effectively is also a key part of the NAP, and gender and equity are addressed in the NAP Framework, and are being integrated into all stages of the NAP process, from planning to evaluation. Fiji has been approaching gender concerns as a universal human right with the National Gender Policy adopted in 2014, and gender is mainstreamed throughout the 2014 Green Growth Framework, which highlights that gender equality is important in education and other aspects for sustainable development and calls for integration of gender concerns and perspectives in policies and programmes for sustainable development by 2025.

These international and national principles are espoused for the LEDS for its governance, policies, implementation measures, and monitoring and evaluation in order to maximise women's potential as active agents of change and drivers of low carbon development. It should be noted that in most of the LEDS sectors, such as in electricity, transport, and waste, there is an imbalance in representation in the workforce with more men than women. At the same time, there are skill shortages in some jobs in these sectors and new skills will be needed. The LEDS provides an opportunity to involve women and youth in filling those gaps and planning for the future.

In order for women and youth to participate fully in the transition to a low carbon economy, it will be essential that employers, trade unions, and government seek to actively end gender discrimination in the workplace and make such discrimination illegal. The establishment of comprehensive antidiscrimination labour provisions and flexibility in the workplace to encourage and promote women's full participation would be a key step. Furthermore, there should be scholarships made available to enable women to study in areas where women have been underrepresented historically, but also where growth is predicted in the LEDS, such as the electricity sector, renewables, energy efficiency, various transport areas, and forestry. There is also an opportunity to address youth unemployment by encouraging students to study for skills that will be needed in a low carbon economy, particularly technical and vocational skills, again in the same sectors as above.

The National Gender Policy directly references climate change in relation to agriculture, rural development, and environment, noting the need to "Promote increased regard for environmental sensitivity, climate change impacts and disaster risks and the role of men and women at all levels in facilitating the harmonious and sustainable use of the country's limited natural resources, and the utilization of gender impact assessments, gender analysis and gender aware approaches in assessing environmental issues and on the utilization, exploitation and preservation of natural resources in Fiji through training and continuous monitoring."[262]

On renewable energy, the policy emphasises the need to "Ensure and implement a policy of access to energy supplies to all persons in Fiji and to ensure that women in communities are consulted in any energy projects, and recognizing that women in rural communities have the most limited access to energy sources including access to renewable energy."[263] The National Gender Policy further notes that different types of energy sources have differential impacts on women.

The LEDS can play a role in achieving SDG5 on gender equality, taking into consideration at all stages of its implementation, in particular SDG sub-outcomes 5.1, 5.4, 5.5, 5a, 5b, and 5c.[264] Collection of gender disaggregated data will be enhanced to inform decisions along the path to a decarbonised economy. The LEDS also recognizes the role of women as agents of change both in homes and larger society. Aspects of the implementation of the LEDS that need to take into account equity in access, participation, contribution, and potential benefits to/impacts on women, youth and vulnerable groups include:

- Access to information about the transition to a decarbonised economy and about the sectors targeted for decarbonisation sector;
- Participation in the formulation of low carbon policies, strategies, and plans;
- Participation in the development of standards and enforcement of those standards;
- Involvement in consultations and decision-making at all levels;
- Equal access to low carbon electricity, water, and other infrastructure services;
- Equal access to training opportunities, new green job opportunities, raising awareness of new job opportunities;
- Awareness of new opportunities and equal access to leadership positions;
- Involvement in data collection, analysis, and research;
- Equal access to finance, incentives, and tax cuts; and
- Consultation as part of land-owning groups and equal access to compensation, where necessary,

"Collection of gender disaggregated data will be enhanced to inform decisions along the path to a decarbonised economy"

[261]Government of Fiji. (2017a). *5-Year & 20-Year National Development Plan.*

[262]Government of Fiji. (2014b). *National Gender Policy.*
[263]Government of Fiji. (2014b). *National Gender Policy.*
[264]https://sustainabledevelopment.un.org/topics/sustainabledevelopmentgoals

6.3 GREEN CITY DEVELOPMENT

Urbanisation in Fiji is taking place at a rapid rate and, as per the latest census figures, 55% of the country's population of 884,887 is urban.[265] This trend is attributed to the extension of urban boundaries for some of the larger cities as well as internal movements from rural to urban areas. Fiji is now an Upper Middle-Income Country and is expected to be 56% urban by 2021, with most major urban populations on the island of Viti Levu. As these urban centres grow, there is an added stress on access to urban services such as water, electricity, waste management, and transportation, and ensuring climate resilient cities. A significant portion of the population resides in informal settlements and also needs access to basic urban services, thus, future urban plans will need to incorporate informal settlements as well. The national Green Growth Framework states that approximately 78,000 people are currently living in 128 squatter settlements in Fiji's major urban areas.

Since Fiji is prone to natural disasters, with maximum impact projected to be in the urban areas, any urban planning and development needs to also focus on climate resilience to minimise the adverse impacts of natural disasters in the future. The Green Growth Framework identifies the need to ensure that the building codes are revised so that, going forward, buildings are cyclone resilient and also use energy and water more efficiently. Further to this, town plans and zone plans need to enforce zoning and buffer zones for coastal areas and develop improved waste collection and management systems as outlined in section 4.7. As has been identified in the NDP, new towns have been identified for development both on Viti Levu and Vanua Levu, two of the larger islands in Fiji. Since some of these new towns are still rural in nature, the LEDS provides an opportunity to skip business as usual development, avoid high emission producing infrastructure and opt for low carbon buildings and transport infrastructure for cities, including increase urban walkability and facilitation of non-motorised modes of transport. In addition, the Fiji government will look at opportunities to weave in technology with expansion to achieve sustainable, resilient urbanisation.

Employment generation in cities will be essential to sustain economic growth in urban areas. To this extent, as urbanisation takes place, an increasing number of people can be employed to fill the gap needed in terms of providing services. Goals under the NDP include: strengthening the urban management and administration of town planning at municipal level, strengthening long-term planning for identification of growth centres and their development into vibrant urban centres, creating an environment that fosters resource efficiency and effective management practices by individual households and corporate bodies within urban centres, and preparing vulnerability assessments which consider projected risks of climate change and natural hazards to infrastructure and urban planning.

Although the LEDS exercise has been conducted at the national level, a key next step will be mainstreaming the LEDS at the town and city level, through town and city councils and associated institutions. Through appropriate consultations, there will be opportunities to conduct smaller-scale exercises of GHG emissions accounting at the city and town level to further inform actions at the local level and empower town and city councils to make their own low carbon plans, based on sound data. These assessments will be done first for each of the larger cities and will also assist in narrowing the focus on high emitting components in urban environments, such as buildings and specific localised industries, which will further assist urban low carbon planning.

6.4 BIODIVERSITY CONSERVATION

As an island nation, the manner in which Fiji's natural resources and biodiversity are managed will have implications on future economic prospects of the tourism and resource-based industries, the potential for developing renewable sources of energy, as well as the resilience and the capacity of communities to deal with climate change and disasters, health, and quality of life.[266] For this reason, it is important that, as the LEDS is undertaken, actions to safeguard biodiversity are implemented whenever needed so that a low carbon transition does not come at the expense of Fiji's unique ecosystems.

[265]Fiji Bureau of Statistics. (2017). Key Statistics – *National Income, GDP by Industry, December 2017.*
[266]Government of Fiji. (2014a). *A Green Growth Framework for Fiji.*

Fiji has fragile island ecosystems, and the biodiversity and ecosystem goods and services have always been one of the important foundations for Fijian life, culture, and economy. Most of Fiji's biodiversity is unique to Fiji. More than 50% of Fiji's birds and plants, all 24 palms, 72 out of the 76 species of psychotria, frogs, and over 90% of some insect groups are all endemic.[267] Fiji has more than 332 islands with 18,272 km^2 of land area, surrounded by over 10,000 km^2 of reefs containing various habitats including: estuaries, mangroves, sea grass beds, macroalgal assemblages, and sand and mudflats which support the biodiversity of the region. This biodiversity has not yet been fully explored and its economic (and natural capital) value is not yet well understood.

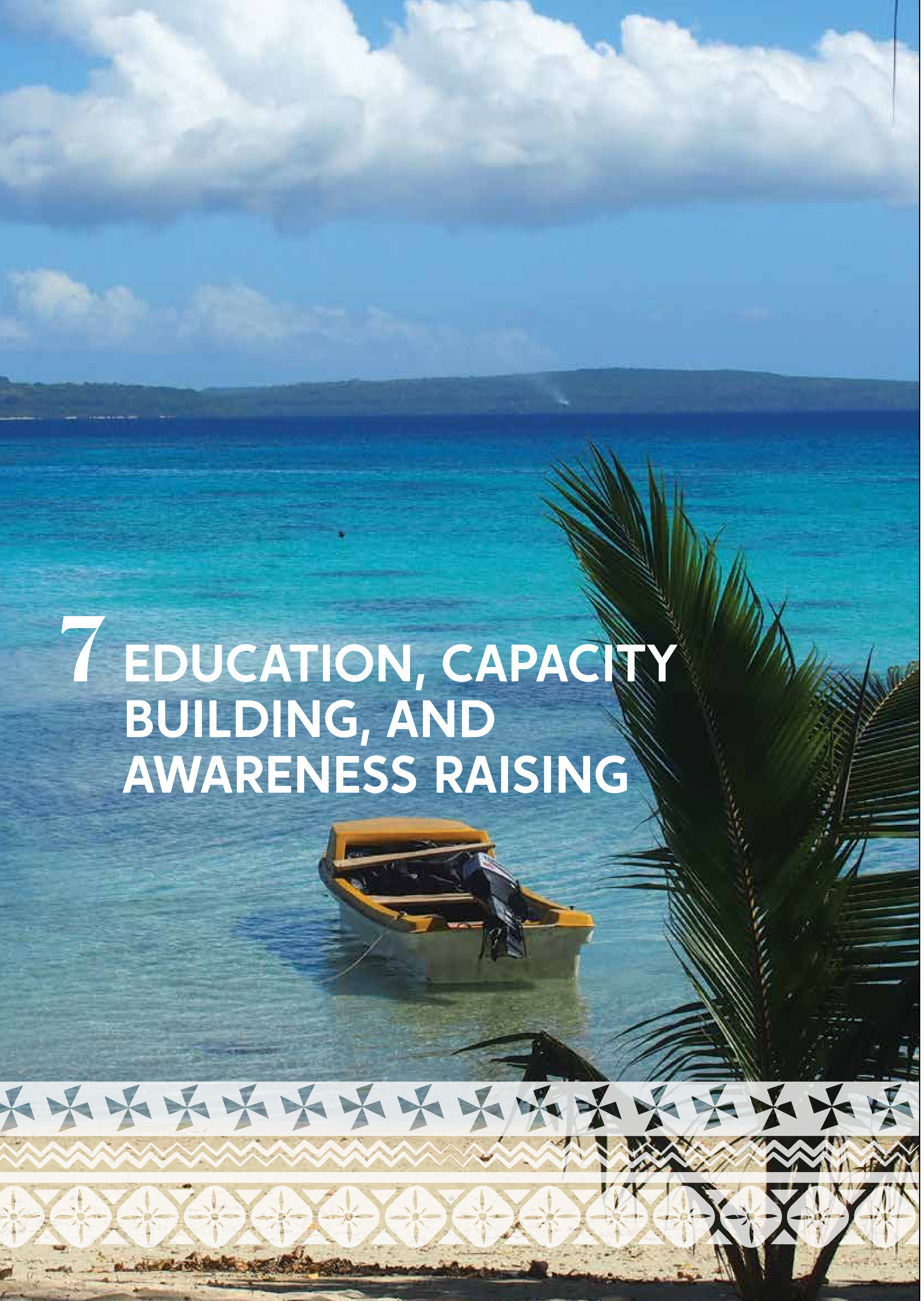
"Efforts to protect ecosystems and biodiversity, will be integrated in implementation of this LEDS"

However, Fiji's biodiversity and ecosystems have been experiencing direct and indirect pressure from different sectors. Even though Fiji's rich biodiversity makes a significant contribution to the GDP and foreign exchange, and has direct contribution to the daily income of numerous households through agriculture and aquaculture activities and tourism, its biodiversity has experienced threats by recent economic development of the urban and peri-urban areas, and tourism and other development, all utilizing or removing significant natural resources. Increased agriculture and aquaculture activities have exploited natural areas, while intensive urbanisation and industrialisation are causing pollution. Developments in the tourism sector that do not follow environmental safeguards can be a serious threat to Fiji's ecosystems and the damage is often concentrated around the coastal, coral-reef ecosystem.

The government has recognized the importance and value of biodiversity and Fiji's unique ecosystems and has identified and established key areas to protect The country's natural resources. A number of adopted measures directly complement and advance the objectives of this LEDS. Many government efforts have been aligned with global efforts to protect biodiversity under the Convention on Biological Diversity. The Endangered and Protected Species Act of 2002 established various protection programs in both territorial and marine ecosystem. The government also established the Environment Management Act in 2005 requiring EIAs prior to any development planning.

As discussed in section 4.7 above, the government has proposed to protect six times the area of mangroves removed for tourism development with replanting. This, and related efforts to protect ecosystems and biodiversity, will be integrated in implementation of this LEDS, and further enhanced so that the decarbonisation of the economy and biodiversity conservation plans remain well aligned and are mutually reinforcing.

[267]https://www.cbd.int/countries/profile/default.shtml?country=fj



7 EDUCATION, CAPACITY BUILDING, AND AWARENESS RAISING

7.1 INTRODUCTION

The transition to a low carbon economy will require far-reaching changes, not only in technology but also in day-to-day decision-making, behaviour, knowledge, and skillsets. In order to adjust, embrace, integrate, adapt to, and ultimately benefit from the low carbon transition, awareness raising, capacity building, and education measures across the whole economy and embracing all parts of the population will be essential. There is also a significant opportunity for Fiji to equip future generations with the skills for a green, low carbon economy and develop services and products which can be exported overseas. With 545,618 people (61.7% of total population) aged below 34, Fiji is a young nation.[268] An investment in education and skill development with an increasing working age population, will provide a pool of human resources which is essential for Fiji's low carbon development. The Fijian Government is committed to making the necessary investment from public resources, while encouraging the private sector to also develop capacity for green, low carbon growth. Without this investment from both the public and private sector, the changes needed in mindsets and skillsets will be hard to achieve.

Education, capacity building, and awareness raising measures are not described in detail in the LEDS. An overview is provided, but the next step will be for government and non-government actors in each sector to review their strategies and ensure they include the actions needed to meet the needs of an economy transitioning to low carbon, using the LEDS as a guide. Both government and non-government entities need to address and answer questions such as: Are we ourselves prepared for this change? Are our staff and stakeholders aware of the LEDS? How will they be affected as LEDS is implemented? How will their jobs change and how do their jobs need to change? Do they have the right skills to implement the LEDS? What new skills are needed and how can we acquire them? What is our timeline for making the needed changes and what are the resources required? These are not simple questions and many of the answers need to be discussed cross-sectorally and vertically, from local to national levels. Institutions will need to work together to implement the solutions identified to respond to the needs of the public, the private sector, and government in terms of education, capacity building, and awareness raising.

All levels of education in Fiji, from primary school to tertiary, and vocational education to continued professional development, will need to be engaged to deliver long-term educational and skills change. This will require substantial revision of many existing curricula through the appropriate Education Standards and Qualification Boards and training for current and future educators and education professionals. For capacity building and awareness raising activities, initial external human resources will likely be needed, but as the skill sets and knowledge increasingly become available in Fiji, these activities should increasingly be delivered locally by academic institutions, local NGOs, national and local government and private sector associations, among others.

This section summarises some key needs already identified overall, as well as by specific LEDS sector (although coverage is not exhaustive). Relevant actions from the NDP and NDC Implementation Roadmap are included, as well as new actions specific to the LEDS sector identified through the consultation process and analysis of needs for implementation of the LEDS.

7.2 CAPACITY BUILDING AND AWARENESS RAISING

The NCCP 2018 emphasises the importance of capacity building, technology transfer, and knowledge sharing as central enablers for Fiji's adaptation and mitigation needs and commitments. It also emphasises that increasing government interactions with academia and global research networks will increase access to cutting-edge innovation, technology transfer, and capacity building. An essential initial prerequisite for capacity building is to clearly identify and quantify current skill

[268] Fiji Bureau of Statistics. (2018a). *2017 Population and Housing, Release 1.*

"Changes to behaviour are required to facilitate a transition to a decarbonised, resilient economy"

deficiencies, and prioritise those requiring significant improvement. Building capacity will be the next step towards normalising and facilitating the changes to behaviour that are required to facilitate a transition to a decarbonised, resilient economy. An important element of the challenge will be retaining in Fiji the trained staff in the targeted institutions and sectors. Incentives will need to be put in place to achieve this.

Cross-Cutting Actions

- Assessment of Skills Needed. Although there is awareness of deficiencies in the skills needed for a low carbon development path for Fiji, a more comprehensive assessment is needed to clearly identify gaps, quantify needs, ascertain priority areas that need addressing now, and develop a broad timetable for skills improvements consistent with the LEDS. Government will work closely with stakeholders on this high-priority need.
- Assessment of Training and Staffing Needs. Staffing, capacity building, and training requirements for low carbon development need to be determined at the national level and sub-national levels. This should start with the CCICD and the Steering Committee, as both have important roles to play in driving LEDS implementation. Specific actions will be required to strengthen core stakeholders, build momentum, and provide a foundation for subsequent actions by the broader set of stakeholders.
- Technical Assistance for the CCICD. Technical assistance is proposed to support CCICD's roles and responsibilities as Secretariat for the LEDS and other climate change policies and processes. The staff of all sections of the Ministry of Economy are the "core" key stakeholders to champion change and will need capacity building to effectively carry out this function of promulgating LEDS through everyday functions and the national budgeting process. This may also require training on technical aspects of sub-sector activities and, also, training in facilitation, coordination, and change management.
- MRV and Data Collection. Training on the design and implementation of a robust and transparent bottom-up MRV system, including: the review of existing data and reporting, assessments of data needs, institutional arrangements, data management systems, standards and procedures for MRV, and evaluation mechanism. This would include capacity building across all sectors to strengthen bottom-up data gathering. In many cases, investment and capacity building will be required to improve the ability of stakeholders to produce, collate, and assess new types of data. This may include multi-agency activities for data gathering, processing, and reporting and include mandatory data through a command and control mechanism. MRV and data initiatives should capitalise on existing institutions and technical architecture for knowledge management.
- Decentralised Capacity Building. The Fijian Government will need to review existing government institutional mechanisms and develop integrated community capacity building programmes at the grassroots level, in close collaboration with NGOs and other partners. Capacity building and awareness programmes will continue at the community level supporting resource owners on the importance of proper environmental stewardship as part of low carbon development. Effective mechanisms are needed to ensure that knowledge is decentralised and distributed to key users and to ensure that local and sub-national actors can collect, and input, data required to support localised actions.
- Integrated Learning. The government will work to introduce systems of knowledge management, which traverse traditional sectors and improve consistency. Partnerships between the public, private, and academic sectors will be key to building awareness across stakeholder groups and enabling coordinated action.
- Capacity Building in the Private Sector. This will be key to ensure that low carbon development becomes a core part of Fiji's business as usual. The private sector must be engaged to support long-term capacity building and the development of new businesses and services relevant to the implementation of the LEDS.
- Knowledge Management. CCICD will support climate change knowledge management through the development and maintenance of communications strategies, data repositories and functions, and products designed to raise awareness within government, the private sector, and the general public of key climate change issues.
- National Advocacy and Awareness: CCICD will work with government ministries to support national climate advocacy and awareness raising campaigns to support public awareness and increase the visibility of key issues within the LEDS.

Electricity Generation

- Energy Efficiency Public Awareness. A nationwide public awareness programme will be developed to increase awareness about the existence and the benefits of energy efficient building design, appliances, and savings.
- Energy Efficiency Training. Training will be provided to key stakeholders (i.e., institutions in charge of boarder control of appliances FRCS, dealers of appliances, staff of coordinating entities, architects, builders, and building inspectors) for implementation of energy efficient appliance standards and minimum energy performance standards for buildings.
- O&M of Renewable Energy Systems. Skilled and highly-skilled domestic labour will be further developed and sustained to operate and maintain various renewable energy power plants in Fiji (e.g., biomass, solar PV, wind, geothermal, biogas, and energy storage).
- O&M of rooftop solar systems. Skilled and highly-skilled domestic labour to design, install, and provide maintenance services will be developed for the solar PV rooftop and solar water heating sectors.
- Biomass Energy Development. There will be large-scale support for specific domestic production (production and processing) of sustainable biomass, including resource surveys and optimisation of the use of sustainable biomass residues, processing techniques, logistics planning, and training of skilled labour.
- Energy Management. Training for key stakeholders (owners and service providers) on energy auditing, application of energy standards within building codes, and the implementation and operation of energy management plans. There will be training for institutions in coordinating and enforcing energy management standards.
- Renewable energy Resources. There will be capacity building support for comprehensive renewable energy resource assessments.

Land and Maritime Transport

- Electric and hybrid Vehicles. Capacity building will be developed for key government ministries and agencies regarding EVs, HEVs, and their batteries, standards, and maintenance to inform policy changes. Buses companies, scrappage facilities, and others will be trained in maintenance, management, and disposal of electric and hybrid vehicles, including replacement and disposal of batteries.
- Vehicle Imports. Training will be provided to key stakeholders (i.e., institutions in charge of border control of vehicles, FRCS, car and truck dealers, and staff of coordinating entity) for enforcement of vehicle standards.
- Public Awareness on Low Emission Transport. A country-wide awareness and dissemination campaign, which is non-discriminatory and gender inclusive, will be prepared and implemented country wide to inform vehicle owners, operators, associations, dealers, and other relevant stakeholders (e.g., banks) about the mitigation actions for a more energy efficient transport sector and incentive schemes. There will be awareness raising programmes (e.g., adverts, campaigns) for drivers and vehicle owners about eco-friendly driving and economic and environmental impacts.

"Capacity building and training will be provided for mangrove and seagrass monitoring, and for carbon sequestration measurements"

- **Marine Transport.** A programme will be developed and implemented for boat building and boat maintenance capacity as many new ship designs and technologies (e.g., Flettner rotors) can be built and installed in Fiji. There will be investment and human capacity development, including Fiji National University (FNU) (e.g., engineering) and Fiji Maritime Authority (FMA) (e.g., seafarers).
- **Capacity Building for Marine Transport.** There will be improved data collection, capacity building, education, and training for maritime transport across all stakeholders in the public and private sectors. There will also be awareness campaigns for owners, operators, associations, and other relevant stakeholders (e.g., shipping companies, associations, and banks) for marine transport and climate change.

AFOLU

- **Sugar.** Training and technical assistance will be provided for increasing sugarcane yield per hectare and harvesting and transport logistics.
- **Fuel wood processing.** There will be training for wood-cutters for reduced-impact felling techniques and training of wood cutters, machine operators, and logging planners in resource-saving reduced impact logging (felling and skidding) with provision of advanced skidding equipment.
- **Livestock Productivity.** Training and financial support will be provided for improving livestock productivity through embryo transfer.
- **Fertiliser Use.** There will be training of farmers in the proper application of synthetic and organic fertilisers (type of fertiliser; quantity and time of application).
- **Farming Practices.** There will be provision of further capacity building and awareness of harmful farming practices and awareness and advocacy of organic farming.
- **Land Management.** There will be a review of administrative processes, digitization of land records, and capacity building to improve the efficiency and effectiveness of land-use administration. There will also be capacity building to develop the Fiji Geospatial Information System, National Land Bank, and National Land Register.
- **Environmental Management Act.** Capacity building will improve administration of the Environment Management Act (EMA) 2004, particularly EIAs.
- **Ecosystem Protection.** Further capacity building will be provided to communities for protection and/or restoration of nearby ecosystems, and protection of biodiversity, in consultation with landowners (through conservation agreements, education, monitoring, etc.). There will be localised capacity building, awareness, and behaviour change initiatives to reach small-holder farmers.

Blue Carbon

- **Improving Monitoring.** Capacity building and training will be provided for mangrove and seagrass monitoring, and for carbon sequestration measurements.
- **Mangrove Replanting**. There will be capacity building and training for establishment of mangrove nurseries, re-planting mangroves, and improving survival of replanted mangroves.
- **Wetlands Awareness.** There will be actions to increase awareness among indigenous communities and commercial and industrial sectors about wetlands and blue carbon economic value and other co-benefits.

Waste Sector

- **Waste Management Awareness.** There will be awareness raising campaigns at national and sub-national levels about the benefits and costs associated with proper waste management and awareness efforts to reach every household about the 3Rs (reduce, reuse, and recycle waste) in rural and urban areas.

Tourism and Commerce

- **Support for low carbon Tourism**. There will be capacity building initiatives for micro, small, and medium scale tourism businesses for implementing the LEDS through beach and reef protection, renewable energy, improved waste and water management, and energy efficiency.
- **Support for Youth and Women.** There will be support women's and youth community-based capacity building programmes on green entrepreneurship development and skills-based training relevant to the LEDS sectors.
- **Energy Management for Businesses.** An awareness and information campaign will be designed and implemented targeting business community and government stakeholders on energy management requirements (e.g., energy standards for new buildings) and opportunities for businesses (including hotels and resorts) and public institutions.
- **Educating Tourists.** There will be actions to improve awareness and educate tourists about more responsible and sustainable environmental behaviour, prior to embarking on nature visits.

7.3 EDUCATION

As stated in the NCCP (2018), the Government of Fiji has a continuing commitment to building a strong and dynamic education system. Education plays a key role in building awareness and setting the foundation for important skill sets and expertise that can be reinvested into society. Fiji's education system must deliver the tools required for an intergenerational response to climate change. It will take considerable time to develop and establish the curricula and train the educators, and even longer to benefit the workforce. Therefore, it is crucial to start immediately on actions to transition the education sector to better support low carbon growth.

Cross-Cutting

- **Education for a low carbon transition.** Quality education for all is essential to create a more skilled and adaptable workforce and create a knowledge-based society. All Fijians will be empowered with education and skill sets so that they may be easily absorbed into the workforce. Government will work closely with industry, tertiary education institutions, and development partners to prepare a workforce of highly skilled Fijians in line with future demand under the LEDS sectors. Education systems should produce a national workforce with the required skills to support long-term low carbon transition. Government and the private sector will work together to provide professional development and re-training opportunities for those employed in sectors where skills needs will change significantly as technology changes (e.g., car mechanics moving from working with combustion engines to electric motors with battery storage).
- **Digitization and teacher training.** Investments will be undertaken to improve existing and new education facilities, purchase new equipment and materials, embrace digital learning, and train teachers in low carbon development.
- **Women's access to education.** Women will have equal access to employment, remuneration, and leadership opportunities from implementation of the LEDS.
- **Technical and Vocational Training.** The government will strengthen and improve the quality of the technical and vocational education and training (TVET) system, as relevant to the LEDS sectors, and by developing a curriculum aligned with the needs of a low carbon economy labour market. Part of this will be to facilitate school-to-work transitions for Fiji's youth by fostering stronger links between education/training institutions and workplaces and encouraging work placements, paid internships, and apprenticeships in the LEDS sectors. A comprehensive and accredited national TVET programme is recommended to create sustainable green jobs among Fiji's youth for renewable energy, energy efficiency, disaster risk reduction, and climate change adaptation.

- **Scholarships.** Postgraduate training scholarships in green jobs and green investment analysis will assist the government to choose investment options that maximise green jobs while reducing other job losses.

Energy

- **Technical Skills.** To meet the human resource needs of the future electricity sector, the government will support education for civil, electrical, mechanical, and hydrological engineers and other required skill needs of the sector, including for renewable energy technologies introduced or scaled-up under the LEDS, and for energy efficiency improvements in the building sector and industry.

Land and Maritime Transport

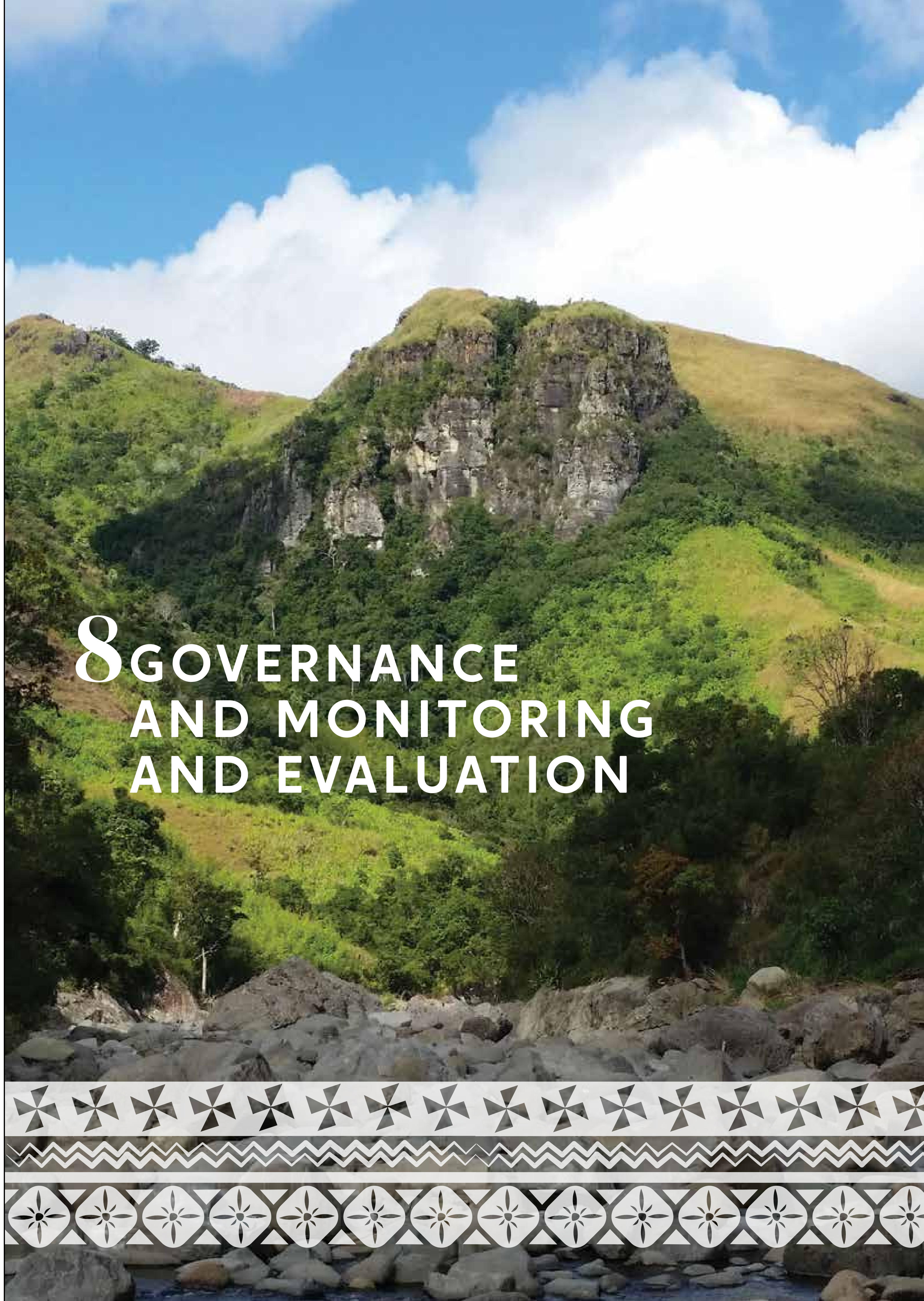
- **Technical Skills.** To meet future human resource needs of the transport sector, government will support education for civil, electrical, and mechanical engineers and other required skill needs of the sector, including for new vehicle and vessel technologies introduced or scaled up under the LEDS. Next generation land and maritime transport "upskilling" training programs will be developed with higher education institutions and TVET providers (mechanics, ship builders, fabricators, sailors, etc.)
- **Sustainable Transport.** Education and awareness-raising about sustainable transport will be introduced to school and university curricula.
- **Practical Skills Development.** Training and education for both public and private sector actors will be provided, including both practical elements for seafarers at all levels of service but, just as importantly, for all related, secondary, and tertiary industries, including marine engineering and maintenance, planning, and policy, senior management, shore side industry, financing, and insurance.
- **Regional hub for maritime training**. For the maritime sector, supporting an integrated regional education and research strategy targeting all sectors (planning, policy, management, operations, secondary support industries) is a step to developing and retaining in-country and in-region long-term capacity development across the maritime sector. This places Fiji at the heart of a future sustainable maritime transport sector in the Pacific.

Domestic Aviation

- **Skills for new standards.** Training and education for aviation professionals (e.g., aircraft engineers, pilots, and air traffic controllers) will be strengthened to meet ICAO standards. This will include training on the LEDS actions for domestic aviation.

Tourism

- **Training**. Tourism training providers and TVET providers with tourism courses will be encouraged to integrate awareness of the LEDS into their training on tourism, with particular attention to energy and water use and solid and waste-water management



8 GOVERNANCE AND MONITORING AND EVALUATION

"The LEDS will serve as the overarching reference document across all ministries, guiding them towards emissions reductions in their particular sectors"

8 GOVERNANCE AND MONITORING AND EVALUATION

8.1 INSTITUTIONAL ARRANGEMENTS AND GOVERNANCE FOR IMPLEMENTING FIJI'S LEDS

The institutional arrangements and governance for implementing the LEDS flow from the Fiji NCCP 2018, are aligned with those for other national climate change-related strategies, such as the NAP, and are guided by the same principles:

- Alignment with national development plans and national climate change policies;
- Enhanced collaboration and inter-government coordination;
- Evidence-based decision-making;
- An integrated approach to resilient development in recognition of the various interactions and co-benefits involved with increased alignment and connectivity between policies, plans, sectors, and ministries; and
- Promotion of policy innovations that help to cross-cut development objectives through the increased involvement and engagement of the private sector.

This section describes the overall governance arrangements for Fiji's LEDS; rather than specific implementing entities, as all ministries, agencies, non-state and private sector actors, and individuals will be responsible for implementing the LEDS. Furthermore, the implementation of the LEDS will be mainstreamed through a variety of sector specific policies, strategies, and plans at national, provincial, and local level. The LEDS will serve as the overarching reference document across all ministries, guiding them towards emissions reductions in their particular sectors. As and when sector specific policies are reviewed and updated, the LEDS will similarly be used as a guidance document to align each sector to the objective of net zero emissions and mainstream LEDS strategies. The general and specific government bodies with the oversight required to progress coordination and governance functions in service of the LEDS follow from those in the NCCP and are described below.

8.1.1 The National Climate Change Coordination Committee

The National Climate Change Coordination Committee (NCCCC) is comprised of the Permanent Secretaries and nominated representatives from government ministries, departments, and agencies. The NCCC functions on behalf of the Fijian Government to:

- Ensure Ministerial and Department activities are aligned with relevant cross-cutting policies and frameworks (such as the LEDS);
- Ensure the creation, implementation, and monitoring and evaluation of these cross-cutting policies;
- Ensure the creation, implementation, and monitoring and evaluation of relevant sector plans;
- Assess its own progress on integrating climate change issues into Ministerial and Department activities and report on that progress;
- Provide advice and assist with resolving strategic-level issues and risks;
- Use influence and authority to assist the cross-cutting policies, frameworks, and plans to achieve their aims and objectives; and
- Review and provide comments on climate change policies and plans.

For purposes of this LEDS, it is recommended that the terms of reference of the NCCCC are reviewed and updated to include greater clarity on the NCCCC's review of NDCs and LEDSs every five years. With these changes to its TOR, the NCCCC would be the appropriate high-level oversight body for the LEDS. The NCCCC would then be able to oversee coordination of LEDS implementation, oversee monitoring of progress of implementation, and ensure action is taken to update the LEDS when needed.

"A key role of the Steering Committee will be to advise on the necessity to update the LEDS"

8.1.2 Cabinet Committee on Climate and Disaster Risk

As outlined in the NCCP, the LEDS (and other climate related plan implementation) would benefit from the formation of a cabinet select committee on climate and disaster risk based on the intra-government considerations involved with national risk management, low carbon, and resilient development. Ministerial oversight in this instance would provide the following benefits:

- Improved high-level oversight of cross-cutting issues that require greater inter-ministerial collaboration;
- A high-level decision-making body for advancing legislation required to anchor Fiji's climate change policy in national law;
- Oversight to support an integrated approach to national risk in support of the NDP process;
- The provision of a high-level 'action-oriented' committee that can respond effectively to issues raised by the NCCCC that required cabinet endorsement;
- The ability to support the NCCCC with high-level input into adaptation and mitigation prioritisation and investment processes; and
- Support for greater understanding of issues that require attention and consideration on the national security agenda.

8.1.3 The LEDS Steering Committee

The LEDS Steering Committee, which was formed for the development of the LEDS and is comprised of relevant sector leads, should be convened at least once every two years to consider the progress on the NDC and LEDS. For this purpose, the CCICD should provide a progress report to the Steering Committee once a year. A key role of the Steering Committee will be to advise on the necessity to update the LEDS (see below).

8.1.4 Review of the LEDS

In keeping with the current duration of the NDC, every four years the LEDS Steering Committee should review progress of the NDC and LEDS, considering relevant technology, finance, and climate context changes, and guide the development of a revised NDC and/or LEDS if and when needed. The Steering Committee will call upon relevant technical experts to support committee meetings and will form technical working groups as needed to inform decision-making. The LEDS process has created consultative groups involving government, non-government, private sector, and civil society representatives which the Steering Committee can utilize in the future to both help inform the review of NDC and LEDS progress and to propose new actions to be considered as part of the NDC and LEDS revision process.

8.1.5 The Climate Change and International Cooperation Division, Ministry of Economy

The CCICD plays a central coordinating role in support of the NCCP and, therefore, also of coordinating implementing the LEDS. There are seven key engagement areas associated with implementing the LEDS:

- **Coordination of Climate Finance:** CCICD acts as a conduit between donors, climate funds, and sector recipients of climate finance to help support an integrated approach to proposal design, funding alignment with priorities, and efficient implementation arrangements. Though CCICD may not coordinate specific funds, it should be involved with all climate finance flows to support coordination, reduce duplication, and enhance climate finance tracking. CCICD works closely with the national budget process and relevant offices within the Ministry of Economy to improve budget coding and tracking systems. CCICD also leads on the reporting and monitoring of domestic climate finance sources ,such as the ECAL, private sector sources, and insurance initiatives. CCICD oversees Fiji's engagement with the Green Climate Fund and will engage internationally to enhance Fiji's access to sustainable climate finance flows and assist to channel those flows to the appropriate entities implementing the LEDS within Fiji.
- **Implementation Coordination, Support, and Reporting:** CCICD is responsible for coordinating implementation and reporting associated with Fiji's LEDS (as well as commitments under the NDP, NDC, and NAP). CCICD will help coordinate sector actions liaising closely with all government ministries and agencies to support the various dimensions of NCCP and LEDS implementation, improve data sharing, and enhance inter- and intra-ministerial cooperation. CCICD will be supported by sector-based climate change officers who will support coordination and integration objectives. CCICD would also act as the Secretariat to the LEDS Steering Committee and would be instructed to act by the Steering Committee to report progress on and to review and update the LEDS as needed.
- **International Reporting and Engagement:** CCICD is responsible for reporting on behalf of the Republic of Fiji to the UNFCCC as well as ensuring transparency, integrity, and consistency in national reporting on the SDGs. CCICD is also responsible for MRV for the NDC, which would feed into reporting on the LEDS. CCICD will recruit specific monitoring and evaluation expertise as required to support this remit. CCICD also plays an ongoing lead role in coordinating Fiji's engagement with the UNFCCC COP and will be responsible for articulated national priorities at the international level.
- **Knowledge Management and Advisory Support:** CCICD supports climate change knowledge management by developing communications strategies, developing and maintaining data repositories, and supporting functions and knowledge products designed to raise awareness of key climate change issues in government, the private sector, and civil society. CCICD works to provide support to government ministries in national efforts to mainstream climate change into development planning, sectoral planning and strategies, decision-making, and policy.
- **National Advocacy and Awareness:** CCICD works with government ministries to support national climate advocacy and awareness raising campaigns to support public awareness and increase the visibility of key issues in adaptation and mitigation.

8.1.6 Sector and Ministry-Based Climate Change Focal Points

As stated in the NCCP, to improve communication, coordination, and integration of Fiji's climate change objectives across government, all ministries and sectors, including state-owned agencies and enterprises (e.g., Water Authority of Fiji, Land transport Authority, etc.) must nominate a designated climate change focal point to CCICD. These individuals will either be existing civil servants, with current obligations relevant to climate change, or newly recruited specialists. These focal points will be equipped to manage strategic planning processes and cross-sectorial and intra-ministerial engagement, including for the LEDS, and this will be part of their job description.

8.1.7 Private Sector Advisory Board

To help integration and alignment between the public and private sectors, and in recognition of the private sector as a catalyst and financier of mitigation and action and the need for the private sector to receive relevant, tailored, and actionable information on climate change mitigation initiatives and impacts, CCICD plans to establish a Private Sector Advisory Board, which will also support LEDS implementation, as outlined in the NCCP. The Private Sector Advisory Board will provide a landing zone for key information arising from the work of the NCCCC and create a space for developing and consulting on new private-public partnership, business development, and investment and financing opportunities in both mitigation and adaption. The Board will help to identify key issues relevant to investment and business planning and ensure that the private sector is updated in a timely fashion in relation to new initiatives, incentives, standards, regulations, and risks. It will also help to support and promote new types of businesses and identify business opportunities that cross-cut climate adaptation and mitigation objectives.

8.1.8 Local and Sub-national Government

Local government entities, including city and town councils, district offices, and provincial councils, play a vital role in the delivery of the NCCP and LEDS objectives at the community and national level. Local government entities will require the resources needed to take further ownership of mitigation (and adaptation) actions at the local level. In many cases, the measures needed to implement the LEDS include behavioural change, which will have to be embedded through campaigns from the local level upward, as well as socialised through national awareness campaigns. Information on new climate-related regulations and policies, incentives, and penalties will need to be disseminated at all levels for compliance and enforcement to be effective. All local and sub-national levels will play a role implementing the LEDS, and should be recognized as such, and provide training and resources.

8.1.9 Legislation and Standards of Compliance

Fiji's response to climate change will be enabled, in part, through the use of standards of compliance designed to improve consistency of practice in ways that reduce GHG emissions and reduce risks to people and to the environment. Climate change-related legislation will help to improve the scope, enforcement, and value-added potential of the use of standards as a way to adjust business-as-usual behaviours, instigate behaviour change, and ultimately help to automate the progression of key priorities. Standards of Compliance should feature as a permanent agenda point for NCCCC meetings.

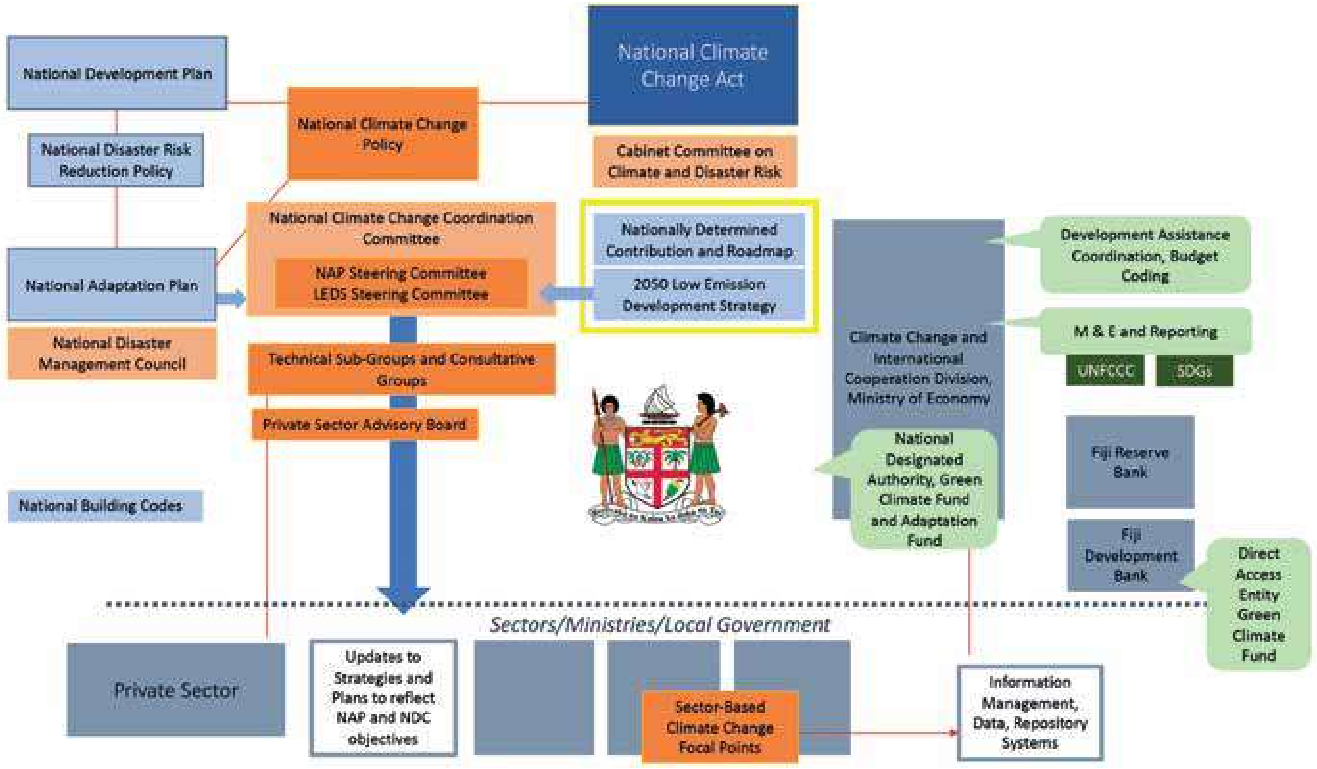
Key existing standards and recommendations for new and improved standards are included in the relevant chapters of the LEDS and are not listed here (e.g., review and update of Fiji's National Building Codes, ongoing enforcement and review of emissions standards for vehicles, white goods, and electrical appliances, standards and codes of practice related to waste management, etc.). EIAs and safeguard policies for land use planning have cross-cutting adaptation, disaster risk reduction, and carbon mitigation implications and should be assessed on an ongoing basis to ensure compliance with the objectives of the LEDS.

Further, it is recommended that a review of legislation and regulations is undertaken to determine the extent to which they encourage or discourage the greener development path of Fiji's NDP and LEDS, and the associated creation of more green employment.

Finally, to further ensure and enshrine governance, the Ministry of Economy recommends the adoption of a Climate Change Act for Fiji to provide a legislative foundation to manage climate risks and drive Fiji's transition to a low carbon, climate resilient economy. The Climate Change Act would strengthen the mandate of the bodies mentioned above, and also enshrine the principles of inter-ministerial cooperation for mitigation and adaptation action, private sector engagement and data collection, management, and sharing for the purpose of climate action and reporting.

Figure 85 below represents the relationships and governance arrangements associated with key intra-government plans such as the NCCP, NAP, and LEDS. This representation provides a visualisation of linkages and is not an exhaustive depiction of Fiji's climate change legislation, plans, policy environment, or institutional arrangements.

Figure 85. Relationships and governance arrangements associated with key intra-government plans such as the NCCP, NAP, and LEDS.[269]



8.2 FRAMEWORK FOR MONITORING AND EVALUATION OF THE LEDS

8.2.1 Monitoring and Evaluation Framework

This section lays out a framework and approach for monitoring and evaluation of the LEDS. These elements will contribute to a full monitoring and evaluation (M&E) plan and MRV system, which will be developed and put in place. The purpose of the approach and processes described below are to provide a framework to transparently demonstrate progress made towards the net zero emission pathways described in the LEDS and in-line with the targets in Fiji's NDC.

The M&E approach will involve using existing government systems, while building capacity and data collection capability where possible. The specific M&E plan required for the actions associated with the NDC and LED implementation (as well as related policies and strategies, such as the NCCP and the NAP) will need performance indicators for each sector. These will need to be identified and decided when the M&E plan is developed, in coordination with the relevant ministries and other bodies. Therefore, the LEDS does not detail M&E and performance indicators for each sector, but will provide high-level guidance to support associated M&E processes.

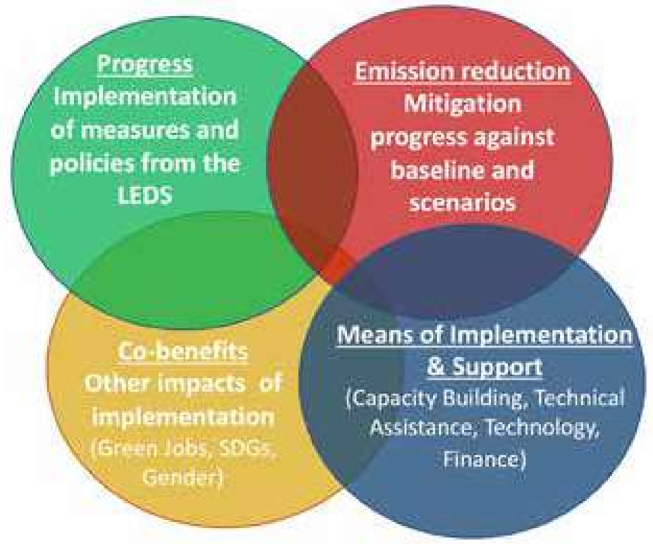
[269]Government of Fiji. (2018b). *National Climate Change Policy.*

Due to the cross-cutting nature of the LEDS, the performance indicators and the data required should be tailored wherever possible to match existing data collection from different sectors and by FBoS. For example, a cross-cutting collection process already takes place for the TNC and the same mechanism could be employed for M&E of the NDC and the LEDS. Where there are gaps, new data collection and indicators will need to be implemented and should be coordinated with the appropriate sector bodies, alongside appropriate capacity building activities, if needed. This may require additional resources (financial in the short-term and most likely human resources in the medium- to long-term).

The monitoring approach for the LEDS should allow for tracking progress of four different dimensions of the LEDS: progress made in implementation of the specific measures and policies as recommended by the LEDS; tracking emissions reductions achieved through the measures implemented; assessing co-benefits in terms of green jobs, gender inclusion, SDGs and others; and, finally, tracking the means of implementation and support, such as capacity building, technical assistance, technology, and finance. The four dimensions of the proposed monitoring system are depicted in Figure 86 below and described briefly here:

1. Tracking specific policies and actions implemented from the LEDS;
2. Tracking the GHG emissions reductions achieved against the baseline and mitigation pathways (this will be linked to the TNC and NDC tracking);
3. Tracking impact of policies and actions in creating co-benefits in terms of green jobs, gender inclusion, and contributing to meeting the SDG targets; and
4. Tracking means of implementation and support, i.e., capacity building, technical assistance, technology transfer, and amount of finance into the LEDS actions. Financial flows would include both domestic and international finance and both private and public money.

Figure 86. Four dimensions of LEDS monitoring and evaluation.[270]



A robust M&E plan for the LEDS will ensure transparency, accuracy, and comparability of information with regards to GHG emissions for each of the five-year periods leading towards 2050. The M&E plan, and supporting activities, will strengthen both national and sectoral data and methodologies required to robustly determined GHG emissions across the defined sectors. As M&E is implemented, lessons learnt should create a positive feedback loop, strengthening data collection processes and enabling greater accuracy in GHG emission calculations. The M&E plan for the LEDS should underpin the national and sectoral GHG data quality and assist in identifying downstream national and sectoral priorities and strengthen policy planning and prioritisation towards a low carbon future.

[270]Adapted from the Fiji NDC Implementation Roadmap, Ministry of Economy, 2017.

8.2.2 General Evaluation Questions and Principles for Indicators

In line with the principles laid out in the NCCP, the M&E of progress of actions associated with the delivery of the LEDS should integrate the following principles and lines of questioning when designing indicators:

1) Coverage: What percentage of the target has been addressed?[271]
2) Impact: What is the cumulative impact in relation to the issue addressed?
3) Sustainability: Is the intervention sustainable?
4) Replicability: Can the intervention be learned from and applied elsewhere? Would the method be used again?
5) Process: How was the intervention designed, prioritised, and justified?
6) Outcomes: What are all of the outcomes associated with the intervention both intended and unintended?
7) Behaviour: Has behaviour been changed by the intervention?
8) Wellbeing: Did the outcome contribute meaningfully to the improvement of welfare?
9) Gender-responsive and sensitive: Have gender-sensitive indicators and targets been used to design, implement, and measure results?
10) Human Rights: Have all potential human rights considerations and interactions been taken into account in the design, implementation, and evaluation of results?
11) Cost: How have funds been utilized? What are the expected budgetary implications to require sustainability. Have available financing sources been leveraged in a complementary way?

The LEDS will also align with the principles laid out in the NCCP to ultimately measure contribution to the following disaggregated classifications of national capital:

1) Human Capital (health, capacity, knowledge, skills, access to vital resources and services)
2) Natural Capital (natural resources, environmental resilience)
3) Social Capital (networks, behaviours)
4) Financial Capital (assets and finance)
5) Physical Capital (infrastructure)
6) Political Capital (trust, international partnership, influence)

The LEDS takes an approach which encourages interventions aimed at producing outcomes which add value across as many different dimensions of national capital as possible by emphasising the co-benefits of climate mitigation aspects (see Chapter 6) and recognizing that mitigation actions to drive decarbonisation of the economy must also result in overall positive contribution to the economy and to the national capital as a whole in order to be sustainable in the long-term.

8.2.3 Monitoring and Evaluation Reporting Responsibilities

Relevant sector-leads and ministries from the LEDS sectors will be responsible for delivering aspects of the LEDS. In each case, these lead agencies and ministries will be required to communicate M&E outcomes and reports to CCICD to support national reporting processes. CCICD is responsible for collating and submitting Fiji's national reporting relating to Paris Agreement and SDG commitments to appropriate UN bodies. The reporting responsibilities of CCICD include, but are not limited to:

- Voluntary National Reports on SDG progress (voluntary);
- National Communications to the UNFCCC (every four years);
- Biennial Update Reports to UNFCCC (two years after each national communication submission);

[271]Coverage is especially important in relation to the range of different environments, contexts, and lifestyles found within the urban, peri-urban, coastal-rural, interior-rural, and outer islands areas of the country.

- NDC to the Paris Agreement: Review and enhancement of Fiji's NDC will take place every five years;
- NAP: M&E process will be implemented on an ongoing basis with formal national reporting at least every five years;
- NDC Roadmap and LEDS Implementation: MRV of sector emissions conducted on an ongoing basis;
- Environment and Climate Adaptation Levy (ECAL): National reporting on use of levied funds;
- Green Bond: Issuance reporting to bond holders;
- Climate finance: Coordination within national budgets and with donors during the design phase of programming will receive support from CCICD. CCICD will work with the relevant offices within the Ministry of Economy to create budget coding and systems for tracking climate finance; and
- Other International Cooperation related reporting.

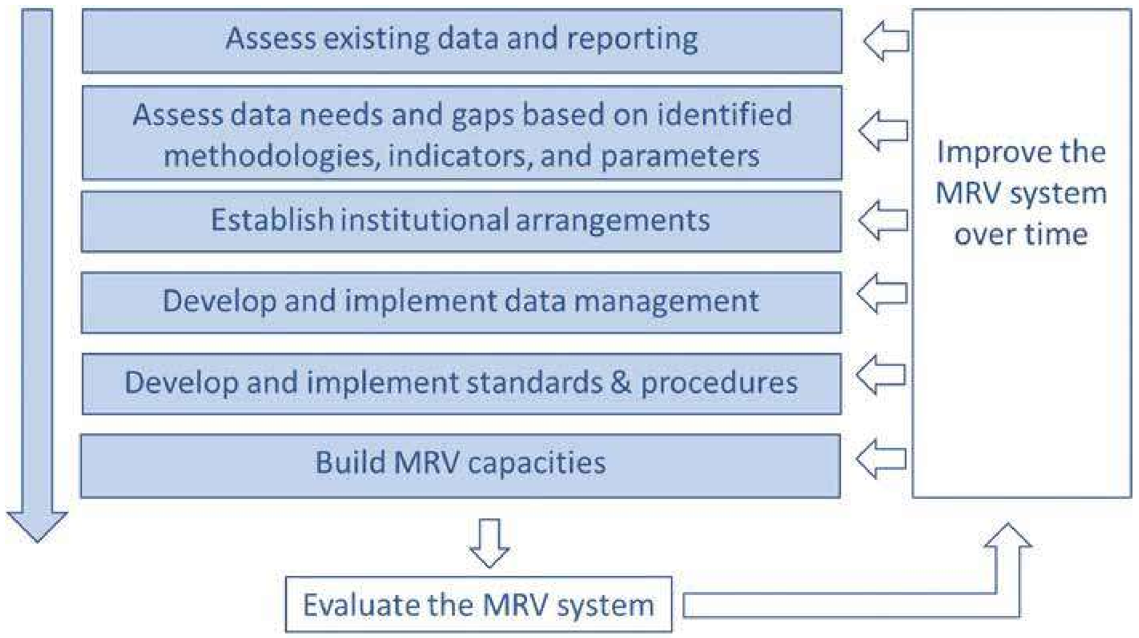
> "The strengthening of data and methodologies will require capacity building and specific actions to be designed and implemented in the next two to three years"

8.2.4 Strengthening of Data and MRV systems

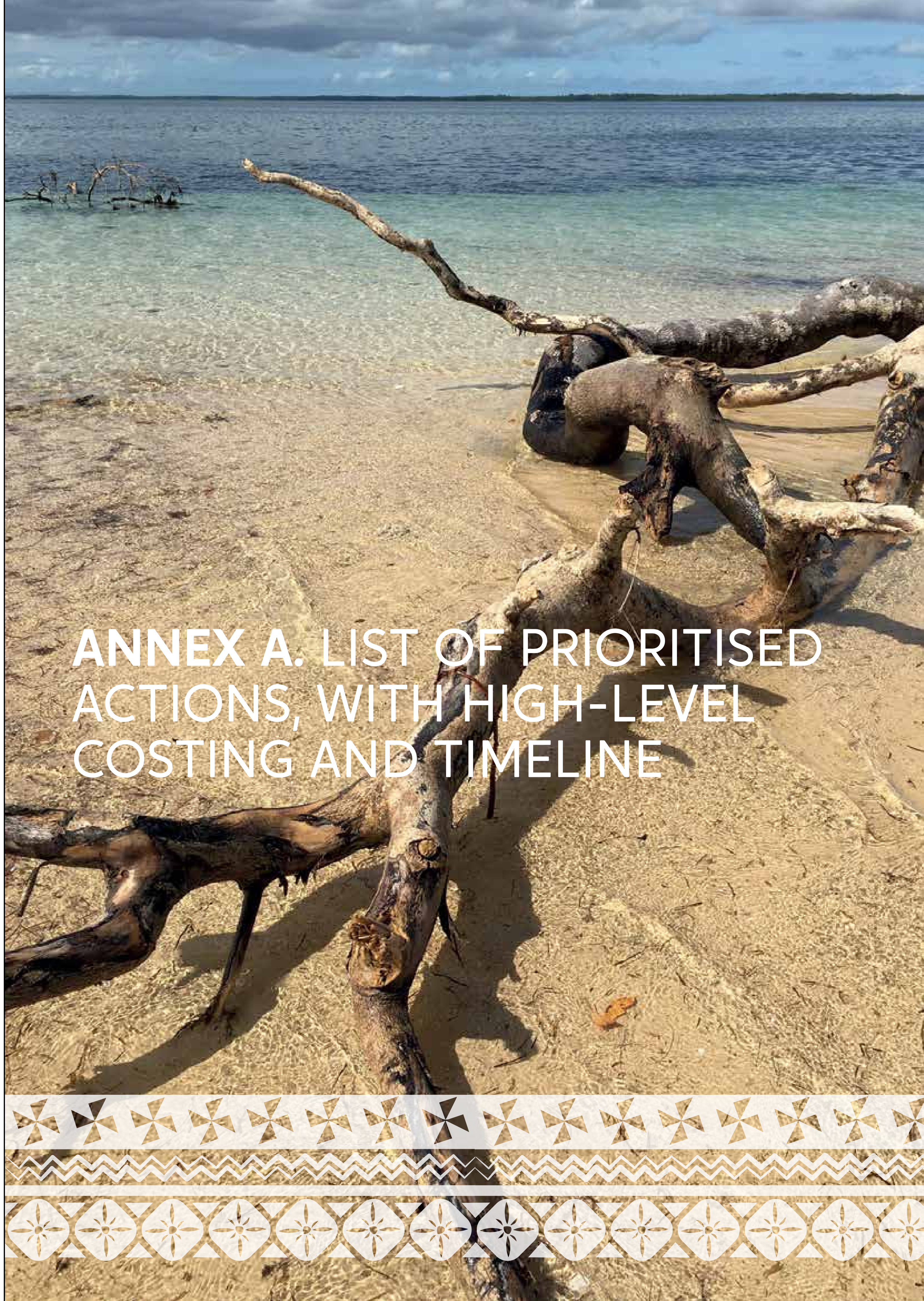
The data required to support various reporting processes will require improved systems for understanding and quantifying national assets and capital. In addition to the financial and physical capital, improved systems will be required to measure, evaluate, and understand changes to natural, social, and human capital.

Implementing the LEDS will require robust systems for both centralized and decentralized reporting. This will require new support to entities collecting and managing data. The M&E approach includes a bottom-up approach which will be used to include the strengthening of data and methodologies, the use of existing data and reporting pathways, the identification of additional data and reporting pathway needs, and improved use of internationally recognized and IPCC methodologies and software. The strengthening of data and methodologies will require capacity building and specific actions to be designed and implemented in the next two to three years to ensure improved data availability and confirm reporting responsibilities before the next review and update on the LEDS. These principles will also be the foundation of setting up an MRV system which will be integrated with the national reporting and inventories system, which is managed by CCICD. Figure 87 below depicts the steps for setting up an MRV system.

Figure 87. Steps for setting up and improving an MRV system.



Strengthening of data collection and management capacity should be a key component of the M&E plan, as the consultations undertaken during the development of the LEDS identified that a key constraint in achieving greater accuracy of the estimated sectoral GHG emissions and future scenarios was the availability and reliability of data. Strengthening of data availability will enable greater standardization of methodologies and for Fiji to move from using IPCC Tier 1 methodologies towards IPCC Tier 3. This strengthening will take place in cooperation between the various implementing entities of the LEDS associated with data gathering and reporting in the different sectors, with CCICD and FBoS playing key coordination and data consolidation roles.



ANNEX A. LIST OF PRIORITISED ACTIONS, WITH HIGH-LEVEL COSTING AND TIMELINE

ANNEX A. LIST OF PRIORITISED ACTIONS, WITH HIGH-LEVEL COSTING AND TIMELINE

For purposes of this table, "short-term" actions are to be implemented between 2018-2025, "medium-term" actions are to be implemented between 2026-2035, and "long-term" actions are to be implemented between 2036-2050. All costs are indicative and, in many cases, will need to be confirmed through further investigation and feasibility studies. It should be noted that this list is not exhaustive, and the costs are not cumulative but depend on the scenarios and specific actions which are implemented.

Action	Scenario[271]				High-Level Costing (USD millions)	Main Implementer	Implementation Timeframe
	BAU-U	BAU-C	HA	VHA			
Energy Sector (Grid electricity, off-grid electricity, cooking fuels)							
Energy policy. Review, update and endorsement of the national energy policy	X	X	X	X	0.05-0.15	DoE	2019
New biomass installation. 22 MW of biomass power	X				88	EFL, IPPs	Short-term
New solar installation. 223 MW of solar PV is installed by 2050	X				1330	EFL, IPPs, DoE	Gradual starting from 2018
New hydro installation. 0.7 MW of new hydro	X				2.1	EFL, IPPs, DoE	Short term
New fossil fuel installation. 105 MW new HFO and 142 MW IDO are installed to satisfy increased demand.[272]	X				185.5	EFL, IPPs	Medium- to long-term
Clean Cookstoves. Open fire cooking is completely replaced with LPG, kerosene, and electric stoves in urban by 2030	X	X			Variable costs	EFL, Private Sector, DoE	Short to medium
Energy Efficiency. Energy efficiency measures, capacity building and education are implemented economy-wide	X	X	X	X	Variable costs	DoE, FCCC, EFL, Academic Institutions (USP, FNU, UoF)	Short to medium
Codes and standards. Updating of codes and standards for buildings and industry	X	X	X	X	0.5	MITT, private sector	Short to medium
Minimum Energy Performance Standards and Labelling. Minimum energy performance standards and labelling are implemented for all major electrical appliances (including public education and awareness raising)	X	X	X	X	1.5	DoE, FCCC, EFL, FRCS, customs, private sector, households	Short to medium
Energy efficiency in the business community. Adoption of ISO 50001:2011 – Energy Management	X	X	X	X	2.0	FCCC, FRCS, DoE, MITT, private sector	Short to medium
Energy efficiency in the public sector. Review of budgeting processes and procurement, adoption of ISO 50001:2011 – Energy Management, energy efficiency demonstration projects for public buildings					4.0	MOE, FCCC, DoE, all government ministries	Short to medium
Renewable Energy Database. A centralized renewable energy resource database is launched, regularly updated, and made available to investors	X	X	X	X	Variable costs	DoE, FCC, EFL, Academic Institutions (USP, FNU, UoF)	Short-term
Solar PV Guidelines and Regulations. Grid-connected solar PV guidelines and regulations are established and enforced, including review of FiT and/or introduction of net metering mechanisms	X	X	X	X	Variable costs	DoE, FCC, EFL, Academic Institutions (USP, FNU, UoF)	Short-term
Capacity Building for Renewable Energy and Smart Grids. Capacity building needs for renewable energy development and smart grids will be continuously addressed	X	X	X	X	Variable costs	DoE, FCC, EFL, Academic Institutions (USP, FNU, UoF, TVET)	Short-term and ongoing to 2050
New solar with storage installations. 272 MW[273] solar PV with storage (including rooftop solar)		X			1,360	EFL, DoE, IPPs, private sector, households,	Gradual –short- to long-term
New biomass installation. 136 MW biomass generation		X			544	EFL, IPPs	Gradual –short- to long-term
New geothermal installation. 52 MW geothermal capacity[274]		X			415	EFL, IPPs	Long-term
New wind installation. 150 MW wind power are installed by 2050		X			975	EFL, IPPs, DoE	Medium- to long-term
New W2E installation. 10 MW Waste to Energy (W2E)		X			35	EFL, IPPs, DoE	Short-term
New biogas installation. Biogas for electricity (1 MW)		X			1.25	EFL, IPPs, DoE	Short-term
Investigation of ocean energy. Initial efforts are undertaken to develop ocean energy namely tidal power, wave energy and Ocean Thermal Energy Conversion (OTEC)		X			Variable costs	EFL, IPPs, DoE, Academic Institutions	Medium- to long-term
New solar and storage installation. 322 MW solar PV (including extensive rooftop solar) with storage			X		1,600	DoE, EFL, IPPs, private sector, and households	Gradual starting from 2018
New wind installation. 200 MW wind power is on the grid by 2050			X		1,300	DoE, EFL, IPPs	Medium- to long-term
Wood Fuel Use Eliminated. For off-grid locations, all household use of wood fuel for cooking is eliminated by 2030		X			Variable costs	EFL, DoE, private sector	Gradual starting 2018
Replacing Diesel Generators. all diesel generators (5.5 MW at present) in off-grid locations will be replaced with solar PV with storage by 2040, including at off-grid resorts		X			33	EFL, DoE, tourism private sector, and other private sector	Gradual – medium-term
Electric Stoves in On-Grid Households. all grid-connected households use electric stoves by 2050			X	X	Variable costs	DoE, EFL, private sector	Long-term
Electric Stoves in Off-Grid Households. all off-grid households use electric stoves by 2050[275]				X	Variable costs	EFL, DoE, private sector	Long-term
New hydro installation. 285 MW new hydropower			X		171	DoE, EFL, IPPs	Gradual – Short- to long-term
New biomass installation: 166 MW biomass power			X		664	EFL, IPPs	Gradual – Short- to long-term
New W2E installation: 10 MW W2E			X		35	EFL, IPPs	Short-term
New geothermal installation: 150 MW geothermal capacity			X		600[276]	EFL, IPPs	Medium- to long-term

[271]BAU-U = BAU Unconditional; BAU-C = BAU Conditional; HA = High Ambition; VHA = Very High Ambition
[272]In the absence of funding for establishing new renewable energy systems under the BAU Unconditional scenario, IDO.HFO generators will be needed to satisfy additional demand, especially from the transport sector. This cost will not be incurred in any of the other scenarios.

[273]This is cumulative, not additional, so including the 223 proposed under the BAU-Unconditional scenario. The same applies for all other renewable energy installations under BAU-Condition, High Ambition and Very High Ambition Scenarios.
[274]Assuming exploration of geothermal resource potential is carried out separately.

[275]An option could be investigated to use biodigesters to produce gas for cooking in off-grid locations in lieu of electric stoves. However, this would apply only where there are also farming activities and sufficient water availability and it has not been considered in this analysis.
[276]Assuming exploration of geothermal resource potential is carried out separately.

Action	Scenario[271]				High-Level Costing	Main	Implementation
	BAU-U	BAU-C	HA	VHA	(USD millions)	Implementer	Timeframe
Ocean power installations. First ocean power installations at feasible sites[277]			X		Variable cost	EFL, IPPs	Long-term
New solar with storage installation. 522 MW solar PV with storage (including extensive rooftop)				X	2,300	EFL, IPPs, DoE	Gradual – short- to long-term
New hydro installation. 435 MW hydropower				X	5,200	EFL, IPPs, DoE	Gradual – short- to long-term
New W2E installation. 10 MW W2E installation				X	35	EFL, IPPs, DoE	Short-term
New biomass installation. 256 MW biomass power is installed by 2050				X	1,000	EFL, IPPs, DoE	Gradual – short- to long-term
Vehicle-to-grid (V2G) Adoption. New V2G technology implemented to support the grid starting 2040				X	Variable cost	EFL, IPPs, private sector, and vehicle owners	Medium- to long-term
New geothermal and ocean energy installation: 350 MW geothermal				X	1,400	EFL, IPPs	Medium- to long-term
New wind installation: 350 MW wind (on and offshore)				X	4,600	EFL, IPPs, DoE	Medium- to long-term
Solar for Off-grid resorts. By 2040, all off-grid resorts are using 10 MW solar PV and 0.5 MW wind power for their electricity requirements				X	42-48	Tourism private sector	Gradual starting 2018- short- to long-term
Land Transport							
National Electric mobility strategy. Development of a national electric mobility strategy for cars, taxis, buses and trucks, including hybrid electric and electric vehicles		X	X	X	0.2	Ministry of Infrastructure and Transport, FRA, LTA	Short-term
Hybrid Electric Vehicles (HEV)s. Promotion of hybrid electric vehicles (HEVs)[278] – cars, taxis, and buses[279]	X				344	Private sector purchases vehicles, government sets targets and regulations	2019 to 2050
Hybrid Electric Vehicles (HEV)s. Promotion of hybrid electric vehicles (HEVs) – cars, taxis, and buses[280]		X			92	Private sector purchases vehicles, government sets targets and regulations	2019 to 2050

[277]This would require resource assessment and also availability of commercially proven devices.
[278]Different target levels for each scenario. Unconditional initially low and then slowly growing HEV target levels and very high ambition starts with high penetration levels of HEV which quickly drop as EVs are promoted within this scenario instead of HEVs.
[279]Incremental CAPEX of USD 1,500 per car and taxi and USD 20,000 per bus; incremental CAPEX is recovered with fuel savings. USD 280 million for cars and taxis; USD 64 million for buses.
[280]This is the capex required for the specific scenario. This also applies for High Ambition and Very High Ambition scenarios.

Action	Scenario[271]				High-Level Costing	Main	Implementation
	BAU-U	BAU-C	HA	VHA	(USD millions)	Implementer	Timeframe
Hybrid Electric Vehicles (HEV)s. Promotion of hybrid electric vehicles (HEVs) – cars, taxis, and buses			X		79	Private sector purchases vehicles, government sets targets and regulations	2019 to 2050
Hybrid Electric Vehicles (HEV)s. Promotion of hybrid electric vehicles (HEVs) – cars, taxis, and buses				X	61	Private sector purchases vehicles, government sets targets and regulations	2019 to 2030
Electric Vehicles (EV)s. Adoption of electric vehicles (EVs) – taxis (50%), buses (90%), cars (20%), urban trucks (40%) [281][282]	X				997	Private sector purchases vehicles, government sets targets and regulations	Starting from 2040 onwards
Electric Vehicles (EV)s. Adoption electric vehicles (EVs) [283] – Taxis, buses, cars, and urban trucks (100%); large trucks (40%)		X			4,469	Private sector purchases vehicles, government sets targets and regulations	Starting from 2025 onwards
Electric Vehicles (EV)s. Adoption of electric vehicles (EVs) – Taxis, buses, cars and urban trucks (100%); large trucks (70%)			X		5,167	Private sector purchases vehicles, government sets targets and regulations	Starting from 2025 onwards
Electric Vehicles (EV)s. Adoption of electric vehicles (EVs) – All vehicles 100% electric				X	7,322	Private sector purchases vehicles, government sets targets and regulations	Starting from 2025 onwards
Public Transport. Promotion of public transport[284] including separated bus lanes, cameras, and ITS	X	X	X	X	8-10	Ministry of Infrastructure and Transport, FRA, LTA	Gradual increase depending on scenario
Non-Motorised Transport. Promotion of non-motorised transport,[285] including bicycle lanes		X	X	X	20	MoIT, FRA, LTA	Gradual increase depending on scenario
Biofuels. Development of a national biofuel strategy and promotion of biofuels including measures such as subsidies or tax exemption as required. These measures would support a bioethanol blend for petrol and biodiesel blend for diesel.	X	X	X	X	3000 per annum[286]	MoIT, MoE, FRCS, Private sector	Up to 2025
Fuel Efficiency in Trucks. Efficiency improvement of trucks by using deflectors and replacement of tyres and development of eco-driving training centres with truck simulators			X	X	3	Private sector, LTA	Up to 2021

[281]Different target levels for each scenario. BAU-Unconditional starts at 0% and then slowly growing EV target levels and very high ambition starts with low penetration levels of EV which quickly increase to reach 100% penetration levels.
[282]Incremental CAPEX based on today's cost differences: incremental CAPEX is expected to be recovered until 2025 with energy and maintenance savings for buses, taxis and urban trucks and by 2030 for private cars and 2035 for long-haul trucks; incremental CAPEX today USD 15,000 per taxi, passenger cars: USD 150,000 per bus; USD 40,000 per urban truck; USD 150,000 per long-haul truck.
[283]Incremental cumulative capex, not additional, so including the capex required under the BAU-Unconditional scenario. This also applies for High Ambition and Very High Ambition scenarios.
[284]Lower target levels for less ambitious scenarios.
[285]Lower target levels for less ambitious scenarios.
[286]Based on incremental cost of biofuels of around USD 0.20 per litre, 5% biodiesel and 10% bioethanol, incremental cost based on price differences in Europe.

Action	Scenario[271]				High-Level Costing (USD millions)	Main Implementer	Implementation Timeframe
	BAU-U	BAU-C	HA	VHA			
Domestic Maritime Transport							
National Action Plan for decarbonisation of maritime transport. Design of a long-term National Action Plan for decarbonisation of the maritime transport sector in Fiji to 2050.		X	X	X	0.2	Ministry of Infrastructure and Transport	Short-term
Maritime Data Collection and Analysis. Domestic maritime data collection, storage, and analysis[287]	X	X	X	X	3	FBoS, MoIT, FRCS, MSAF	From 2019 and ongoing to 2050
4-Stroke Engines. Implementation of a national program of transition from 2-stroke to 4-stroke to electric outboard motors	X	X	X	X	0.5 -1	MoIT, MoE, FRCS	Short-term
Demonstration Vessels. An integrated series of 'proof of concept' demonstration low carbon government department vessels at various scales from village to inter-island transport. This will be accompanied by GSS 30-year fleet replacement strategy with addition of low carbon vessels over time.	X	X	X	X	10 – 100[288]	GSS, Ministry of Health, Min of Education, MoIT, MSAF, MoE, Police, Navy	Short- to medium-term
Research, Education, and capacity Building. Adoption and implementation of a long-term research, education, and capacity building strategy to underpin a successful domestic low carbon maritime transition.	X	X	X	X	Variable cost	USP, SPC, FMA/ FNU, Ministry of Education	2019 and ongoing
Financing modalities for first phase of investments in proven technologies. Identification and **developm**ent of financing modalities[289] to support private sector uptake of commercial proven measures at scale.	X	X	X	X	50 -100	MoIT, FRCS, MoE	Short- to medium-term
Economic Opportunities. Identification of the long-term positive economic opportunities for Fiji's maritime service delivery industry, tourism industry, manufacturing, and finance sectors from positioning Fiji as the Pacific hub for low carbon maritime transition.			X	X	0.05 – 0.2	MoIT, MoE	Immediate
Policy Incentives. Economic instruments (e.g., tax incentives) to drive transition of all small motors from fossil fuel to sail or RE powered small motors (e.g., electric outboards)		X	X	X	0.1 – 0.25	MoE, FRCS	Immediate
Fuel Efficiency Standards. Vessel imports subject to increasingly stringent efficiency standards and fossil fuel powered vessels increasingly penalized	X	X	X	X	0.05-0.15	MITT, MSAF, FRCS	Immediate
Financing modalities for second phase of investments established to support uptake of new technologies. Vessel financing modality programme established and implemented to support public and private sector uptake of new technologies including wind hybrid, battery hybrid, Wing-in-Ground.		X	X	X	50-100	MoEcon, MoIT, FRCS	Medium- to long-term
Shipping Franchise and Sea Route Licensing. Review of Shipping Franchise and Sea Route licensing in favour of low/zero carbon vessels and operational efficiencies	X	X	X	X	0.1-0.15	MoIT	Short-term

[287]USD 200,000 for set-up and 100,000 per year to 2050.
[288]Over 10 years.
[289]For example, soft loans, green bonds.

Action	Scenario[271]				High-Level Costing (USD millions)	Main Implementer	Implementation Timeframe
	BAU-U	BAU-C	HA	VHA			
Traditional Sailing. Revitalisation of Traditional sailing culture.	X	X	X	X	0.5 - 1	Ministry of Culture, Ministry of Education	Short-term, ongoing
Domestic Air Transport							
Efficient Aircraft. 40% of domestic fleet activity replaced with efficient aircraft by 2030 and increases to 80% by 2050.		X			120 -400[290]	Fiji Link, Northern Air	Medium- to long-term
Efficient Aircraft. 100% domestic fleet replaced with efficient aircraft			X		500-600	Fiji Link, Northern Air	Medium- to long-term
Off-Grid Airports. All off-grid airports are 100% powered by solar PV	X	X	X	X	8-10	Airports Fiji Limited; Civil Aviation Authority of Fiji (CAAF)	Short- to medium-term
Gate Power. All aircraft at off-grid airports rely on dedicated solar PV systems for auxiliary power while at gate (replacing diesel generators)	X	X	X	X	10	Airports Fiji Limited; CAAF	Short- to medium-term
Biojet Fuel. 20% of flight activity using biojet by 2040 which increases to 40% by 2050.			X	X	Variable costs[291]	Ministries of Economy, Agriculture, Sugar and Fiji Link, Northern air	Medium- to long-term
Energy efficiency. Improved load factor and aircraft traffic management at all airports, single engine taxiing, continuous descent	X	X	X	X	Variable costs	Fiji Link, Northern Air and AFL	Gradual: short- to medium-term
Electric Aircraft. 20% of all passenger activity is via electric planes				X	Undetermined at the moment	Fiji Link, Northern Air	Long-term
AFOLU							
Reduced logging emissions in Natural Forests. Decrease emissions from logging in natural forests (forest degradation) by 1%.[292] The action can be implemented by training of wood cutters in the field of reduced impact felling techniques in order to reduce felling residuals.	X				0.2	Ministry of Forestry	Short-term
Reduced logging emissions in Natural Forests. Decrease emissions from logging in natural forests (forest degradation) by 10%. This includes training of wood cutters, machine operators and logging planners in the field of resource-saving reduced impact logging (felling and skidding) techniques and by providing advanced skidding equipment.		X	X	X	0.4	Ministry of Forestry	Medium-term
Reduced Deforestation.[293] Decrease emissions from deforestation by 10%.[294] The avoidance of clear-cutting and land use changes can be achieved by designating protected areas or restrictions on use.	X	X			6	Ministry of Forestry, Forest owners, Local stakeholders	Short-term
Reduced Deforestation. Decrease emissions from deforestation by 20%[295] The avoidance of clear-cutting and land use changes can be achieved by designating protected areas or restrictions on use.			X		12	Ministry of Forestry, Forest owners, Local stakeholders	Mid-term

[290]Assuming the cost of new aircraft to be around USD 40-50 million each (mainly ATRs or similar).
[291]Studies have indicated that Biojet fuel costs could fall within the same range as fossil fuel costs by 2030, for example see Hayward et al. (2015). *The economics of producing sustainable aviation fuel: a regional case study in Queensland, Australia.*
[292]These measures and the measures for 10% reduction in forest degradation can be implemented through the Fiji Forest Harvesting Code of Practice.
[293]For all reducing deforestation actions, the forest owners must be compensated for financial losses, and all relevant local stakeholders must be given due consideration in design of incentives, etc. Further, these actions can be implemented as part of REDD+.
[294]Assumes annual average volume extracted of 600,000 m^3, 10% would amount to 60,000 m^3. With an average price USD 100/m^3, loss of income amounts to USD 6,000,000.
[295]Assumes annual average volume extracted of 600,000 m^3, 20% would amount to 120,000 m^3. With an average price USD 100/m^3, loss of income amounts to USD 12,000,000.

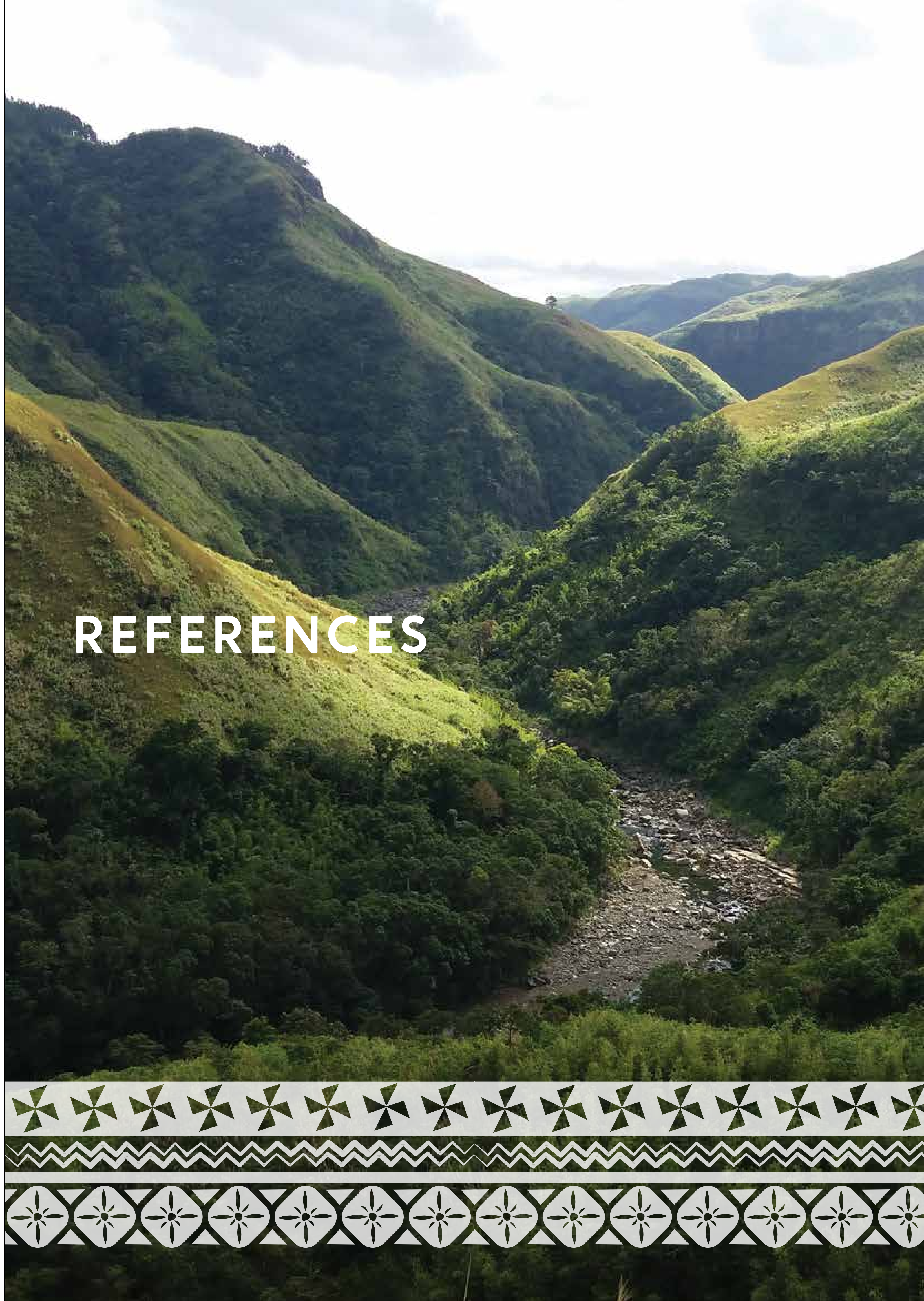
Action	Scenario[271]				High-Level Costing (USD millions)	Main Implementer	Implementation Timeframe
	BAU-U	BAU-C	HA	VHA			
Reduced Deforestation. Decrease emissions from deforestation by 80%[296] The avoidance of clear-cutting and land use changes can be achieved by designating protected areas or restrictions on use. Possible compensation areas for alternative land use must be designated. This requires adapted land-use planning policies.				X	48	Ministry of Forestry, Forest owners, Local stakeholders	Long-term
Increased plantation Productivity. Increase productivity in forest plantations by 20%. This includes measures to increase survival rates after planting and exploitation of the potential site productivity. To increase timber production, higher numbers of seedlings should be planted during plantation establishment and thinning should be applied for stand maintenance. These measures are taken by the operators of the plantations and do not require any specific policy measures other than financial support, if needed.		X			0.5	Fiji Pine Ltd, Fiji Hardwood Ltd	Short-term
Increased plantation Productivity. Increase productivity in forest plantations by 30%. In addition to the above-mentioned measures, site specific growth models should be derived which allow for an optimisation of the time of harvest. These measures are taken by the operators of the plantations and do not require any specific policy measures other than financial support, if needed.			X		1	Fiji Pine Ltd, Fiji Hardwood Ltd	Mid-term
Increased plantation Productivity. Increase productivity in forest plantations by 40%. Further increases in productivity can be achieved through tree improvement and the cultivation of alternative tree species. This requires extensive forest growth trials. These measures are taken by the operators of the plantations and do not require any specific policy measures other than financial support and permission to grow non-native tree species.				X	2	Fiji Pine Ltd, Fiji Hardwood Ltd	Long-term
Afforestation.[297] Afforestation of 10,000 ha with mahogany or equivalent hardwoods.[298] Pine can also be used as pine plantations show higher growth than mahogany plantations and thus sequester higher amounts CO_2. These measures require adapted land-use planning policies.			X		12[299]	Fiji Pine Ltd	Mid-term
Afforestation. Afforestation of 77,400 ha with mahogany, pine, other hardwood species and native species. These measures require adapted land-use planning policies.				X	93[300]	Fiji Pine Ltd	Long-term
Enteric Fermentation in Livestock. Reduce emissions from enteric fermentation in commercial livestock by 1%. Measures to be taken are training of farmers and the financial support for improving livestock productivity through embryo transfer and genetic improvement.		X			1	Ministry of Agriculture, Koronivia Research Station, Fiji Livestock Corporation, local farmers	Short-term

[296]Assumes annual average volume extracted of 600,000 m^3, 80% would amount to 480,000 m^3. With an average price USD 100/m^3, loss of income amounts to USD 48,000,000.
[297]Afforestation measures can be part of the REDD+ implementation.
[298]Assumes costs incurred for planting. Income from logging would exceed the costs of the plantation, including rent, and compensation for landowners.
[299]Financing can take the form of long-term loans, which are repaid when the timber is harvested.
[300]Financing can take the form of long-term loans, which are repaid when the timber is harvested.

Action	Scenario[271]				High-Level Costing (USD millions)	Main Implementer	Implementation Timeframe
	BAU-U	BAU-C	HA	VHA			
Enteric Fermentation in Livestock. Reduce emissions from enteric fermentation in commercial livestock by 5% through extended training of farmers and financial support for improving livestock productivity through embryo transfer and genetic improvement. Policies to encourage changes in livestock breed are recommended.			X		3	Ministry of Agriculture, Koronivia Research Station, Fiji Livestock Corporation, local farmers	Medium-term
Enteric Fermentation in Livestock. Reduce emissions from enteric fermentation in commercial livestock by 10% through extended training of farmers, support for improving livestock productivity through embryo transfer and genetic improvement, and changes of diets. Policies to encourage changes in livestock breed and support of changing diets are recommended.				X	9	Ministry of Agriculture, Koronivia Research Station, Fiji Livestock Corporation, local farmers	Long-term
Manure Management. Reduce emissions from manure management in commercial livestock by 2% through improved animal diets and instalment of bio-digesters. These measures may be part of guidelines for the promotion of bioenergy.			X		1	Ministry of Agriculture, Koronivia Research Station, Fiji Livestock Corporation, local farmers, DoE	Medium-term
Manure Management. Reduce emissions from manure management in commercial livestock by 10% through improved animal diets and instalment of bio-digesters. These measures may be part of guidelines for the promotion of bioenergy.				X	9	Ministry of Agriculture, Koronivia Research Station, Fiji Livestock Corporation, local farmers, DoE	Long-term
Synthetic Fertilisers. Reduce emissions from the use of synthetic fertilisers by 1%. Measures are the training of farmers in the application of synthetic fertilisers (type of fertiliser; quantity and time of application).			X	X	0.4	Ministry of Agriculture, Koronivia Research Station, Fiji Livestock Corporation, local farmers	Medium-term
Synthetic Fertilisers. Reduce emissions from the use of synthetic fertilisers by 1% through training.			X	X	0.4	Ministry of Agriculture, Koronivia Research Station, Fiji Livestock Corporation, local farmers	Medium- to long-term
Wetlands (Blue Carbon)							
Review and adoption of the Mangrove Management Plan	X	X	X	X	0.03 - 0.05	MOE&W, Ministry of Forests, Ministry of Lands	2019
Carry out carbon sequestration studies for the seagrass meadows in Fiji		X	X	X	0.1-0.2	USP	Short- to medium-term
Obtain high-resolution satellite imagery and map mangrove cover and land use changes		X			0.15-0.2	SPC, Ministry of Lands, MoE&W	Short- to medium-term

Action	Scenario[271]				High-Level Costing (USD millions)	Main Implementer	Implementation Timeframe
	BAU-U	BAU-C	HA	VHA			
Replicate above-ground and below-ground biomass studies for mangroves and soil carbon content an all major locales nationally		X			0.5	USP	Short- to medium-term
Include Blue Carbon in the next National Communication to the UNFCCC		X	X	X	0.05 - 0.1	Ministry of Economy, MoE&W	Short- to medium-term
Establishment of nurseries for rearing of seedlings for replanting & training and capacity building in mangrove protection, planting, and restoration		X	X	X	0.15 – 0.2	MoE&W	Medium-term
Establishing a database for all management activities in mangroves and seagrass beds		X	X	X	Variable cost	MoE&W	Medium-term
Formulate baseline for seagrass emissions in Fiji			X	X	Variable cost	MoE&W	Medium-term
Design, prepare, and adopt policy for replanting of mangroves and carry out awareness to private sector and public			X	X	0.3	MoE&W	Short- to medium-term
Waste							
3R policy. A national 3R policy to be developed and implemented to minimise waste going to landfill, encourage recycling and composting of household kitchen and green waste		X	X		0.5[301]	Ministry of Waterways and Environment	Short-term (2018 – 2025)
Increased Composting. Composting facility launched and operational.		X			0.7[302]	Suva City Council, Nasinu Town Council, Nausori Town Council	Short-term
Waste management awareness program. Creating awareness amongst society for behavioural change in successful implementation of 3R policy.		X			0.15[303]	Department of Waterways and Environment	Short-term
Development of transfer waste station. Reduces the transportation time and cost and emissions associated with carting waste to Naboro Landfill. The waste transfer station will provide opportunity for separating organic waste and diversion of organic waste from the landfill.		X			0.12 - 0.7[304]	Private company (WasteClear) and Nasinu Town Council	Short-term
Enforcement of Container Deposit Legislation. Legislation has been passed by the cabinet. This action would implement and enforce the legislation, including public awareness and engagement, consultation and planning with the private sector.			X		Variable cost	Ministry of Waterways and Environment	Medium-term
Waste-to-Energy. Kinoya Waste-to-Energy, electricity cogeneration facility – launched and operational			X		3.8[305]	Water Authority Fiji	Medium-term
Landfill Methane. Naboro landfill methane recovery and utilization facility – launched and operational				X	2[306]	Mo W&E and HG Leach	Long-term

[301] Department of Environment. (2018). *National Integrated Waste Management Strategies 2016-2028.*
[302] The amount includes the cost of land, infrastructure, machinery, and labor cost for 1 year.
[303] Department of Environment. (2018). *National Integrated Waste Management Strategies 2016-2028.*
[304] A proposal was recently submitted to Department of Environment by waste clear company. To have the waste transfer station launched and operational (basic) it would cost approximately USD 117,000 which mostly includes the cost of the land and minimum infrastructure. To have an enclosed waste transfer station, mechanical handling of materials, mechanical sorting of waste and collection and treatment of leachate then it would cost approximately USD 705,000.
[305] A proposal was made to WAF by EVO Energy Technologies for power cogeneration for Kinoya. Based on the current capacity of inflow rates a total investment of FJD 2.65 million was estimated. Due to the ADB investment and current extension plans at Kinyoa the capacity will almost increase by three-fold and therefore the costing is upscaled by a factor of three as well and is estimated to be approximately USD 3.8 million.
[306] Mani et al. (2016). *Pre-feasibility study for methane recovery at Naboro Landfill, Suva, Fiji Islands.*



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